APPENDICES
FINAL
ENVIRONMENTAL IMPACT REPORT

BIG WAVE WELLNESS CENTER AND OFFICE PARK PROJECT

Lead Agency:
County of San Mateo
Planning and Building Department
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SCH No. 2008102109
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APPENDIX A: INFORMATION SUBMITTED BY LEN ERICKSON

- Local Government Commission, Highway 1 Safety and Mobility Improvement Study

APPENDIX B: PRESENTATIONS FROM THE NOVEMBER 18, 2009 PLANNING COMMISSION PUBLIC HEARING

APPENDIX C: ATTACHMENTS TO COMMENT LETTER 204 FROM BIG WAVE GROUP, SCOTT HOLMES, DATED DECEMBER 23, 2009

APPENDIX D: ATTACHMENTS TO COMMENT LETTER 205 FROM SHUTE, MIHALY & WEINBERGER, LLP., WINTER KING, DATED DECEMBER 23, 2009

APPENDIX E: ATTACHMENTS TO COMMENT LETTER 209 FROM WITTWER & PARKIN, LLP., JONATHAN WITTER, DATED DECEMBER 23, 2009

APPENDIX F: ATTACHMENTS TO COMMENT LETTER 185 SUBMITTED BY SEAL COVE AND PILLAR RIDGE HOME OWNERS, DATED DECEMBER 24, 2009

- Seal Cove Road Closures
- Letter Regarding the Big Wave Facilities Plan, dated March 26, 2009
- Summary of Printed Materials
- The San Andreas and San Gregorio Fault System in San Mateo County
- USGS, Earthquake Hazard Program
- California Emergency Management Agency, My Hazards
- Grand Jury of San Mateo County, Summary of Tsunami Alter and Evacuation on the San Mateo County Coast
- City of Half Moon Bay Tsunami Information
- Designing For Tsunamis – Seven Principles For Planning And Designing For Tsunami Hazards
- An Introduction to the Historical Ecology of the Fitzgerald Marine Reserve CCA
- California Climate Change Center, Impacts of Seal-Level Rise on the California Coast
- Pacific Institute, Coastal Populations Vulnerable to Seal-Level Rise
- Pacific Institute, Impact of Seal Level Rise on the California Coast
- Sea Level Rise Preparedness
- California Natural Resources Agency, 2009 California Adaptation Strategy
- SFGate, Eroding Cliff Prompts Pacific Evacuations
- Coastsider, We Need a Way to Cross Highway 1 Safely in Moss Beach and Montara
- Half Moon Bay Review, Highway 1 Re-Opened After Moss Beach Accident
- Golden Gate Regional Center, Policy Guidelines

- Abuse and Neglect of Adults with Developmental Disabilities: A Public Health Priority for the State of California
- National Resources Center for Respite and Crisis Care Services, Abuse and Neglect of Children with Disabilities
- Goals for the Building Partnership Initiative
- National Disability Rights Network, A Decade of Little Progress Implementing Olmstead
- National Disability Rights Network, Press Room
- National Disability Rights Network, Restraint and Seclusions Resources
- The National Children Traumatic Stress Network, Facts on Traumatic Stress and Children with Development Disabilities
- Williams Syndrome Foundation, Retardation and Abuse
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APPENDIX J: ATTACHMENTS TO COMMENT LETTER 230 FROM MID-COAST COMMUNITY COUNCIL, NEIL MERRILEES, DATED DECEMBER 23, 2009.

APPENDIX A

INFORMATION SUBMITTED BY LEN ERICKSON

Highway 1 Safety and Mobility Improvement Study

San Mateo County Midcoast: Princeton, El Granada and Miramar

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Views and opinions presented in this report do not necessarily represent the views or opinions of Caltrans or the California Business Transportation and Housing Agency.

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Introduction

This report describes the background, process, and outcomes of the planning effort conducted in El Granada in June, 2009. The study focused on Highway 1 and adjacent communities between Frenchman's Creek in the City of Half Moon Bay, and the intersection of the Half Moon Bay Airport in unincorporated San Mateo County.

This document is the result of an intensive community-based planning process. The California Department of Transportation provided a Community Based Transportation Planning Grant to San Mateo County, in partnership with the Local Government Commission (LGC). LGC is a Sacramento-based nonprofit organization that works with local leaders and agencies to build livable communities. LGC assembled a professional multi-disciplinary consultant team to develop plan components.

Study Area

The study includes two unincorporated coastal villages, Princeton and El Granada, and the village of Miramar, which is partially within the City of Half Moon Bay. State Route 1, a regionally significant roadway serving through and local traffic, provides the only access between the villages and neighborhoods.

Multiple agencies have jurisdictional authority in the study area. The unincorporated villages of El Granada and Princeton are governed by San Mateo County. City of Half Moon Bay boundaries include the beach and coastline along El Granada, and a portion of Miramar. Pillar Point Harbor, adjacent to El Granada and Princeton, is under San Mateo County Harbor District's jurisdiction. Caltrans maintains and operates Highway 1, and the City of Half Moon Bay and San Mateo County maintain and operate other roadways. The entire study area is within the jurisdiction of the California Coastal Commission. The study area has about 11,000 residents.

Transportation along this segment of coast was once provided by rail and dirt roads. Later, the County provided a roadway, some of which eventually eroded into the ocean or was integrated into Route 1 (also known as Cabrillo Highway in this section).

Traffic flow on the highway ranges from rural conditions, where movement is typically free, to congested conditions during commute times with level of service issues at certain intersections, to unavoidable gridlock on weekends with good weather.

2008 Caltrans data indicate that the average daily traffic volume on the highway is 27,000 cars north of Frenchmans Creek Road, and then drops to 18,900 cars by Capistrano Road, and then to 16,300 north of Capistrano Road. During the busiest seasonal peak month, volumes increase by 2,500 north of Frenchmans Creek Road, and then drops to 1,300 by Capistrano Road. Posted speed limits vary between 45 and 50 miles per hour.

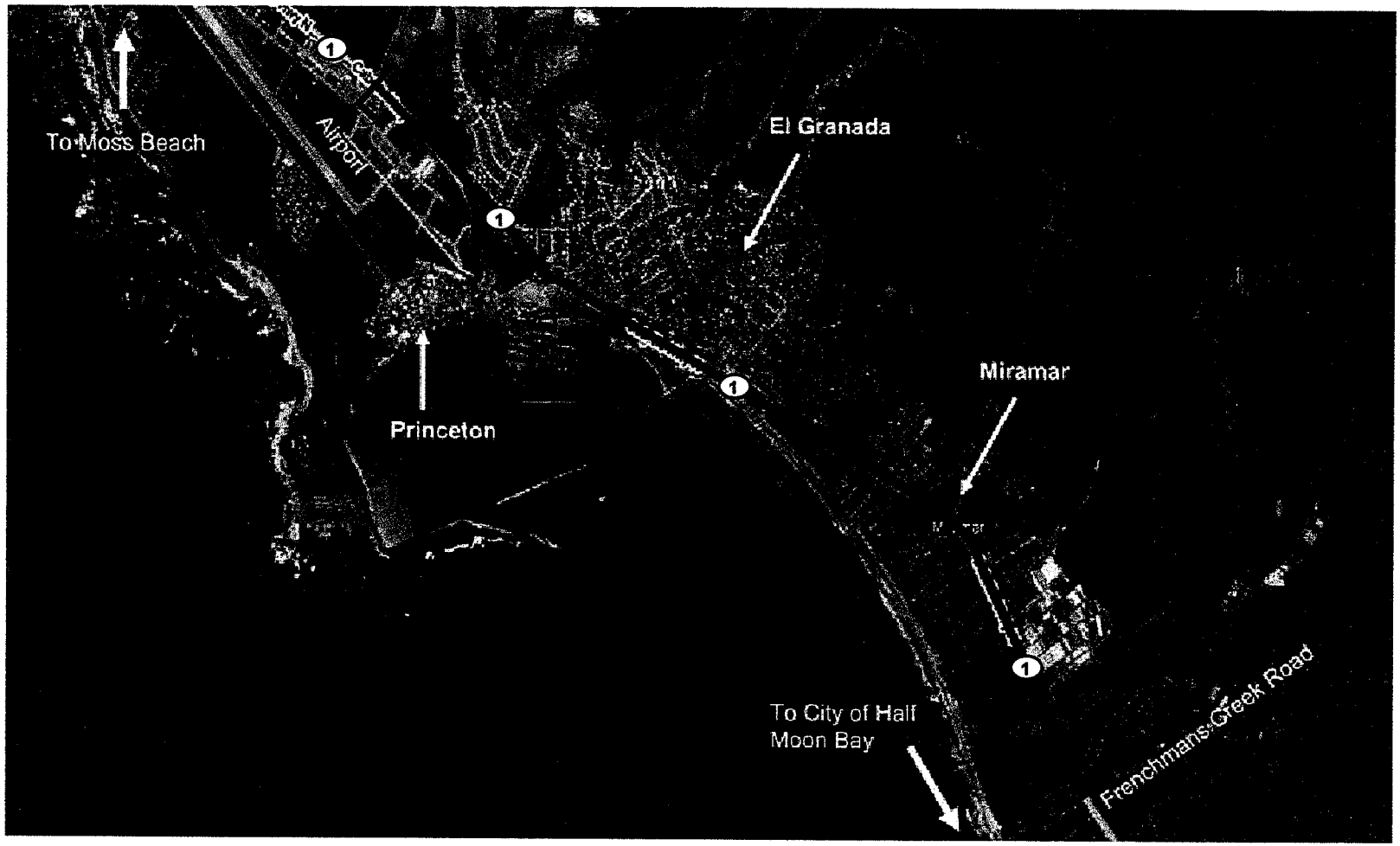
The Devil's Slide highway improvement project north of the study area, just south of Pacifica, has the potential to attract more use. In addition, a proposed office park and wellness center west of the highway between Princeton and Moss Beach (if approved and constructed as proposed) will also add more users to the highway.

Visitors park on Highway 1 shoulders in several locations, crossing the highway on foot, carrying picnic and surfing supplies. Through bicyclists make their way along the coast using road shoulders, some ride on completed portions of the Coast Trail. Mass transit, originally provided by the railroad, is now limited to a few bus trips each day.

Study Purpose

The study purpose is developing a plan for Highway 1 to better serve all users. Planning efforts by San Mateo County and other agencies are shaping development, recreation,

Study Area


To Moss Beach
Airport
El Granada
Princeton
Miramar
To City of Half Moon Bay
Frenchmans Creek Road

infrastructure, and environmental policies within the study area. The community-based planning process engaged citizens in developing short- and long-term transportation improvement strategies consistent with established regional policies.

One of the biggest challenges is that the corridor must provide for commuters and high volume vehicle traffic on weekends, while maintaining safety and comfort for residents. It must also provide for pedestrians, people with mobility impairments, and bicyclists who are using the highway right of way or trying to cross.

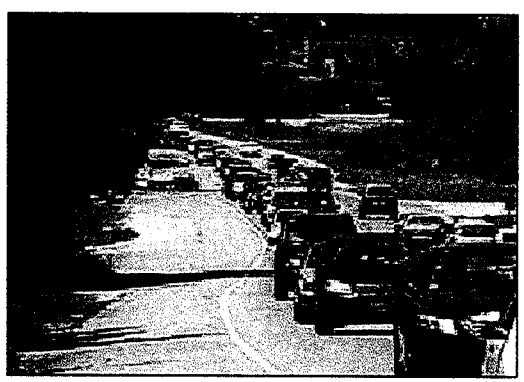
The primary goals of this project are:

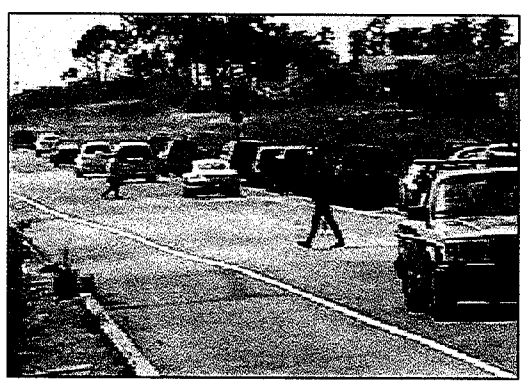
- Increased pedestrian, bicycle and vehicle safety along Highway 1.
- More transportation options for those that cannot, or choose not to use cars for local trips and commuting, reducing congestion and maintaining road capacity.
- A network of secondary alternatives for pedestrian and bicycle circulation, built upon existing and planned trails and other opportunity sites, such as El Granada's historic medians.
- A consistent highway corridor that supports the character and vitality of adjoining villages, recreation and natural surroundings.
- A long term vision for the corridor that addresses the challenge of shoreline erosion and is sensitive to the dynamic coastal environment.
- Reduced greenhouse gas emissions through the reduction of vehicle miles traveled.

AB 32 and SB 375

The Global Warming Solutions Act of 2006 (Assembly Bill 32) set carbon emission reduction requirements in California. Passenger vehicles are the largest single source of greenhouse gas emissions in the state. Senate Bill 375 will set new reduction targets and require jurisdictions to adopt strategies to reduce vehicle miles traveled.









Public Process

A multi-day design effort, or charrette, was conducted from June 25 to June 30, 2009. Staff, community leaders, and residents participated in a series of events designed to identify concerns, priorities, and potential solutions.

The events began with a series of focus group meetings. Groups included agencies and districts; parks, trails, and open space; Caltrans engineers, planners, and architects; and the El Granada Sanitary District. The facilitator encouraged each group to share their knowledge, concerns, and ideas about the study area. Highlights of the focus groups appear in the Appendix.

A Community Workshop was held in El Granada at the elementary school on Thursday, June 25. Participants shared ideas and viewed a slide presentation highlighting study area issues and techniques used in other communities. Participants described their vision for how they would like the area to be twenty years in the future. They took part in activities to identify values they held in common for their community and to identify leading issues to address for the future of the Highway 1 corridor, the coastal villages and natural surroundings.

Many envisioned a trail network linking Coastside communities. Some would like to see trails from San Francisco to Half Moon Bay, Pescadero, or Santa Cruz. Everyone agreed about the need for safe crossing for all Coastsiders from Montara to Half Moon Bay. Fewer cars, more transit, and improved parking management were other common themes. Landscaping with native plants and adding bathrooms and water fountains were popular. See the Appendix for other participant ideas and priorities.

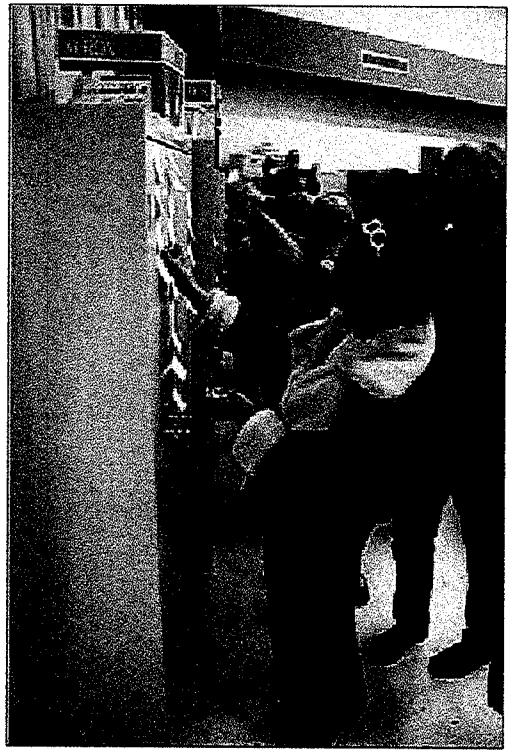
On Saturday, participants joined the consultant team to conduct walking audits. The group observed traffic and pedestrian patterns in the field, discussed concerns, and considered some ideas for resolving problems. After the field review, participants viewed a presentation recapping the Thursday night concepts and illustrating concepts for addressing issues within the study areas. Participants then gathered at tables to develop suggestions for improvements and present their results to the entire audience.

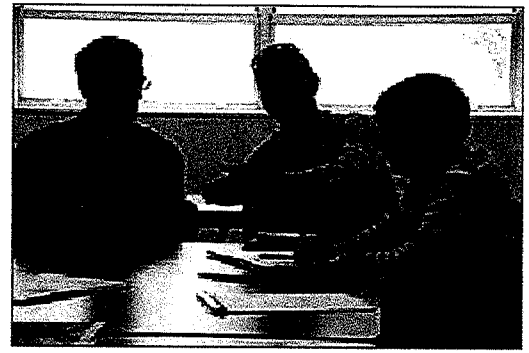
Some community concerns were beyond the scope of this project, but the improvement plan developed during the next four days reflected most of the input. On Tuesday, June 30, 2009, Consultants presented slides of the plan's key points at a Closing Workshop. Detailed notes from public processes appear in the Appendix.













Top: focus group participants share ideas, information and concerns about the study area. Left and above: workshop participants identify common values and vote priority issues. Far left, middle: participants walk, observe and discuss field conditions with a member of the consultant team. Far left, bottom: participant reports ideas developed through group table map activity.

Highway 1 Profile

The highway's context and roadway classification determine the type of roadway changes that can be considered. California statutes designate Route 1 from Higgins-Purissima Road south of the City of Half Moon Bay to I-280 as part of the California Freeway and Expressway system. The designation influences speed limits, access, and design features. State law also recognizes the dynamic nature of transportation planning, leaving an opening for designation changes.

Caltrans approaches transportation decision-making and design using the principles of Context Sensitive Solutions (CSS). CSS considers the communities and lands around highways. This approach addresses the physical settings and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSS and Caltrans Complete Streets policy described in Deputy Directive DD-64-R1 recognize that bicycle, pedestrian, and transit are integral elements of the transportation system.

The Route 1 corridor within the study boundaries (northern end of Capistrano Road and Frenchmans Creek) is a relatively short section of a primary State highway that follows the coastline. A brief overview of a longer portion of Highway 1, from south of Pacifica to south of the City of Half Moon Bay, is useful for understanding the highway's larger, overall context and study area concepts that follow in later chapters.

Caltrans Deputy Directive 64-R1

Caltrans policies define Complete Streets as "...a transportation facility that is planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit riders, and motorists appropriate to the function and context of the facility."

At the northern end of the corridor, near Pacifica, there is a steep, unstable geological formation referred to as Devil's Slide. A long history of closure due to rock slide and land slippage in the vicinity prompted Caltrans to construct two 30-foot wide tunnels, one for northbound traffic, and one for southbound traffic and a bridge to bypass the problem area. The bypassed section of Route 1, together with 70 acres of State right-of-way, will be available for public access and recreational use following the planned tunnel opening in 2011.

Most of Highway 1 from south of Pacifica to south of the City of Half Moon Bay has relatively gentle grades, balanced horizontal alignment, and rural highway super-elevations (embankments on curves to serve higher speeds). Highway cross sections along the corridor are inconsistent, and intersections and driveway treatments vary considerably. Adjacent and nearby land uses include open space, recreational, commercial and small urban areas, and residential neighborhoods. Near some recreation areas, vehicles park on highway shoulders and pedestrians cross the highway at frequent and unpredictable intervals. Highway 1 serves both local and through traffic, with numerous public and private driveways and other access points.

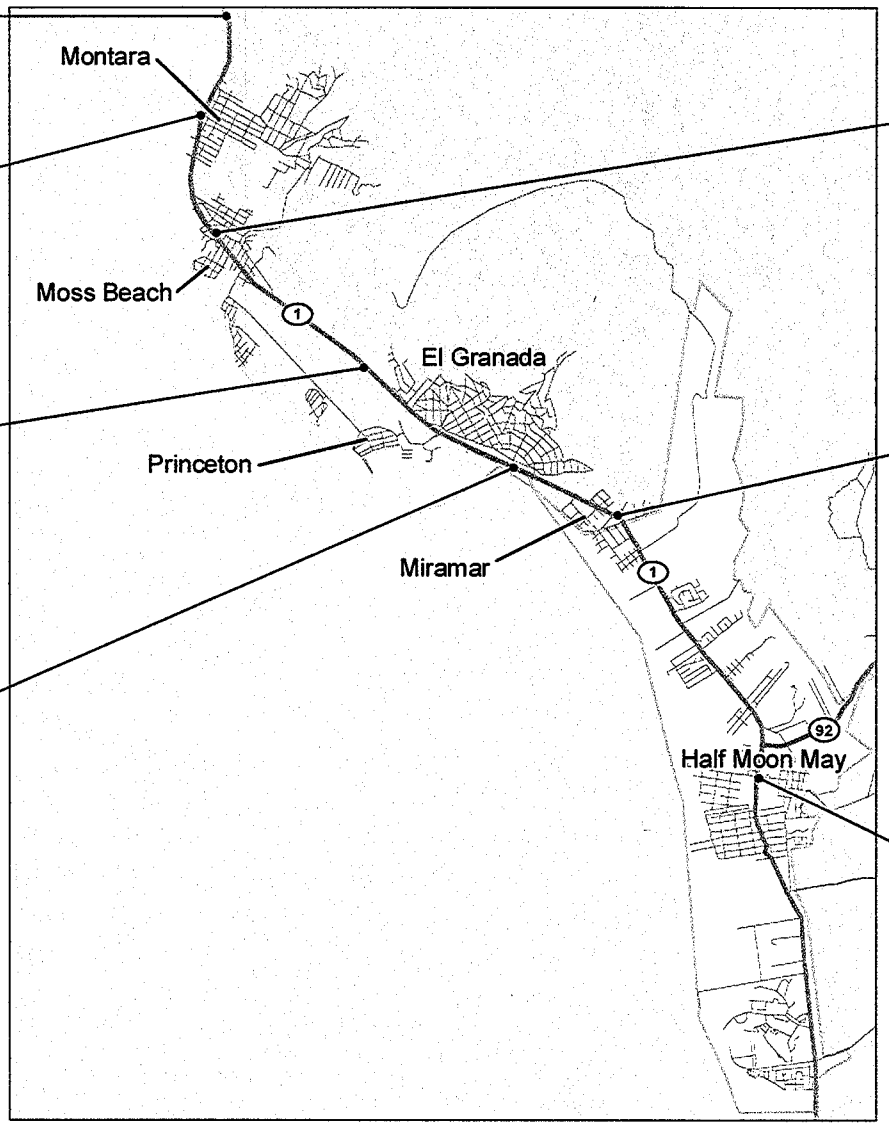
A summary of general highway corridor observations and issues from north of Montara to the City of Half Moon Bay is included on the next page.

North of Montara
- Grade changes
- Minimal shoulders
- Relatively sharper curves
- Bike/Vehicle conflicts
- Recreation parking conflicts

Montara
- Speeds
- Access management
- Highway adjacent parking loaded development
- Side street sight distance

Airport Segment
- Open cross section
- Gentle alignment
- Adjacent agricultural use and access
- Undefined airport access intersection
- Inconsistent number of lanes northbound
- Speed transition needs to El Granada

El Granada
- Coastal erosion
- Speed management
- High pedestrian crossing demand
- Varying traffic volumes and speeds
- Turning traffic at driveways and streets
- Sight distance challenges at cross streets
- Sight triangles and vertical alignment

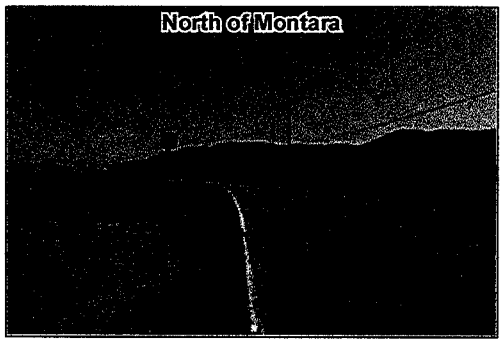


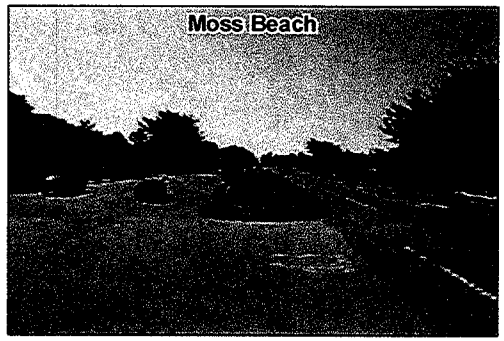
General Corridor Observations and Issues

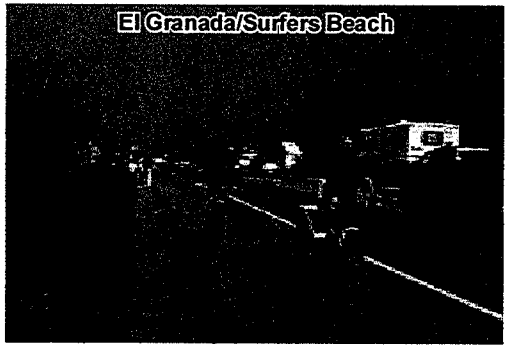
Moss Beach
- Speeds
- Number of public street accesses
- Crossing traffic
- Inconsistent roadway edge
- Underdeveloped frontage "Main Street"
- Storm water treatment opportunity

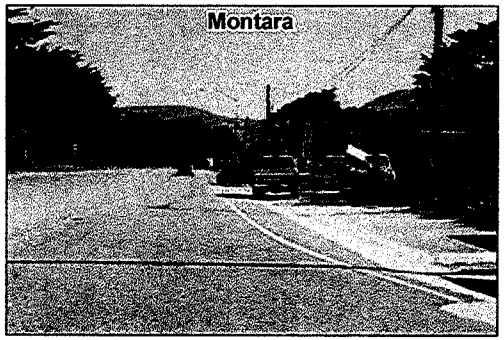
Miramar to Half Moon Bay
- Transitional segment
- Varying traffic volumes and speeds
- Relatively high number of accesses
- "Isolated" signalized intersection
- Turning traffic at driveways and streets
- Sight distance challenges at cross streets
- Sight triangles and vertical alignment

Half Moon Bay
- Heaviest volumes
- Signalized intersections
- Significant highway crossing demand
- Inconsistent edge treatments
- Inconsistent typical cross section south of Kelly Avenue
- Unbalanced treatments to Main Street

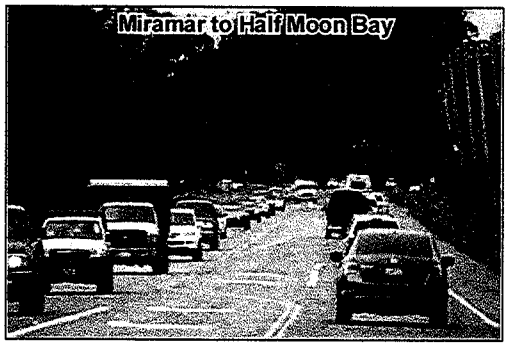








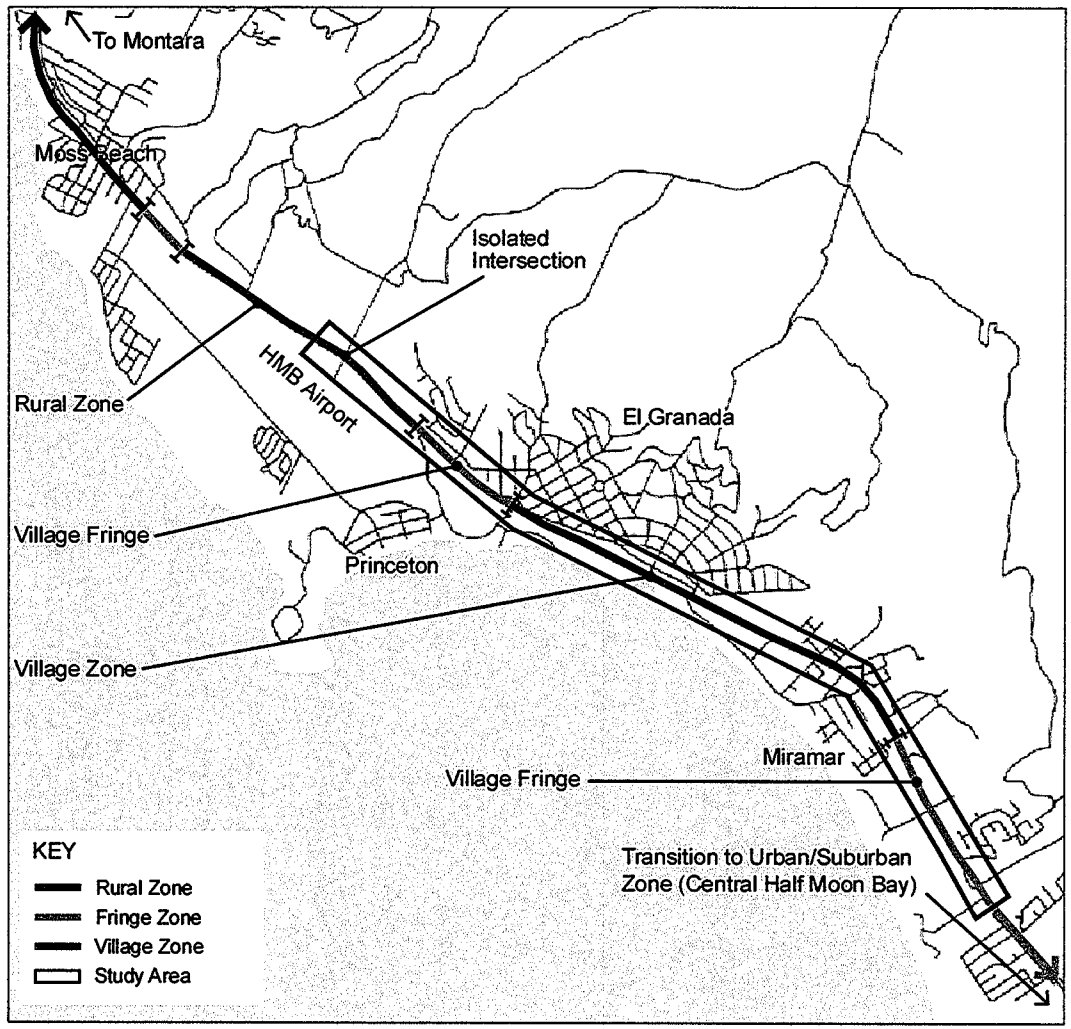






Top Left, Middle and Bottom: narrow shoulder on Highway 1, looking north from the fringe of Montara; potential parking conflicts with through traffic, pedestrians and bicyclists; multiple crossing traffic locations in central Moss Beach. Top Middle and Bottom: parallel road to the highway provides opportunity for main street development and space for stormwater retention and treatment; isolated intersection at Half Moon Bay Airport is difficult to detect. Top Right, Middle and Bottom: High pedestrian and bicycle activity and crossing demand in El Granada; varying traffic volumes and speeds from El Granada to Half Moon Bay; suburban intersection in City of Half Moon Bay.





The map above divides the study area into three types of context zones.

Context Zones

The surrounding land uses and historic development patterns vary throughout the Highway 1 corridor and within the study boundaries. The various areas can be described as context zones with similar characteristics and user needs. Although the Route 1 corridor is legally defined as a freeway/expressway, motor, pedestrian and bicycle traffic function differently within each of the context zones.

Rural Zones

Rural zones are sparsely developed and primarily agricultural or recreational uses. An example includes Route 1 between the southern fringe of Moss Beach and access to Princeton, north of El Granada. In rural zones, there are generally few pedestrians, bicyclists, and access points. Vehicle speeds tend to be high.

Isolated Intersections

Isolated intersections are infrequent intersections with no traffic control. An example is the intersection that provides airport access in the rural segment between El Granada and Moss Beach. In isolated intersection zones, drivers slowing to make a turn or entering the highway pose a potential conflict. There may be pedestrians or bicyclists crossing at or near the intersection. Driver awareness and intersection visibility are key safety factors. Motorists may not recognize or be aware of all intersections

and the increased potential conflicts at these locations. Relatively high speeds increase stopping sight distance requirements and the risk of injuries associated with conflicts.

Village Fringes

Village fringes are transitional segments on approaches and exits at village edges, where rural context attributes begin changing. Pedestrian and bicycle activity is likely to increase in the fringe areas, and more traffic turns on and off Highway 1 to access residential and commercial areas. Driver speeds should begin to lower as drivers become aware of the changing context and anticipate potential conflicts or seek access to local sites. In many places, mixed and undefined adjacent land uses provide few cues to trigger speed reduction.

Village Zones

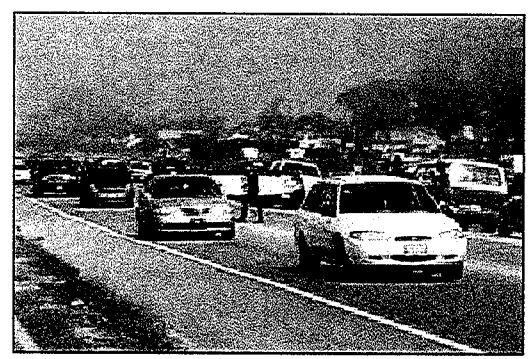
Village zones include the coastal communities of Montara, Moss Beach, Princeton, El Granada, and Miramar. In Villages, potential traffic conflicts increase as visitors and residents seek parking, recreation, retail, transit stops, and restaurant sites. Pedestrian and bicycle traffic increase, and traffic movements at major intersections may be controlled with signs or signals.

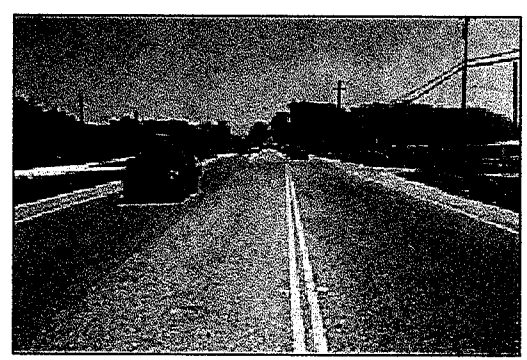
Urban/Suburban Zones

Urban and suburban zones along Highway 1 occur in the City of Half Moon Bay. These areas are similar to village zones, but with greater traffic volumes and more access points. Slower speeds are appropriate in village and urban/suburban zones to allow drivers time to see and react to multiple users and traffic conditions. These locations have more urbanized roadway features (sidewalks, curbs, traffic signals, cross walks) than other areas along the corridor.

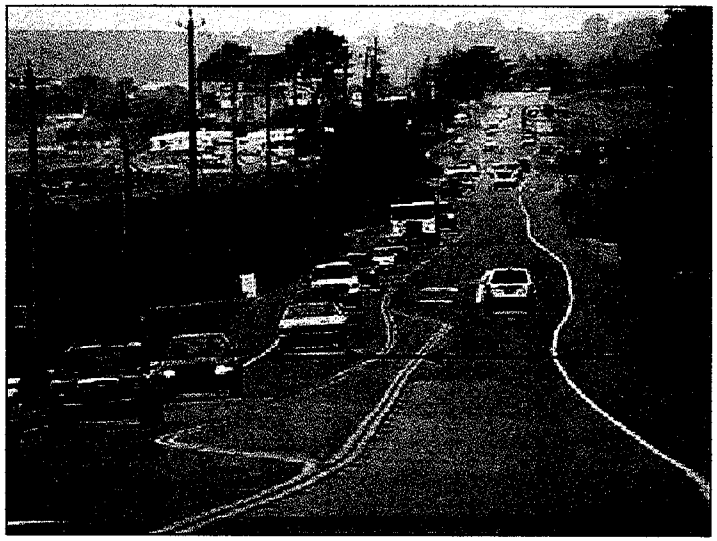
Site design and roadway characteristics in each of the zones influence speeds at which drivers will be comfortable, the ease of street crossings for pedestrians and bicyclists, and the comfort and sense of security of those walking and bicycling along Highway 1. Along parts of the corridor, roadway features and land use suggest high speeds are appropriate. These speeds may be incompatible with other user needs within the various context zones. Strategies to encourage safe operating speeds and behaviors within each zone are discussed in the following section.







Top right: the roadway segment approaching the intersection at Half Moon Bay Airport exhibits rural characteristics with open agricultural and largely undeveloped lands. Middle: this segment between Surfer's Beach and El Granada exhibits village-type characteristics with increased development, high pedestrian activity, varying traffic volumes and speeds, and turning traffic at driveways and intersections. Bottom: this segment between Miramar and Half Moon Bay exhibits fringe characteristics, with lighter development but numerous access points, turning movements and changing traffic speeds and volumes.





Top: Miramar looking north toward El Granada. Bottom: Miramar looking south. The photos show a lack of consistent built cross section width and characteristics and lack of defined inside and outside edges.

Recommended Strategies

This section outlines an overall corridor strategy and tools suitable in the various context zones along Highway 1. The approach is intended to facilitate highway consistency throughout the study area, with changes adapted and sensitive to the varying physical surroundings and operational needs of the roadway.

Define Edges

Currently, Highway 1's wide range of roadway cross section characteristics and features vary from rural shoulder applications with inconsistent widths to painted medians that vary in their application and widths. Curbed locations are intermittent and the location of property lines, lot development, or driveway edges occur at different distances from the edge of the travel way. This variation reflects a highway facility that has developed piecemeal over time.

A consistent roadway contributes to driver understanding of the environment. Roadway edges, intersections, and driveways should be easily identified.

Travel lanes should be well-defined on the shoulder edge and on the inside edge. Shoulders or striped on-street bike lanes along Route 1 would positively influence driver interpretation of the roadway. Other features to define edges in some context zones include contiguous curbs or edged treatments.

Inside travel edges can be defined by consistent median width, with changing treatments to define context zones. For example, the median might be a flush, center turn lane in rural zones, a colorized, stamped flush median in village fringes, and a raised median with turn pockets in villages.

Medians improve highway safety in various ways. Flush medians or center turn lanes remove turning traffic from through lanes and provide consistent inside edges. Turning vehicles have an area away from through traffic in which to wait for a gap in oncoming traffic so they can turn. Flush medians provide space between through lanes where pedestrians can wait for a gap in traffic, but there are still potential conflicts with turning vehicles.

When the median is raised, curbs prevent drivers from using the space so the conflict between drivers and pedestrians is eliminated. Raised medians also prevent crashes caused by head-on and crossover traffic. Raised medians can be continuous, with openings where turns are permitted, or they may be short segments strategically placed within flush median areas to facilitate pedestrian crossings, restrict vehicle turning movements, or prevent traffic from using the center turn lane for through travel or passing slower vehicles. Raised medians provide space opportunities for landscaping and reducing impervious coverage.

The Highway 1 roadway sits within a wide Caltrans right-of-way, averaging 160 to 180 feet from Miramar to El Granada. The addition of medians and road edge improvements could be accomplished without the need for property acquisition. Street cross section drawings are presented on the following pages to serve as guidelines for developing a consistent roadway edge through each of the Route 1 context zones.

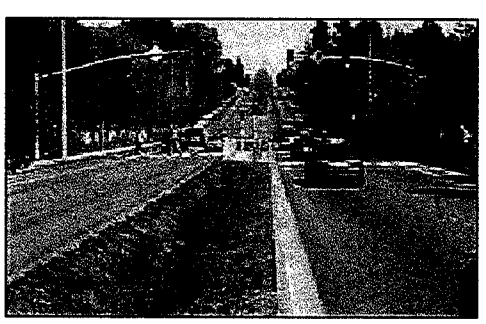




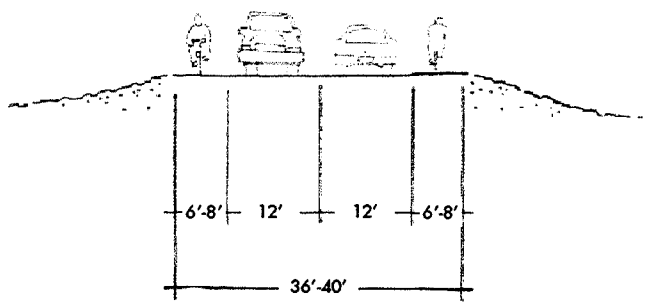




Top Left: Shoulder with stamped, colorized pavement clearly defines road edge on State Highway 16, Capay Valley, Ca. Top Right: landscaped swale delineates the road edge and provides area for natural drainage, and separation between the road and sidewalk. Above Right: raised median with high contrast decorative landscaping. Right: center median designed with a landscaped swale for natural drainage and pedestrian refuge area at a signalized, stop-controlled pedestrian crossing.

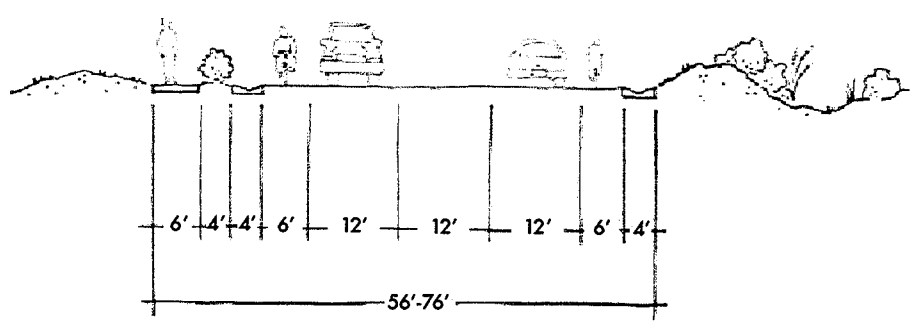


Section A: Typical Rural



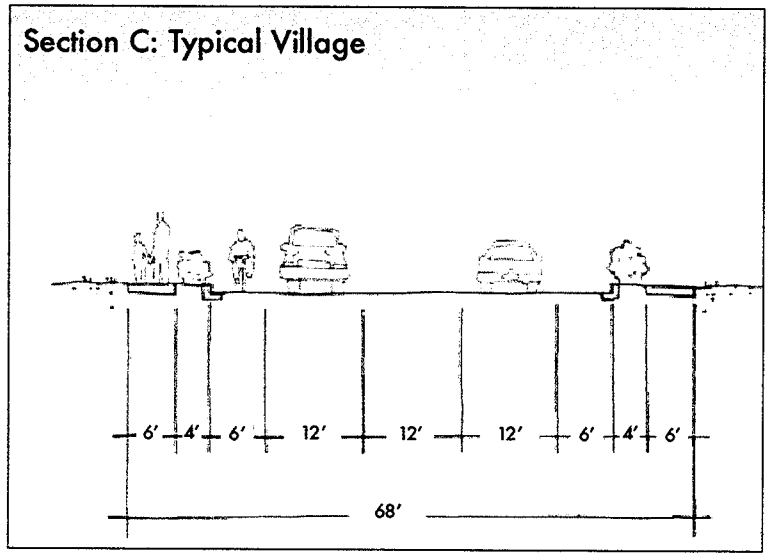
Section A (left) is applicable to some rural areas where intersections are infrequent and speeds are posted at or above 45 mph. Since higher speed zones require wider lanes, 12-foot lanes would be typical in rural areas. Shoulders 6 to 8 feet wide provide breakdown parking, emergency passing, and room for bicycling or walking (where there are no trails or sidewalks). This type of treatment would apply between the north terminus of Capistrano Road to the village fringe of Moss Beach. In areas with more frequent turns, a center turn lane, or striped (flush) median, may be needed.

Section B: Typical Fringe



Section B (left) shows a typical section where the rural section transitions to a more strongly defined edge. Both sides of the road show a valley gutter to set the edge. Here, lane widths less than 12 feet may be considered if speeds are reduced below 45 mph. Reduced lane widths can help signal a change in context and encourage speed moderation. A sidewalk with a planted buffer between the travel lane and the sidewalk is shown on one side. This does not mean a sidewalk is only needed on one side of the highway. It simply illustrates the sidewalk concept in fringe areas where they are needed.

Section C (right) is a typical village cross section with some urbanized features, including curb and gutter, median, bike lanes, and sidewalks. Lane widths less than 12 feet wide may be appropriate in these zones. Reduced lane widths in village areas can help moderate speeds, reduce crossing distances for pedestrians, provide room within the same right-of-way for streetscape enhancements, and reduce the overall amount of land consumption for pavement.



Improve Intersection Visibility

Intersections and driveways are locations of increased conflicts for all roadway users. Speed reduction is not always necessary at intersection locations in all context zones. However, drivers should be aware of all intersection locations to be prepared to respond to increased conflicts. Intersection treatments should make them noticeable when entering and traveling through the intersection influence area. Treatments can include illumination and changed cross section elements such as curbing or median treatments.

Many intersecting side streets with Highway 1 in the study area are below the level of the highway, forcing vehicles to the edge or into the travel way to look for clearance before turning onto the highway. Raising the approach grade on these intersecting side streets would improve intersection sight distance and promote more efficient turning maneuvers.

Where possible, curb radii at intersections should be kept tight, 15 feet or less, to encourage safe turning speeds. Compact curb radii are especially useful in zones where pedestrians are expected, because they slow vehicle turning movements and shorten pedestrian crossing distances.

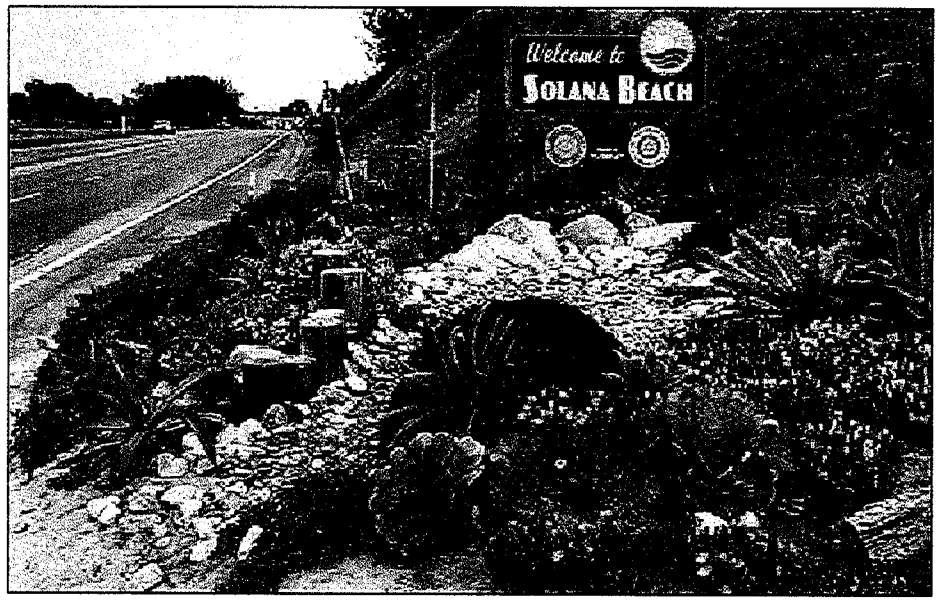


The change in approach grade reduces driver sight distance.



Entry Treatments

In addition to identifying place, gateways send a message to drivers that the environment is changing. Gateways along Highway 1 could include roadside signs or landscaping, landscaped raised medians, or roundabouts. Flags and banners are visual aids for vehicle occupants as well as for people who are walking or bicycling.



Roundabouts

Roundabouts are one strategy to improve some intersections within the study area. Roundabouts are un-signalized intersections in which traffic circulates counterclockwise around a raised center island. Vehicles in the roundabout have the right-of-way over entering traffic. Motorists slow down as they approach the intersection, yielding to any pedestrians in the crosswalk. The yielding driver looks left, waiting if necessary for a gap in the traffic flow before merging into the roundabout. Once inside the roundabout, drivers turn right at their exit.

Roundabouts have 76% fewer injury crashes and 30-40% fewer pedestrian crashes than signalized intersections. The most severe intersection crashes, often caused by red light running, are eliminated at roundabouts.

Roundabouts generally reduce motorist delays at controlled intersections, though there may be some delay at a roundabout during peak periods, just as there would be at a signal. But during periods when traffic levels are low motorist do not have to stop. This is especially beneficial in the study area because traffic volumes vary widely from day to day. Roundabouts also reduce pollution, save fuel, reduce the need for storage lanes, and improve traffic flow at intersections with frequent left turns.

Pedestrians cross roundabouts at designated crosswalks. They cross one direction of traffic, wait in the refuge island to be sure a driver is going to yield, then complete their crossing. People with visual impairments rely on audio information to determine when it is safe to cross. At roundabouts it may be difficult for them to determine when traffic has stopped to wait for them.

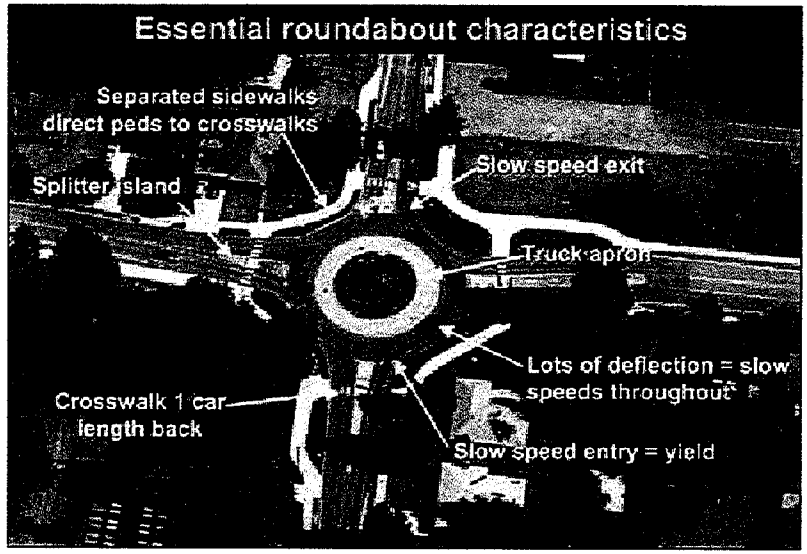
Experienced bicyclists can proceed through the roundabout in a traffic lane, following the same rules as other vehicles. Cyclists may also use sidewalks or trails and pedestrian crossings.

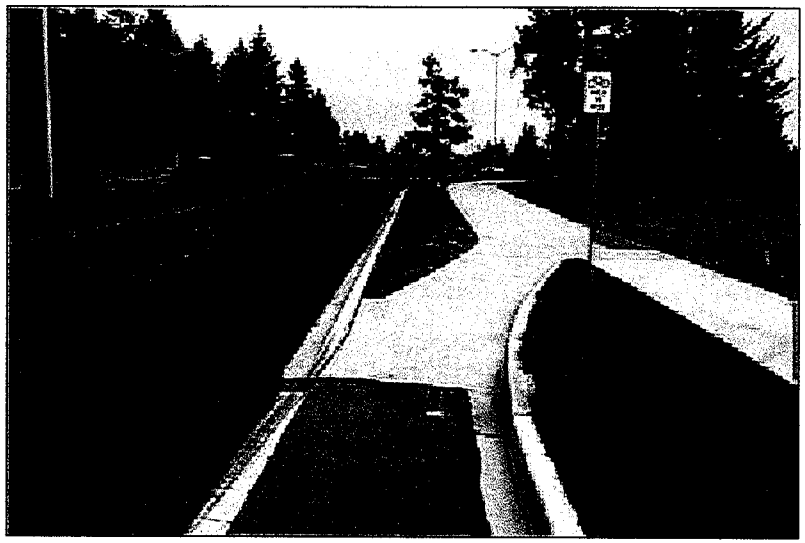
Large trucks and long fire engines drive over the curb on the truck apron in the middle to make the tightest turns. The truck apron surrounding the center island uses contrasting paving and slopes slightly up toward the middle. Normal vehicles stay off the truck apron.

Roundabouts save signal maintenance and power costs. The service life of a roundabout is 25 years versus the 10-year service life of signal equipment.



Roundabout size is dependent upon the volume and type of traffic that will pass through the intersection. Roundabouts can be designed to accommodate large trucks.





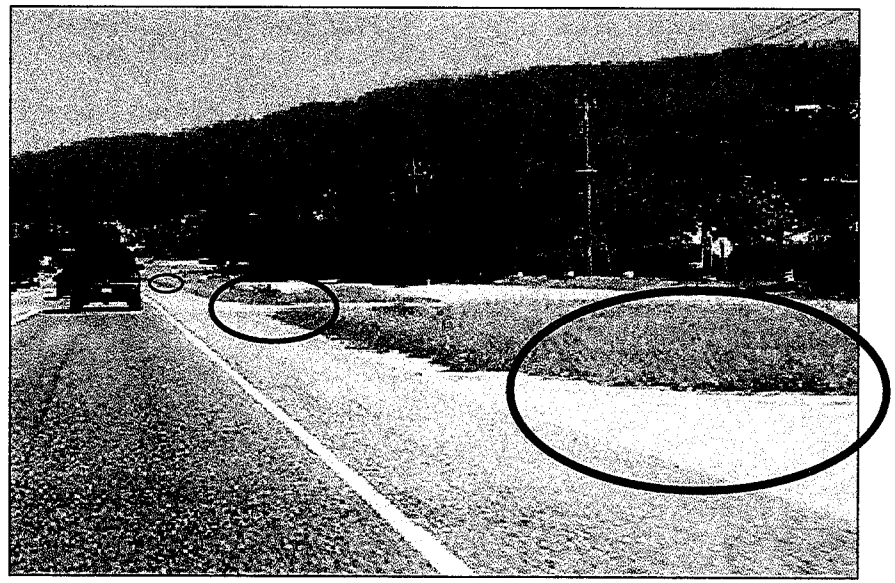
Roundabouts are still new in the U.S. and many communities express concern when they are first proposed. However, once built, residents often embrace them and recognize that they are safer, quieter and more attractive than signalized intersections. Traffic engineers are recognizing that roundabouts can be more efficient than a typical stop-controlled or signalized intersection. The lower speeds and more predictable vehicular movement also make them safer for pedestrians and bicyclists. Other important reasons for considering roundabouts include:

- A typical 4-way intersection has 32 vehicle-to-vehicle conflicts. At a roundabout these conflicts are reduced to 8.
- Properly designed roundabouts will bring vehicle speeds down to 15-20 mph, speeds at which motorists are much more likely to yield to pedestrians and the frequency and severity of accidents are greatly diminished.
- The splitter island in a roundabout provides a refuge for pedestrians as they cross the street and simplifies the crossing by letting them focus on vehicles traveling in only one direction.
- Roundabouts also work well for bicyclists. Most bicyclists simply take the travel lane since vehicles are circulating at a comfortable bicycle speed. Less confident bicyclists can be provided a ramp on the approach to the roundabout so they can exit and walk their bicycle across at the crosswalk. (In areas with high bicycle use, sidewalk and crosswalk areas should be wide enough to avoid creating conflicts between bicyclists and pedestrians.)
- Roundabouts can be designed to accommodate the largest trucks with a mountable truck apron to allow space for wheels or equipment to pass over for turning movements.

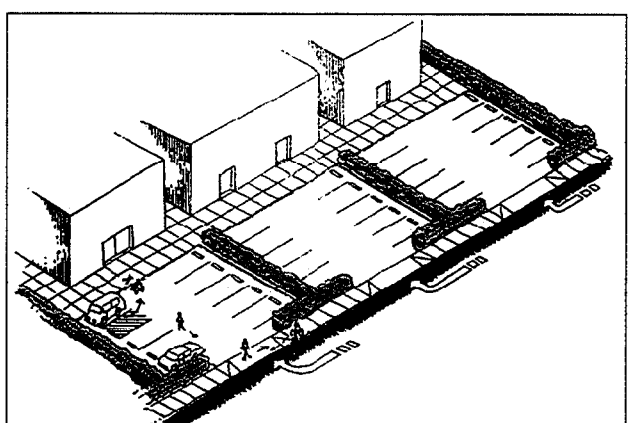
Manage Access

"Access management" means managing vehicle turning movements on to and off the highway. The purpose is to improve safety and traffic flow while maintaining access to property.

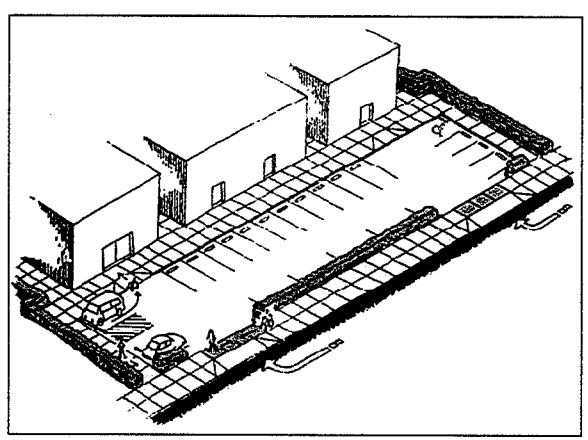
The Route 1 corridor offers opportunities to consolidate driveways, limit turning movements to and from side streets, and re-configure parking. This would reduce the number of turning movements and points of conflict without sacrificing access. Driveways can often be consolidated so that there is one entry and one exit. In some cases, access can be moved to side streets, such as parallel frontage roads or small service roads.



Above: Multiple driveway path openings on Route 1 detract from a consistent edge condition and introduce potential conflicts between turning vehicles and high speed through traffic.



Multiple driveway access points increase points of conflict between motorists and between motorists, pedestrians and bicyclists.



Consolidating driveway access reduces vehicle turning vehicle conflicts with through traffic and extends the pedestrian's and bicyclist's path without conflict opportunity.



Sidewalks are needed along Route 1 in village and fringe areas where there are no adjacent trails.

Add Walkways and Bikeways

All context zones along the Route 1 corridor currently have some level of pedestrian and bicycle use, although pedestrian activity in rural zones may be limited to parking near recreation sites. Some of the tools already discussed enhance pedestrian and bicyclist safety and mobility. Examples include:

- Access management strategies reduce pedestrian and bicyclist exposure to turning conflicts.
- Medians between through lanes provide space to wait for a safe crossing opportunity
- Improved visibility and lighting at intersections makes it more likely a driver can see and react to those who are crossing

Walkways

Pedestrian needs vary in different context zones. In rural and some fringe zones there will be few pedestrians, and a roadway shoulder or bike lane may be adequate. In locations served by transit, pedestrians of all ages and abilities should have ADA compliant walking routes to transit stops. Within the study area, pedestrians generally need sidewalks separated from the highway between Capistrano Road (southern end) and the City of Half Moon Bay. People usually walk on the side of the street that is most convenient and avoid crossing the street twice to access a destination, so walkways are needed on both sides of the highway. In village fringe zones, a walkway on one side of the highway may be all that is practical or necessary in the short term, but the need for highway crossings should be addressed, especially at transit stops, since transit users need to access buses on foot or by bike. Long term plans should include walkways on both sides of the highway.

The typical Fringe and Village cross sections (Sections B and C) show 6-foot minimum sidewalk widths separated by a minimum 4-foot wide buffer zone between the sidewalk and roadway. 6-foot sidewalks will enable people to walk side by side. Wider sidewalks may be needed where high pedestrian traffic exists or is desired (for example, near beach access or commercial activity areas). The buffer zone provides distance and space for landscaping and other vertical treatments to separate the pedestrian environment from motor traffic and help direct pedestrians to safe crossing areas.

Bikeways

There are opportunities for including bikeways along Route 1. Bikeways are defined by Caltrans as facilities provided primarily for bicycle travel, but sometimes shared with pedestrians. Trails could include off-street bike paths, hiking trails, equestrian trails, unpaved walking or mountain-biking routes. Design of bikeways considered Class I, II, or III are guided by the Caltrans Highway Design Manual.

Class I Bikeway: Bike Path/Multipurpose Trail

Bike paths provide a separated right of way for



Trails along the coast are well-used. Trails need to be wide enough to accommodate bicyclists and pedestrians. Where use is very high, separated facilities may be needed.

the exclusive use of bicycles and pedestrians, with cross flow by motorists minimized. Crossings should be limited because they are the most common point of conflict between motorists and bicyclists. Drivers turning across bike paths are often focused on finding a gap in traffic, and may not be watching for bicyclists or pedestrians. Some bicyclists have a tendency to maintain momentum through crossings, and may fail to stop or yield to vehicle traffic. Conflicts can be minimized with good visibility, but bike paths that parallel roadways will best serve bicyclists if the number of driveways and streets that cross the path are limited. Bike paths must be located at least 5' from the edge of the shoulder, or include a physical barrier, such as railing. Physical barriers can present visibility issues at crossing points.

Class II Bikeway: Bike Lanes

Bike lanes are one-way lanes on streets, marked on the right side of the vehicle travel lane closest to the curb. Bike lanes pockets are often provided where motorists turn left. Where parking is permitted, the bike lane is between parked cars and the travel lane. At traffic signals, a bicyclist needs a marking to show where to place the bike to actuate the signal for a green light, or to have access from the bike lane to a pedestrian push button.

Although many bicyclists prefer riding on bike paths or multipurpose trails, some prefer to ride in bike lanes. In bike lanes, bicyclists follow the rules of the road, and are only required to yield or stop for cross traffic under the same conditions in which a motorist would yield or stop. Bicyclists in streets must ride in the same direction as traffic. In addition to providing space for bicycling, bike lanes provide a buffer between pedestrians and traffic, visually narrow the roadway to encourage slower speeds, and serve as a walkway in rural areas.

Class III Bikeway: Bike Route

Bike routes provide for shared use with pedestrian or motor vehicle traffic. Not all shared streets are designated as bikeways, and in fact, most bicycling occurs on streets that are not designated facilities. The designation is generally reserved for facilities which provide continuity to other bicycle facilities or for preferred routes through high demand corridors.

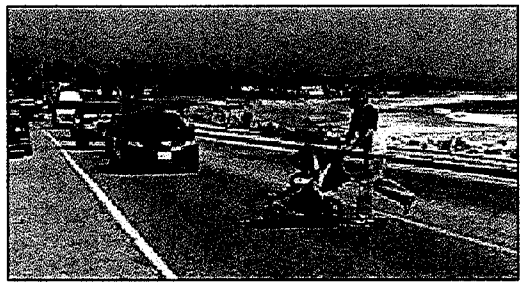






Top left: many bicyclists use the shoulder on Route 1 for commuting, exercise and recreation. Top right: riders choose the shoulder against traffic over the adjacent multipurpose trail. Above: clearly designated lanes and a consistent edge condition like the example above placed on both sides of Route 1 would provide clarity for motorists and bicyclists alike.

The typical Fringe and Village cross sections (Sections B and C) propose 6-foot on-street Class II bike lanes. The typical Rural cross section (Section A) proposes a finished shoulder suitable for a Class II bike lane or Class III bike route designation. For all cross sections, striped lanes, especially when combined with shoulder treatments such as different pavement types, patterns and colors, will further distinguish the road edge, add visual friction and visually narrow the perceived travel way while maintaining adequate travel lane width for safe motor vehicle operation. Visual definition and tightening of the roadway will in turn encourage moderate speeds. Changes in the shoulder edge treatments can be used to help signal the transition from rural to more urban village conditions.



People want and need to cross the highway at convenient locations. Providing well-designed, highly visible crosswalks at convenient locations can help consolidate random crossings. Fences and barriers to force pedestrians to use inconvenient access points can be expensive, unsightly, and futile.



Highway Crossings

Pedestrians want and need to cross the highway for a variety of reasons. Some will walk to enhanced crossing areas if they know where they are, but the distances people are willing to walk varies. Although it can be tempting to consider installing fences or barriers to "channelize" pedestrians, these solutions are costly, are not totally effective, and could obscure ocean views.

Many Route 1 crossings in the study area do not occur at crosswalks because the majority of residents live on the northeast (inland) side of the highway and there are no marked crosswalks nearby to reach destinations on the ocean side. Visitors also randomly cross the highway between the beach and parking areas due to the lack of convenient, well-marked crosswalk locations.

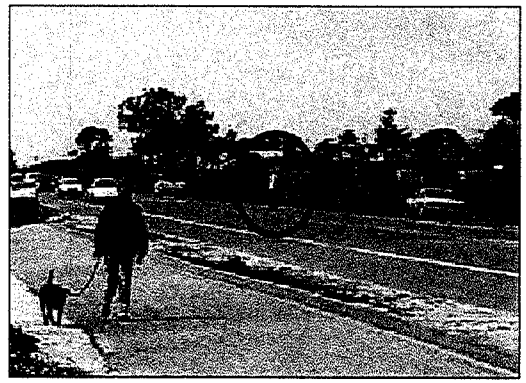
Adding striped medians as proposed in the typical cross sections would provide a first



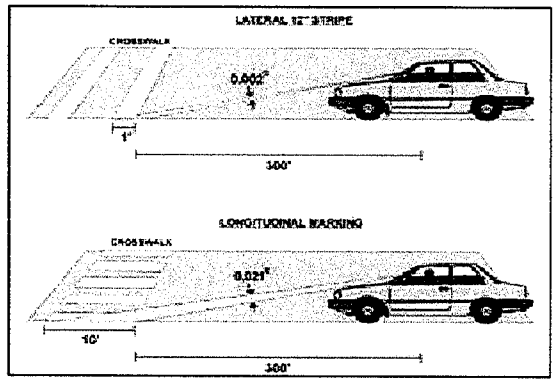
Where can pedestrians legally cross Route 1?

A crosswalk exists at every intersection, whether or not it is marked, unless there is a sign prohibiting crossings at that location. Crosswalks exist between intersections only when they are marked. California law requires drivers to yield to pedestrians at marked or unmarked crosswalks. Pedestrians cannot step into the path of a vehicle that is so close there is an immediate hazard. Pedestrians may cross where there are no crosswalks unless the adjacent intersections are controlled by signals or officers, but they must yield to drivers. Pedestrians crossing at signals must enter the crosswalk before the flashing hand is displayed.

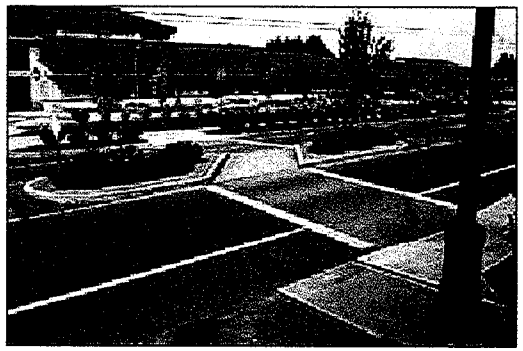
step toward creating opportunities for safe, orderly crossing points by establishing a space between lanes of moving traffic. A second step would be consolidating highway crossings at desired access points and enhancing a marked crosswalk so it becomes a prominent and appealing crossing location to pedestrians, and highly visible to motorists. The crosswalk must be conveniently located. Improvements could include raised medians designed to serve as pedestrian refuge islands, crosswalk markings and pavement contrast to heighten the visibility of the crossing area, flashing lights, or pedestrian signals or flashing beacons.



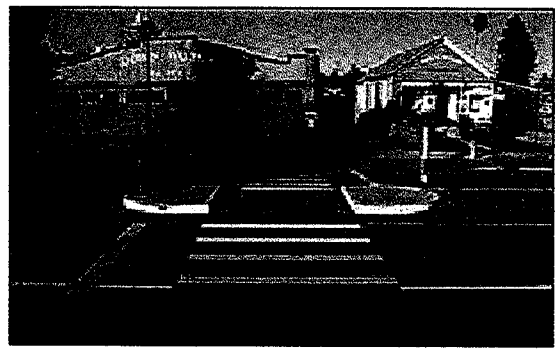
Pedestrian waits for gap in traffic to complete crossing.



Longitudinal crosswalk markings are more visible to motorists than horizontal striping.

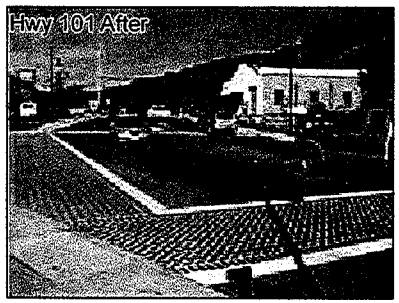


Raised medians allow pedestrians to cross one-half of the roadway and wait in the center for an opportunity to cross the other half. Some raised medians walkways are angled so pedestrians face oncoming traffic before crossing.



Raised median island with high visibility markings. The stop bar for vehicles is set back from the crosswalk.



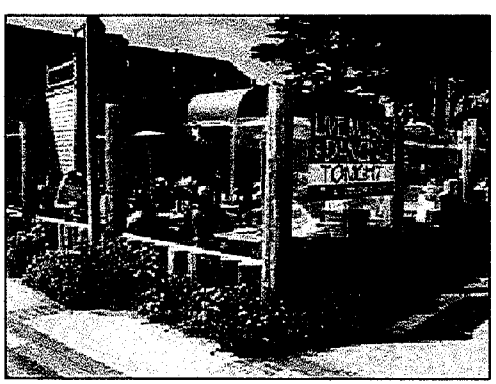


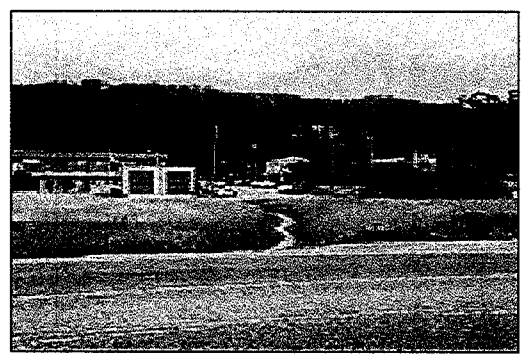
High contrast pavement treatment to highlight the pedestrian crossing area is added to an intersection on Highway 101.

Coastal Village Economic Opportunities

There are small commercial areas within the three coastal villages of Princeton, El Granada, and Miramar. Enterprises include a grocery store that features mostly convenience foods, several restaurants, tourist-oriented shops and services near the harbor, a hardware store/ café and several other small entities. These businesses rely on tourist and local residential trade. Some businesses are not highly visible to tourists because the highway does not pass close to their location, and recreational visitors may not notice them because parking is not close to the businesses. Some stores do not enjoy local patronage because many residents make frequent trips to the bayside and buy what they need while there.

Highway strategies have the potential to enhance economic opportunities while improving traffic flow and safety. Slower speeds in village areas, for example, give motorists time to notice attractions, decide where to turn, and assess parking opportunities. Parking areas, trails, and crossings close to shopping and restaurants can encourage visitors to stop, park once, and eat or shop.







Corridor improvements could help stimulate village-oriented economic development in areas such as Portola Avenue in El Granada (top photo) and Miramar (bottom photo).

Infill development takes advantage of under-used or vacant properties within developed areas. This approach conserves land, takes advantage of existing infrastructure, and brings new life to existing areas. Within the study area, there are ample opportunities for infill near existing village commercial areas. Clustering commerce in one area increases its desirability as destination where tourists and residents can access a variety of goods and services.

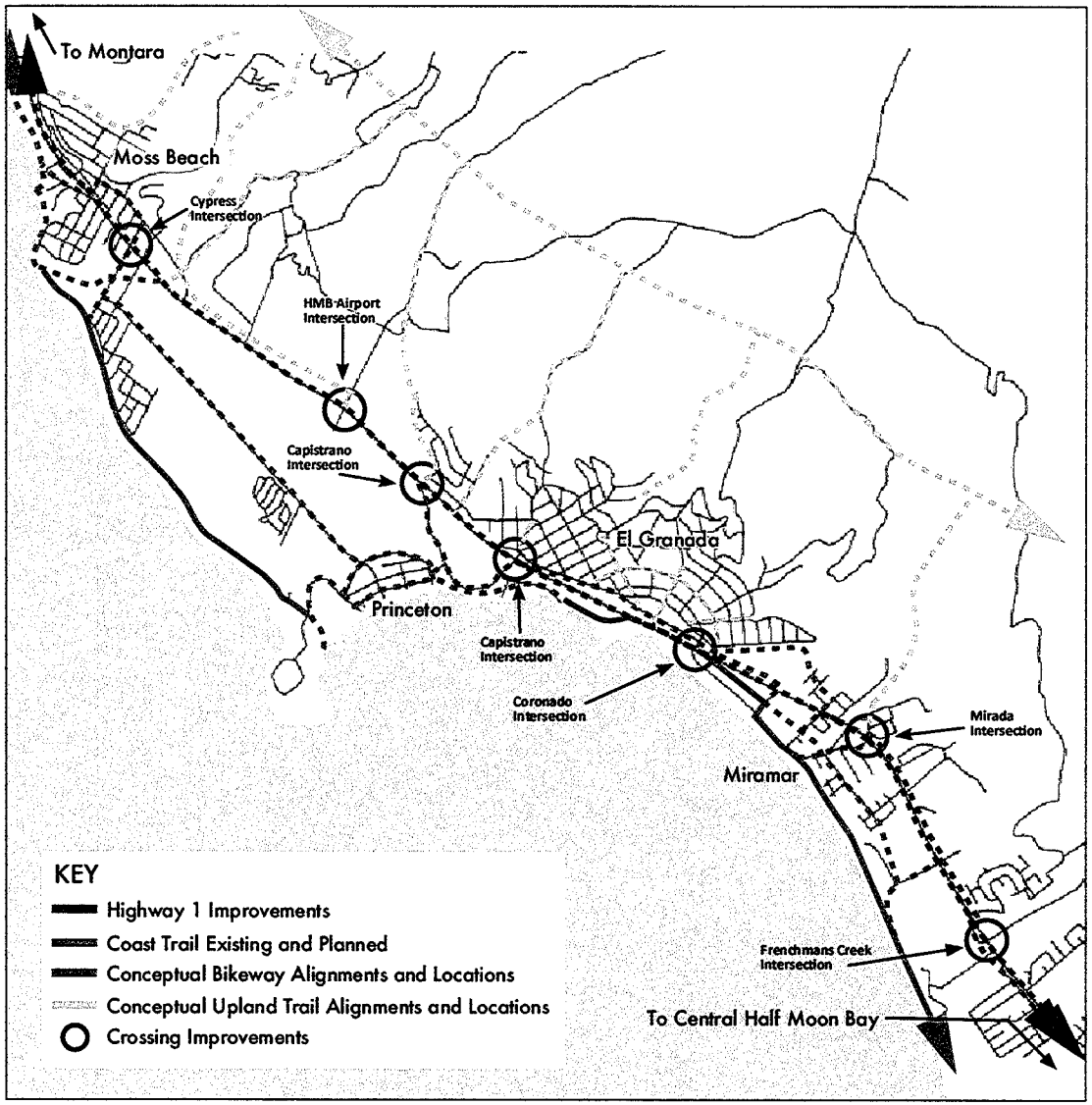
Mixed-use development provides space for a variety of uses that often includes retail, office, and residential uses within a compact area or a single building. Mixing in residential uses provides living quarters for shop keepers, workers, or others. When done in conjunction with pedestrian and bicycle-friendly access, mixed-use in-fill development encourages people to reduce car trips and support local business.

Intersection improvements, including roundabouts, can provide opportunities for in-fill development in highly-visible areas, where businesses can take full advantage of potential tourist trade and improved access for all modes of transportation. Strategies for specific intersections near existing commerce are discussed in more detail in later chapters.

Connectivity and Mobility Framework

The corridor strategies outlined in the previous section are intended to improve the safety, efficiency and experience of Highway 1 for users of all types and abilities. This is especially important because the highway serves as the principal and perhaps only viable motor vehicle travel route linking the uses, neighborhoods and communities of the San Mateo County Midcoast. Residents and visitors are largely dependent on the highway for commuting and many local trips. Developing additional links for different travel modes that provide alternatives to vehicle trips on the highway can help improve roadway function and maintain capacity.

Charrette participants emphasized the need to connect existing trails, add new trails for all user groups, and provide additional defined highway crossings. The map on the right illustrates concepts for a completed pedestrian and bikeway network within the study area and surrounding communities. Completing missing links in the existing Coastal Trail and providing additional trails, bikeways, walkways and crossing opportunities would enable residents and visitors to make more trips on foot or by bicycle instead of in cars.



Study Area Bicycle and Pedestrian Transportation Network

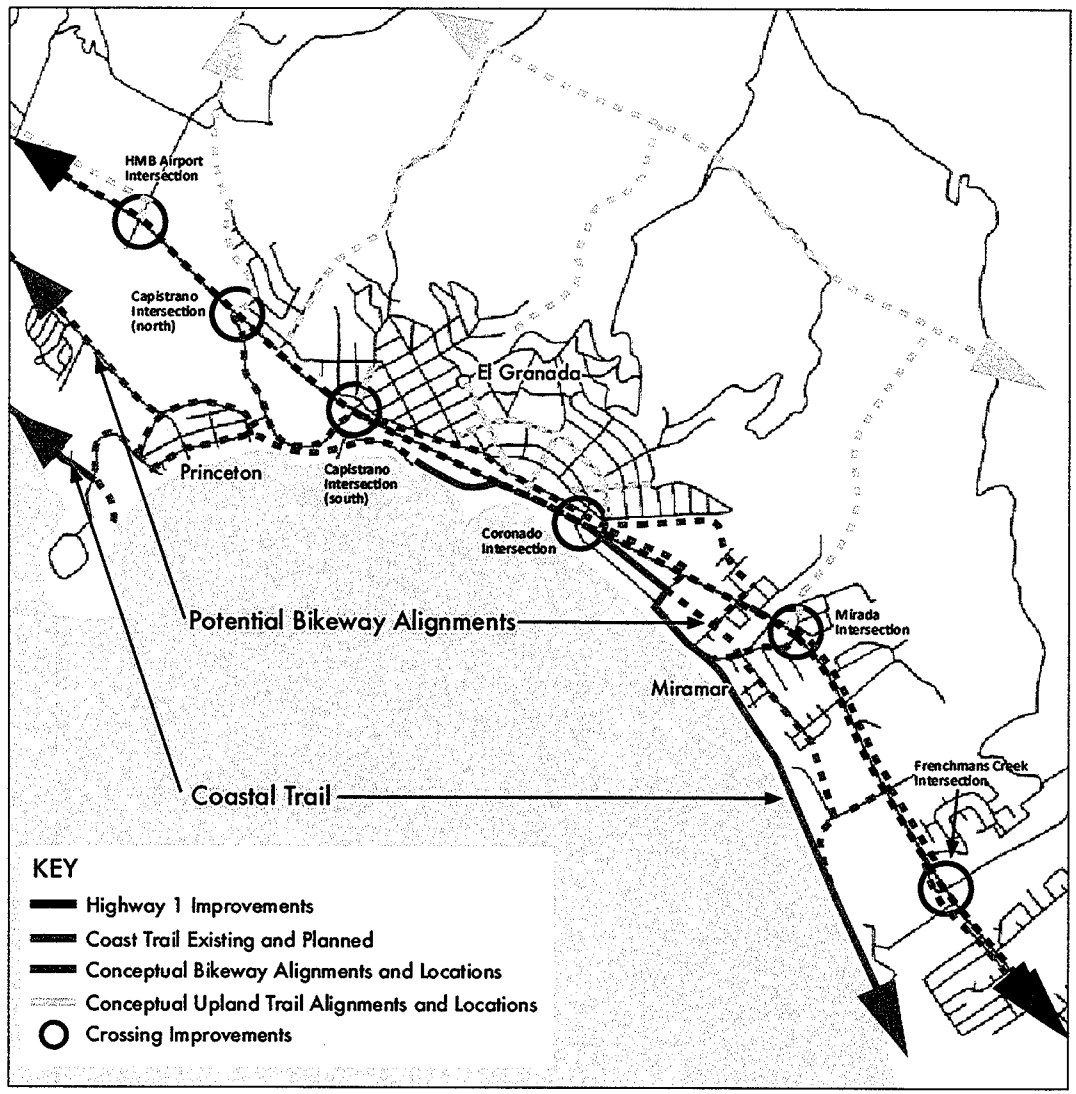
As described in the previous chapter, Highway 1 has the potential to serve as a primary route for bicyclists and pedestrians through shoulder improvements, provision of bike lanes, and provision of sidewalks in village and village fringe areas.

There are additional opportunities for an off highway route system for pedestrian and bicyclists to improve connectivity between Midcoast communities and connect key destinations. Different portions of the route network could be developed with the following treatments:

- Separated bicycle or multi-modal trails.
- Improved low speed, low traffic streets for shared bicycle and motor vehicle use.
- Striped on-street bike lanes.
- Added or enhanced sidewalks.

The California Coastal Trail alignment provides a north-south inter-community mode of travel that largely avoids the highway. Completed and planned portions of the trail facilitate community connection with the region's wildlife and natural beauty, and provide access to open space and recreational opportunities.

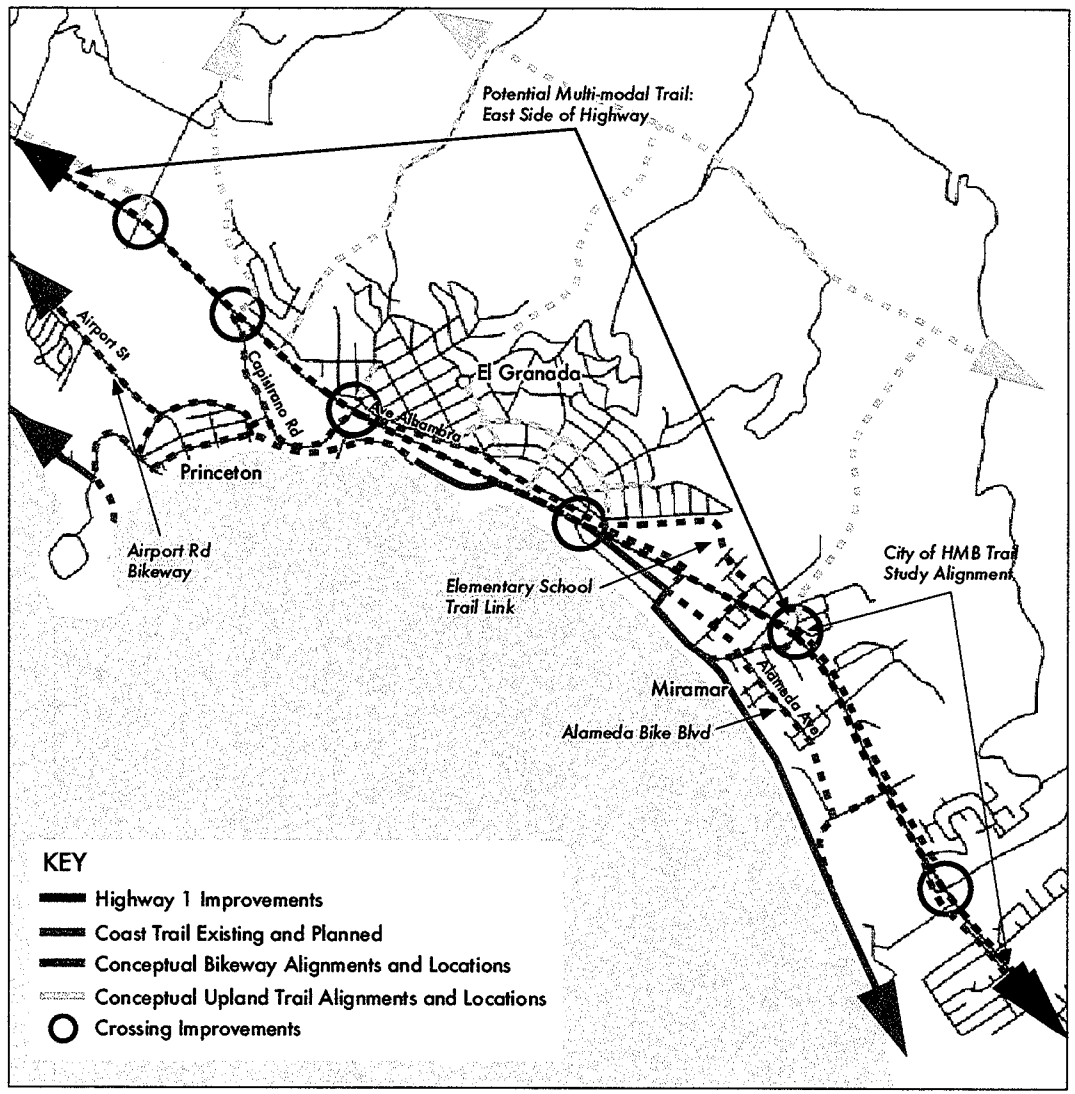
Within the study area, south of Pillar Point,



completed and planned paved trail segments provide an accessible pedestrian and bicycle connection between residences, lodging, businesses, services and visitor attractions on the coastal side of the highway. North of Pillar point, rugged and steep terrain allow for hiking and jogging but constrain the trail's potential as a routine travel route for all types of users.

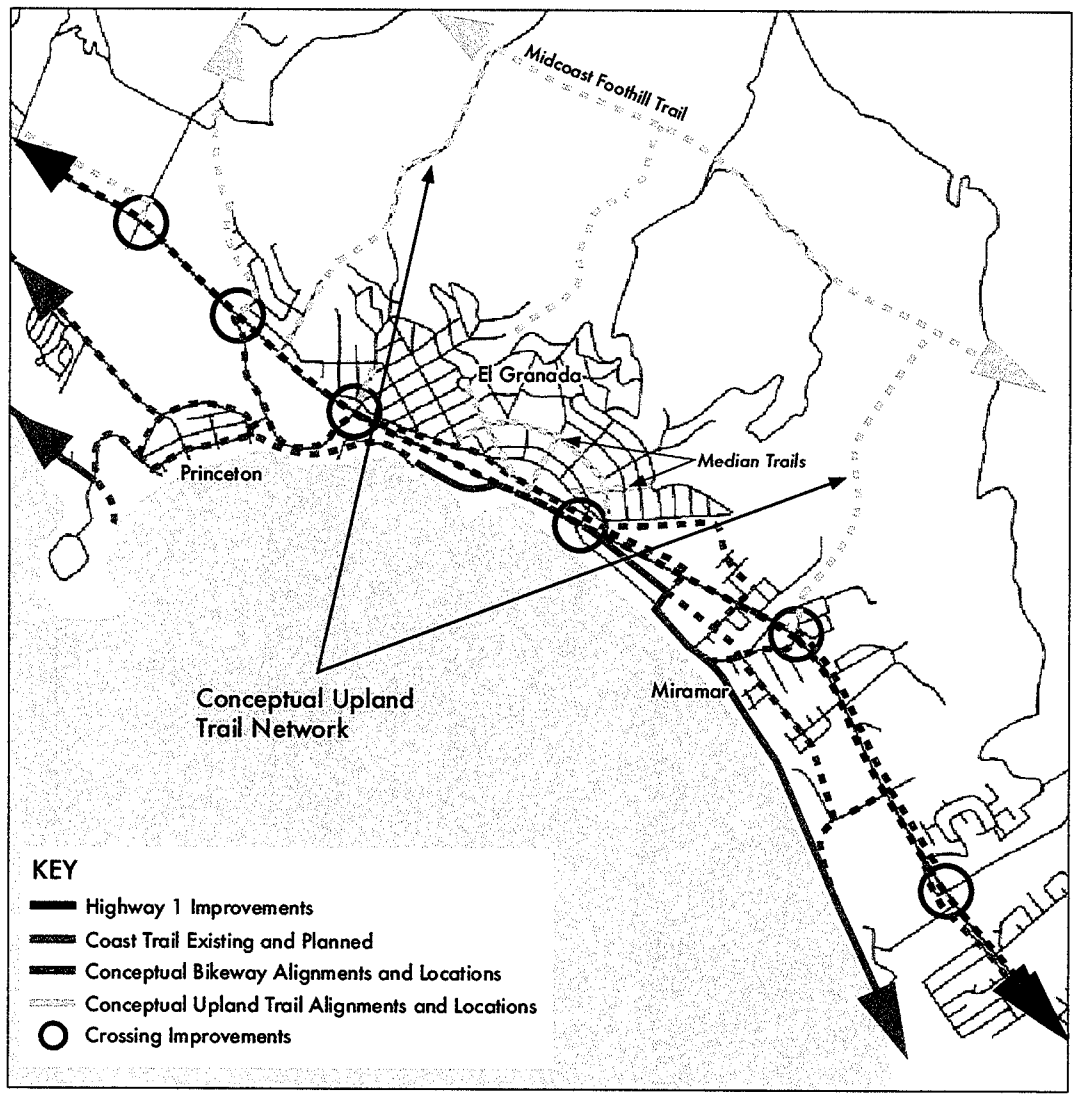
In addition to the Coastal Trail, various studies, including the Highway 1 Trail Concept Study prepared for the City of Half Moon Bay in 2004, envision a continuous multipurpose separated trail for bikes and pedestrians that mostly services the east side of the highway the length of the corridor through the study area. Detailed changes could be considered based on local context zones and site constraints, such as the presence of intersections and driveways.

Certain streets could be prioritized for enhancements because of their ability to provide effective bicycle and pedestrian linkages. For example, Airport Street, which is a light traffic road on flat terrain that provides a direct connection with limited cross traffic between Princeton and Moss Beach, could eventually be improved with striped bike lanes or a separated path. Alameda Avenue, a slow speed, low volume residential street in Miramar could be enhanced with signage and treatments to serve as a "bicycle boulevard," in which cars and bicyclists share the travel way.



Based on review of materials from past workshops, review of County parks and trails plans, and input from the charrette, the design team also delineated a tertiary network of upland trails and paths shown on the right that would connect laterally to the coast-side system. The network would include access into future Golden Gate National Recreation Area lands and the Midcoast Foothill Trail. But it would also provide "feeder" access from residential neighborhoods to the main line pedestrian and bicycle circulation system. Broad medians on El Granada's historic avenues, including Granada, The Alameda, Balboa, Portola and Cabrillo, provide additional opportunities for neighborhood trail connections.

Portions of the trail system would be unpaved and limited to walking, hiking, jogging, and equestrian use, while others may be more intensively structured to enable various types of bicycle use.





What is a Bike Boulevard?

Bicycle boulevards are designated bike routes that are integral to a bikeway system, but may be too narrow for a bicycle lane or have such low vehicle volumes that a bicycle lane is unnecessary. Ideally, motor vehicle traffic is slowed to approximately the same speed as the bicycle speeds. The development of a bicycle boulevard may include the alteration of intersection controls and the installation of signs and stencils. Stop signs and traffic signals on the bicycle boulevard are limited, except where they aid bicyclists in crossing busy streets. Typically, these and other modifications to enhance bicycle safety and convenience will also calm traffic and improve pedestrian safety.

For more information: http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6690

Shared Pedestrian and Bicycle Trails
Trails shared with bicyclists may be adequate for pedestrians when use rates are low and trail widths ample for users to avoid conflicts. In areas of heavy use, pedestrians and bicyclists should be separated. Any facility designed for pedestrian use must meet Americans with Disabilities Act (ADA) requirements.

Sidewalks should not be designated as bikeways. Trail signing would help distinguish sidewalks from trails.

Equestrians
An equestrian trail parallels portions of the Coastal Trail. Some charrette participants expressed a desire for additional equestrian facilities, and explained they have been gradually losing access to open space. When equestrian trails are provided, they should be separated from other trail users, except at crossings. Where crossings are paved, designers should work with equestrian experts to develop nonskid treatments for horses.



Horseback riders and pedestrians share trail at Half Moon Bay State Beach.

Summary of Potential Key Trail Links

Princeton

1. Connect Princeton to Highway 1 with a Class II on-street bike lane on Capistrano Road.
2. Connect Princeton to Moss Beach with a Class II on-street bike lane on Airport Street.
3. Long term, develop a Class I bike path along the coast line through Pillar Point Harbor and Princeton.
4. Complete Coastal Trail in phases, beginning by connecting existing sections with bike boulevards and bike lanes. Short and long-term recommendations are currently under exploration by the Midcoast Parks and Recreation Committee Trails Team.

El Granada

1. Provide Class II on-street bike lane on Avenue Alhambra and Obispo, connecting to Santiago Avenue.
2. Connect proposed City of Half Moon Bay trail on the east side of the highway to Mirada Drive to continue to Santiago Avenue.
3. Connect Coastal Trail on west side of Highway 1 through Miramar.

Miramar

1. Consider replacing the existing corrugated metal culvert under Highway 1 between Furtado Lane and Miramar Drive with a precast concrete system that includes a low flow channel and walking edges. Any such design would have to address ADA issues and have trail connections on both ends. The culvert replacement could accommodate environmental improvements to Arroyo de en Medio that would maintain the integrity of the waterway.

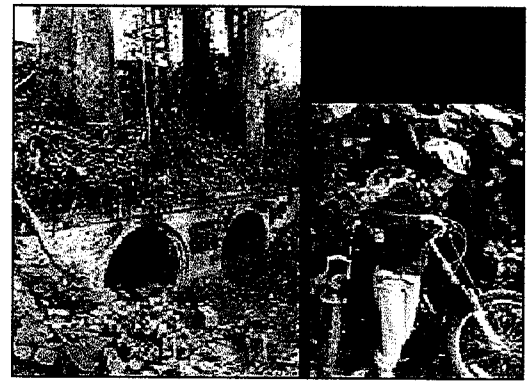
2. Consider designating Alameda Avenue a bike boulevard with an additional non-motorized pedestrian/bicycle bridge across the ravine that divides the west segment of Alameda Avenue from the east segment. Consider adding a trail connection from the east terminus of Alameda Avenue to the Coast Trail/Balboa Boulevard.

3. Provide a trail connection between the elementary school and residential areas to the south on the east side of the highway.

4. Construct the trail planned by the City of Half Moon Bay on east side of Highway 1. Align trail between Nurserymen's service road and Highway 1.

5. Provide link from the above mentioned trail to the Coastal Trail via Mirada Road and Medio Road.





These bicyclists emerged from the Miramar neighborhood east of Route 1 on Medio Avenue, and pedaled against traffic to a culvert, where they crossed under the highway. School children explained during an earlier meeting this is a common, but forbidden, practice. It illustrates the need for a safe and convenient pedestrian/ bicyclist highway crossing in Miramar.

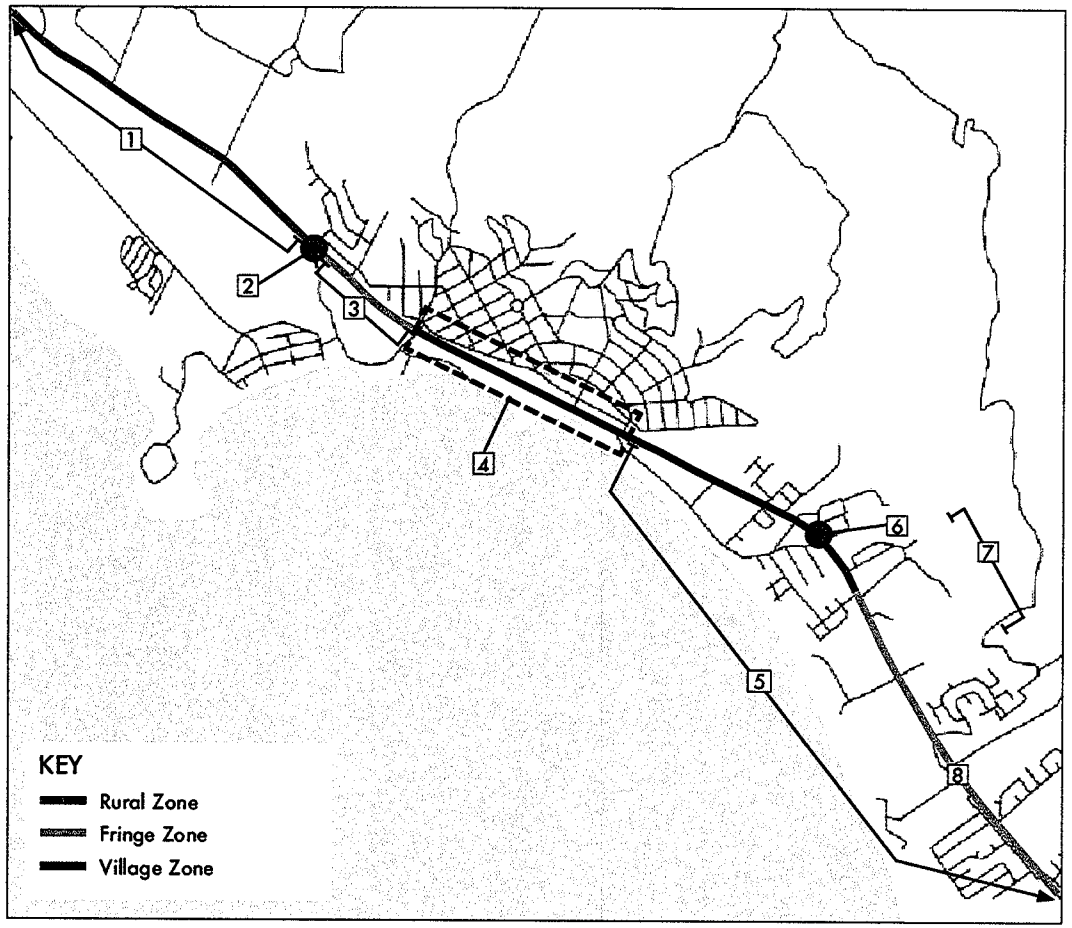


This pedestrian/ bicycle bridge on the Coastal Trail crosses a ravine that would otherwise divide the neighborhood. An additional bridge across the ravine that divides Alameda Avenue would create another north-south connection that spans the length of Miramar.



Improvements to the culvert in the top photo could provide a convenient crossing under the highway. If a crossing is developed, it should also accommodate equestrians, although they may need to dismount to minimize height requirements.

Design Strategies Locator Map



Design Concepts

Based on input from the charrette, analysis of planning data and field review of the study area, the design team prepared a series of proposals to improve mobility for all users along the Highway 1 study area. The concepts employ tools described in preceding pages and some additional strategies selected for specific sites.

The location of specific concepts are enumerated in the diagram on the left and listed below.

1. Apply rural section attributes north of Capistrano Road.
2. Create gateway intersection at north terminus of Capistrano Road.
3. Apply fringe section attributes between north and south terminus of Capistrano Road.
4. Short and long-term concepts to improve multi-modal access, and respond to coastal erosion between Capistrano Road and Coronado Street.
5. Apply village and fringe section attributes between Coronado Street and Frenchmans Creek Road.
6. Redesign intersection at Mirada Road.
7. Consolidate access in front of Nurseryman's Exchange.
8. Consolidate intersections at Frenchmans Creek Road.

1. Apply rural cross section attributes north of Capistrano Road

As shown in Cross Section A on Page XX, typical attributes in this section of the roadway would include 12-foot travel lanes and 6 to 8-foot paved shoulders to provide space on the side of the road to accommodate bikes and pedestrians where there are no trails or sidewalks.

There is an isolated intersection on this section of the highway that provides access to Half Moon Airport on the west side of the highway and access to an agricultural service road on the east side of the highway. The intersection is difficult for motorists to detect and speeds are high on this straight and open section of roadway.

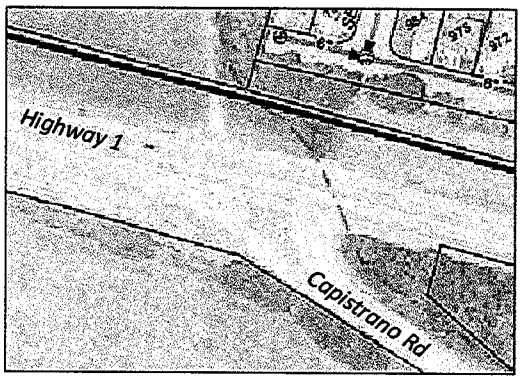
There is a striped median with a left-hand turn pocket northbound on the highway to accommodate left hand turns at the intersection at Half Moon Bay Airport. One strategy to consider to increase visibility and safety would be to change the median to a raised island to facilitate left turn shadowing and positive channelization of turning vehicles. Other treatments could include raising the approach grade of the airport road side street to improve intersection sight distance and promote more efficient turning maneuvers. Localized roadway illumination might also be improved.

2. Create gateway intersection at north Capistrano Road

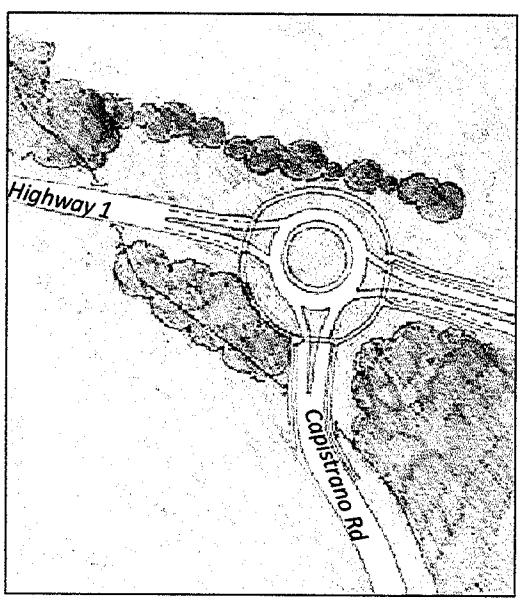
Princeton is a small village on the coast line, north of Pillar Point Harbor, and south of the Half Moon Bay Airport. The village is a mix of residential, light industry, and retail establishments, with approximately 300 inhabitants as of the 2000 census. Access to the village and harbor is from Capistrano Road.

Capistrano Road forms a loop connection to Highway 1 at two intersections, approximately one-half mile apart. The northernmost intersection provides access to Princeton and Pillar Point Harbor. The southern intersection of Capistrano and Highway 1 is the largest of the two intersections and also provides access to El Granada.

The consultant team explored the opportunity to create an entry transition for southbound traffic on Highway 1 at the northern intersection with Capistrano Road. The proposed concept would convert the intersection from a higher speed "Y" intersection to a three-point "T" intersection and install a roundabout. This would help increase motor awareness of an approaching shift in context, facilitate safe turning movements, and increase the prominence of the north intersection as an alternative route to Princeton and the harbor area.



Intersection of Highway 1 with north leg of Capistrano Road



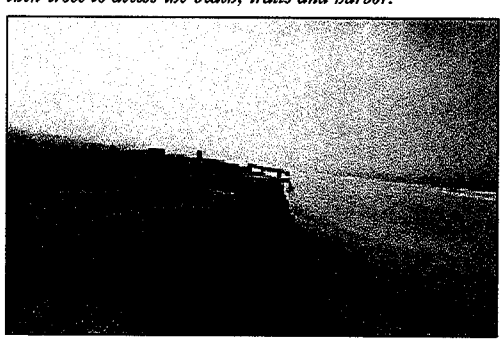
Capistrano Road is shifted south to form a simplified intersection with a roundabout.



Surfer's Beach is a popular City of Half Moon Bay beach located west of El Granada.



Many visitors park on the east side of the highway and then cross to access the beach, trails and harbor.



Erosion destroyed old roadways through El Granada and continues to move toward Highway 1.

3. Apply fringe cross section attributes between north and south terminus of Capistrano Road

Cross Section B, as shown on Page XX, would generally apply to the approach to the southern intersection with Capistrano Road, adding road edge definition to signal the transition from a rural to more urban condition. Introduction of a continuous median will establish a space for designated turning areas and the possibility of paved and landscaped treatments for visual impact, village entry features, and reduced imperviousness for storm water drainage. Formal drainage is added, defining separation between the road edge and adjacent land as development begins to appear.

The addition of sidewalks should be considered in the fringe areas, but may not be required the full length of the road segments on both sides where there are alternative direct ADA accessible walkways to key destinations.

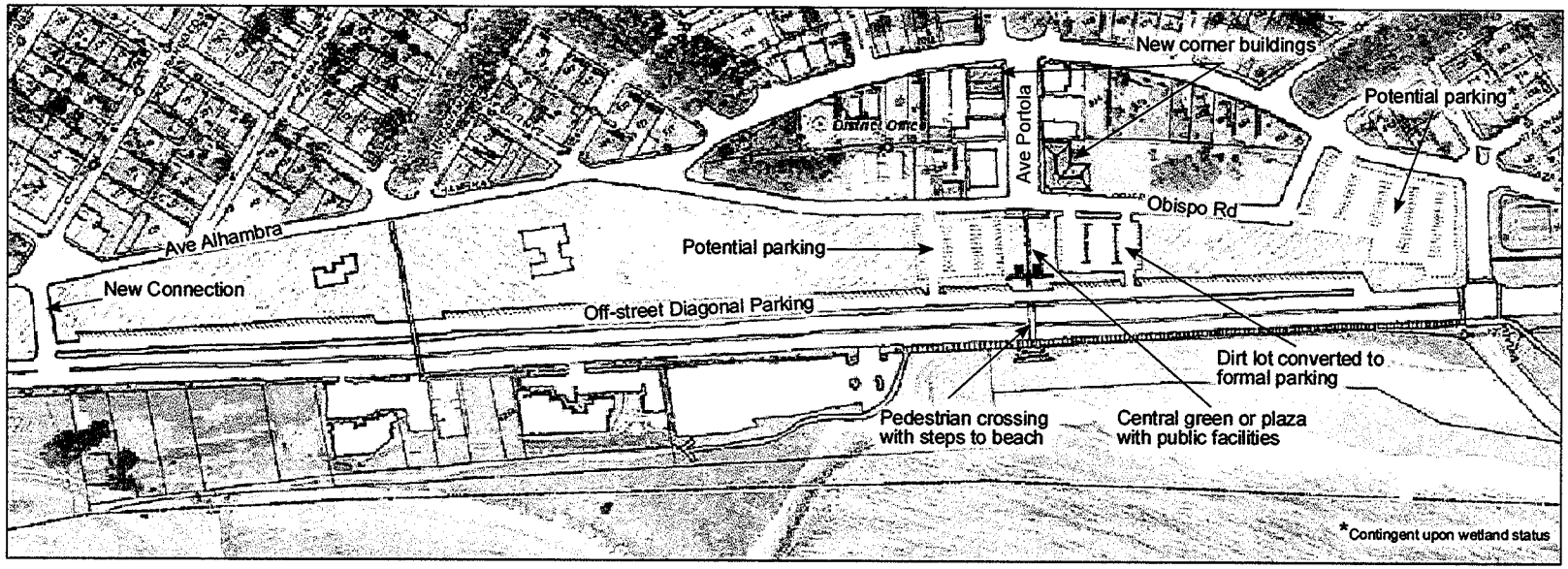
4. Short and long-term concepts to improve multi-modal access and respond to coastal erosion between Capistrano Road and Coronado Street.

The overall design concept for this section covers areas along Highway 1 from the south intersection with Capistrano Road to Coronado Street. El Granada, the largest of the three coastal villages, lies east of the highway. West of the highway are beach and commercial areas that are within the jurisdiction of the City of Half Moon Bay and San Mateo County Harbor District.

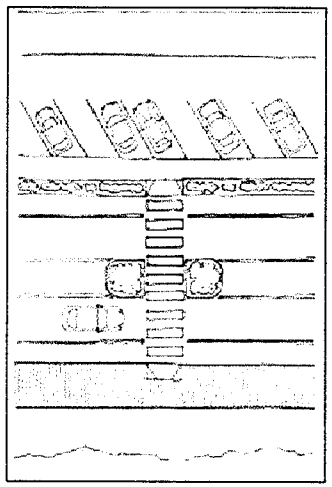
El Granada's distinctive street pattern was planned by Daniel H. Burnham, famed as the "father of the city beautiful movement." Housing was arranged to take advantage of the ocean view. A site originally planned as a casino is now a coveted, mostly undeveloped area locally referred to as the Burnham Strip. The Strip separates residences and businesses in El Granada from Highway 1 and the coastline.

The coastline near El Granada between Pillar Point Harbor and Miramar is eroding and moving toward the highway. Erosion poses access challenges for those who wish to enjoy Surfer's Beach, complicates completing gaps in the existing Coastal Trail, and brings into question how long the existing alignment will remain intact.

The unique challenges between Capistrano Road and Coronado Street resulted in many creative suggestions during the charrette. The consultant team refined this input and developed four concepts for this central portion of the study area. The first concept suggests elements to consider for near-term implementation with the existing roadway alignment. The other three present alternatives that would involve long-term realignment of the roadway.



Plan details are labeled above. A plan view is shown on the left of a midblock crosswalk connecting the parking area to the boardwalk with a channelized pedestrian island.



Section C shown on Page XX, minimum six-foot wide sidewalks should be considered for both sides of the highway, the length of this segment, except where it is supplanted by an adjacent 12-foot wide boardwalk connection between Coronado Street and the Surfers Beach parking lot.

Pedestrian Crossings

Two potential new crosswalk locations are identified at Surfer's Beach and Sam's Chowder House with raised median crossing islands. These islands can be designed with vertical elements and high contrast pavement or landscaping to maximize visibility. Treatments can be used to narrow the perceived travel way, encouraging driver alertness and caution, and increasing the willingness of drivers to yield to pedestrians.

Both proposed locations should be evaluated for possible installation of a pedestrian signal. An innovative signal has been tested in numerous communities, and may soon be allowed on California highways. It is called a Pedestrian Hybrid Beacon, and nicknamed HAWK. This signal can be used midblock or at intersections. It is dark until a pedestrian pushes the button. It then begins flashing yellow to the driver, turns to a steady yellow, and

then turns to a steady red for the driver, while a WALK symbol (walking man) is displayed to the pedestrian. When the flashing hand is displayed to the pedestrian (which means they can continue crossing, but they cannot enter the crosswalk if they are not already in it), the driver sees a wig-wag red that moves from side-to-side. This indicates the driver may proceed after stopping if the pedestrian has cleared the travel lane. Pedestrian signals are most effective when they provide a "hot call." This means that the pedestrian pushes the button, and they receive a prompt walk interval. If the signal does not change fairly quickly, and there is a gap in traffic, the pedestrian may cross against the light. Short signal cycles also help prevent pedestrian crossings against the light.

Another innovative strategy for use at un-signalized crosswalks is the rapid flash LED beacon. Recent studies indicate these devices increase driver willingness to yield to pedestrians in crosswalks.

Pedestrian crossings should be illuminated, with light standards placed on all four corners to ensure the pedestrian is front-lit to an approaching driver. Sidewalk and trail lighting can be dark-sky friendly, pedestrian scale lamps to protect ocean and night sky views.

Intersections

At the intersections with Capistrano Road and Coronado Street, several improvements could be introduced to reduce pedestrian exposure to traffic and encourage driver awareness and caution.

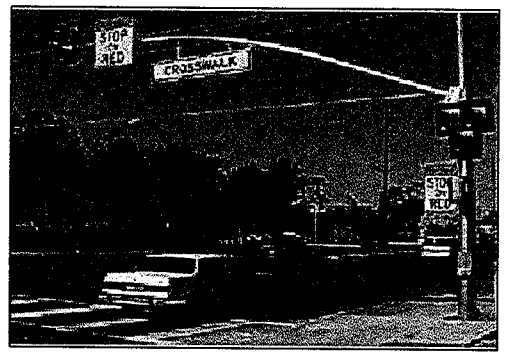
Starting with Capistrano Road, extension of curb and gutter is recommended on both sides of the highway to approximately 500 feet north of the intersection. This will cue motorists that they are arriving at an urbanized intersection at the entryway to El Granada, Princeton and the harbor.

The southwest corner of the intersection needs to be completed with curb and gutter, sidewalk and corner ramps. The median tip in the crosswalk should be removed to provide a clear path for pedestrians.

All crosswalks should be re-striped with high-visibility longitudinal markings.



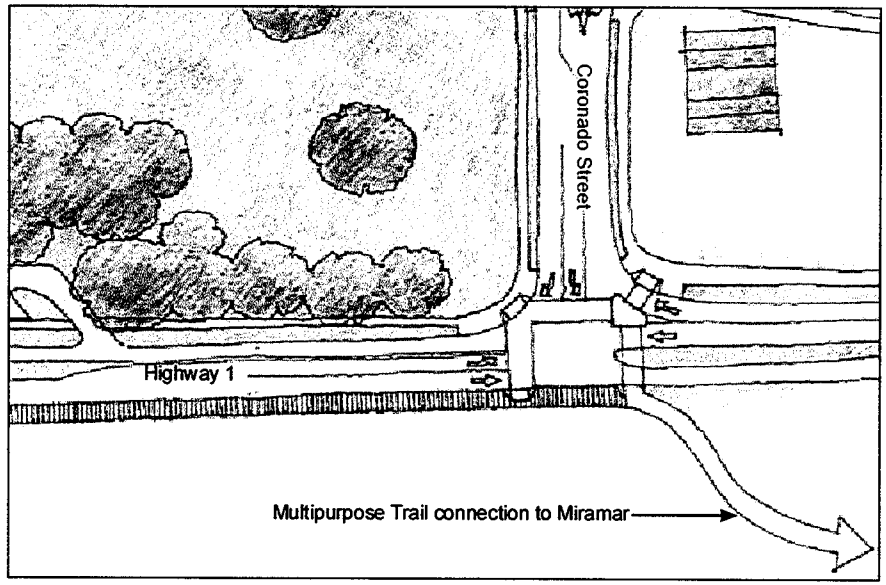
Corner needs to be finished with curb and sidewalk, and median tip should be removed at Capistrano intersection.



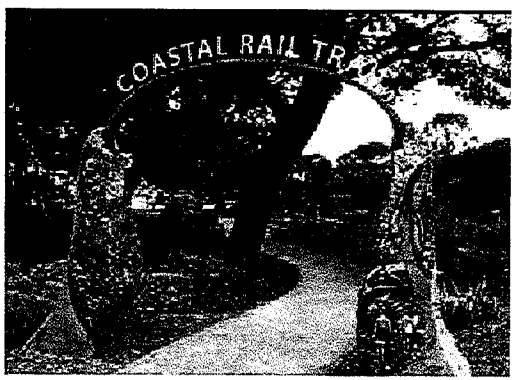




Top Photo: Pedestrian Hybrid Beacon, or HAWK. Above and Left: Rapid Flash LED Beacon.







Signs help pedestrians and bicyclists select the most appropriate routes and access goods and services along their way. Some wayfinding systems include information such as estimated walking or bicycling time to destinations. Information such as water and restroom locations should be included. Distinctive features such as the archway above add beauty and memorable landmarks to trails and commercial centers.

Raised medians on both sides of Highway 1 should be widened and extended. The median on Capistrano on the west side of Highway 1 should be adjusted to straighten the north-south crossing.

At the Coronado Street intersection, recommendations include tightening corner radii and adding a crosswalk to the south side of the intersection. All three crosswalk legs should be striped with high visibility longitudinal markings. The addition of a right-hand slip lane with a elongated island would shorten pedestrian exposure to traffic. It would also shorten pedestrian clearance time from the crosswalk, reducing delay for waiting motorists.

Wayfinding

Signs directing drivers to parking, bicyclists to trails, and visitors to services are needed in the El Granada area. People need information to orient themselves, understand the environment, and find their way to destinations in cars, on foot or bicycle. Signs are an essential component of a wayfinding system, but other elements, such as flags or distinctive architectural features may also provide information. Wayfinding and aesthetic features could send a clear message that there are viable commercial nodes. Wayfinding information can increase walking, bicycling, and transit use. Charrette participants suggested walking could be increased by providing visitors with route maps explaining local points of interest.

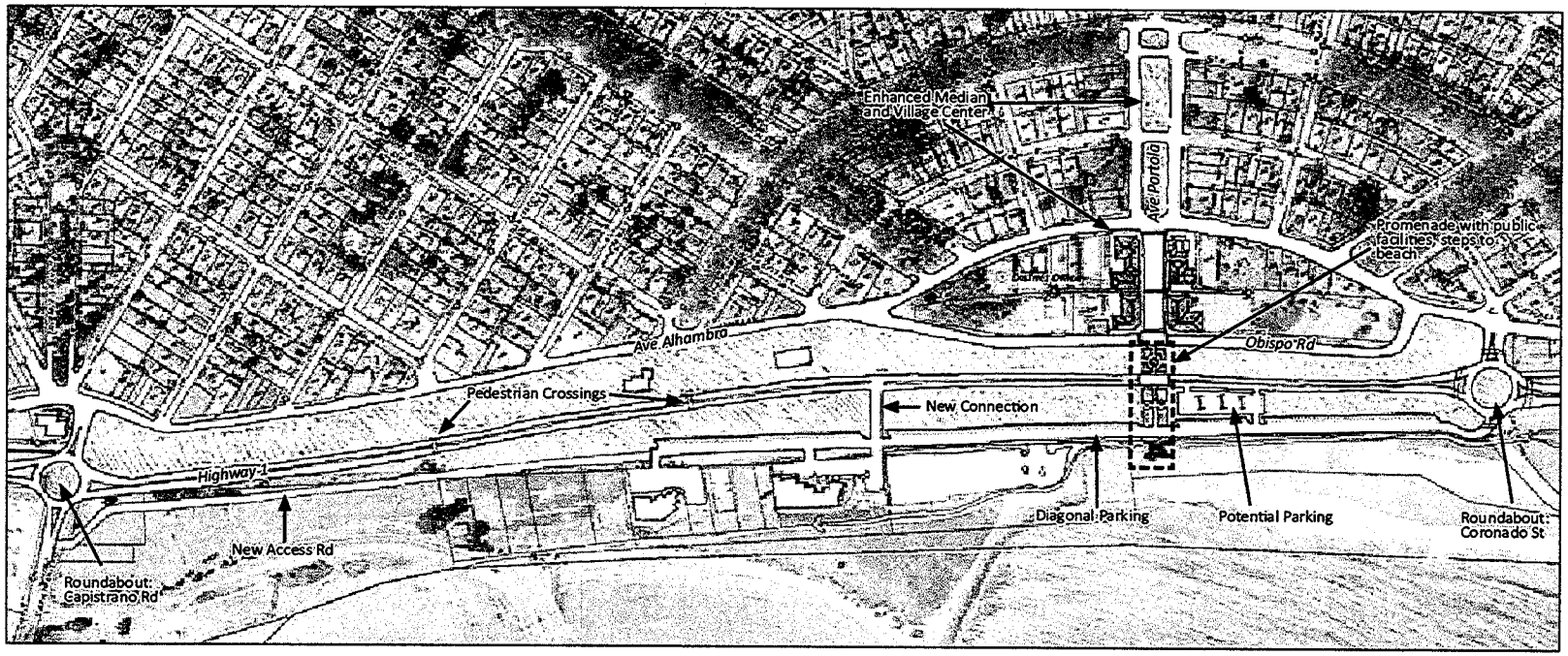


Perspective drawing of El Granada with Highway 1 realigned eastward. A central plaza at the terminus of Portola Avenue is framed by iconic buildings forming a gateway to the coastline and Coastal Trail.

Highway 1 Realignment Study Alternatives

Three long-term alternatives are presented in the pages that follow. All three involve realignment of Highway 1 to address the challenge of coastal erosion and create new opportunities for preservation and restoration of the coastal environment.

All of the concepts address priority issues and reflect suggestions made during the charrette, but not everyone agreed on every proposed improvement. The community will need to continue to discuss attributes of the concepts and work with stakeholders to refine a final plan. It is possible that Concept A could be implemented while the core features and final details of a long-term plan are developed. But it is important to note that the need for a long term realignment alternative may become much more immediate if a storm event occurs that damages the highway in its current location beyond repair.

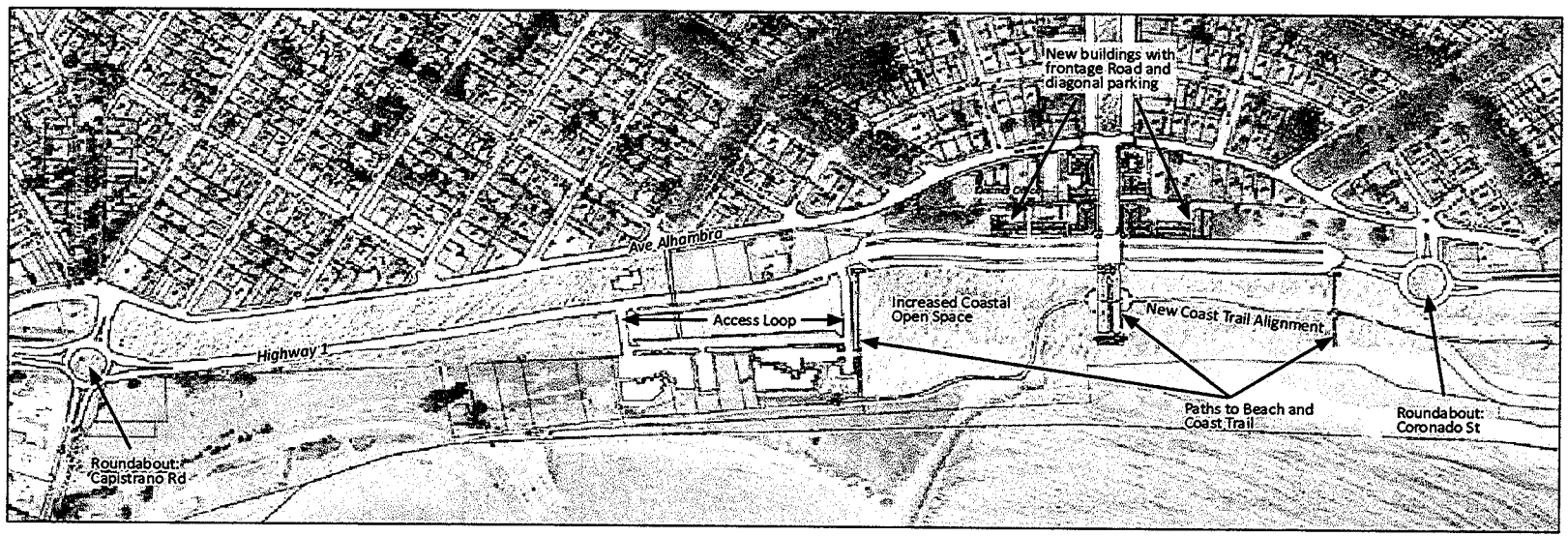


Concept B: Center Alignment

This concept shifts the roadway alignment toward the eastern edge of the Caltrans right-of-way, away from the coastal erosion area. Visitor parking is located on the west side of the highway, reducing some of the demand for pedestrian crossing from the east side of the highway to the beach and other attractions. Additional public parking is also made available for businesses on the west side of the highway, creating potential opportunities to convert some on-site parking to higher and better uses.

Additional elements include:

- A roundabout pair at Coronado Street and Capistrano Road would facilitate U-turns and circulation.
- The old roadway is narrowed and retained for parking, access and provides and emergency alternative route.
- The link between Highway 1 and an access road would improve traffic circulation.
- Connects Coastal Trail with a boardwalk between existing segments.
- A buffer is maintained between the village and highway.
- A landscaped promenade between beach parking and Portola Avenue would encourage a village main street environment to promote economic growth and focus on historic features.

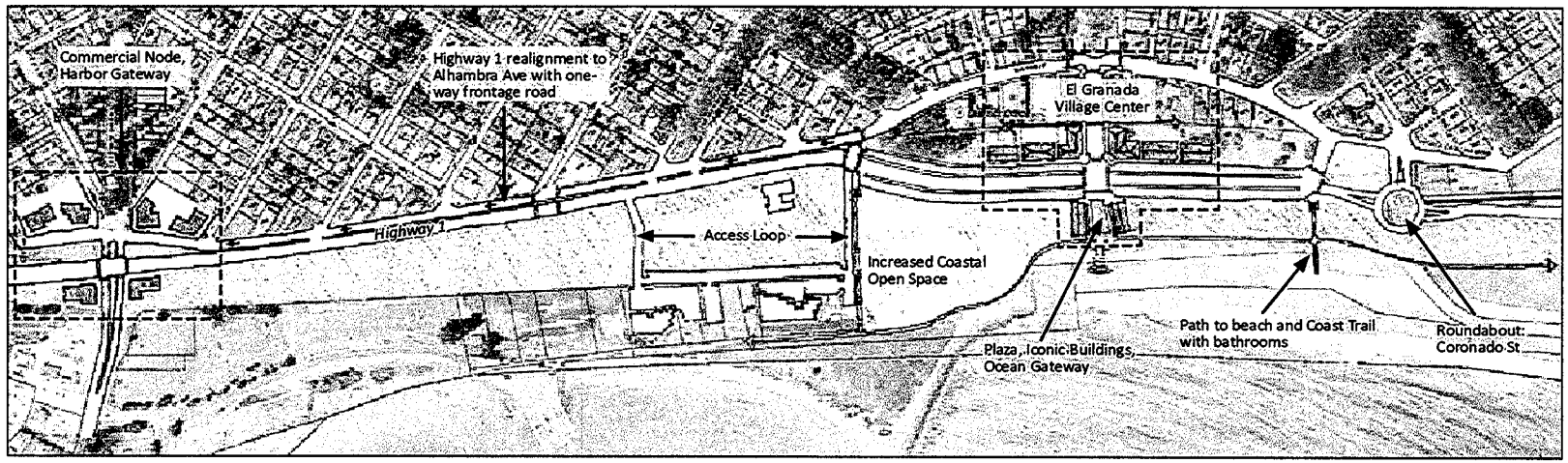


Concept C: Center/Obispo Alignment

This concept shifts the roadway alignment to the eastern edge of the Caltrans right-of-way and beyond for a portion, with parking concentrated on the east side of the highway. This adds a buffer of restored open space between the eroding coastline and the roadway. It also creates an opportunity to increase the significance of central El Granada as a viable commercial village core.

Additional elements include:

- Installation of roundabouts at Coronado Street and Capistrano Road pair to facilitate U-turns and circulation.
- Realignment of Highway 1 away from coastal erosion area to the edge of the Caltrans right-of-way, then moved farther east to align on Obispo Road.
- Diagonal on-street parking on both sides of the highway with access roads in the village core.
- Abandonment of the old highway and creation of an access loop to coastside businesses.
- Enlargement of open space west of the highway which could be used to reestablish native plant systems and possibly dunes to combat erosion.
- Re-routing of the Coastal Trail through open space.
- New highway alignment would bring traffic and parking closer to a compact village center which may stimulate economic growth and concentration of local services within walking and biking distance of residences.

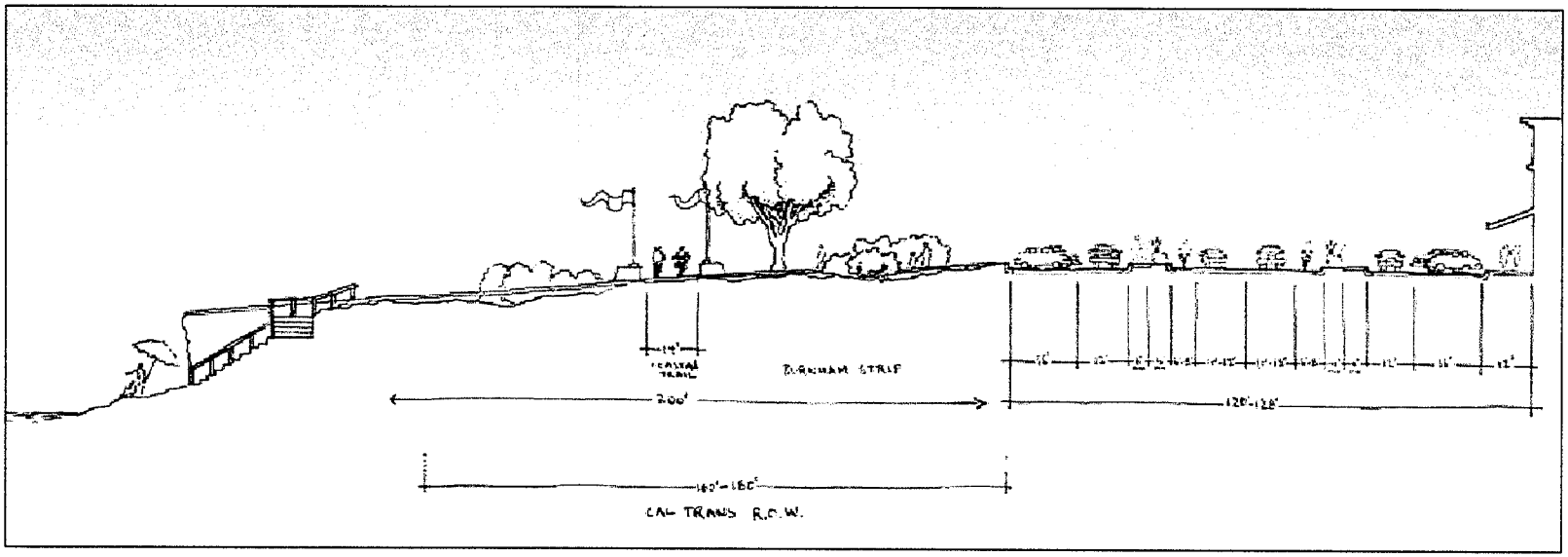


Concept D: Avenue Alhambra/Obispo Alignment

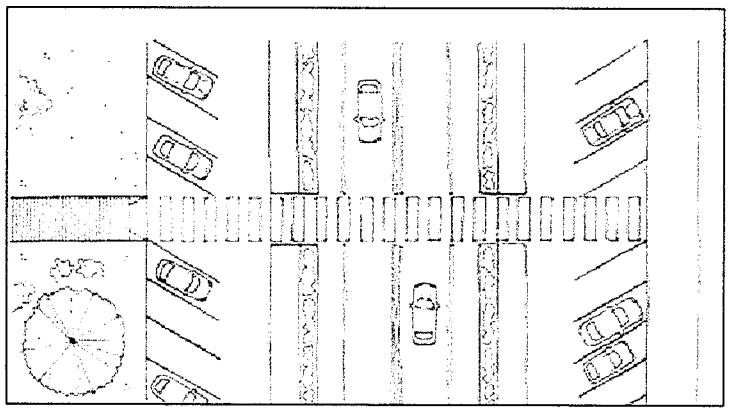
This concept re-routes Highway 1 through the existing alignment of Alhambra Avenue and Opispo Road. The three roadways would be unified into a single roadway with adjacent frontage roads for circulation and parking. Appropriate-scaled and designed development could occur on the west side of the El Granada Village Center, that would frame a public area suitable for outdoor gatherings, entertainment, a farmers markets and other events.

Additional elements include:

- Realignment of Highway 1 away from coastal erosion area outside of the Caltrans right-of-way.
- Separation of the highway from El Granada by a one-way frontage road.
- As in Concept C, there is angled on-street parking on both sides of the highway with access roads in the village core.
- As in Concept C, a section of the old highway would be converted to diagonal parking with an access loop to coastside businesses.
- As in Concept C, open space would be increased west of the highway which could be used to reestablish native plant systems and possibly dunes to combat erosion.
- The highway alignment would bring traffic closer to the village center and commercial development on the east side of the highway at the intersection with Capistrano. This can help stimulate existing and new development that can fulfill more shopping and services needs locally, reducing the need for travel to other communities.



Cross section illustrating basic features of Highway 1 realigned through El Granada.



Plan view of a mid-block pedestrian crossing in the El Granada Village Center.

As shown in the illustration above, the roadway in the El Granada Village Center area would include separated access roads on both sides of the highway with diagonal parking. Sidewalks and bike lanes would be included on both sides of the highway. Travel lanes might be reduced to 11 or 10 feet to facilitate a slower speed environment and shorten pedestrian crossings. Roadway dimensions could be adjusted to include a center median to separate traffic, facilitate pedestrian crossings and provide a space for landscaping, signage and other elements.

West of the roadway, much of the Burnham Strip would be combined with coastal land to create a wider, unified area of open space west of the highway that would continue to provide open views of the landscape and coastline from the roadway and El Granada.

5. Apply village and fringe cross section attributes between Coronado Street and Frenchmans Creek Road

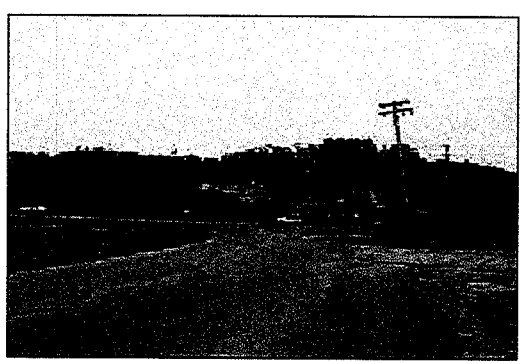
The coastal village of Miramar lies between the southern study area boundary, Frenchman's Creek Road, and the coastal village of El Granada. As shown on the location map, the village has a fringe zone on the southern end, but blends into the village of El Granada in the north. Miramar is primarily residential, with a commerce node along the highway near the intersections of Mirada Road and Guerrero Avenue, and small establishments along the coastline. Nurserymen's Exchange, a wholesaler, is located on the east side of the highway. Portions of Miramar are unincorporated, but areas south of Mirada Road are within the City of Half Moon Bay.

Village Cross Section C would generally apply between Coronado Street to approximately 500 feet south of Roosevelt Boulevard. Fringe Cross Section B would generally apply from the Roosevelt Boulevard area southward to Frenchmans Creek Road. A median, bike lanes, and shoulders finished with a concrete edge (valley gutter or curb and gutter) is recommended from Coronado Street to Frenchmans Creek Road.

Walkways are needed throughout the Miramar segment, but further study is needed to determine appropriate roadway segments for the addition of sidewalks. Sidewalks adjacent to the highway would be appropriate and are generally recommended from Coronado Street southward to at least the terminus of the restaurant parking lot south of Roosevelt Boulevard. However, variation in uses and location of development may make sidewalks adjacent to the roadway less practical in some locations. As noted previously, wide areas of land between the roadway and property lines might provide space for the development of parallel trails that can accommodate pedestrians. For example, the City of Half Moon Bay Trail Study envisions a multipurpose trail alignment along the east side of the highway to the City boundary at the Mirada Road/Alto Avenue intersection. This alignment could be extended northward to link to other pedestrian and bikeway connections.

6. Redesign Intersection at Mirada Road

Lodging, restaurants, a cafe and nursery, and small vacant buildings form a commercial hub on the west side of Highway 1, south of the intersection with Mirada Road. Highway 1 has a curved, super-elevated (embanked) segment just north of the intersection with Mirada Road. This contributes to a high speed environment. Vacant land, poorly defined corners at the intersection and multiple, wide commercial driveways create numerous hazards for drivers entering and exiting Mirada Road and accessing



Mirada Road looking east toward the highway. Vacant land suggests potential infill opportunities for local and visitor-oriented commercial development, accessible from neighborhoods by foot or bike, as well as the highway.



Recent new development near the southwest corner of the intersection with Mirada Road. Highway 1 is visible on the right.

nearby services, and for higher speed through motorists as they encounter slower moving turning vehicles.

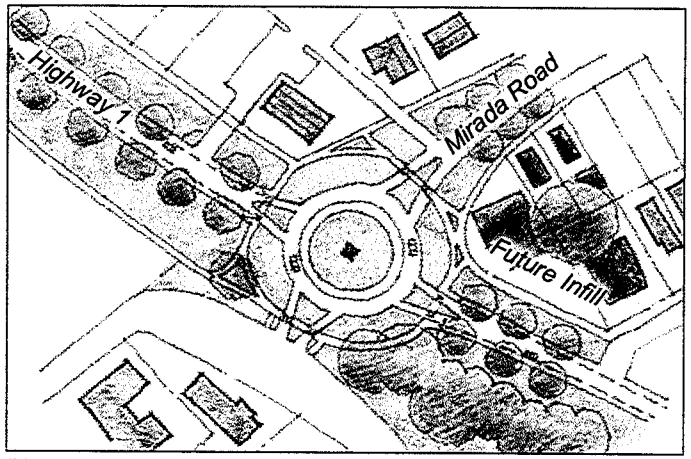
Installation of a roundabout at this location would assist drivers trying to merge with Highway 1 traffic and maintain slower speeds. It would also facilitate safe crossings for pedestrians and bicyclists. Finally, improving conditions at this intersection with a roundabout would promote infill opportunities for enhanced commercial development, and help the area evolve into a viable. pedestrian-oriented village center.

7. Consolidate access in front of Nurserymen's Exchange

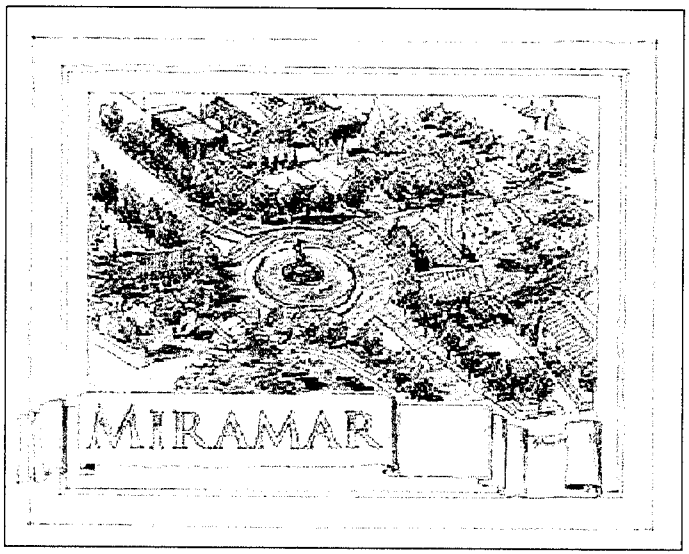
Currently, parallel informal, gravel drives provide access to Nurseryman's Exchange operations and facilities on the east side of Highway 1, roughly between Guerrero Street to the north and slightly south of Young Avenue to the south. The drive is discontinuous and punctured by many access points to the highway.

As noted previously, a City of Half Moon Bay trail study proposes the alignment of a trail on the east side of the highway in front of the Nurserymen's property. Implementation of this trail could occur in tandem with a consolidation of the many service access points along the Nurserymen's property into a continuous structured access road of uniform width and material and limited access points. This service road could begin at the Young Avenue intersection to the south and continue northward to at least Roosevelt Boulevard and perhaps continue on to Guerrero Street or even Mirada Road/Alto Avenue.

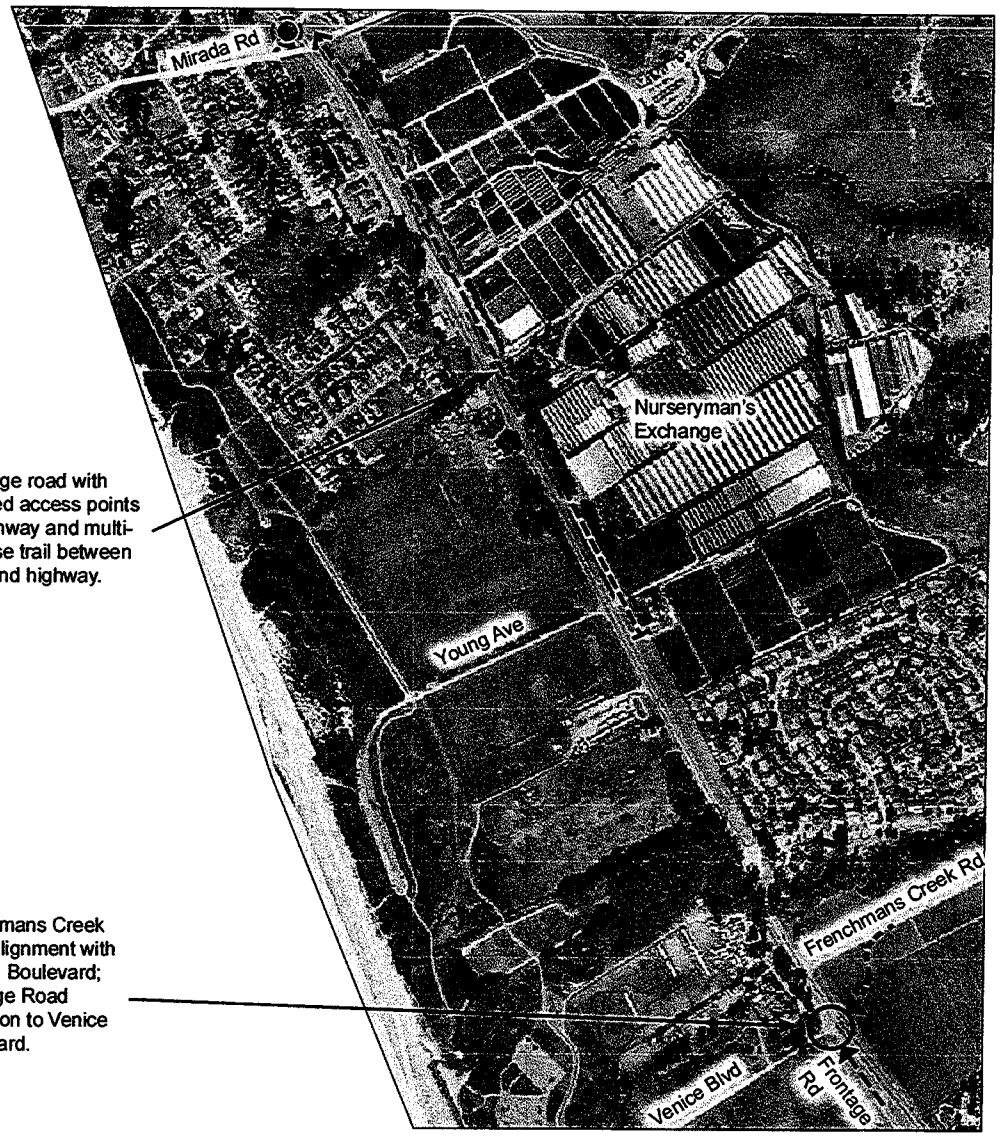
The median between the highway and the service road could integrate the off-street trail with pedestrian amenities such as lighting and landscaping. Limiting the access points for industrial vehicles would



Plan view of roundabout at Highway 1 and Mirada Road.



Perspective view of future village center.



Frontage road with reduced access points to Highway and multi-purpose trail between road and highway.

Frenchmans Creek Road alignment with Venice Boulevard; Frontage Road extension to Venice Boulevard.

make this route safer for pedestrians and reduce the number of turning conflicts with the highway.

8. Consolidate intersections at Frenchmans Creek Road

Another possibility to consider for consolidating access points on Highway 1 exists at Frenchman's Creek Road. The road intersects and terminates at the highway from the east. Approximately 300 feet to the south, Venice Boulevard intersects and terminates at the highway from the west. Frenchmans Creek Road could be realigned southward to connect with the existing alignment of Venice Boulevard. Frontage Road, which runs parallel on the west side of the highway providing access to a residential subdivision, could be extended approximately 400 feet to the north to join at Venice Boulevard. The current intersections at Frenchmans Creek Road, Venice Boulevard and Frontage Road would be consolidated into a single unified intersection.

The proposed strategy would establish the prominence of Venice as a primary access route to state beaches, parking, the Coast Trail and equestrian paths. In the long term, the intersection could be enhanced for pedestrian crossing and eventually meet warrants for signalization.

Appendix

Implementation: Action Plan

The action table below proposes tasks be accomplished in the following time frame:

Short Term: 0 - 2 years
Mid Term: 2 - 5 years
Long Term: 5 - 10 years

Category	Suggested Action/Strategy	Time Frame
Policies and Studies	Explore Route 1 freeway/expressway re-designation to highway designation	Short Term
	Conduct parking study to assess needs and identify preferred sites, size and configuration	Short Term
	Review and refine potential future highway realignment alternatives	Short Term
	Study feasibility of roundabouts at Capistrano (north) and Mirada Road	Short Term
	Review and revise local coastal plan to direct infill development into Village Centers	Mid Term
	Consider creation of form-base code to implement infill development in village centers and residential locations	Mid Term
	Prioritize bikeways and trail connection links for improvements	Short Term
Corridor Improvements	Stripe bike lanes and medians on Highway 1 per recommended context appropriate cross sections	Short Term
	Improve crossing treatments at Capistrano Road and Coronado Street	Short Term
	Complete 400' portion of trail linking the Coastal Trail between Surfers Beach and Coronado Street	Short Term
	Construct sidewalks and edge treatments both sides of Highway 1 per recommended context appropriate cross sections	Mid Term
	Install flush and raised median treatments	Mid Term
	Install one or more mid-block crossings in El Granada	Mid Term
	Construct preferred parking alternative in accord with San Mateo County Sustainable Green Streets and Parking Lots Design Guidelines	Mid Term
	Consolidate driveways and parking lot entries in Miramar and El Granada	Mid Term
	Improve frontage drive at Nurseryman's Exchange	Mid Term
	Raise approach grades at the Airport intersection, Magellan and Medio Avenues, and Mirada Road to highway grade level	Mid Term

Category	Suggested Action/Strategy	Time Frame
Corridor Improvements	Realign Frenchmans Creek Road to Venice Boulevard	Mid Term
	Install roundabouts	Mid Term
	Construct highway realignment and intersection improvements	Long Term
	Implement coastal open space restoration	Long Term

Process Notes

Community Workshop
Thursday, June 25, 2009 7 - 9 PM
El Granada Elementary School

The participants were asked to write the values they consider most important in one or two words for the community on separate sticky notes. They then placed each value on a wall next to values that were the same or that most closely resembled their own. Top values included:

- Nature/Wildlife
- Ocean
- Community/Friends/Family
- Walk/Bike
- Quiet/Peaceful
- Open Space
- View/Beauty Recreation
- Fresh Air
- Beach
- Safety
- Weather
- Schools

The participants created a list of issues and ideas to address through a rapid brainstorming session, then identified their top choices with voting dots. These included:

1. Parallel trail to Highway 1 for pedestrians and bikes
2. Preserve/protect view corridors
3. Easier access to the beaches
4. Preserve agricultural, rural qualities
5. Design of trails for different types of users
6. Native plants
7. Pedestrian tunnel or overpass
8. Eastside trail that includes hills
9. Low cost solutions
10. Balance needs of residents and visitors
11. Reduce light pollution
12. Low impact, low asphalt, meandering trail design
13. Restrooms, trash receptacles, tables and benches
14. Include Princeton in study area recommendations
15. Trail to Mavericks with parking off the highway
16. Clustered community services
17. Separate identity for communities

Saturday Community Walk and Design Ideas
Saturday, June 27, 2009 9 am - 2 PM
El Granada Elementary School

The participants broke into two groups and walked the El Granada neighborhood near the elementary school and Highway 1 near the intersection with Coronado Avenue. Afterwards, they viewed a training presentation and worked in groups around table maps and suggested improvements in the study area. Key suggestions and discussion points are summarized below.

Group 1

- Crossing in Miramar: improve culvert under road for safe undercrossing.
- Improve beach access off Coastal Trail.
- Miramar surf east dirt parking lot improvement.

- Safer crossing at Magellan.
- Looking for bike lanes both sides of highway 1.
- Bike trail along highway 1.
- Surfers Beach area: move highway east into right-of-way; create median. Allow parking on west side up to the point of Surfers Beach turnout, then drop off structure on the east. Looking for an opportunity for a drop off area to be used by both north and southbound traffic – a turnaround to avoid left turn into drop off area.
- Consider circulating shuttle to serve harbor and Oceano Hotel parking areas.
- Longer term, more parking up toward airport.
- At end of Coral Reef Avenue provide one trailhead from Rancho to provide open space access.
- Coastal trail branches off, going through harbor district either on Princeton or in front of Ocean Blvd. Long term, trail continues up to Pillar Point Marsh.
- Provide parking across from little shopping area at Portola.
- Notes on maps: First Aid, trash/recycling, water/toilets, shuttles for major events, benches.
- Frenchman Creek pedestrian access improvement.

Group 2

- Coastal trail is currently in place.
- Add commuter trail parallel to highway 1 from Princeton harbor to Frenchmans Creek with physical barrier between hwy 1 and trail.
- Some conception plans for oceanside boardwalk.
- Heart of El Granada – looking at Surfers Beach, Sam's Chowder House to Coronado, move highway back 100 to 200 yards. Use roundabouts at connections.
- Narrow Ave Alhambra with bike trail/walking.
- Feeder trails, benches, tree cleanup in major corridors.
- Tourist industry along new highway.
- Crossings to allow people to access beach – see lights on map.
- If we move the road back people have 3 different access points.
- Don't want cement – we want an amphitheater and access to beach where people can congregate.
- Take advantage of community tourism and coastal trail.
- Segment south of Princeton to harbor district, need to bring through to Pillar Point Bluff where it is complete. Have harbor district support for bringing trail through harbor line, but at north end of parking lot there is a bottleneck in front of Oceano Hotel, Fish Trap, brewery; sidewalk narrows and doesn't work at all for pedestrians or bikes. There is a congestion problem. Bring a boardwalk behind Fish Trap, connect to vacant lot and run frontage trail along coast line. A second bridge over the creek, two bridge points connected to boardwalk. In the interim come up Princeton Avenue until funds are available to construct the boardwalk. The Coastal trail is all about having the trail where you can see the water. The interim trail won't have a view, but hopefully it would be a short term solution.
- Bridge creek and tail end of Broadway.

Group 3

3 year plan:

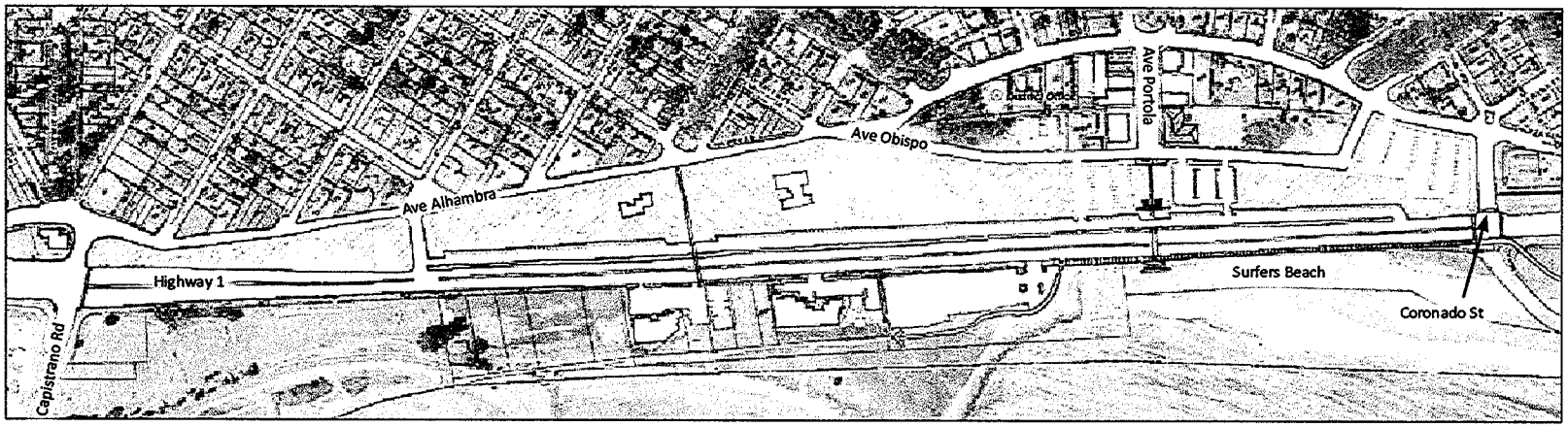
- To replace the broken stairs at Mirada and Magellan, great access could be made with a few loads of gravel dropped at the beginning of every year right by the ancient bridge.
- Another problem is there is no rest room – would be nice to have a bathroom walking distance from the beach.
- Surfers beach - possibility for bathroom: the problem to deal with is the connector between where sidewalk ends and the intersection. A temporary bridge with little impact could be built using telephone poles in the ground with a boardwalk over that riparian area.
- Surfers beach – a similar wooden ramp temporary solution could be used. It would have to be redone in a year or two.

Next layer (longer term ideas):

- Traffic circle to separate traffic into two separate lanes of one-way traffic – north bound on business side; break off parking lots. Use permeable parking lots and trees. Try not to block view corridors with parking lots. Some of the problems with this is that having one way traffic on this stretch of Alhambra would create problems with residential area. Broke it off at Coronado.
- Create a median in northern section of highway 1. Talked about bringing promenade down to beach; at high tide stairs go directly into water.
- Suggestion on the bluff, in the Caltrans right-of-way below the schools you can fairly easily make a parking area that comes in at that point and would accommodate about 90 cars.
- In discussing parking we tried a scheme within the Caltrans right-of-way to maintain the two lane program and have more parking on the street on Obsipo. This would feed the beach promenade and business district.
- In Princeton we wanted to look at how different people use bike paths. Using the roads by Mavericks, we would make that nice bike paths where people could ride with their kids.
- Make sure we have signs about recreational opportunities, like kayaking.
- On Rancho Corral de Tierra POST property comes to corner. Need a pedestrian trail on Alcatraz. Vehicles access Corral Reef.
- Slow traffic on highway 1.
- Safer access onto highway 1.
- Pedestrian and bike tunnel under bridge on top of rise.
- Bike path going down to Frenchmans creek.
- A lot of people working at the nursery walk along highway to get to/ from home. Bike/pedestrian trail along highway 1.
- No connections from Mirada to existing trails
- Mirada Road, no place for pedestrians except in the street.
- What about the special events on the coast and that will probably increase?

Charrette Participants

Dorothy Baughman
Yvonne Bedor
Yuonru Bedos
Jim Blanchard
Bruce Blarnerhorn
Merrill Bobele
L.E. Boydston
Sabrina Brennan
Amy Broome
Stuart Brunow
Paula Burns
Jo Chamberlain
Elaina Cuzick
Michelle Daher
Yuri Daher
Mary DeLand
Carla Edwards
David Edwards
Grey Edwards
John Edwards
Robert Edwards
Guy Elus
Sandy Emerson
Gael Erickson
Len Erickson
Marisa Espinosa
Joel Farbstein
Lyndall Ferb
Laura Fernandes
Ben Forchini
Andrew Georgeades
Steven Goldberg
Christine Granahan
Michael Granahan
Lisa Grote
Stuart Grunow
Kim Harrington
Samantha Havens
Elizabeth Hennings
Manu Hipkins
Dave Holland
Nancy Hornor
Don Horsley
Joseph Hurley
Tyler Jackson
Patric Jonsson
Paul Keel
Joanne Kerhavez
Lisa Ketcham
Jerry Laster
Anna Lee
Doris Lee
Sung Lee
Margot Lowry
Constance Malach
Charise McHugh
Neil Merrilees
Claudia Miller
Norma Miramontes
Steve Monowitz
Tracy Morish
Sherry Morrish
Duat Nguyen
Peggy O'Leary
Joanna Parness
Richard Parness
Barry Parr
Dennis Paul
Paul Perkovic
Jenn Petrie
Tom Pohl
Robin Pon
Chris Powell
Helen Rogers
James Ryan
Bob Ryerson
Laura Sanders
Ron Sanders
Mechan Scanlon
Cathy Schultz
Leni Schultz
Paul Shenkmans
Diane Shu
Kurt Simrock
Kathryn Slater-Carter
Jan Sleqmaies
Mark Sleqmaies
Steve Slowika
Aprile Smith
Bern Smith
Bill Sorfleet
James Stanton
Sandra Tate
Beth Thomas
Mike Thomas
Carolann Towe
Sanda Trotter
Elizabeth Vespremi
Laslo Vespremi
Dianne Whitaker
Leonard Woren
Jan Wyer

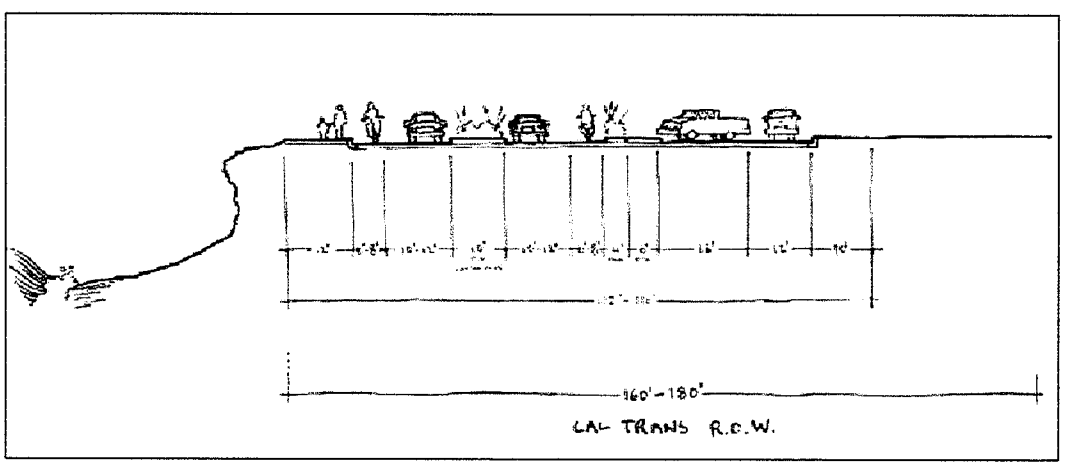


Concept A: No Realignment

Concept A retains the existing roadway alignment, and is a candidate for early, phased-in implementation. Informal parallel parking is removed from the highway shoulder and unpaved areas beyond the shoulder and organized into diagonal parking east of the highway with a one-way northbound access way. A new connection allows traffic from the parking the area to access Alhambra. Additional parking lots are accessible from Alhambra and Obsipo.

A continuous raised center median would be added, with turn pockets for access to commercial areas and the parking access road.

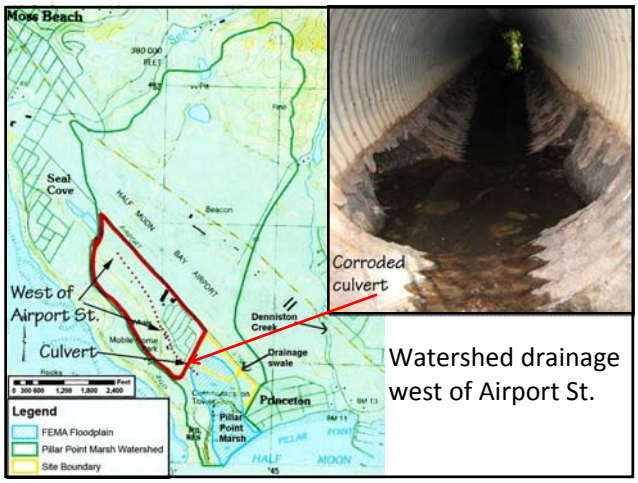
Consistent with the Typical Village Cross



Above: cross section for Highway 1 between Surfers Beach parking lot and Coronado Street.

APPENDIX B

PRESENTATIONS FROM THE NOVEMBER 18, 2009 PLANNING COMMISSION PUBLIC HEARING



Watershed drainage west of Airport St.











1/19/2006
Mud and debris removed from marsh at culvert outfall.



1/19/2006



Mud & debris moved alongside access road in Wetland A

Big Wave DEIR Views and View Corridors

Presentation for San Mateo County Planning Commission
Len Erickson - El Granada Resident
November 18, 2009





The Big Wave DEIR presents a total of five views to assess visual impact. Any site needs to be seen from a number of positions to assess visual impact. For a project as large as Big Wave, each DEIR view should be considered from a number of positions in an extended view corridor.

Story poles depict with accuracy the profile of a building from a number of view points.



In the absence of story poles, a structures position can be shown by inserting shaded areas or pictorial renderings with accurate perspective.



Analysis of DEIR Views

- The larger the site, the more difficult it is to present accurate renderings without formal simulation software.
- This report uses shaded areas of the type shown in the previous slide.
- Each of five DEIR views were photographed from several positions in a corridor. At least two photographs are shown for each corridor in this report.
- The visual impact for each DEIR view was rated as "Less than significant". This report shows that when viewed with careful detail from multiple positions, there is significant impact on representative corridors that contain each of the five views.

View 3: West Point Avenue Pillar Point Marsh Corridor



View 3.A Looking northeast towards the project site from Mavericks Parking Lot with immature landscaping

- Photo emphasizing road and parking surface, not the vistas that attract the eye
- Does not show view from heavily used trail to Mavericks / Pillar Point Beach
- Does not show road view and parking lot view when entering the area

Significant impact



Pillar Point Marsh:
Trail near the shore line
looking toward Montara Mountain



Pillar Point Marsh:
Trail near the shore line
looking toward Montara Mountain (Big Wave profile)

Pillar Point Marsh:
Wellness Center from West Point Rd and Parking Lot



View 5: Highway 1
Highway 1 Corridor



View 5.A. Looking southwest across the airport towards the project site from Highway 1 with immature landscaping.

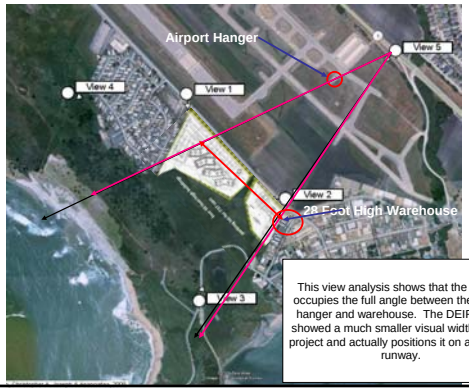
- DEIR Photo minimizes vista that eye takes in - open airport and background mountains
- Does not show transition views along highway 1
- DEIR photo mis-positions project.

Significant impact

Highway 1 - DEIR View 5:
Near exit onto Capistrano toward harbor

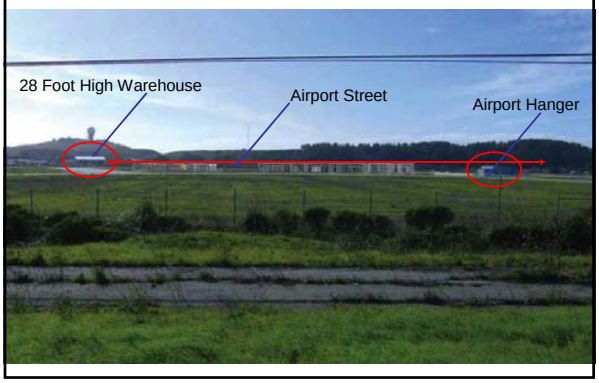


Analysis of DEIR View 5

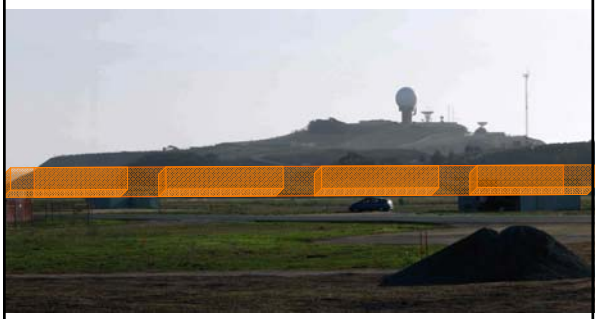


This view analysis shows that the project occupies the full angle between the airport hanger and warehouse. The DEIR photo showed a much smaller visual width for the project and actually positions it on an airport runway.

Big Wave DEIR View 5



Highway 1:
Airport entrance/3-0 Cafe



View 1: Airport Street
Airport Street Corridor



View 1A: Looking south across the project site from Airport St with immature landscaping.

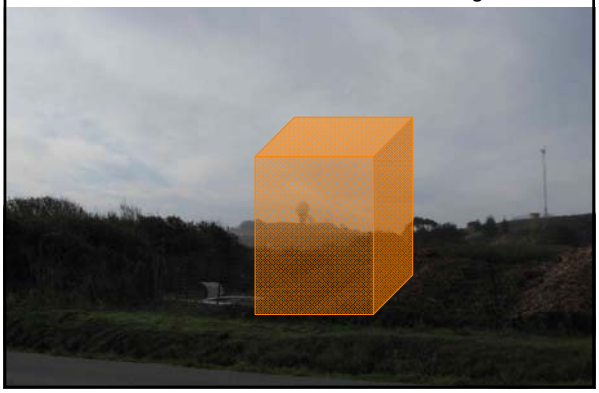
- DEIR Photo emphasizing road and parking surface, not the vistas that attract the eye
- DEIR photo does not show changing views while driving on Airport Street
- DEIR does not show impact of buildings when viewing site directly in front of the building at street level.

Significant impact

Airport Street Corridor
Across street from center of Office Park site



Airport Street Corridor
Across from Communications Building



Airport Street Corridor
Across street from Wellness Center



View 2: Airport Street / Stanford Avenue
Princeton / South Airport Corridor

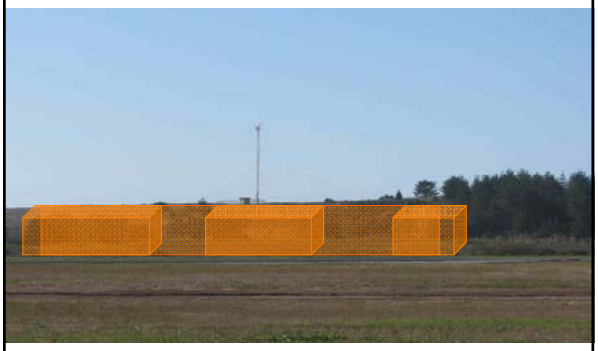


View 2.A Looking northwest across the project site from Airport St with immature landscaping

- DEIR photo emphasizes road and parking surface, not the vistas that attract the eye
- Does not show changing views while driving on streets leaving Princeton or at the airport south perimeter.

Significant impact

Princeton / South Airport:
From Capistrano Road



Princeton / South Airport:
Wellness Center / Storage Building /
Part of Office Park Site from Cornell Avenue



View 4: North Trail
Bluff Trail Corridor



View 4.A Looking east towards the project site from North Trail with immature landscaping

- Photo minimizes vista that eye takes in - open airport, mountains, harbor
- Does not show transition of views along trail

Significant impact

North Trail:
1/2 Up Hill

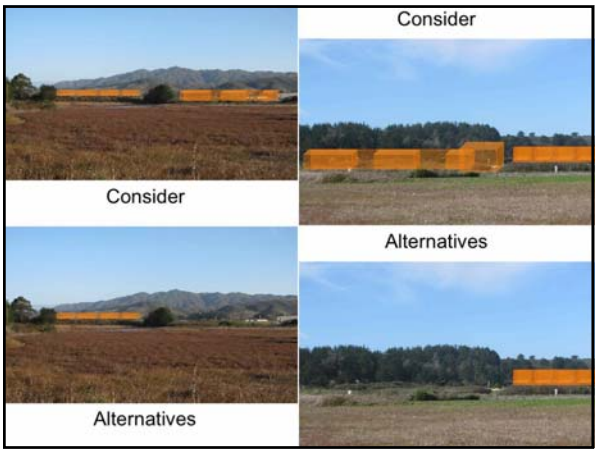


North Trail:
2/3 Up Hill



Alternate Methods

- A preferred alternative to story polls for very large project is a true computer simulation which lets a person view alternatives configuration.
- The DEIR is essentially using cut and paste of site renditions, leading to the problems documented at View 3.
- Simulations allow moving views
- Simulations make it possible to accurately assess alternatives.
  - For example - What if Wellness and Office Park were on the north site?
- As another important factor, only a true simulation can let a viewer experience the effect of light emission from the site at dusk and night.



In Conclusion…

- The Big Wave project site is visible throughout all key travel (car and foot) corridors in the largest flat land open space on the Midcoast.
- There is a significant impact of the project on project views, requiring both more accurate study and evaluation for alternate site configurations.
- This analysis presented in this report provides a broader review than the DEIR with respect to whether it has a demonstrable negative negative aesthetic effect on the public view space.
- This analysis shows that the Big Wave will substantially degrade the existing visual character of the airport /agricultural plain.
- For decision makers and the the public to make an informed review of the project's effect on existing views and vistas additional documentation and analysis with better tools (story polls and true computer simulations) is required.

Flawed Public Comment Process

- Laslo Vespremi, MFA
- Moss Beach resident for 26 years
- 25 years of 3D Computer Graphics experience

1. Visual Misrepresentation in DEIR

- My method:

  Model buildings to scale using Google Earth and place them at actual location to get true views.

Perspective View



Top View



5 Views



Hwy 1 (View 5)



- Google View

5 Views



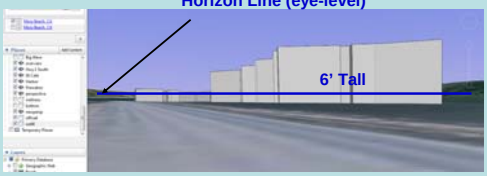
Airport Rd. (View 1)

Pole=40'



- DEIR View

Horizon Line (eye-level)



- Google View



From Hwy 1

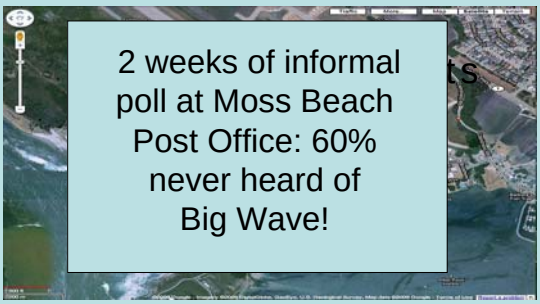


From Hwy 1

Hwy 1 South



Only 500' notification!



2 weeks of informal poll at Moss Beach Post Office: 60% never heard of Big Wave!

Conclusion

1. With misleading graphics and no story poles the public cannot judge the scale of the project.
2. Notification to 500' radius laughable for a project this size and impact
3. Missing parts of DEIR printed copies

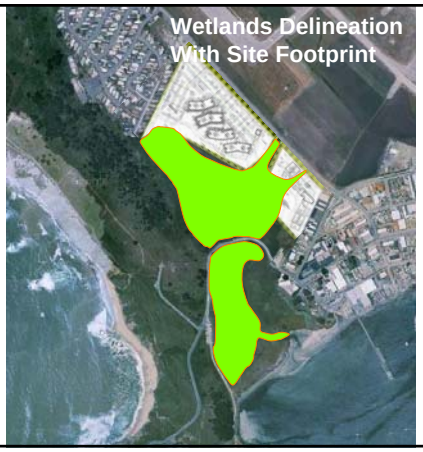
- As a result we consider the public comment period flawed and open to challenge. Many residents signed petition that the public comment period restart in February 2010 with better notification + story poles are set up.

Big Wave DEIR

Presentation for San Mateo County Planning Commission
Lennie Roberts - Committee for Green Foothills
November 18, 2009







Disking Southern Parcel Wetland September 1987





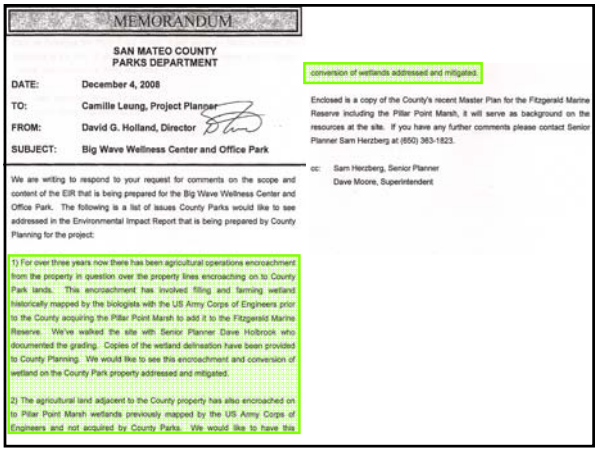


Disking and dumping southern parcel
6/8/2006









MEMORANDUM

SAN MATEO COUNTY
PARKS DEPARTMENT

DATE: December 4, 2008

TO: Camille Leung, Project Planner

FROM: David G. Holland, Director

SUBJECT: Big Wave Wellness Center and Office Park

We are writing to respond to your request for comments on the scope and content of the EIR that is being prepared for the Big Wave Wellness Center and Office Park. The following is a list of issues County Parks would like to see addressed in the Environmental Impact Report that is being prepared by County Planning for the project:

1) For over three years now there has been agricultural operations encroachment from the property in question over the property lines encroaching on to County Park lands. This encroachment has involved filling and farming wetland historically mapped by the biologists with the US Army Corps of Engineers prior to the County acquiring the Pillar Point Marsh to add it to the Fitzgerald Marine Reserve. We've walked the site with Senior Planner Dave Holbrook who documented the grading. Copies of the wetland delineation have been provided to County Planning. We would like to see this encroachment and conversion of wetland on the County Park property addressed and mitigated.

2) The agricultural land adjacent to the County property has also encroached on to Pillar Point Marsh wetlands previously mapped by the US Army Corps of Engineers and not acquired by County Parks. We would like to have this conversion of wetlands addressed and mitigated.

Enclosed is a copy of the County's recent Master Plan for the Fitzgerald Marine Reserve including the Pillar Point Marsh, it will serve as background on the resources at the site. If you have any further comments please contact Senior Planner Sam Herzberg at (650) 363-1823.

cc: Sam Herzberg, Senior Planner
Dave Moore, Superintendent





Alternative affordable housing site



Pillar Ridge – right next door



- designated affordable housing site under the County's Local Coastal Plan
- non-profit ownership
- space rent control



-swimming pool -playground
-basketball court -barbecue & picnic areas



Community Center – 5500 sq. ft.
kitchen, fireplace, billiards, ping pong
fitness room
trail access to bluff



227 homes – all owner occupied
2, 3, 4-bedrooms
safe streets





Presentation to the San Mateo County Planning Commission
November 18, 2009
by Lisa Ketcham, President, Pillar Ridge Homeowners Association

Big Wave Project Draft EIR -- Alternatives

In the draft EIR, alternative sites for the housing component of the project are rejected by the developer because other undeveloped Coastside affordable housing sites have obstacles, and because they consider the housing is best located within the Princeton industrial district near the Office Park.



But there is another alternative right next door. The manufactured home community of Pillar Ridge is a designated affordable housing site under the County's Local Coastal Plan. There is non-profit ownership and space rent control.



There is a community center, swimming pool, fitness room, playground, basketball court, and trail access to the bluff.



There are safe interior streets in a multi-cultural neighborhood of families, children, and retired people. There are developmentally disabled adults and children already living here. We would welcome more. They would be members of our diverse community rather than living in isolation.



Golden Gate Regional Center helps their clients who live here, picking them up every day to go to their jobs or activities. The Big Wave Farming operation could start now, giving the residents the proposed jobs in the nearby airport fields that are already being farmed.



With 227 two, three, or four-bedroom homes, there are usually a few for sale at any particular time. There are opportunities to install new homes. Group homes could be formed as long as the owner lives in the home. The owner could be a DD adult or a caregiver.

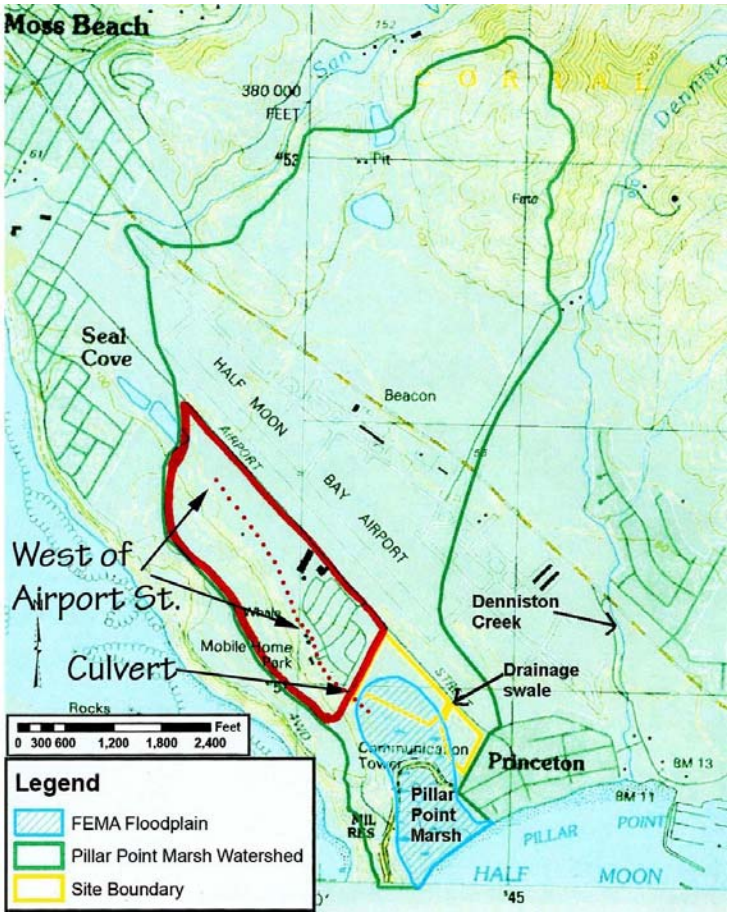


This isn't the exact description of the Wellness Center, but it is available now. The hope that has been held out to these young people, for a place they can live & work with their friends in their own homes, does not have to wait or depend on the support from a controversial 225,000 sq.ft. office and commercial development on a challenging site in an even more challenging economic environment.



Presentation to the San Mateo County Planning Commission
Meeting of November 18, 2009
Big Wave Impact Hydro-4 Drainage/Flooding

- The Draft EIR states that "Placing fill or other structures in such a way as to block existing drainage paths could result in increased onsite or offsite flooding, particularly if there is significant offsite drainage that flows through the site. However, since no drainage report was provided by the applicant, it is unknown if there are substantial stormwater discharges that would travel onto the site from neighboring areas, particularly the residential development to the northwest."



There is no mention in the Draft EIR of the significant portion of the watershed drainage west of Airport St. and north of Big Wave which includes the community of Pillar Ridge, the open fields to the north and the hillside to the west. The drainage follows a creekbed through the fields and then along the base of the bluff behind the Pillar Ridge community.



All this drainage enters the marsh at one point, through a badly corroded 36” culvert under the access road at the northern perimeter of the Big Wave Office Park parcel.

In December 2005, a Big Wave contractor, clearing vegetation from this long-overgrown access road with bobcat or similar equipment packed mud and vegetation into the marsh, totally blocking the culvert outfall.









Several blocks of the Pillar Ridge community were flooded.



Pillar Ridge Management was luckily able to locate the contractor on their own to resolve this emergency situation.

Big Wave L.L.C. never replied to letter and pictures concerning this event.

Mud and debris removed from marsh at culvert outfall. (photo 1/19/2006)



photos: 1/19/2006



The mud and debris were just moved to an adjacent area of the marsh (labeled Wetland A in the Draft EIR).

The Draft EIR includes Source Control "Best Management Practice" of regular maintenance of the storm drain system. Given our past experience with the applicant's maintenance of their storm drain system, the flooding it caused in our community, the lack of any drainage report in the Draft EIR, and the complete oversight in the report that this drainage even exists, we do not agree that there are no significant impacts regarding drainage at this project.

Pillar Ridge Homeowners Association
Lisa Ketcham, President

SAN MATEO COUNTY PLANNING COMMISSION

5

PUBLIC HEARING

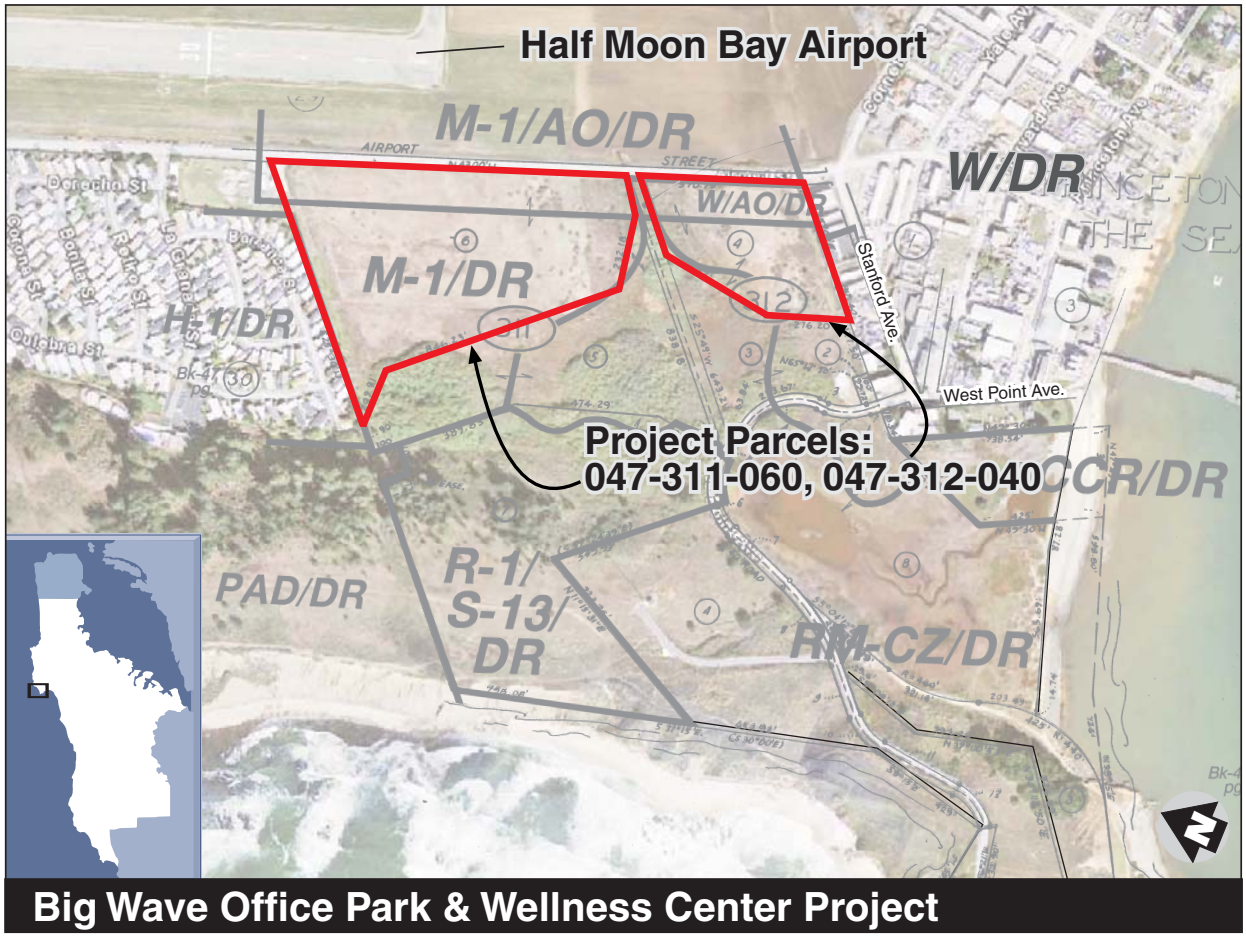
MEETING NO. 1498

Wednesday, November 18, 2009
9:00 a.m.
Board of Supervisors Chambers
400 County Center, Redwood City

REGULAR AGENDA

Item	9:00 a.m.
Owner/Applicant	**Big Wave Group, LLC**
File Number	PLN2005-00481 and PLN2005-00482
Location.....	Airport Street and Stanford Avenue, Princeton
Assessor's Parcel Nos.	047-311-060, 047-312-040

pc title page.cdr



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pln05-481-482.cdr rev 11-16-09 yc

DRAFT

ENVIRONMENTAL IMPACT REPORT

BIG WAVE WELLNESS CENTER AND OFFICE PARK PROJECT

Lead Agency:
County of San Mateo
Planning and Building Department
455 County Center, 2nd Floor
Redwood City, CA 94063

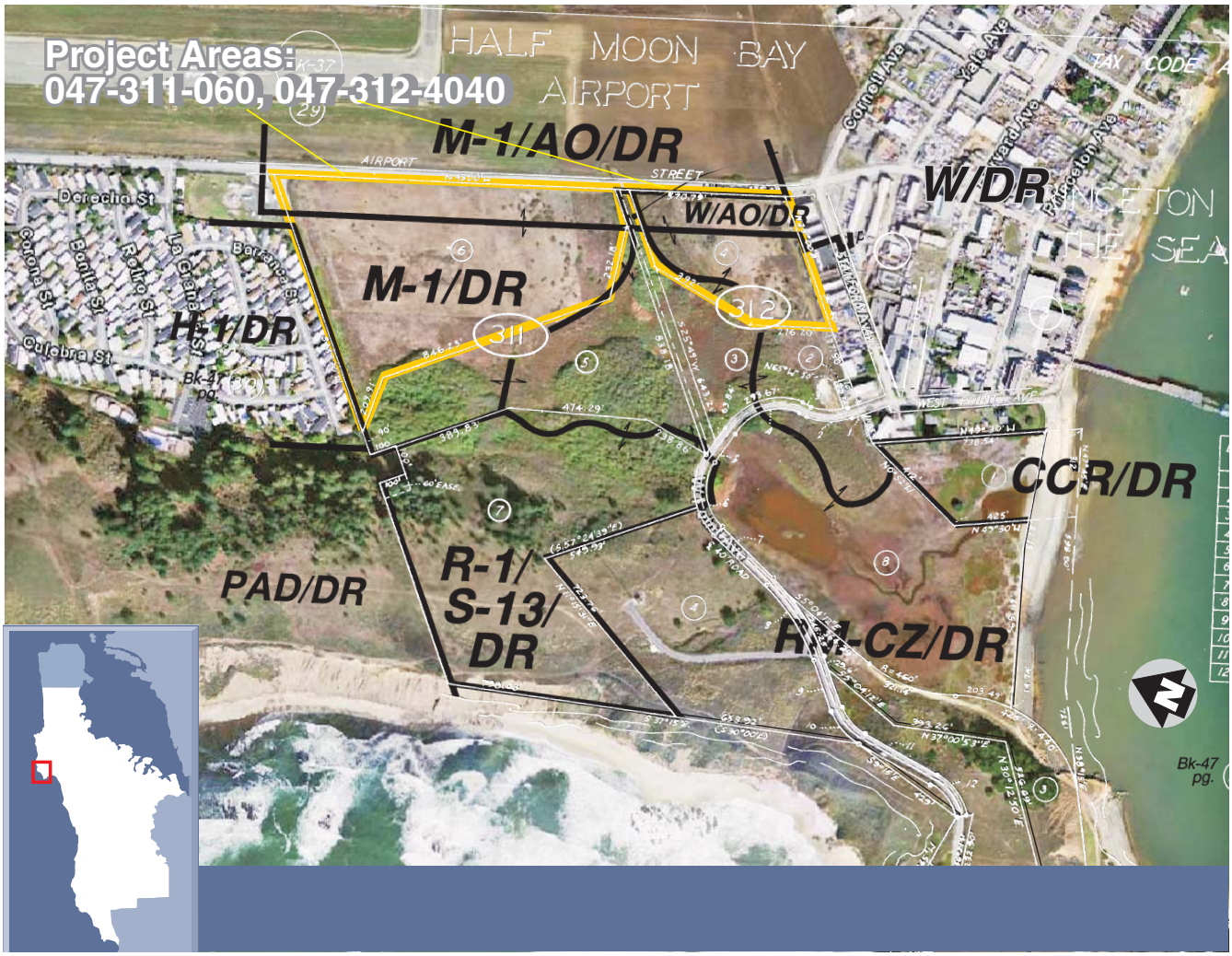
SCH No. 2008102109
October 2009

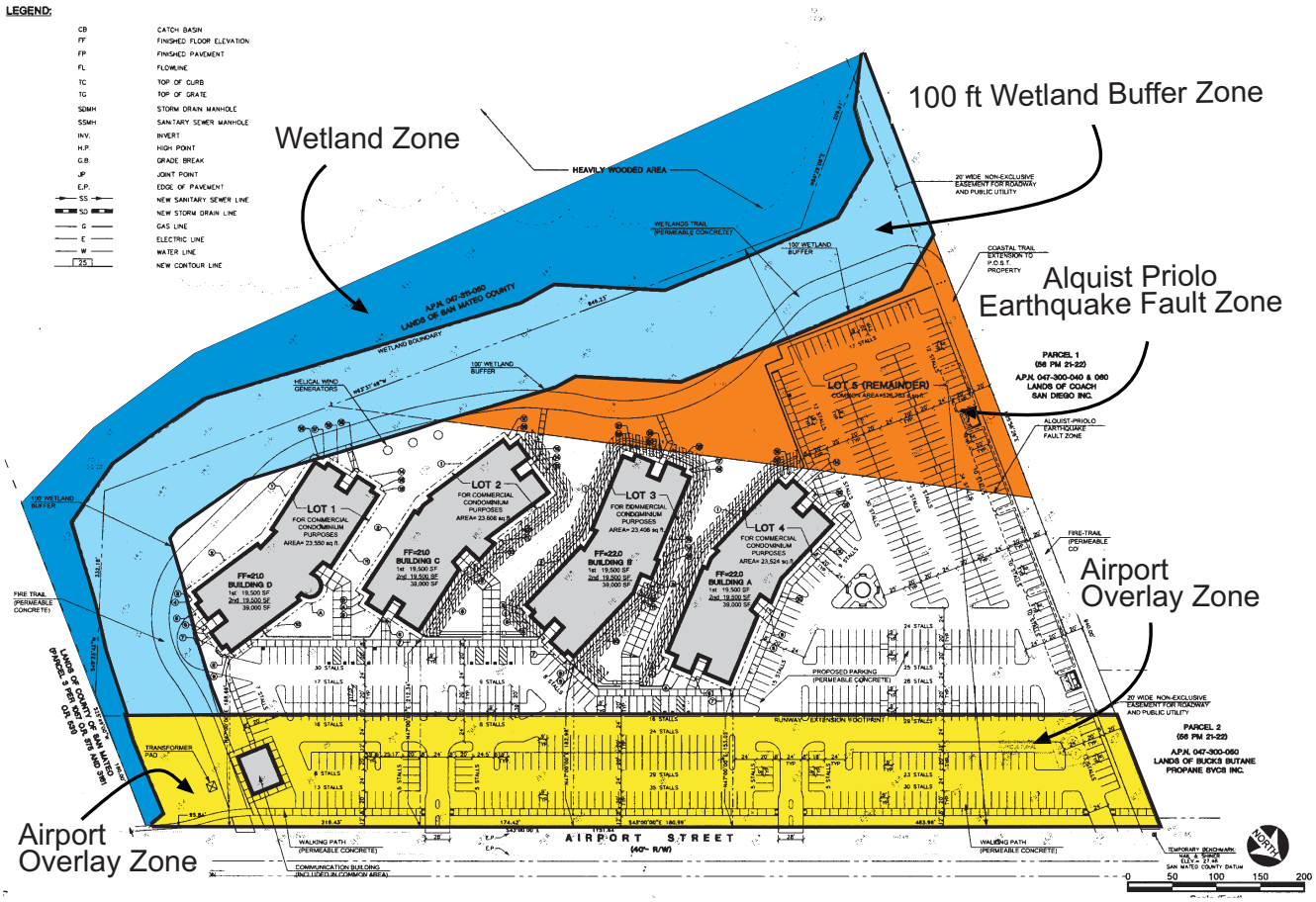
Extensions to Public Review Period

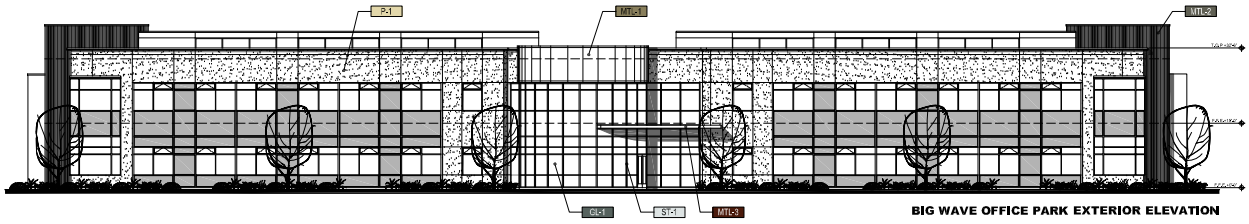
- Draft EIR Release Date: October 22, 2009
- End Dates:
  - Original End Date (45-Day): December 7, 2009
  - Extension to 62-Days: December 22, 2009
    - Based on requests from the public due to length of document
  - Extension to 64-Days: December 24, 2009
    - Based on inadvertent omission of Chapter IV.N from hard copies of Draft EIR

Availability of Draft EIR

- Copies of the Draft EIR have been available at the following locations:
  - 1) Planning Department's web site
  - 2) Planning Department Counter
  - 3) The Half Moon Bay Library







Legend

SCHEME 2– BIG WAVE OFFICE PARK

P-1 FIELD PAINT SHERWIN WILLIAMS SW7723 COLONY BUFF

MTL-1 METAL PANEL FIRESTONE – UNACLAD SIERRA TAN

MTL-2 CORRUGATED METAL FIRESTONE – UNACLAD SLATE GRAY

MTL-3 METAL CANOPY FIRESTONE – UNACLAD COLONIAL RED

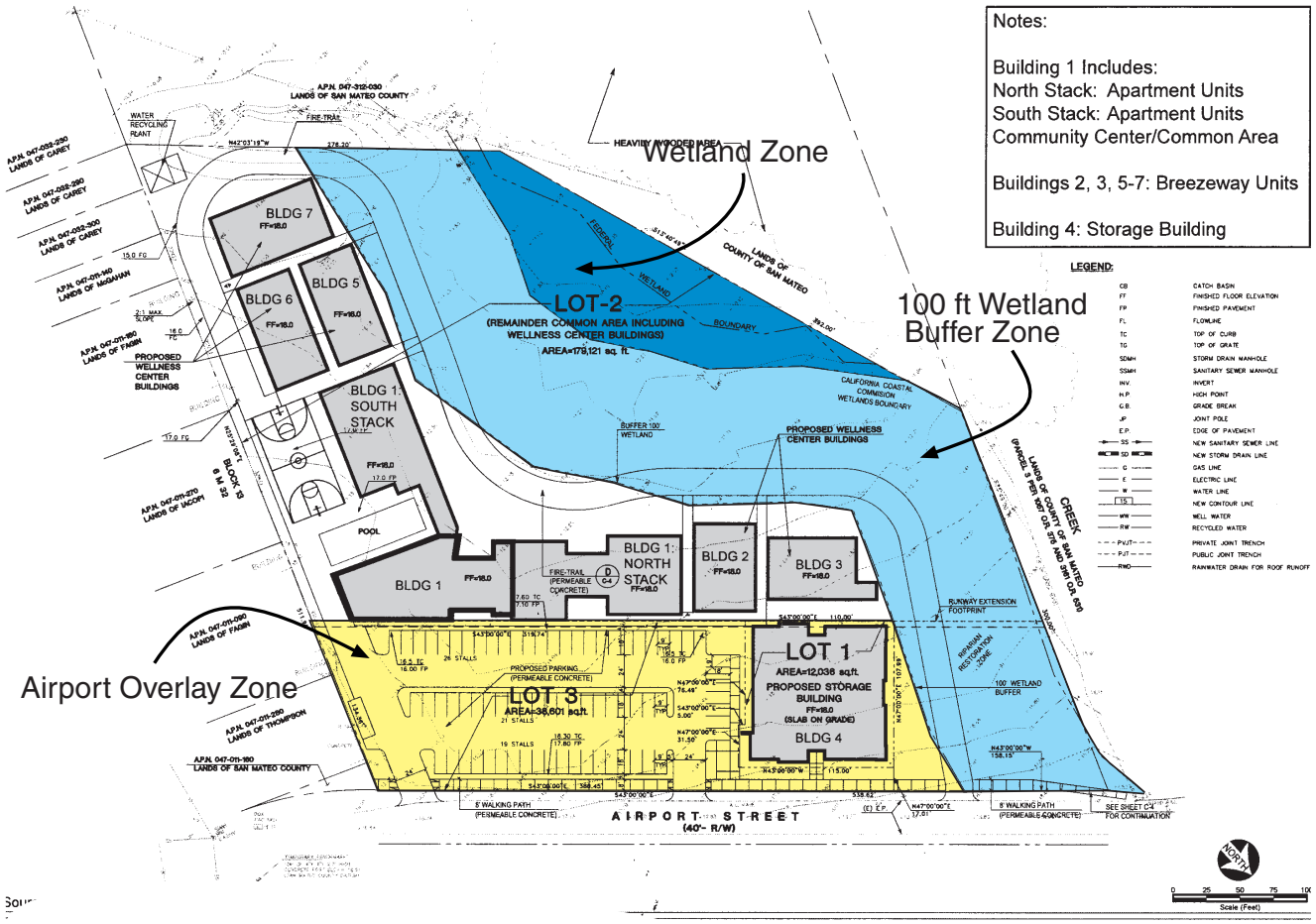
ST-1 STOREFRONT KAWNEER CLEAR ANONDIZED

GL-1 GLASS PPG IDEASCAPES SOLARGRAY

Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-14
Office Park Exterior Finishes Materials

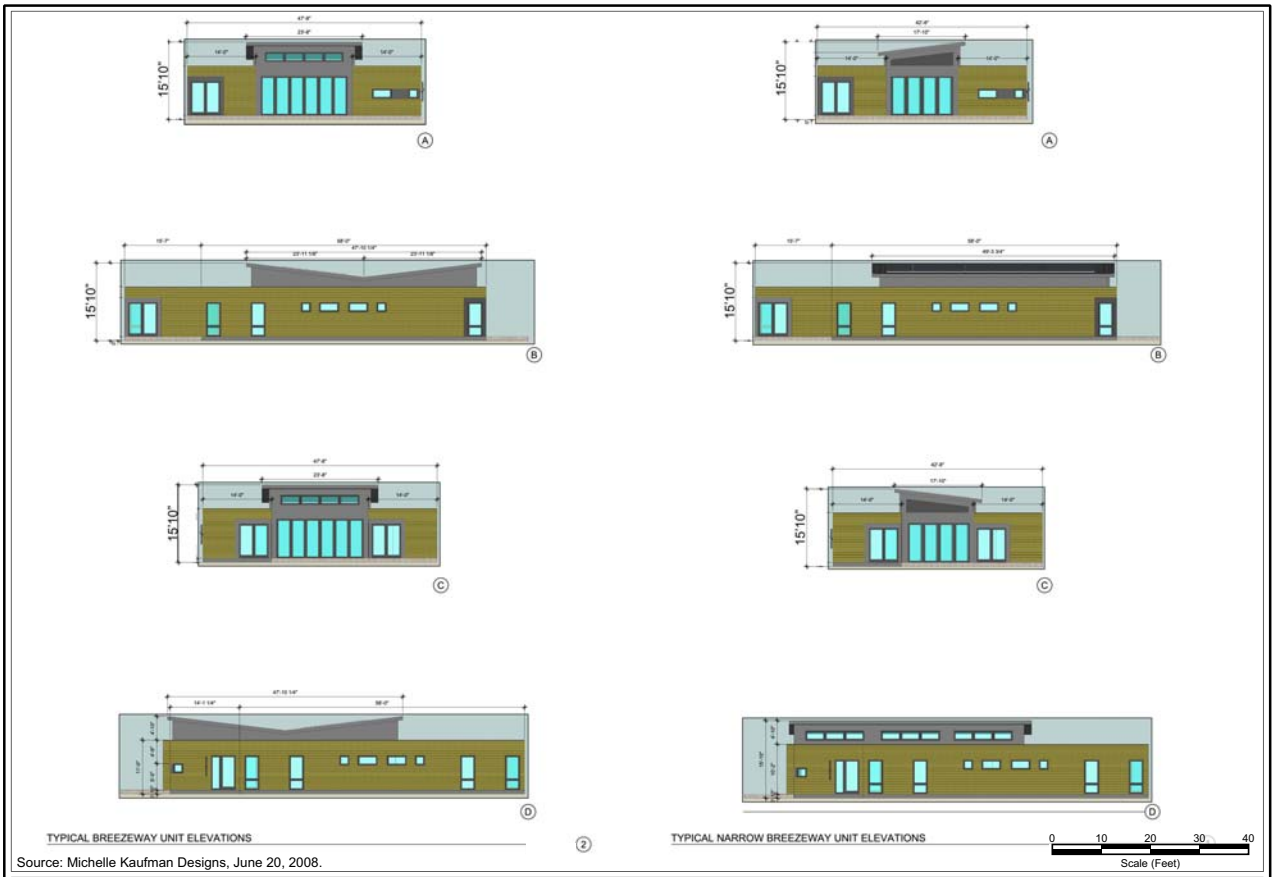




Source: Michelle Kaufman Designs, June 20, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

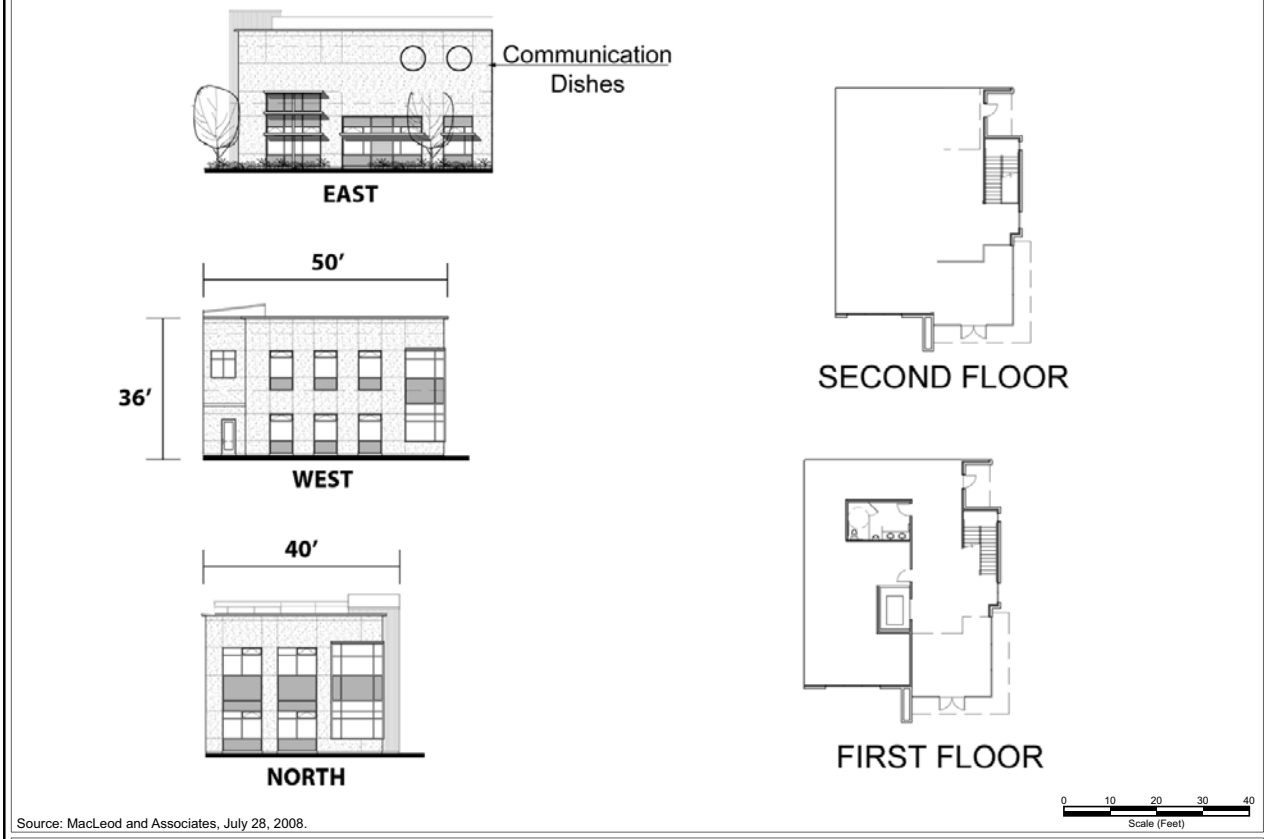
Figure III-18
Wellness Center, Building 1 (South Stack) Elevations



Source: Michelle Kaufman Designs, June 20, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-20
Wellness Center, Breezeway Units Elevations



Source: MacLeod and Associates, July 28, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-15
Office Park Property Communications Building

Required County Permits

For Entire Project:

- Major Subdivision
  - Northern parcel into 5 lots
  - Southern parcel into 3 lots
- Design Review Permit: Structures, Grading
- Grading Permit: 22,745 cy of balanced cut & fill

For Wellness Center: Use Permit for modern sanitarium

For Office Park: Off-Street Parking Exception, to allow 640 parking spaces where 735 parking spaces are required

Coastal Development Permit: Appealable to Coastal Commission

Summary of Impacts

- Aesthetics: Visual Simulations of views from Airport Street (2), West Point Avenue, the North Trail, and Highway 1
- Biological: special-status wildlife species
- Cultural Resources: Site CA-SMA-151
- Geology and Soils: Final report required
- Hazards: Proximity to HMB Airport



Source: Google Earth, Christopher A. Joseph & Associates, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-1
Photo-location Map for Simulations



View 1.A: Looking south across the project site from Airport St with immature landscaping.



View 1.B: Looking south across the project site from Airport St with mature landscaping.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-4
View 1: Post Project Views with Landscaping



View 2.A: Looking northwest across the project site from Airport St with immature landscaping.



View 2.B: Looking northwest across the project site from Airport St with mature landscaping.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-5
View 2: Post Project Views with Landscaping



View 3.A: Looking northeast towards the project site from Mavericks Parking Lot with immature landscaping.



View 3.B: Looking northeast towards the project site from Mavericks Parking Lot with mature landscaping.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-6
View 3: Post Project Views with Landscaping



View 4.A: Looking east towards the project site from North Trail with immature landscaping.



View 4.B: Looking east towards the project site from North Trail with mature landscaping.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-7
View 4: Post Project Views with Landscaping



View 5.A: Looking southwest across the airport towards the project site from Highway 1 with immature landscaping.



View 5.B: Looking southwest across the airport towards the project site from Highway 1 with mature landscaping.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-8
View 5: Post Project Views with Landscaping

Summary of Impacts

- Hydrology and Water Quality: Groundwater and Tsunami/Seiche
- Noise: Temporary construction activities occurring within 100 feet of an occupied residences
- Transportation and Traffic: Intersection of SR 1 and Cypress Avenue is shown to meet signal warrants
- Utilities and Service Systems: Potential inadequate GSD capacity

Big Wave Draft EIR Schedule

- 64-Day Public Comment Period: October 22, 2009 – December 24, 2009
- Planning Commission Meetings:
  - November 18, 2009: Informational Hearing for Draft EIR
  - February 24, 2010: Consideration of Project, Draft EIR and Final EIR

SAN MATEO COUNTY PLANNING COMMISSION

PUBLIC HEARING

MEETING NO. 1498

Wednesday, November 18, 2009
9:00 a.m.
Board of Supervisors Chambers
400 County Center, Redwood City

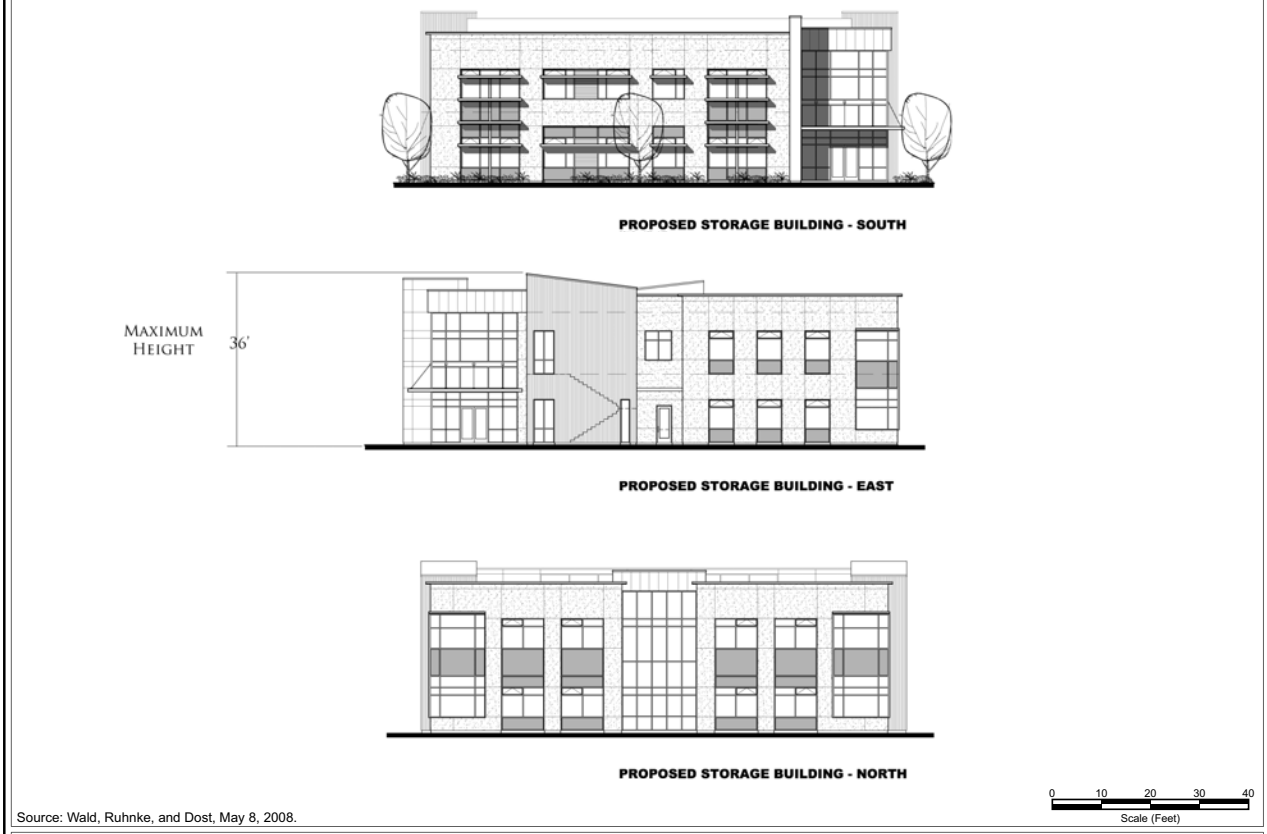
REGULAR AGENDA

Item	**9:00 a.m.**
Owner/Applicant	**Big Wave Group, LLC**
File Number	PLN2005-00481 and PLN2005-00482
Location.....	Airport Street and Stanford Avenue, Princeton
Assessor's Parcel Nos.	047-311-060, 047-312-040

pc title page.cdr

Big Wave Draft EIR Schedule (continued)

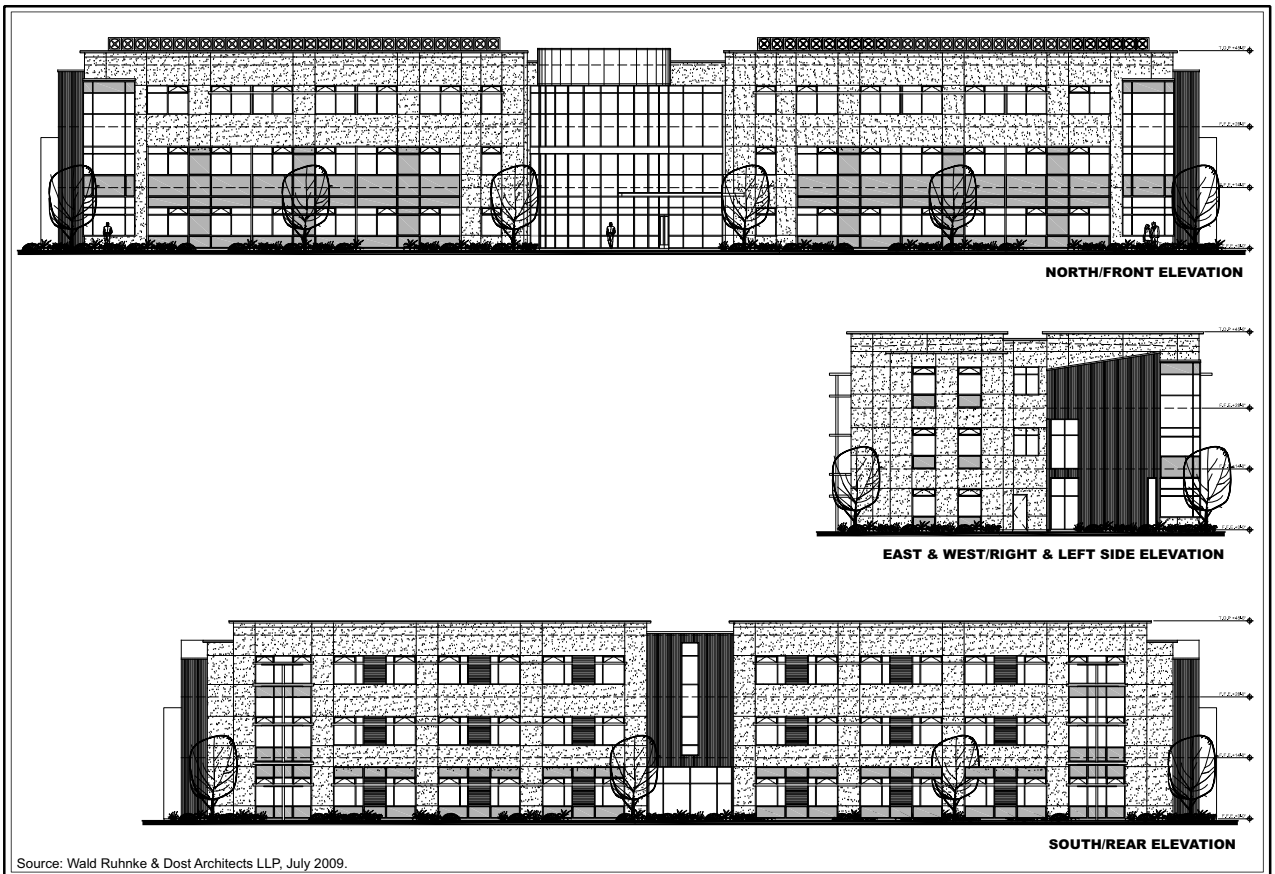
- Hearings that are <u>not</u> required:
  - <u>March 24, 2010 (PC)</u>: Follows PC hearing in case the item is continued by the Planning Commission
  - <u>April 27, 2010 (BOS)</u>: Follows PC hearing in case the item is appeals to the Board of Supervisors
  - Project is appealable to the CA Coastal Commission



Source: Wald, Ruhnke, and Dost, May 8, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

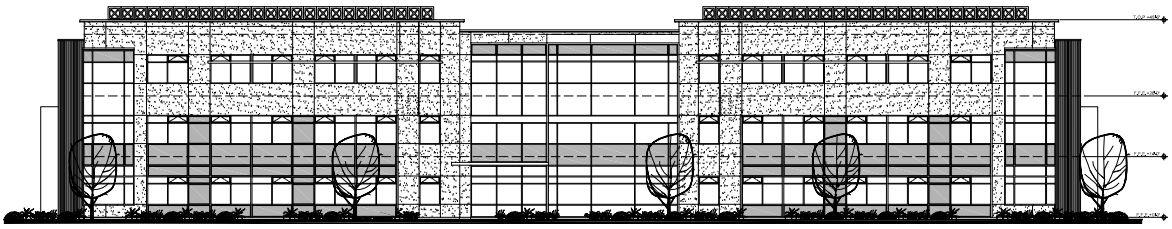
Figure III-21
Wellness Center Property, Storage Elevations



Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

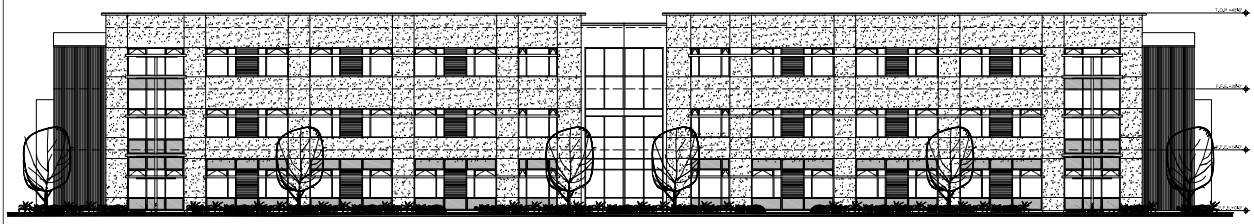
Figure III-10
Office Park Building A Elevations



NORTH/FRONT ELEVATION



EAST & WEST/RIGHT & LEFT SIDE ELEVATION

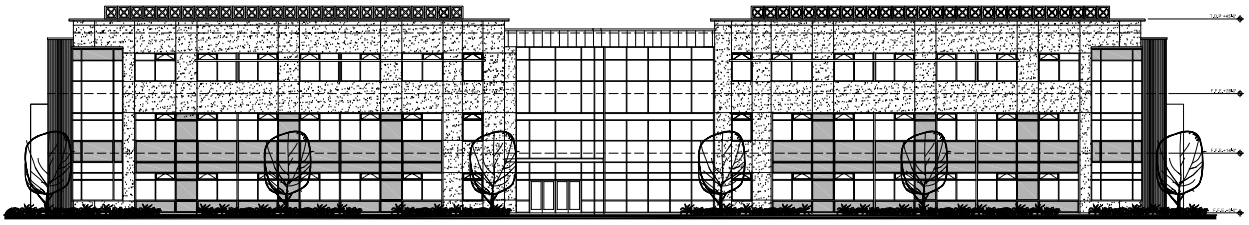


SOUTH/REAR ELEVATION

Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-11
Office Park Building B Elevations



NORTH/FRONT ELEVATION



EAST & WEST/RIGHT & LEFT SIDE ELEVATION

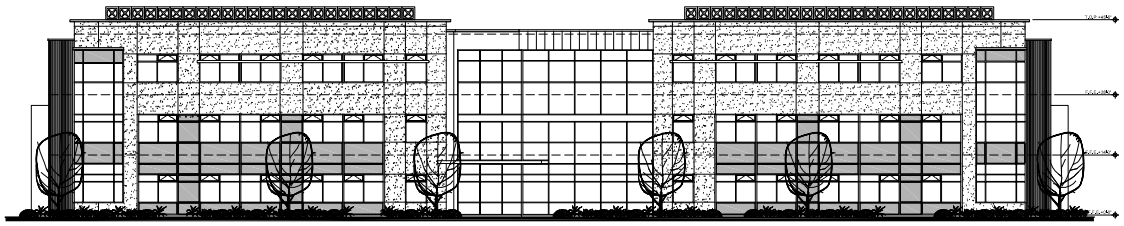


SOUTH/REAR ELEVATION

Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

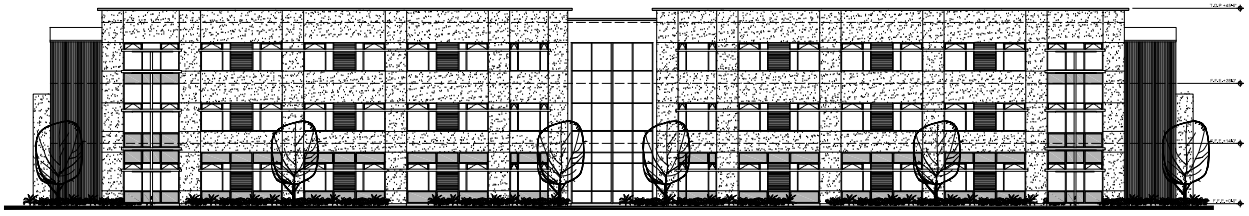
Figure III-12
Office Park Building C Elevations



NORTH/FRONT ELEVATION



EAST & WEST/RIGHT & LEFT SIDE ELEVATION



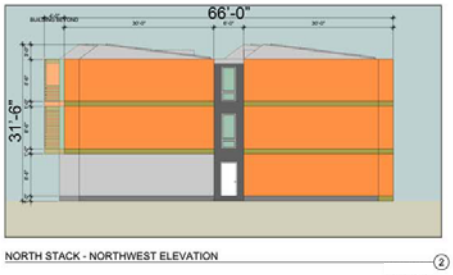
SOUTH/REAR ELEVATION

Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-13
Office Park Building D Elevations







0 8 16 24 32
Scale (Feet)

Source: Michelle Kaufman Designs, June 20, 2008.

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Environmental Planning and Research

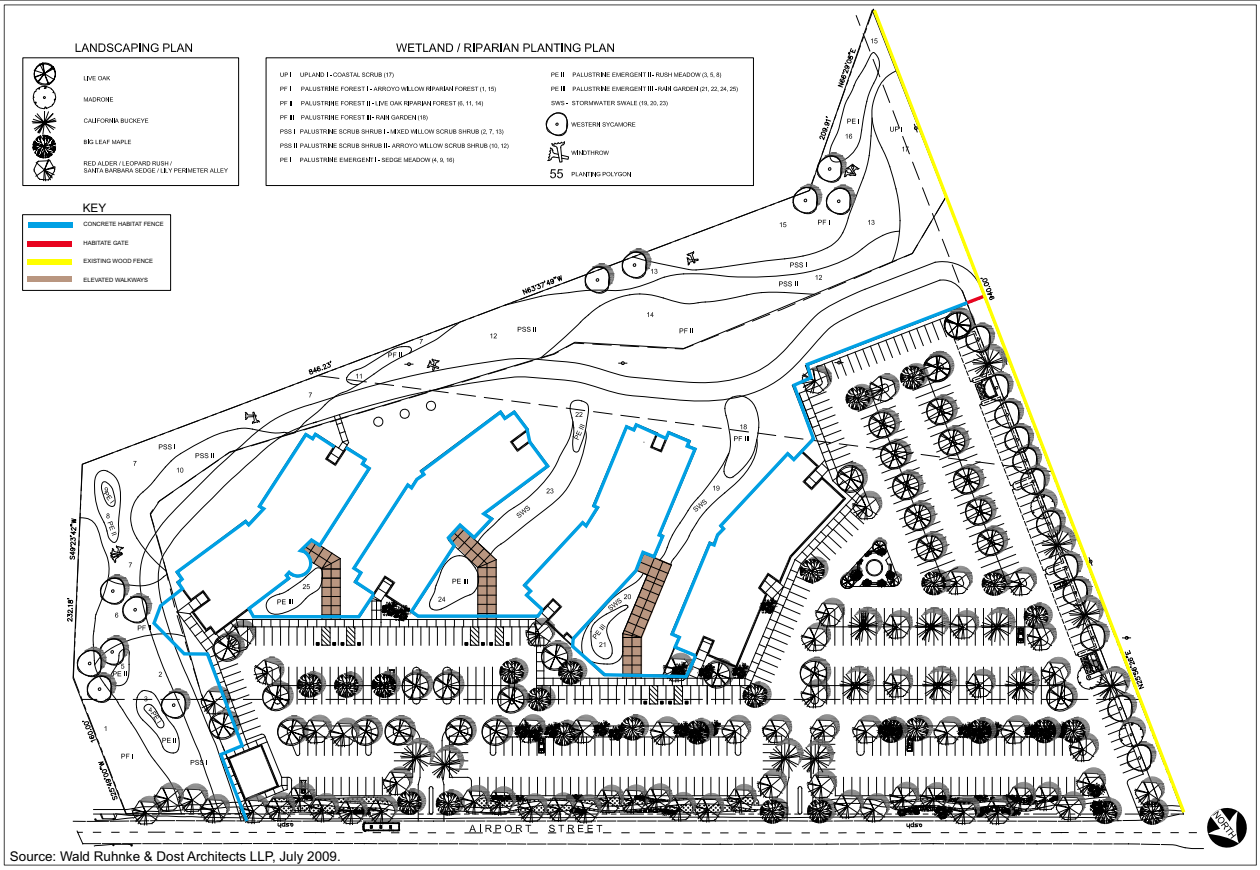
Figure III-17
Wellness Center, Building 1 (North Stack) Elevations



Source: Michelle Kaufman Designs, June 20, 2008.

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Environmental Planning and Research

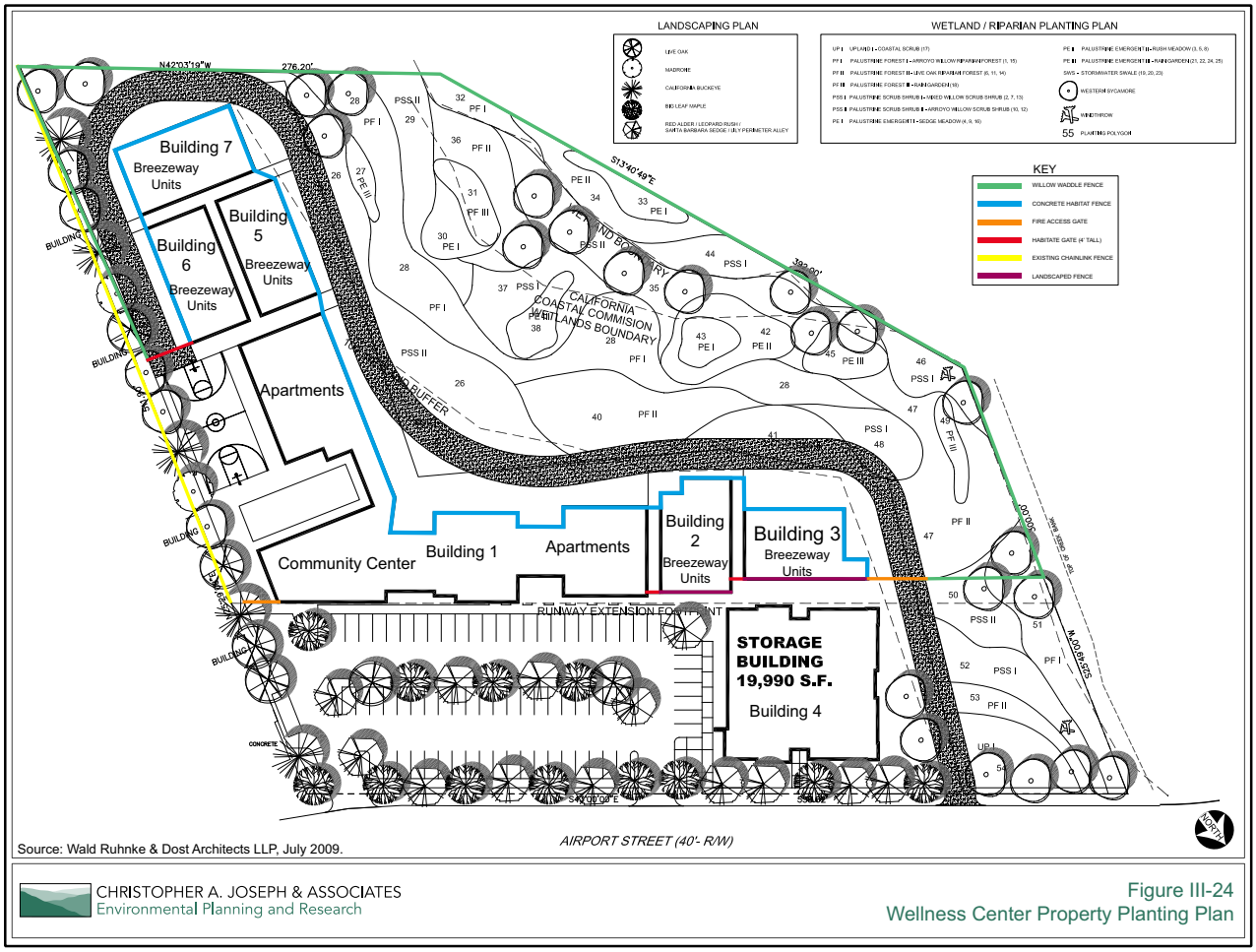
Figure III-19
Wellness Center, Building 1
(Community Center/Common Area) Elevations



Source: Wald Ruhnke & Dost Architects LLP, July 2009.

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Environmental Planning and Research

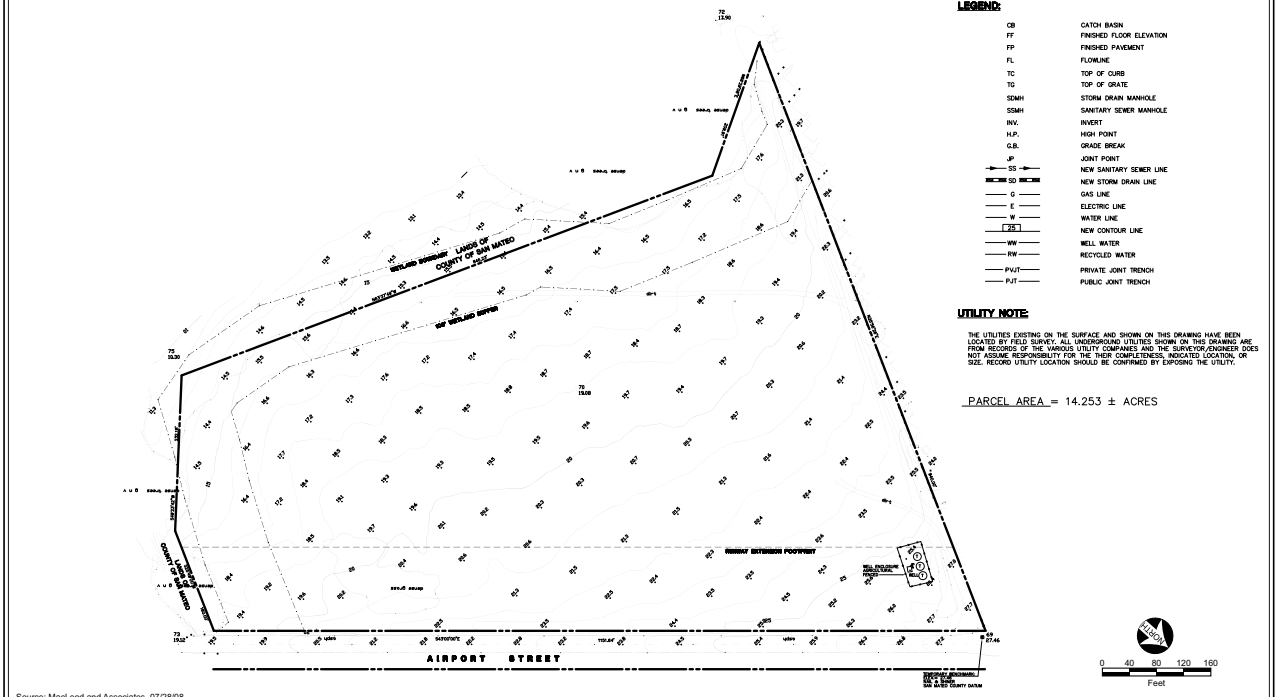
Figure III-23
Office Park Property Planting Plan



Source: Wald Ruhnke & Dost Architects LLP, July 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

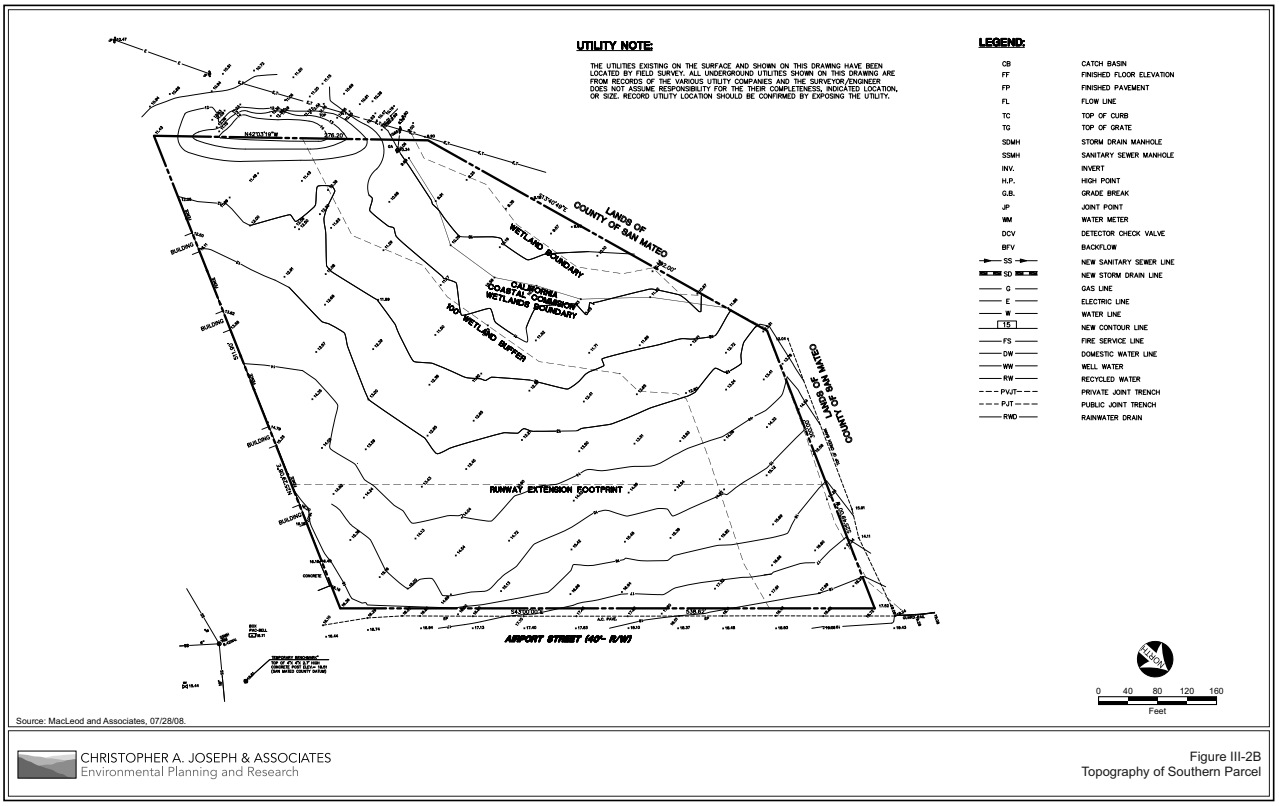
Figure III-24
Wellness Center Property Planting Plan



Source: MacLeod and Associates, 07/28/08.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-2A
Topography of Northern Parcel



Source: MacLeod and Associates, 07/28/08.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-2B
Topography of Southern Parcel



Source: Google Earth Pro, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-3
Aerial Photograph of the Project Site



Source: Google Earth Pro, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure III-4
Aerial Photograph of the
Project Site and Surrounding Area



View 1: Looking south across the project site from Airport Street.

View 2: Looking west across the project site from the intersection of Airport Street and Cornell Avenue.





View 3: Looking northeast towards the project site from Mavericks Parking Lot.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-2
Views of the Project Site
Views 1-3



View 4: Looking southeast across the project site from North Trail.



View 5.: Looking southwest across the airport towards the project site from Highway 1.

Source: Christopher A. Joseph & Associates, 2009.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.A-3
Views of the Project Site
Views 4-5



Source: HJW GeoSpatial, Inc., MacLeod and Associates and Christopher A. Joseph & Associates, May 2007; WSP, March 17, 2008.

CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure IV.D-1
Vegetation Communities Map

Public Noticing

Draft EIR:

- News Ads in Half Moon Bay Review and san Mateo County Times
- All owners of the Pillar Ridge Mobile Home Park
- Interested Parties
- Responsible Agencies

PC Hearing (in addition to above):

- Owners of Property within 300-feet




LANDSCAPING PLAN
LIVE OAK
MADRONE
CALIFORNIA BUCKEYE
BIG LEAF MAPLE
RED ALDER / LEOPARD RUSH / SANTA BARBARA SEDGE / LILY PERIMETER ALLEY
WETLAND / RIPARIAN PLANTING PLAN
UP I UPLAND - - COASTAL SCRUB (17)
PF I PALUSTRINE FOREST I - ARROYO WILLOW RIPARIAN FOREST (1, 15)
PF II PALUSTRINE FOREST II - LIVE OAK RIPARIAN FOREST (6, 11, 14)
PF III PALUSTRINE FOREST III - RAIN GARDEN (18)
PSS I PALUSTRINE SCRUB SHRUB I - MIXED WILLOW SCRUB SHRUB (2, 7, 13)
PSS II PALUSTRINE SCRUB SHRUB II - ARROYO WILLOW SCRUB SHRUB (10, 12)
PE I PALUSTRINE EMERGENT I - SEDGE MEADOW (4, 9, 16)
PE II PALUSTRINE EMERGENT II - RUSH MEADOW (3, 5, 8)
PE III PALUSTRINE EMERGENT III - RAIN GARDEN (21, 22, 24, 25)
SWS - STORMWATER SWALE (19, 20, 23)
WESTERN SYCAMORE
WINDTHROW
55 PLANTING POLYGON
KEY
WILLOW WADDLE FENCE
CONCRETE HABITAT FENCE
FIRE ACCESS GATE
HABITATE GATE (4' TALL)
EXISTING CHAINLINK FENCE
LANDSCAPED FENCE
N42°0'19"W
276.20'
S13°40'49"E
WETLAND BOUNDARY
CALIFORNIA COASTAL COMMISION WETLANDS BOUNDARY
100' WETLAND BUFFER
Building 7
Breezeway Units
Building 6
Breezeway Units
Building 5
Breezeway Units
Apartments
Community Center
Building 1
Apartments
Building 2
Breezeway Units
Building 3
Breezeway Units
RUNWAY EXTENSION EQUIPMENT
STORAGE BUILDING 19,990 S.F.
Building 4
BUILDING
CONCRETE
N-00°04'25"E
NORTH

Planning Commission Hearing

Wednesday, Nov. 18th 2009

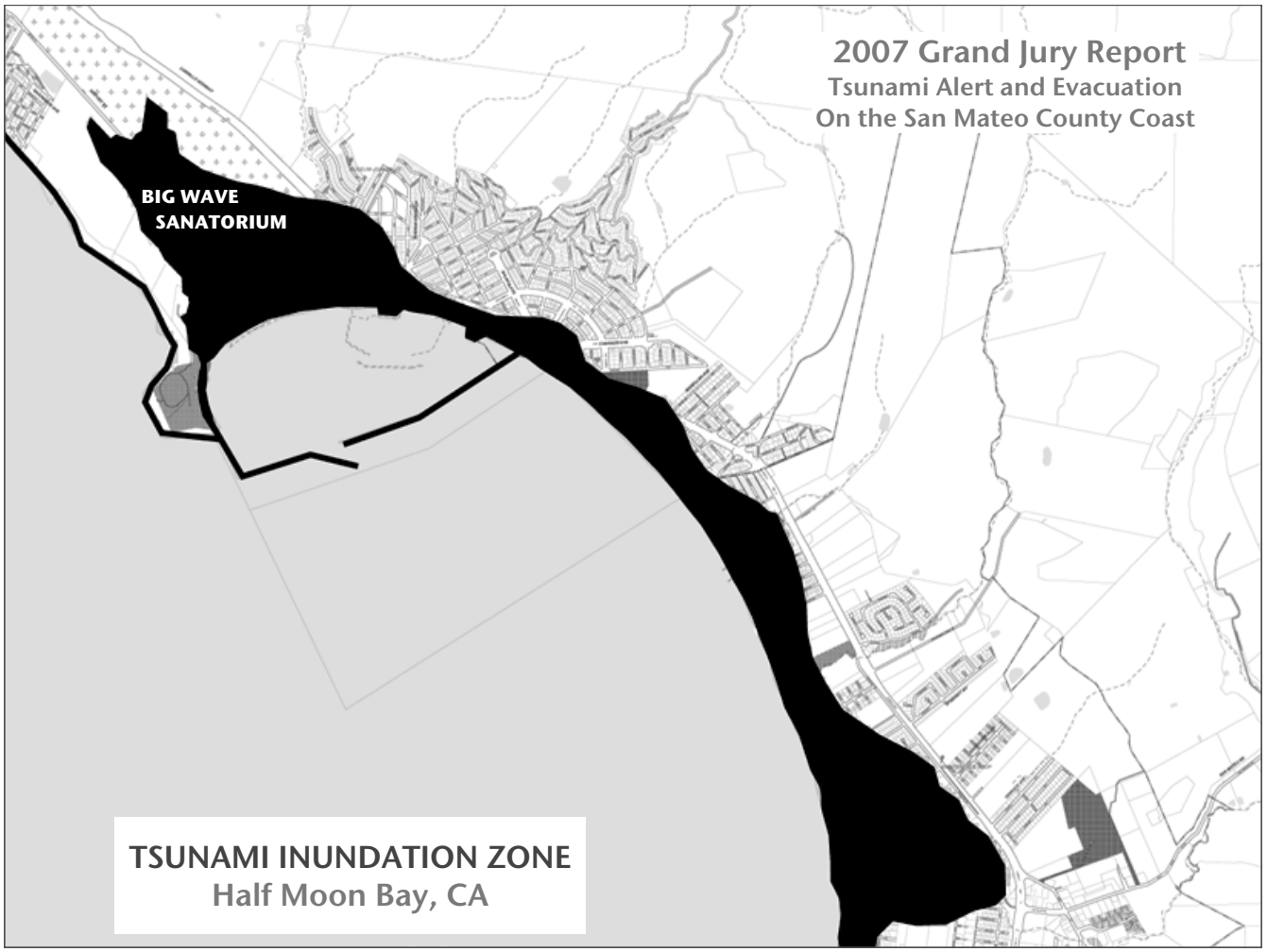
Board of Supervisors Chambers 400 County Center, Redwood City



"The proximity of the project to the partially enclosed **Pillar Point Harbor** and the potential for **tsunami** events could expose people to inundation by **seiche**, which represents a potentially significant impact."

Big Wave Project DEIR
IV.H Hydrology & Water Quality
Page IV.H-61


Rancho Corral de Tierra
POST
Pillar Point Bluff
POST
OFFICE PARK
SANATORIUM
FMR
Is the Big Wave Project
prepared for a BIG WAVE?


2007 Grand Jury Report
Tsunami Alert and Evacuation
On the San Mateo County Coast
BIG WAVE
SANATORIUM
TSUNAMI INUNDATION ZONE
Half Moon Bay, CA



A seiche (pronounced /'seɪʃ/ "saysh") is a standing wave in an enclosed or partially enclosed body of water.

Hilo Bay Seiche

April 1st 1946

The tsunami that hit Hawaii in 1946 had a fifteen-minute interval between wave fronts. The natural resonant period of Hilo Bay is about thirty minutes. That meant that every second wave was in phase with the motion of Hilo Bay, creating a seiche in the bay.

As a result, Hilo suffered worse damage than any other place in Hawaii, with the tsunami/seiche reaching a height of 26 feet along the Hilo Bayfront, **killing 96 people** in the city alone. Seiche waves may continue for several days after a tsunami.

In 1946 a Tsunami hit Princeton By-The-Sea



April 1, 1946
Tsunami Debris

Water Resources Center Archives: Robert L. Wiegel

Half Moon Bay 4-1-46 (About 10:30 A.M.) Photos by Howard Anderson. Miscellaneous pictures of tidal wave receding.

Half Moon Bay 4-1-46 (About 10:30 A.M.) Photos by Howard Anderson. Miscellaneous pictures of tidal wave receding.



April 1, 1946
Princeton By-The-Sea

Water Resources Center Archives: Robert L. Wiegel



Romeo Pier: April 1, 1946

Water Resources Center Archives: Robert L. Wiegel

Half Moon Bay 4-1-46 (About 10:30 A.M.) Photo by Howard Anderson. Coast Guard pier and Romeo Fish Company. Tidal wave receeding, highest level of water lifted boat in davits (at end of pier) and came to deck stringers. Highest tide reached 14.8 stage.

11623 B elow: April 2, 1946, tide at 3.7 stage showing normal appearance of pier. Water came level with porch deck of Coast Guard shack at left.



Water Resources Center Archives: Robert L. Wiegel

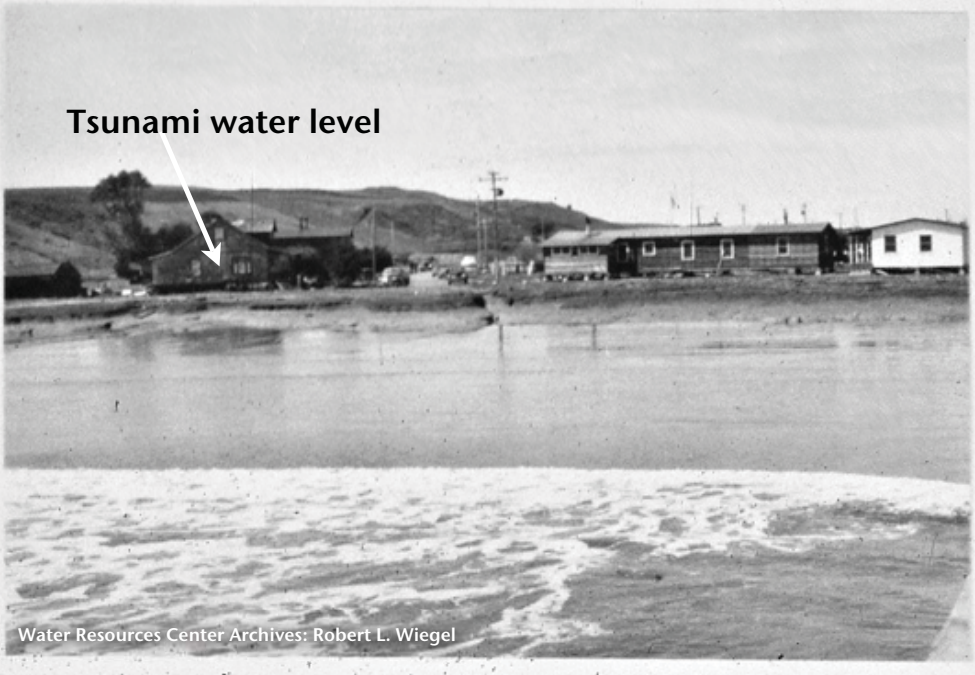
Romeo Pier: April 2, 1946 (day after the Tsunami)

April 1, 1946
Princeton By-The-Sea



Half Moon Bay 4-1-46 About 10:30 A.M. Photo by Howard Anderson. Tidal Wave receding, level of water is said to have come to the window sills of the house. (Tide of 14.8)

11624 Below: April 2 , 1946 Tide at 3.7 stage. Same scene from end of pier. Coast Guard shack at right center. Beach was formerly fine sand; is now denuded leaving hard clay base.



April 2, 1946 (day after the Tsunami)

"Structures should either be placed at elevations above those likely to be adversely affected during a **tsunami or seiche event** or be designed to allow swift water to flow around, through, or underneath without causing collapse."

Big Wave Project DEIR
IV.H Hydrology & Water Quality
Page IV.H-61

ABAG tsunami maps show that the project would place residential and commercial structures within a mapped tsunami zone.

This would represent a **significant risk** to human life.



NORTH STACK - SOUTHWEST ELEVATION

3

Wellness Center, Building 1

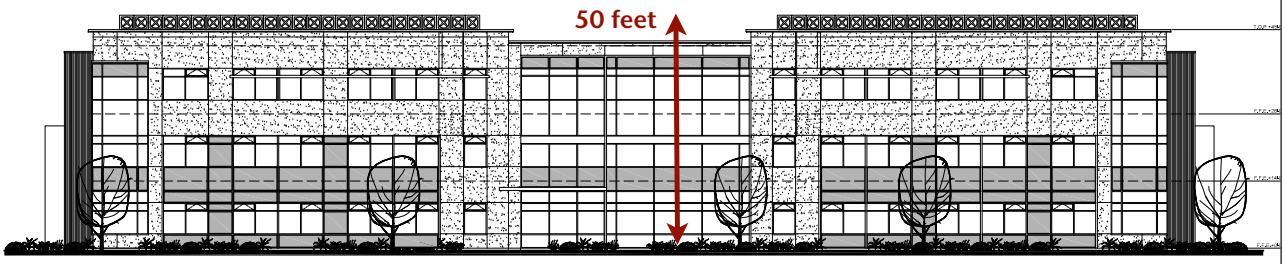
SANATORIUM

Emergency Evacuation

Would you want to be trapped with swirling water and debris all around you?

Would you want to be desperately trying to escape a natural disaster with traffic from the office park choking your exit?

How do special needs people get the necessary evacuation help needed?



NORTH/FRONT ELEVATION

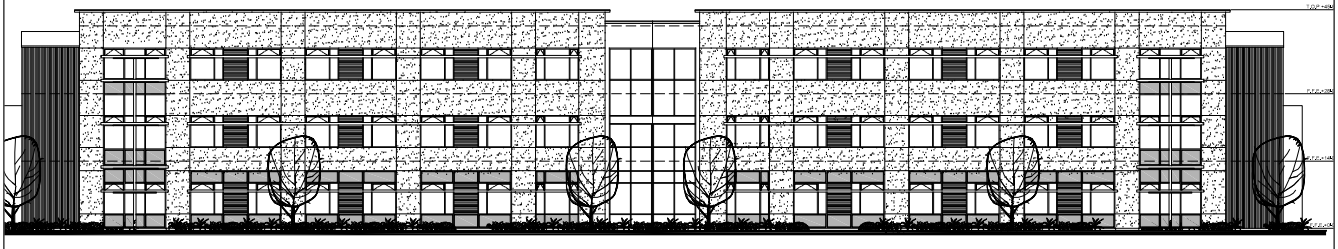
ABAG tsunami maps show that the project would place residential and commercial structures within a mapped tsunami zone.



EAST & WEST/RIGHT & LEFT SIDE ELEVATION

This would represent a **significant risk** to human life.

OFFICE PARK



SOUTH/REAR ELEVATION

ce: Wald Ruhnke & Dost Architects LLP, July 2009.

Grand Jury Report

The San Gregorio fault, just off the San Mateo County Coast, has the potential of causing a tsunami with essentially

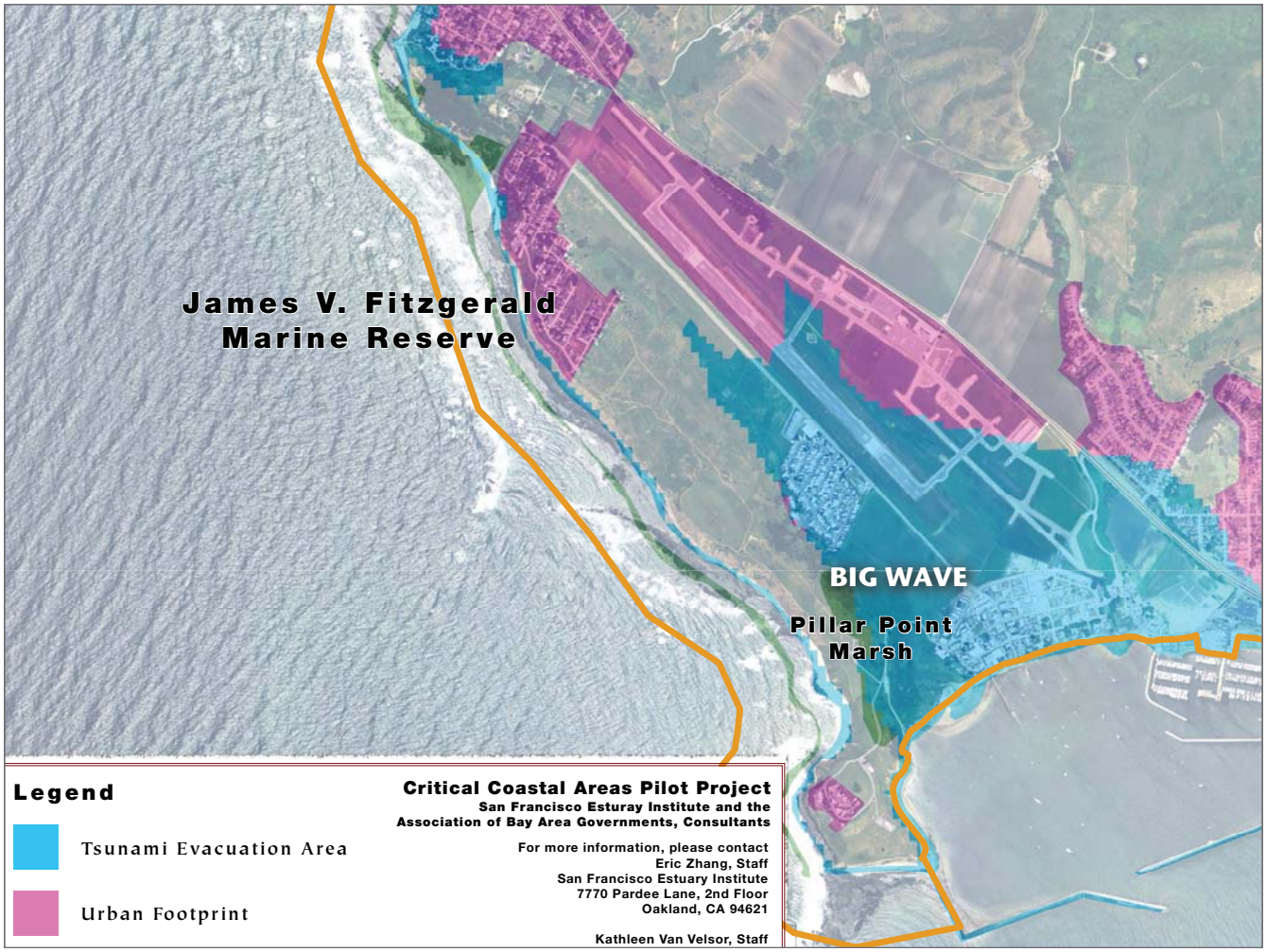
no warning time.

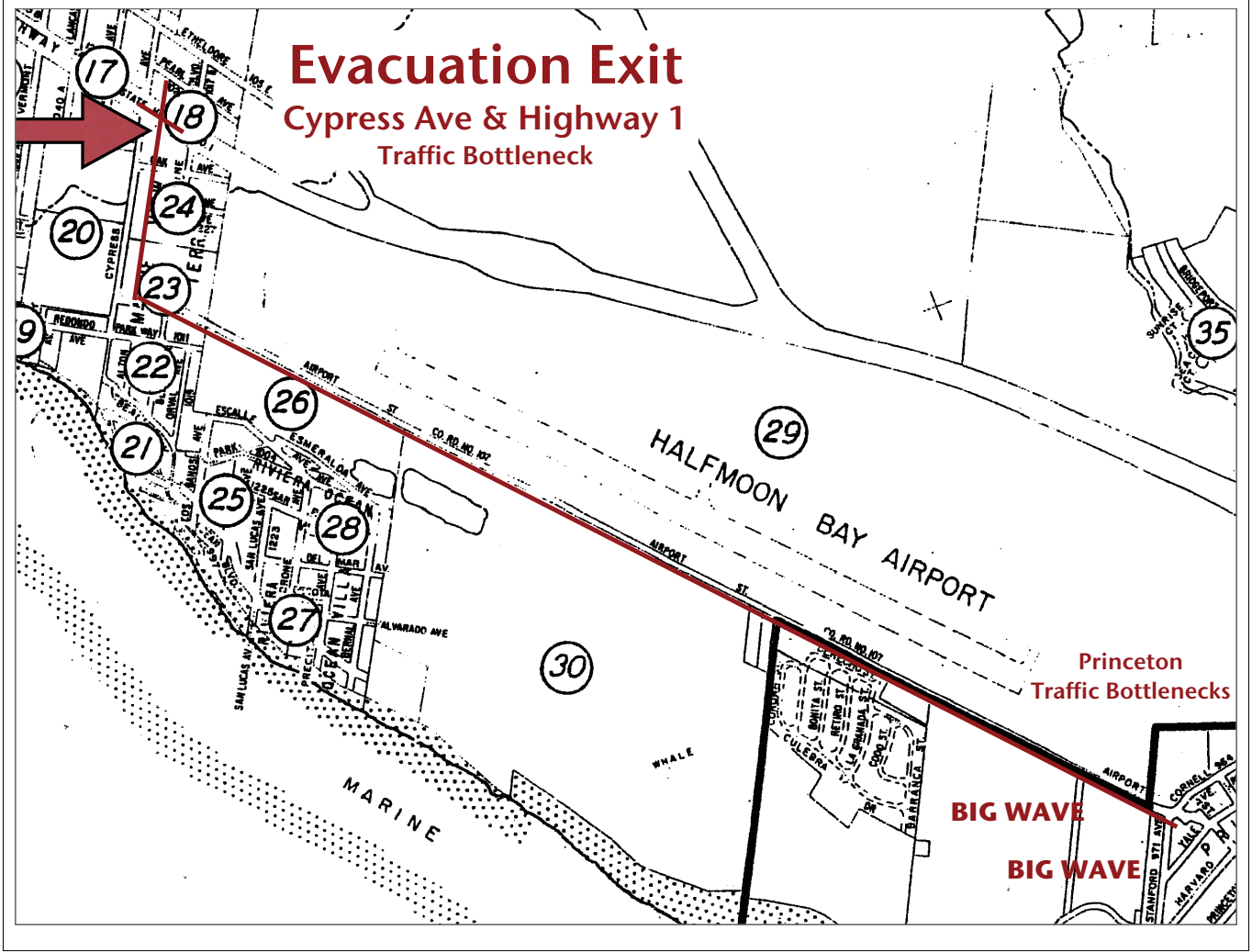
The San Mateo County Office of Emergency Services (OES) advises that members of the public who are in low-lying areas immediately head for high ground when an earthquake occurs.

Grand Jury Report: 2007
Tsunami Alert and Evacuation
San Mateo County Coast

Princeton, Pillar Ridge & Seal Cove only have ONE Tsunami Evacuation Exit

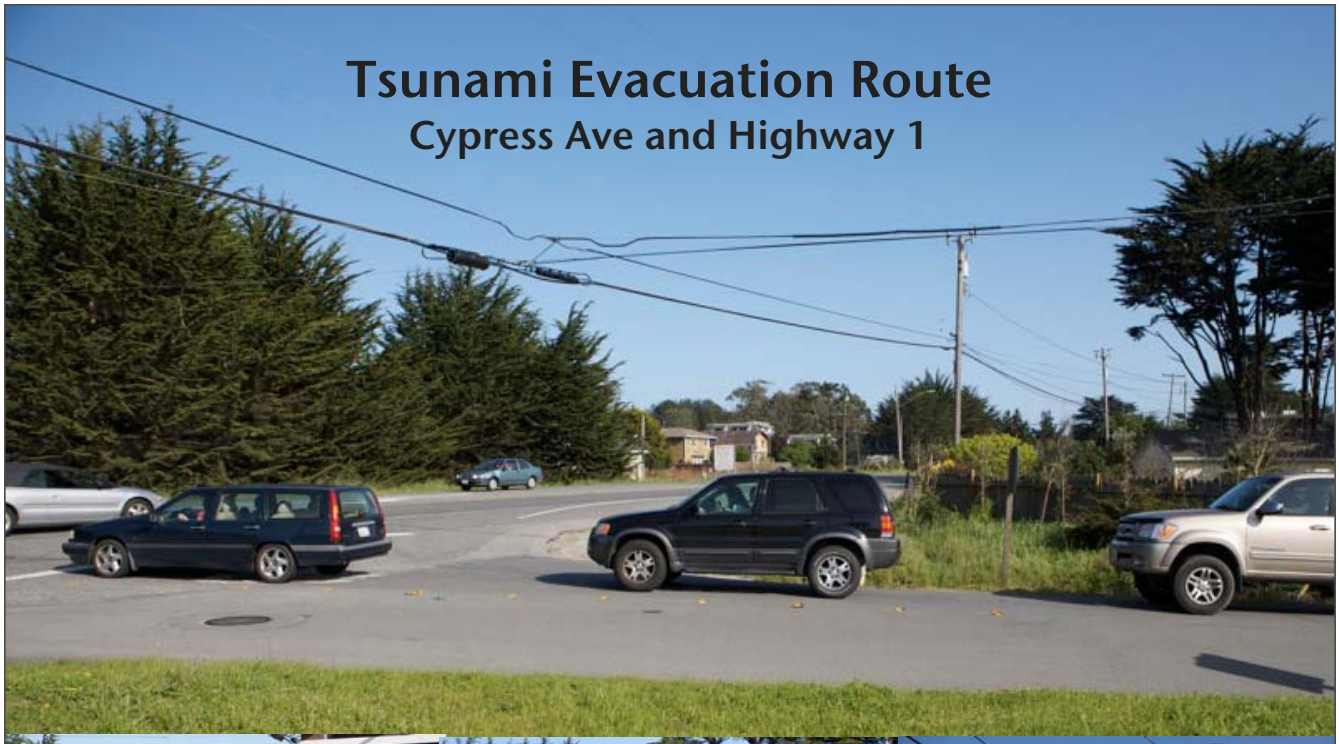



James V. Fitzgerald
Marine Reserve
BIG WAVE
Pillar Point
Marsh
Legend
Tsunami Evacuation Area
Urban Footprint
Critical Coastal Areas Pilot Project
San Francisco Esturay Institute and the
Association of Bay Area Governments, Consultants
For more information, please contact
Eric Zhang, Staff
San Francisco Estuary Institute
7770 Pardee Lane, 2nd Floor
Oakland, CA 94621
Kathleen Van Velsor, Staff


Evacuation Exit
Cypress Ave & Highway 1
Traffic Bottleneck
HALFMOON BAY AIRPORT
Princeton
Traffic Bottlenecks
BIG WAVE
BIG WAVE
MARINE
WHALE
AIRPORT ST
CO. RD. NO. 107
ALVARADO AVE
CYPRESS
ESCALLE
SUNRISE ST

Tsunami Evacuation Route

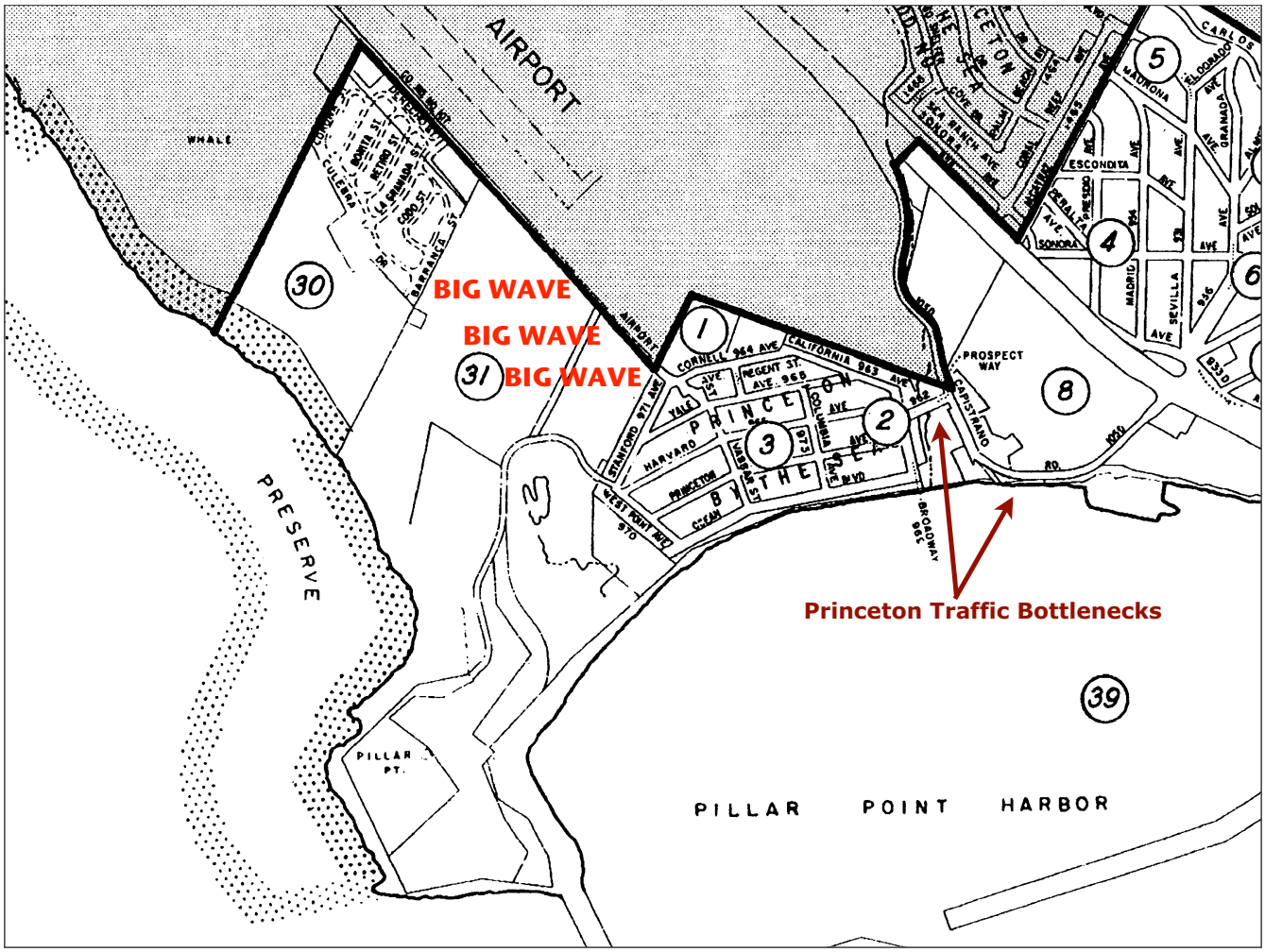
Cypress Ave and Highway 1







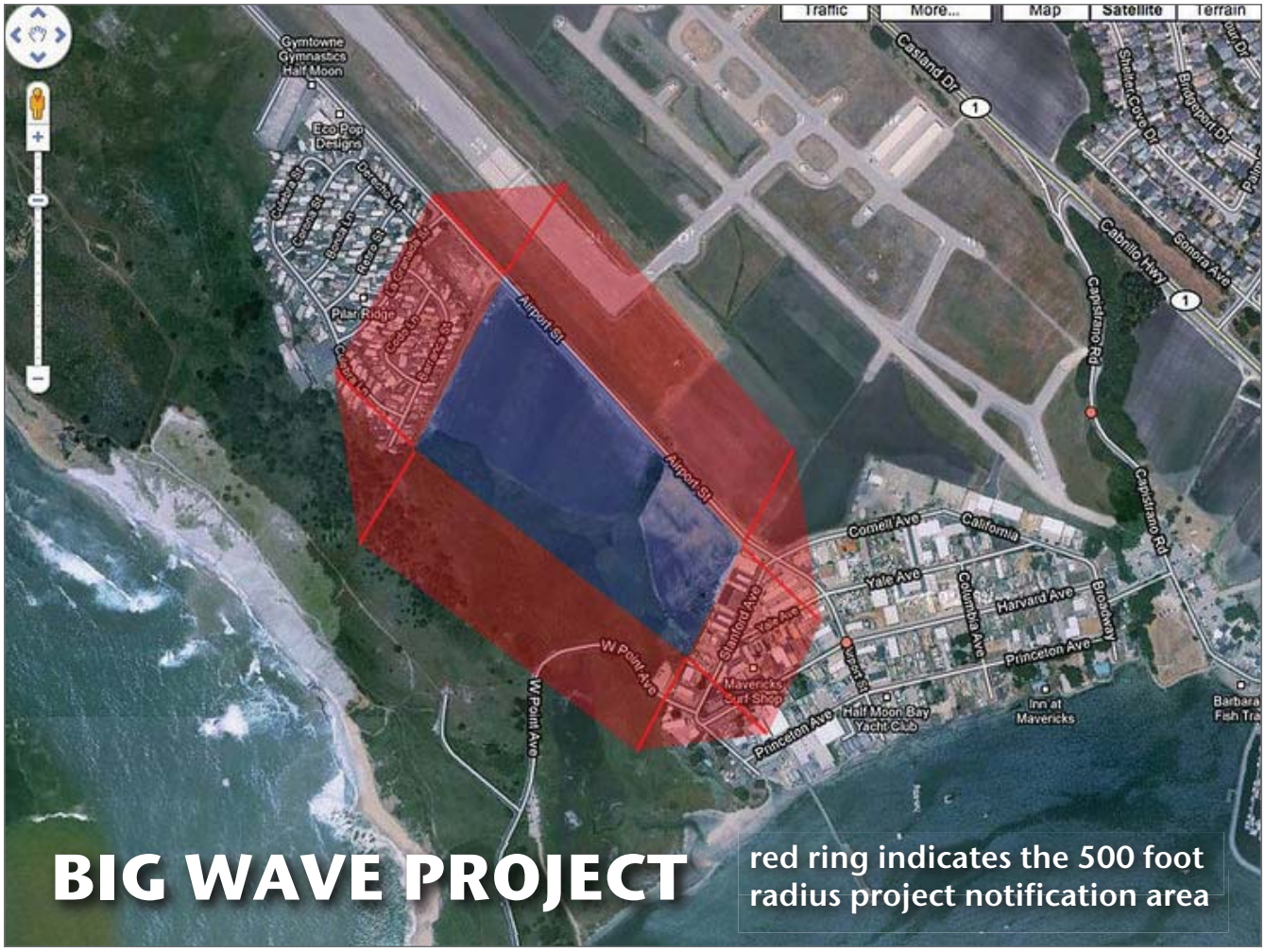






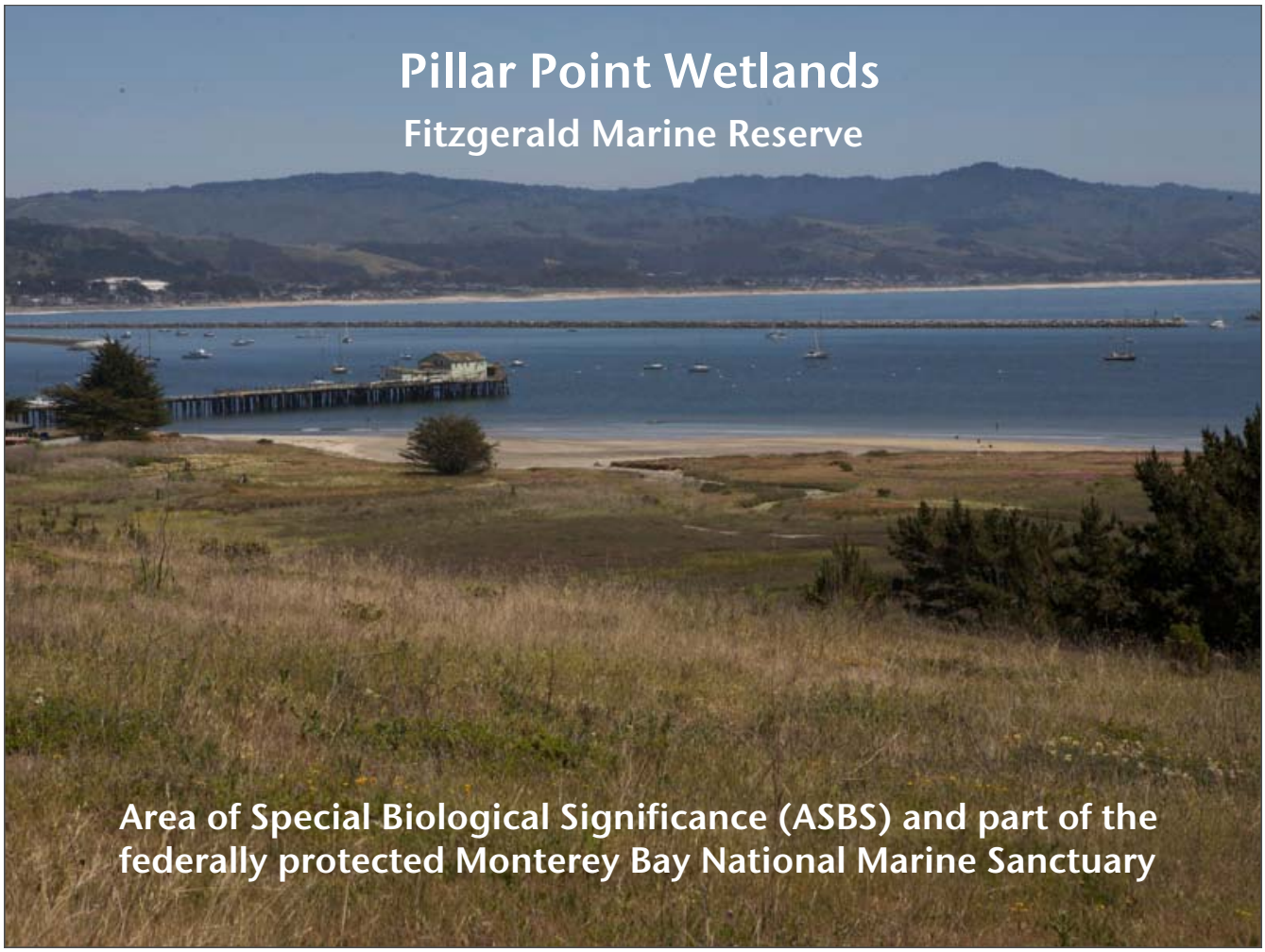


Why did the County decide this project only required a 500 foot notification area?



Why are the developers refusing to put up story poles during the CEQA public comment period?


Fitzgerald Marine Reserve
Pillar Point Wetlands
OFFICE PARK


Pillar Point Wetlands
Fitzgerald Marine Reserve
Area of Special Biological Significance (ASBS) and part of the federally protected Monterey Bay National Marine Sanctuary

James Fitzgerald Marine Reserve

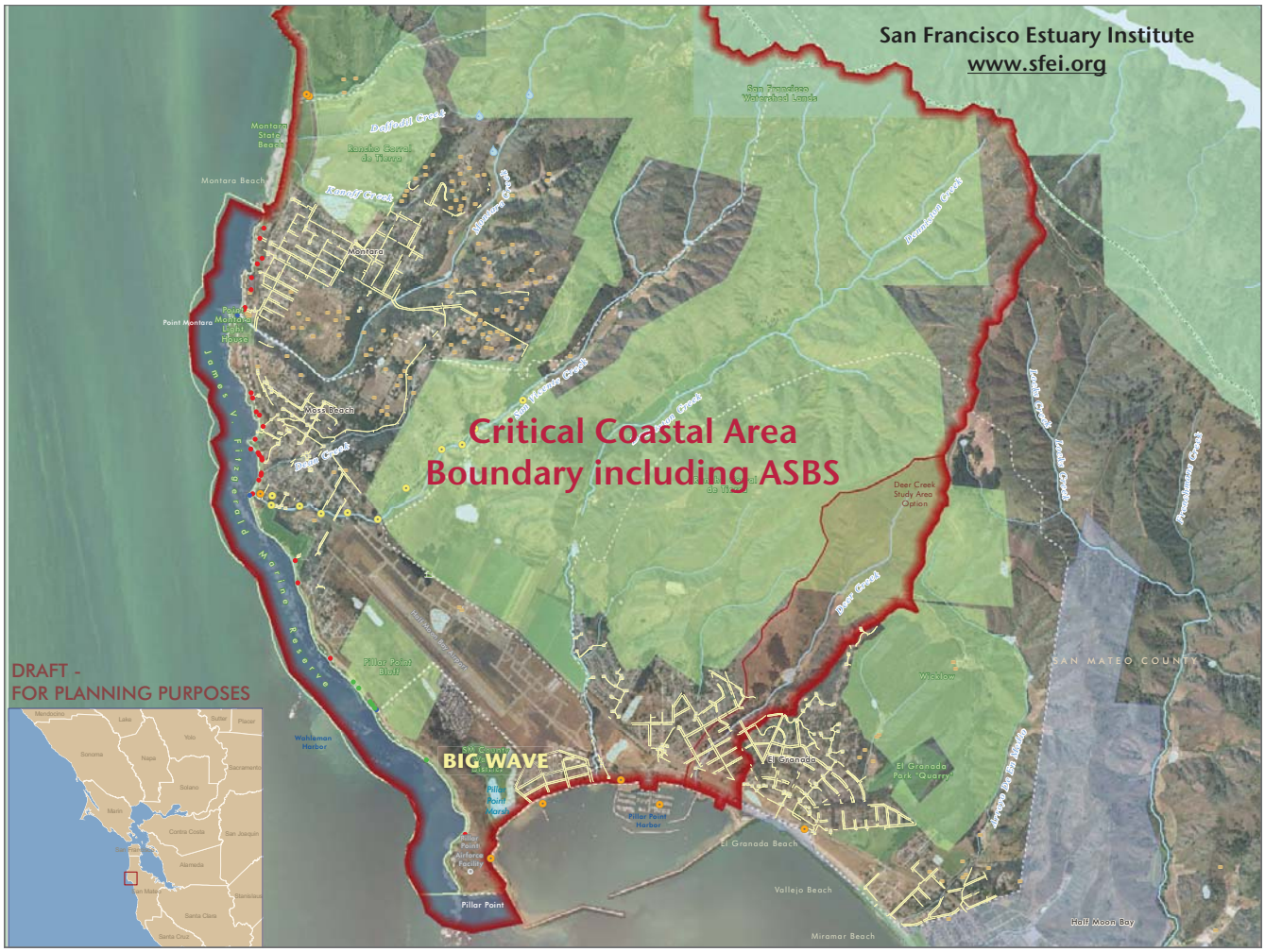
Critical Coastal Area

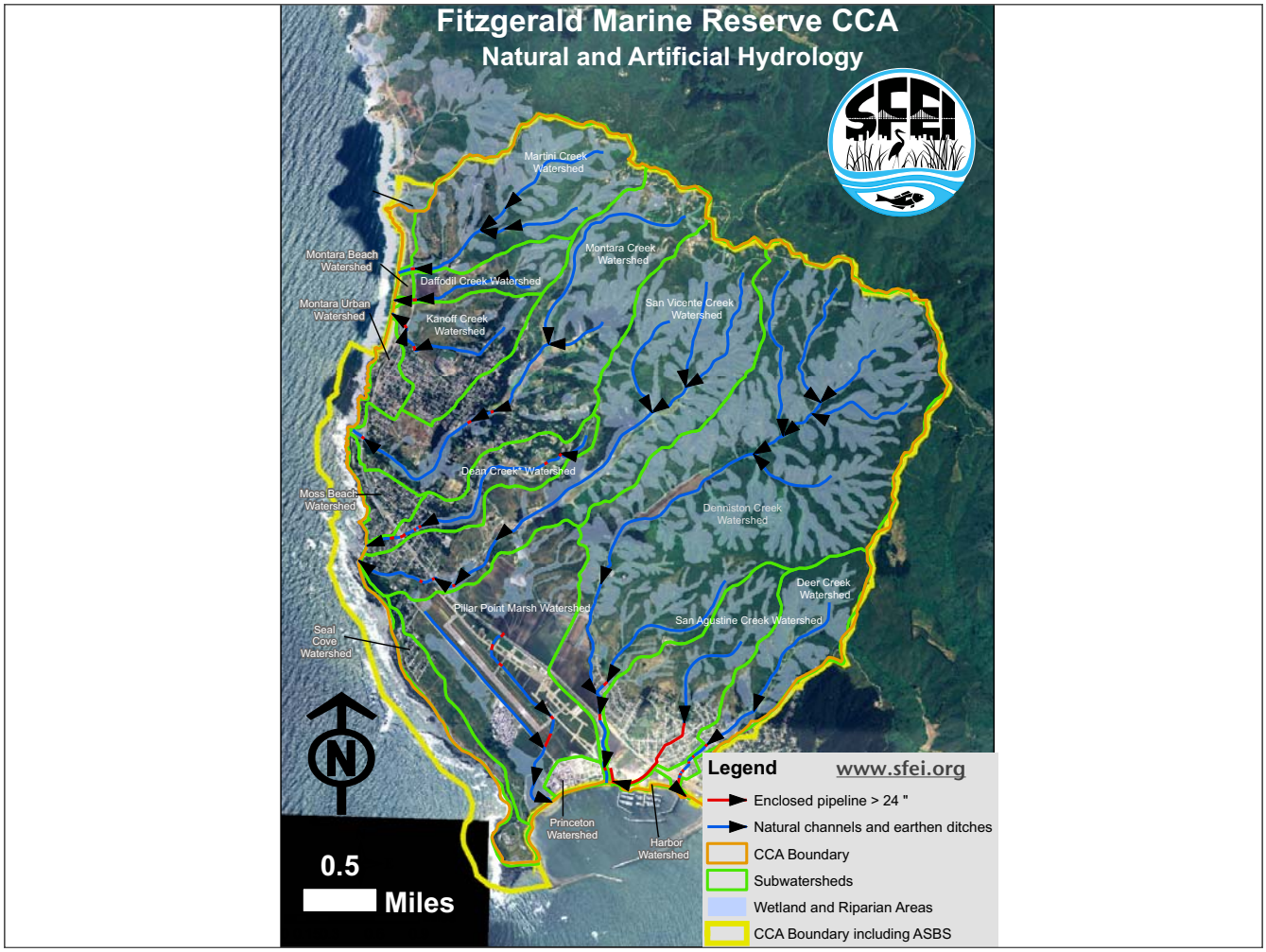
State of California

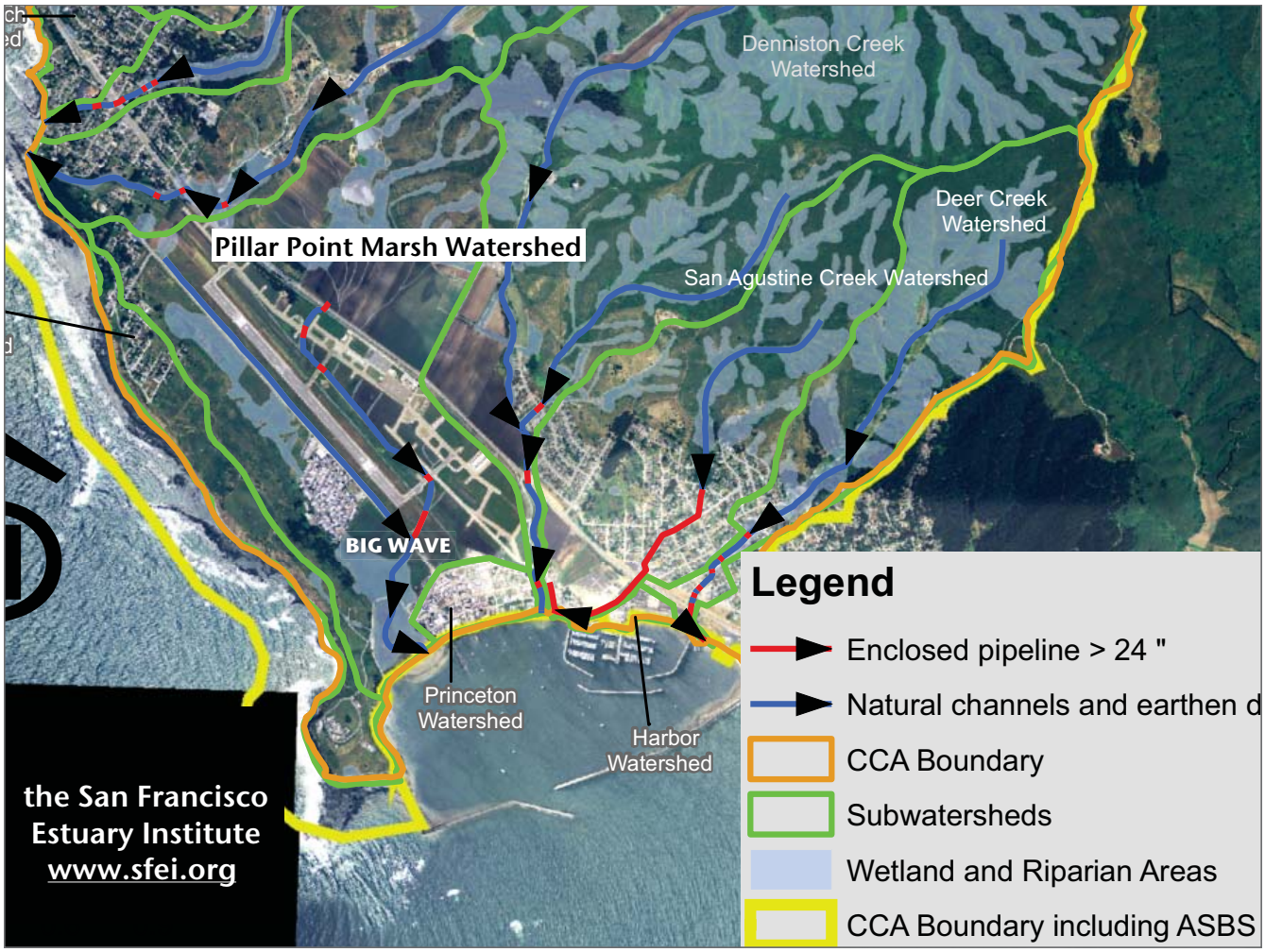
Area of Special Biological Significance (ASBS)

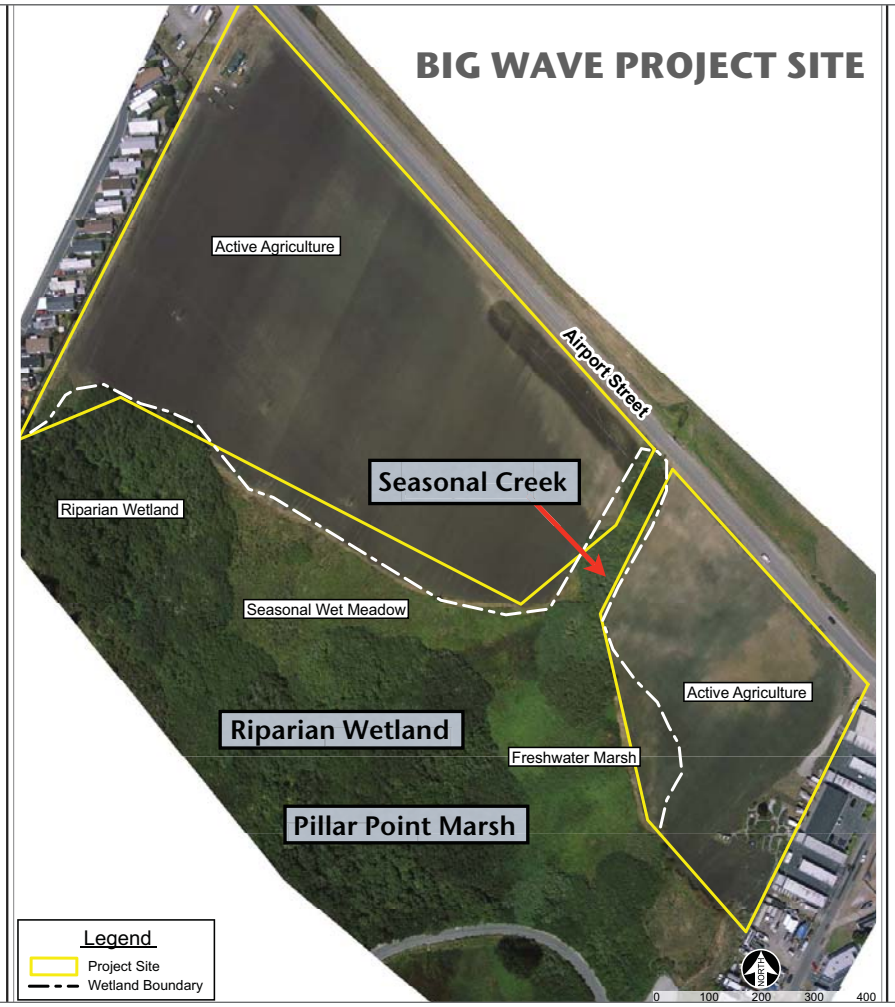
part of the federally protected

Monterey Bay National Marine Sanctuary




Fitzgerald Marine Reserve CCA
Natural and Artificial Hydrology
SFEI
Martini Creek Watershed
Montara Beach Watershed
Montara Creek Watershed
Daffodil Creek Watershed
Montara Urban Watershed
Kanoff Creek Watershed
San Vicente Creek Watershed
Deer Creek Watershed
Moss Beach Watershed
Denniston Creek Watershed
Deer Creek Watershed
Pillar Point Marsh Watershed
San Agustine Creek Watershed
Seal Cove Watershed
N
0.5
Miles
Princeton Watershed
Harbor Watershed
Legend
www.sfei.org
Enclosed pipeline > 24 "
Natural channels and earthen ditches
CCA Boundary
Subwatersheds
Wetland and Riparian Areas
CCA Boundary including ASBS


Denniston Creek Watershed
Deer Creek Watershed
Pillar Point Marsh Watershed
San Agustine Creek Watershed
BIG WAVE
Princeton Watershed
Harbor Watershed
the San Francisco Estuary Institute
www.sfei.org
Legend
Enclosed pipeline > 24 "
Natural channels and earthen d
CCA Boundary
Subwatersheds
Wetland and Riparian Areas
CCA Boundary including ASBS



Incomplete
Draft Environmental Impact Report

On Nov 4th 2009 it was brought to the Counties attention that agencies and the public were provided an incomplete printed draft EIR.

One week later on Nov 11th 2009 the missing section N. was delivered via FedEx to agencies and the Half Moon Bay Library.

Why didn't the County restart the 60 day CEQA review period on Nov 11th after the incomplete draft EIR had been supplemented with the 63 page missing chapter N. Utilities and Service Systems?

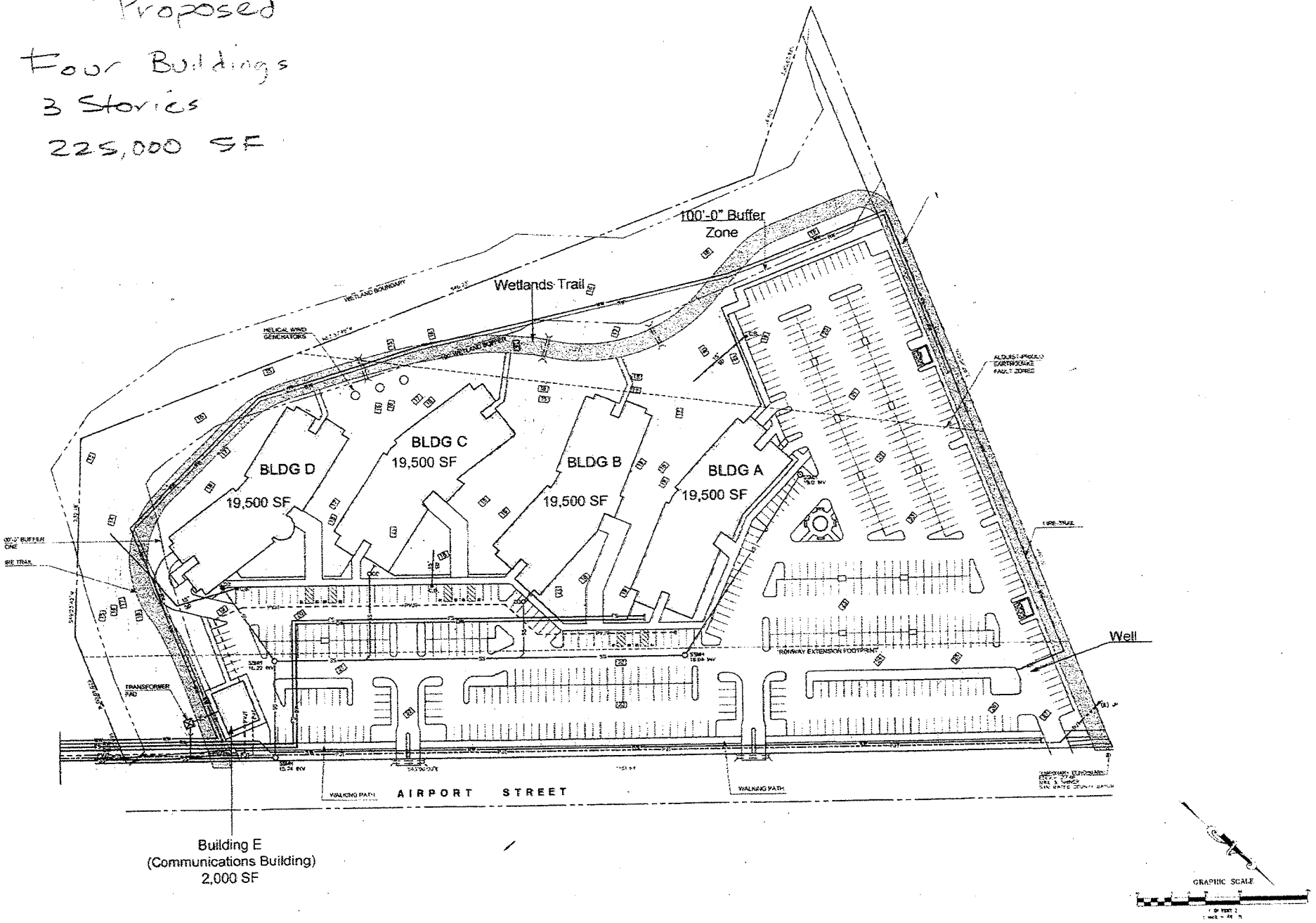

Thank
You
Sabrina Brennan
Seal Cove, Moss Beach

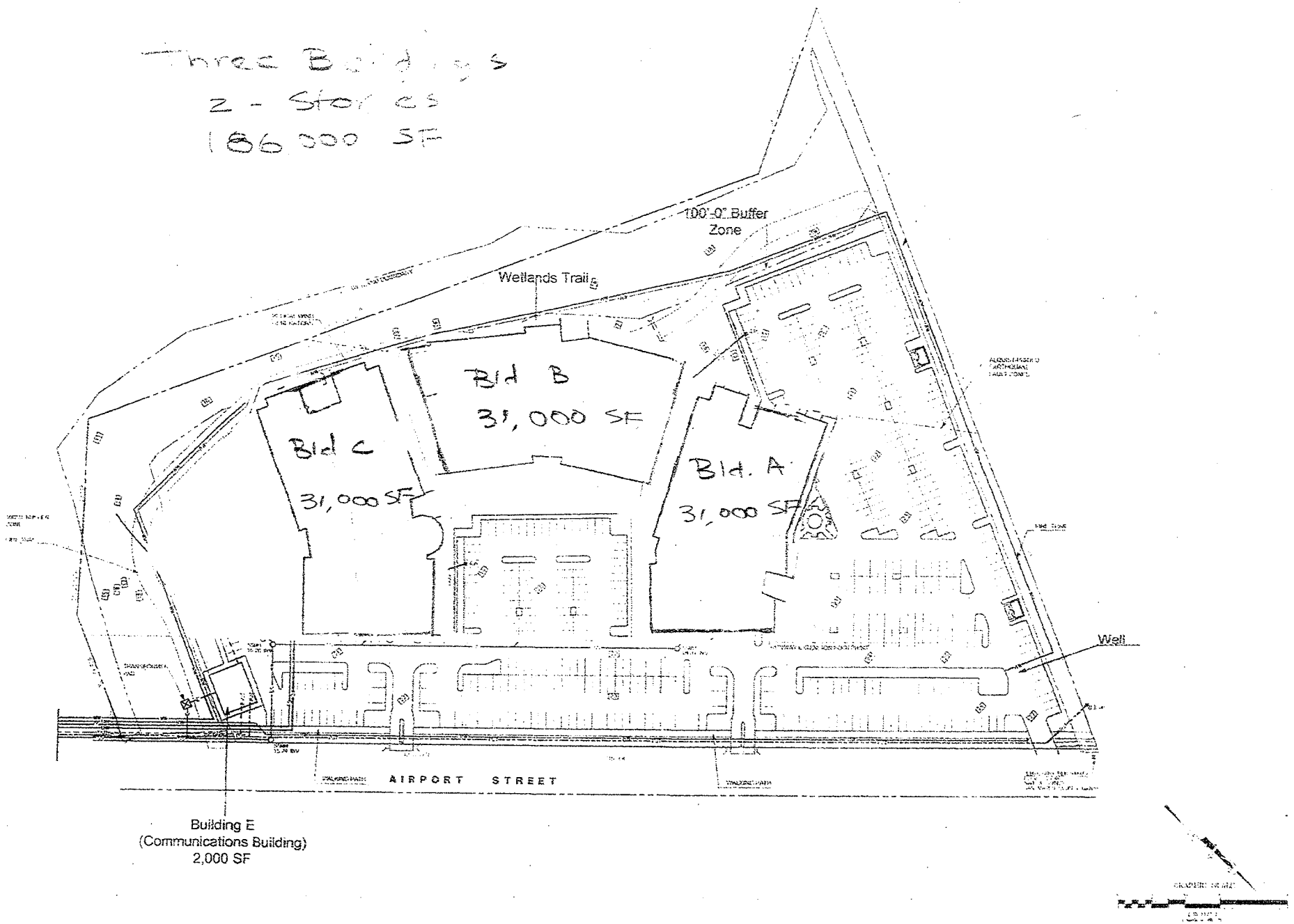
APPENDIX C

ATTACHMENTS TO COMMENT LETTER 204 FROM BIG WAVE GROUP, SCOTT HOLMES, DATED DECEMBER 23, 2009

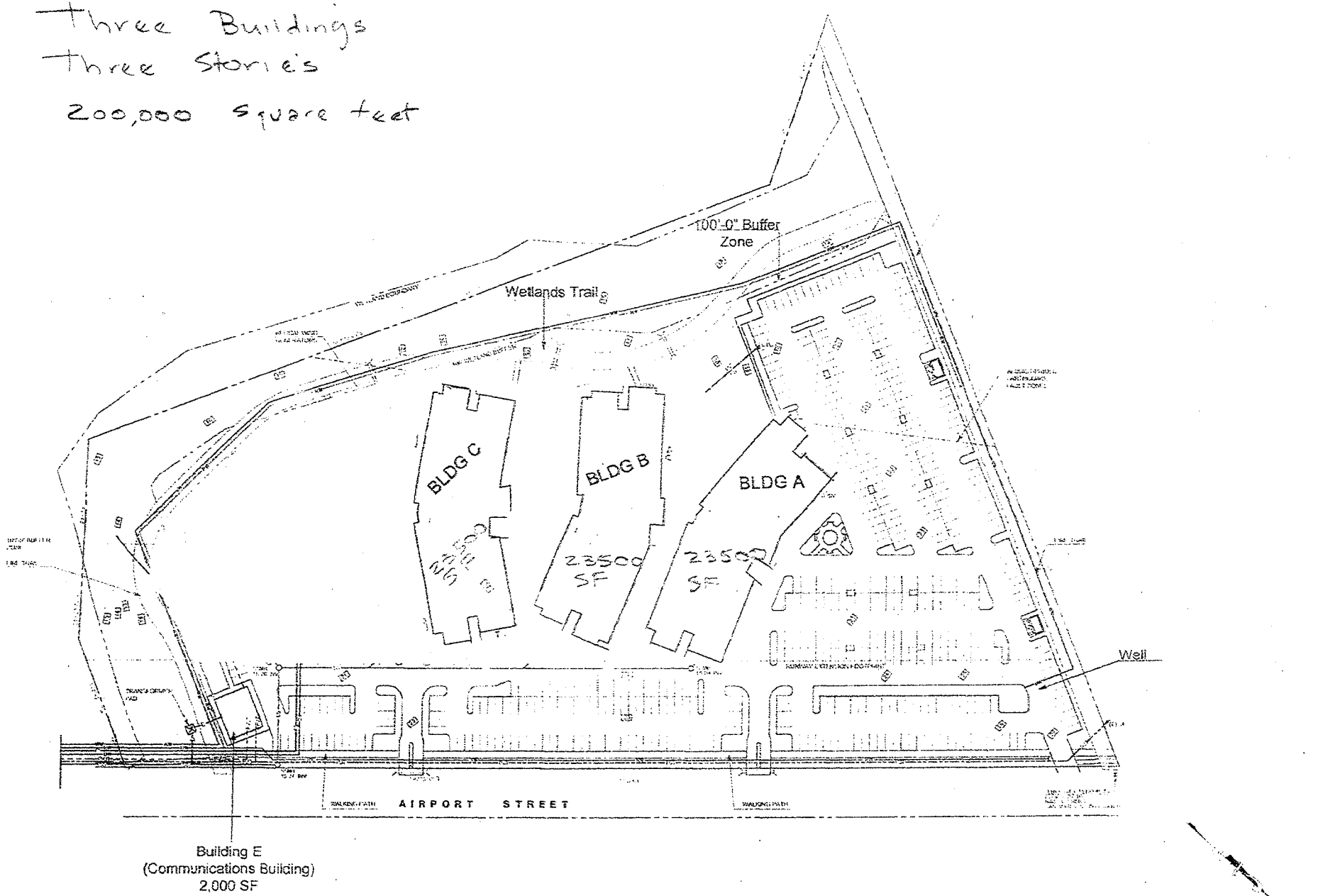
Office Park Options

Proposed
Four Buildings
3 Stories
225,000 SF

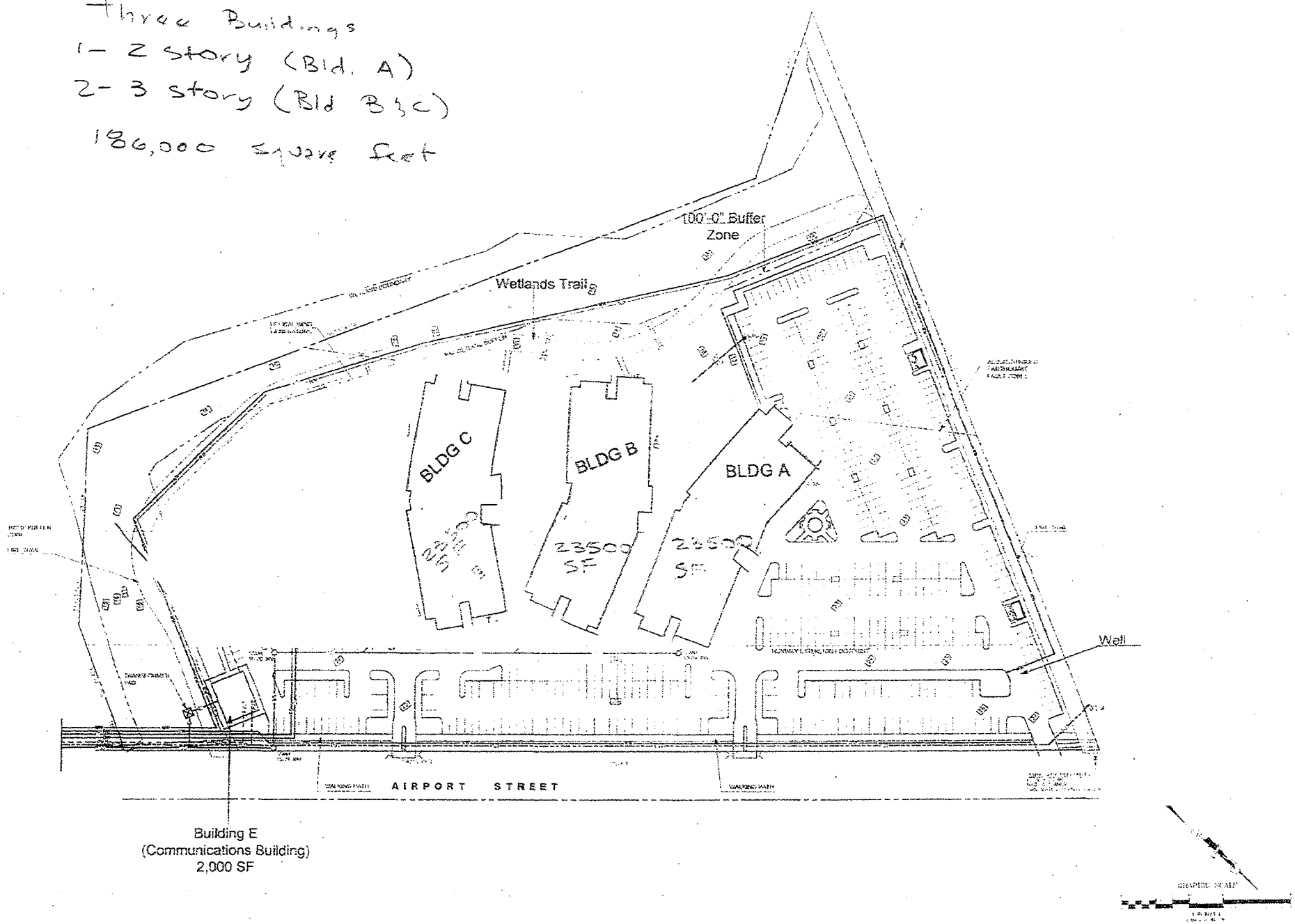


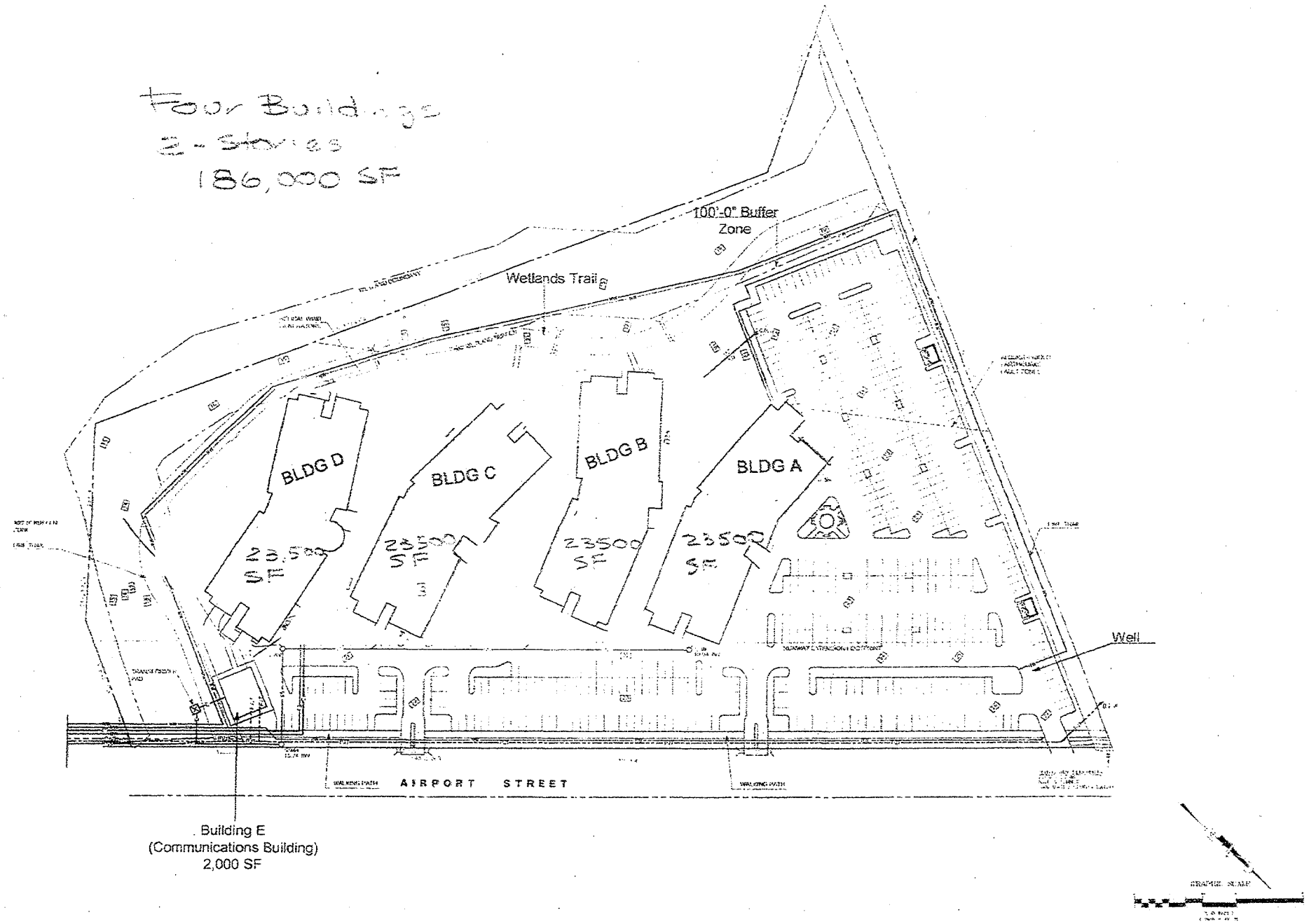

Three Buildings
2 - Stories
186,000 SF
100'-0" Buffer Zone
Wetlands Trail
Bld B
31,000 SF
Bld C
31,000 SF
Bld. A
31,000 SF
Well
AIRPORT STREET
Building E
(Communications Building)
2,000 SF

Three Buildings
Three Stories
200,000 square feet

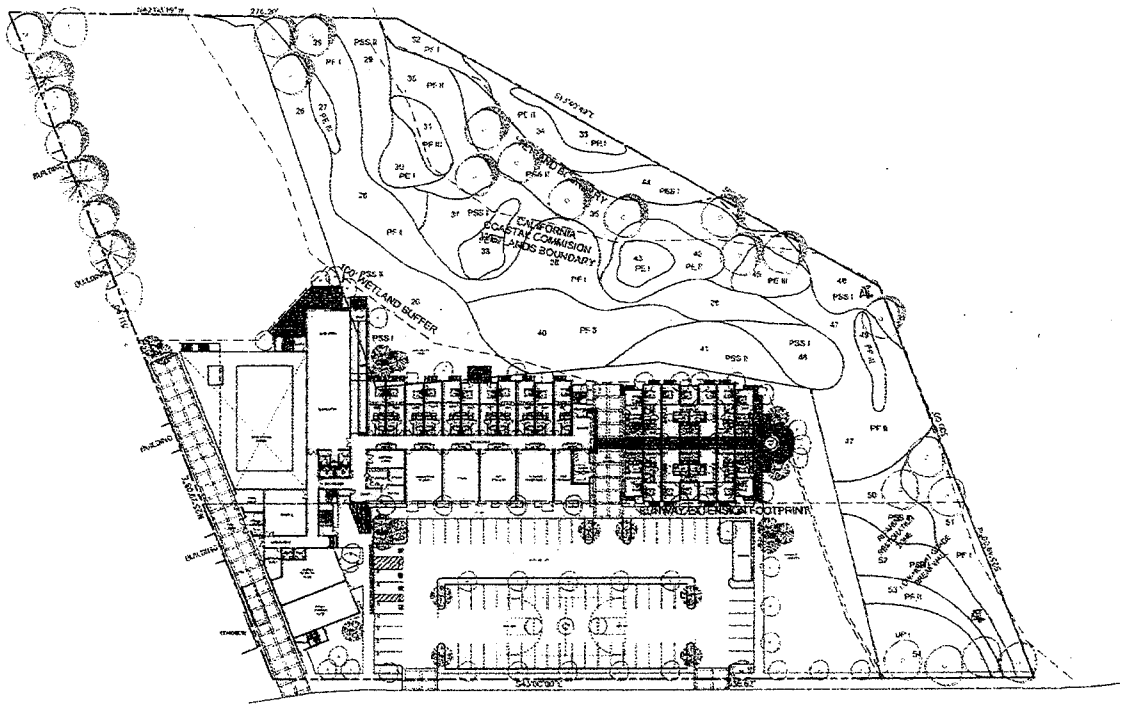


Three Buildings
1- 2 story (Bld. A)
2- 3 story (Bld B & C)
186,000 square feet




Four Buildings
2-Stories
186,000 SF
100'-0" Buffer Zone
Wetlands Trail
BLDG D
23,500 SF
BLDG C
23500 SF
BLDG B
23500 SF
BLDG A
23500 SF
Well
AIRPORT STREET
Building E
(Communications Building)
2,000 SF

Wellness Center Site Plan



1 OVERALL SITE PLAN

KEY NOTES

WR&D

WARD RANKINE & DOST ARCHITECTS LLP

BIG WAVE WELLNESS CENTER

05153

OVERALL SITE PLAN

A100

Trip Estimates for Environmentally Superior Alternative

Project Trip Generation Estimates (Modified Wellness Center and 225,000 sf office)

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate	Trips	Rate	In	Out	Total	Rate	In	Out	Total
Office Park											
General Office	90,000	11.01	991	1.55	123	17	140	1.49	23	111	134
Research & Development	56,250	8.11	456	1.22	57	12	69	1.07	9	51	60
Storage	33,750	3.56	120	0.30	8	2	10	0.32	3	8	11
Light Manufacturing	45,000	3.82	172	0.73	26	7	33	0.73	12	21	33
Wellness Center											
Residential (Units)	57	0	0		0	0					
Storage	10,000	3.56	36	0.30	3	1	4	0.32	1	3	4
Trips			1775		217	39	256		48	194	242

Project Trip Generation Estimates (Modified Wellness Center and 200,000 ft office)

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate	Trips	Rate	In	Out	Total	Rate	In	Out	Total
Office Park											
General Office	67,000	11.01	738	1.55	104	14	118	1.49	21	100	120
Research & Development	54,250	8.11	440	1.22	66	13	79	1.07	10	58	68
Storage	33,750	3.56	120	0.30	8	2	10	0.32	3	8	11
Light Manufacturing	45,000	3.82	172	0.73	26	7	33	0.73	12	21	33
Wellness Center											
Residential (Units)	57	0	0		0	0					
Storage	10,000	3.56	36	0.30	3	1	4	0.32	1	3	4
Trips			1505		207	37	244		47	190	237

Project Trip Generation Estimates (Modified Wellness Center and 186,000 ft office)

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate	Trips	Rate	In	Out	Total	Rate	In	Out	Total
Office Park											
General Office	51,000	11.01	562	1.55	79	11	90	1.49	16	76	92
Research & Development	50,250	8.11	408	1.22	61	12	74	1.07	9	54	63
Storage	33,750	3.56	120	0.30	8	2	10	0.32	3	8	11
Light Manufacturing	45,000	3.82	172	0.73	26	7	33	0.73	12	21	33
Wellness Center											
Residential (Units)	57	0	0		0	0					
Storage	10,000	3.56	36	0.30	3	1	4	0.32	1	3	4
Trips			1297		177	33	210		41	162	203

Project Trip Generation Estimates (without storage)

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate	Trips	Rate	In	Out	Total	Rate	In	Out	Total
Office Park											
General Office	51,000	11.01	562	1.55	79	11	90	1.49	16	76	92
Research & Development	50,250	8.11	408	1.22	61	12	74	1.07	9	54	63
Light Manufacturing	45,000	3.82	172	0.73	26	7	33	0.73	12	21	33
Wellness Center											
Residential (Units)	57	0	0		0	0					
Trips			1141		166	30	197		37	151	188

Project Cypress Trip Generation Estimates From North

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate (x.29)	Trips	Rate (x.29)	In	Out	Total	Rate (x.29)	In	Out	Total
Office Park											
General Office	67,000	3.219	216	0.45	30	4	34	0.43	6	29	35
Research & Development	50,250	2.3519	118	0.35	18	4	21	0.31	3	16	18
Light Manufacturing	45,000	1.1078	50	0.21	10	3	12	0.21	5	10	15
Wellness Center											
Residential (Units)	57	0	0		0	0					
Trips			384		57	11	68		14	54	68

Trip Generation Estimates, Seal Cove, Pillar Ridge, Commercial on Airport St and Cypress

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate	Trips	Rate	In	Out	Total	Rate	In	Out	Total
Commercial, Airport Street, Cypress											
General Office	10,000	11.01	110	1.55	16	2	18	1.49	3	15	18
Research & Development	5,000	8.11	41	1.22	6	1	7	1.07	1	5	6
Light Manufacturing	15,000	3.82	57	0.73	11	3	14	0.73	6	11	17
Seal Cover Pillar Ridge											
Residential (Units)	420	6.65	2793	0.51	54	214		0.62	260	130	391
Trips			3001		86	221	307		271	161	432

Cypress Est. To North for Seal Cove, Pillar Ridge, Commercial on Airport St and Cypress*

Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
		Rate (.29)	Trips	Rate (x.29)	In	Out	Total	Rate (x.29)	In	Out	Total
Commercial (Airport St., Cypress)											
General Office	10,000	3.1929	32	0.45	4	1	5	0.43	1	4	5
Research & Development	5,000	2.3519	12	0.35	2	0	2	0.31	0	2	2
Light Manufacturing	15,000	1.1078	17	0.21	3	1	4	0.21	2	3	5
Seal Cove, Pillar Ridge											
Residential (Units)	420	1.9285	810	0.15	16	62		0.18	76	19	94
Trips			870		25	64	89		78	28	106

*Assuming 29% of Seal Cove Residents Commute North and 29% of Commercial access from the north

Cypress To North for Seal Cove, Pillar Ridge, Commercial on Airport St and Cypress, Big Wave

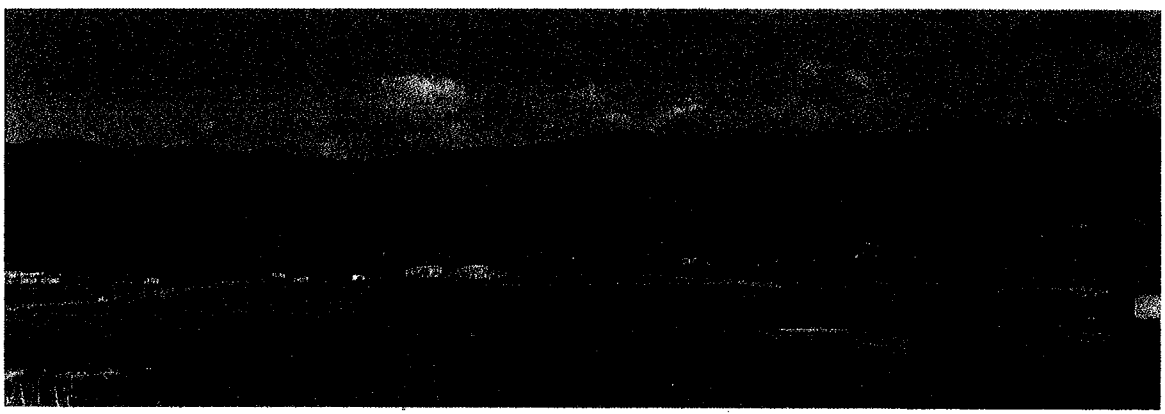
Use	Size (sf)	Daily		AM Peak Hour				PM Peak Hour			
			Trips		In	Out	Total		In	Out	Total
Big Wave											
Option 1: Project Description	225,000 sf		615		70	14	84		18	60	78
Option 2: Modified Wellness	225,000 sf		515		63	11	74		14	56	70
Option 3: DEIR Env. Sup	186,000 sf		384		57	11	68		14	54	68
Option 4: Alt. D	200,000 sf		436		60	11	70		14	55	69
95%Traffic Diverted to Capistrano											
Option 1			30		4	1	5		1	3	4
Option 2			19		3	1	4		1	3	4
Option 3											
Local			870		25	64	89		78	28	106
Local + Option 1			1485		95	78	173		96	88	184
Local + Option 2			1385		88	75	163		92	84	176
Local + Option 3			1254		82	75	157		92	82	174
Local + Option 4			1306		85	75	159		92	83	175
Local + 5% of Option 1			900		29	65	94		79	32	110
Local +5% of Option 2			889		28	65	92		79	32	110

Top Soil Addition

Final WSP Basis Design Report

Draft (90%) Basis of Design Report

Riparian & Waters/Wetlands Ecosystem Restoration for Big Wave Wellness Center and Office Park San Mateo County, California



August 4, 2008

Prepared for:

Big Wave LLC
1333 Jones Street
Suite 307
San Francisco, CA 94109

Prepared by:

Ecosystem Science & Natural Resources Management Services
160 Franklin Street, Suite 300
Oakland, CA 94607

DISCLAIMER

WSP Environment & Energy has prepared this basis of design report for use by Big Wave LLC. Waters of the U.S., including wetlands (waters/wetlands) boundaries presented in this report are described in a previous report by WSP (2008a). These waters/wetlands boundaries have been approved by the U.S. Army Corps of Engineers, San Francisco District (File No. 2008-001025; Regulatory Division, U.S. Army Corps of Engineers, San Francisco District, June 5, 2008). Wetland boundaries under California Coastal Commission jurisdiction have not received formal approval.

Lyndon C. Lee **August 4, 2008**

Lyndon C. Lee, Ph.D. Date
Principal Ecologist & Vice President
Ecosystem Science and Natural Resources Management Services
WSP Environment and Energy

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EXECUTIVE SUMMARY

The Big Wave Wellness Center and Office Park Project (hereafter, "Project") consists of the construction of a residential village and an adjacent commercial property/office park complex. The residential village is designed to provide affordable housing and independent living for a developmentally disabled community, and the office park is designed similarly to provide a state-of-the-art "green", LEED-certified working environment. The primary objective of the project is to construct innovative living and work environments that foster independent and meaningful living/work experiences for disabled young adults. The proposed Project also includes restoration of the waters of the U.S., including wetlands (*i.e.*, waters/wetlands) and California Coastal Commission (state) wetlands on the property that are currently used in agricultural production.

This basis of design report outlines a restoration plan for the riparian/wetland ecosystem that encompasses the federal and state waters/wetlands and their buffer that lie within the project area. This 90% restoration design describes a suite of activities that would increase waters/wetlands ecosystem functions, and to develop a native, diverse, and aesthetically pleasing landscape. Best management practices for stormwater treatment are designed to incorporate retention/detention microdepressions (rain gardens) and swales planted with native species.

The riparian/wetland ecosystem restoration plan includes five elements:

1. Earthwork, including mass and fine grading,
2. Installation of large wood,
3. Planting and irrigation,
4. Weed management, and
5. Monitoring and adaptive management.

The riparian/wetland ecosystem restoration design integrates the built environment with natural communities through utilization of native species for landscaping, locally adapted plant stock, and when possible, use of propagules obtained from the Project Site and adjacent landscape. Additionally, the Project design encourages community involvement by offering educational opportunities for village residents in the restoration process as well as via an informal foot path within the restored buffer. If implemented as designed, the riparian/wetland ecosystem will result an increase in the hydrologic, biogeochemical, native plant community, and faunal support/habitat functions of the currently farmed wetlands. A monitoring and adaptive management program will be implemented to ensure success of the restoration efforts.

I. INTRODUCTION

The Big Wave Wellness Center and Office Park Project (hereafter, "Project") consists of the construction of a residential village and an adjacent commercial property/office park complex. The residential village is designed to provide affordable housing and independent living for a developmentally disabled community, and the office park is designed similarly to provide a state-of-the-art "green", LEED-certified working environment. The primary objective of the project is to construct innovative living and work environments that foster independent and meaningful living/work experiences for disabled young adults.

The proposed Project also incorporates a restoration plan for the riparian/wetland ecosystem which for the purposes of this project includes (a) the waters of the U.S., including wetlands (hereafter, waters/wetlands), (b) California Coastal Commission (state) wetlands, and (c) a 100 foot wide buffer around these waters/wetlands. The majority of all three areas is currently are used in agricultural production. For the purposes of this Project, a "riparian/wetland ecosystem" is defined as upland, transitional, and waters/wetland habitats, all of which will be restored in a complex mosaic within a 100 ft buffer adjacent to existing federal and state waters/wetlands. Restoration of the buffer will provide significant benefits to waters/wetlands ecosystem functions, relative to existing conditions, particularly with respect to the native plant and animal communities. Of particular importance is the restoration of potential breeding habitat for the California red-legged frog (*Rana aurora draytonii*) and potential foraging habitat for the San Francisco garter snake (*Thamnophis sirtalis tetrataenia*). The restoration design integrates the built environment with natural communities through utilization of native species for landscaping, locally adapted plant stock, and when possible, use of propagules obtained from the Project Site and adjacent landscape. Additionally, the Project design encourages community involvement by offering educational opportunities for village residents in the restoration process as well as via an informal foot path within the restored buffer.

A. Project Site

The Big Wave Project Site (hereafter, "Project Site") is located in unincorporated San Mateo County, adjacent to Princeton-by-the-Sea, California (Figure 1). The Project Site consists of two agricultural fields totaling 19.5 ac. These fields are separated by a small, county-owned, unnamed intermittent stream that is an extension of San Mateo County's Pillar Point Marsh. As such, it drains directly to the Pacific Ocean, entering the Pacific Ocean via Pillar Point Harbor immediately north of the mouth of Denniston Creek.

The Project Site is bordered to the northeast by the Half Moon Bay Municipal Airport (Figure 2) and to the south by Pillar Point Marsh, a nature reserve that is part of the County of San Mateo Fitzgerald Marine Reserve complex managed by the County's Parks and Recreation Division. A public trailer park is immediately north of the Project Site along Airport Road. Elevations at the Project Site range from 9.0 to 27.7 feet NGVD, although the agricultural fields are generally flat but slope gently to the south and west.

B. Existing Conditions at the Big Wave Project Site

1. Soils and Geomorphic Context

The Project Site is situated on the uplifted Half Moon Bay marine terrace formation within a partially filled coastal basin. The coastal basin consists of Pleistocene coarse-grained, alluvial fan and stream terrace deposits. Underlying sediments include poorly consolidated sand, gravel, and silt comprising the headward-most extent of old alluvial fans (Brabb and Pampeyan 1983). Montara Mountain, a northern spur of the Santa Cruz Mountain sequence of the Outer Coast Ranges, separates this low-lying coastal area from San Francisco Bay to the north and east.

Soils within the Project Site are mapped by the Natural Resources Conservation Service (NRCS, formerly U.S. Department of Agriculture Soil Conservation Service) as Denison clay loam on nearly level slopes (DcA) and Denison clay loam on nearly level slopes that are imperfectly drained (DdA) (NRCS 1961). These soils are derived from granitic alluvium, and have formed on low coastal terraces under the influence of herbaceous vegetation (grass). Denison clay loam soils occur on 0 to 2 percent slopes and the mapping unit has approximately 1 percent hydric inclusions, which typically are found in depressions across the mapping unit. Denison clay loam soils are generally highly fertile. Overall, Denison soils are classified as fine, smectitic (*i.e.*, clay derived from the alteration of the minute glass in volcanic ash, formerly known as bentonite), isomesic (*i.e.*, summer and winter temperatures differ by less than 6°C at 50 cm depth) pachic argixerolls (see Soil Survey Staff 2006).

2. Climate

The Project Site has a mild Mediterranean type climate maintained by persistent sea breezes. Temperatures rarely exceed 90°F and seldom drop below 32°F. Average daily temperatures (by month) range from 51°F to 59°F (NRCS 2007). Cloud coverage and fog are common during the evening and early morning hours, but typically dissipate during mid-day. Total average annual precipitation is 28 inches (NRCS 2007).

3. Hydrology

Hydrologic inputs to the project site are dominated by precipitation and surface runoff. The majority of surface runoff comes to the Project Site via the Half Moon Bay Airport storm water runoff collection system. Within the airport property, runoff is consolidated in a series of channels, culverts, and pipes leading to a pair of concrete culverts (44" diameter) that run southwest under Airport Street. The 44" culverts form the headward-most extent of a stream reach of an unnamed intermittent tributary that bisects the Project Site. This tributary passes through two culverts under West Point Avenue and connects with the tidally influenced Pillar Point Marsh, eventually flowing into Pillar Point Harbor (WSP 2008a).

4. Plant Communities

The Project Site, consisting of two more or less adjacent agricultural fields, currently is under active cultivation. The site is annually plowed, disked, and planted in one or more rotations; therefore, little to no adventive (uncultivated) vegetation persists or has the opportunity to

colonize across the great majority of the Project Site. In those areas where agricultural clearing had not occurred recently (*e.g.*, along Airport Street verge and in very small, scattered patches within agricultural fields), non-native annual grasses and forbs occur. Dominant species along the main verge include wild oats (*Avena* spp.), bristly oxtongue (*Picris echioides*), and common vetch (*Vicia sativa*).

Along the unnamed intermittent tributary that bisects the property and the southern perimeter of the property adjacent to Pillar Point Marsh, riparian (palustrine scrub shrub) and seasonal freshwater wetland plant communities persist (palustrine persistent and non-persistent emergent) (Cowardin *et al.* 1979). Dominant species within the unnamed drainage include willows (*Salix lasiolepis, S. scouleriana, S. sitchensis*), California blackberry (*Rubus ursinus*), and poison hemlock (*Conium maculatum*). Dominant species along the southern edge of the property included slough sedge (*Carex obnupta*), soft rush (*Juncus effusus*), silverweed (*Potentilla anserina* var. *pacifica*), field mint (*Mentha arvensis*), arroyo willow (*Salix lasiolepis*), and California blackberry. Overall, the vegetation on the proposed project site has been significantly altered and reflects a long history of regular disturbance and agricultural cultivation.

5. Protected Species

No rare plants of conservation concern have been observed on the project site (WSP 2008b). Four rare plant species have been documented by the California Natural Diversity Database (CNDDB) within two miles of the Project Site, but they are unlikely to occur on the Project Site due to lack of suitable habitat.

No rare, threatened or endangered animal species have been observed on the Project Site (WSP 2008b). The WSP field team observed 29 wildlife species on the property during a field survey in early Spring 2008. One species on the watch list of the California Department of Fish and Game, the sharp-shinned hawk, was observed flying above the property. Two special status animal species, *Rana aurora draytonii* (California red legged frog) and *Geothlypis trichas sinuosa* (saltmarsh common yellowthroat) have been recorded in the past on adjacent property (CNDDB 2008). The California red legged frog, including one adult and one sub-adult, were observed in a wetland near the Project Site near West Point Road on May 7, 1999 (CNDDB 2008). The saltmarsh common yellowthroat has been observed near the site in the past; specifically, observations of individuals or breeding pairs were recorded in 1985, 1988, 1989, and 1990, but have not been document since then (CNDDB 2008). During the 2008 field effort, the WSP team observed one common yellowthroat perched in willows in the wetlands adjacent to and to the southwest of the Project Site. These protected species are not expected to occur on the Project Site as no suitable breeding or foraging habitat currently exists.

6. Extent of Jurisdictional Waters/Wetlands and their Buffers

Approximately 0.45 acres of wetlands of "other waters" (Type 3 waters of the U.S.), 0.74 acres (32,180 ft^2) of California Coastal Commission waters/wetlands, and 4.26 acres of buffer are delineated at the Big Wave Project Site (WSP 2008a, Figure 3). The great majority of these waters/wetlands are found along the southern margin of the property. The proposed development will avoid all direct impacts to waters/wetlands and the 100 foot buffer set back.

II. OBJECTIVES

WSP Environment & Energy (WSP) was retained by Big Wave LLC to assist in the restoration of the native coastal ecosystems at the Project Site. The purpose of the restoration effort is to increase the functioning of the native coastal ecosystems at the Project Site. Specifically, in this report, WSP was asked to assist with the following tasks:

1. Prepare a restoration plan for riparian waters/wetland ecosystem within the buffer area of the Project Site.
2. Design a natural landscaping plan of native species for the residential and commercial areas.
3. Assist in the design of natural storm water management/rain garden system using native plant species genetically adapted to the central coast of California.

Sections III, IV and V of this report describe designs developed for the riparian buffer restoration, native landscaping, and natural storm water management, respectively.

III. DRAFT (90%) RIVERINE WETLAND ECOSYSTEM DESIGN

A. Guiding Principles

WSP used the following set of principles to guide design of the riverine/riparian waters/wetland ecosystem restoration:

1. Give due diligence to federal, state and local regulatory requirements.
2. Target no net loss of waters/wetlands area and/or ecosystem functioning.
3. Base the restoration design on attainable regional reference conditions.
4. Aim to restore the native hydrological, biogeochemical, plant community, and faunal support/habitat functioning.
5. Target restoration of riverine ecosystem functions (*e.g.*, through maintaining hydrological connectivity within the landscape and restoring microtopography).
6. Integrate the form and function of the natural and the constructed landscapes.

B. U.S. Army Corps and EPA Guidance on Wetlands Compensatory Mitigation

In April 2008, the U.S. Army Corps of Engineers along with the U.S. Environmental Protection Agency issued new standards to improve wetland restoration and protection policies (Federal Register 2008). The new "wetlands compensatory mitigation standards" were offered to promote the use of best available science, promote innovative approaches to the "no net loss of area and/or function" national policy, and to focus on the results of restoration and protection.

Relevant to the Big Wave Wellness Center and Office Park Project, these new Corps/EPA mitigation standards reaffirm the mitigation sequence of avoid, minimize, and mitigate (compensate). The Big Wave Project is avoiding all impacts to existing waters/wetlands (including both waters of the U.S. and Coastal Commission wetlands) and therefore is in line with the new guidance on mitigation sequencing. As described in this basis of design, the proposed restoration of riparian areas adjacent to waters/wetlands will likely result in expansion of at minimum 5.3 acres of state wetlands.

C. General Description and Design Rationale

The riparian waters/wetlands ecosystem buffer design includes ten plant community types that support approximately 75 native California taxa (Figures 4-10). The community types are based upon the U.S. Fish & Wildlife Service's hierachical classification system (Cowardin *et al.* 1979) of five wetland systems – marine, estuarine, riverine, lacustrine, and palustrine. Only wetlands within the palustrine system are appropriate to the Project Site. As such, three palustrine forest communities, two palustrine scrub-shrub communities, three palustrine (persistent) emergent communities are proposed. Additionally, an upland community that supports native coastal scrub species and similarly a plan for the storm water swales also is included.

A total of 54 polygons at the Wellness Center and Office Park (inclusive) will be restored, representing a total 5.3 acres of riparian and waters/wetlands within the buffer and across the built landscape. Specifically, a total of 1.89 acres of palustrine forest, 2.47 acres of palustrine scrub shrub, 0.51 acres of palustrine emergent wetlands will be restored, in addition to 0.26 acres of upland coastal scrub and 0.18 acres of stormwater wetland swales (Figures 4-10).

In the design process of the riparian buffer along the adjacent waters/wetlands of Wellness Center and Office Park, WSP focused on achieving the highest level of ecosystem functioning possible. Design elements relative to ecosystem function were developed based on site history and landscape context and will be monitored over a minimum of ten years post restoration. Importantly, an increased level of function has to be achieved while also achieving a natural, unbroken, visually attractive transition between the restored ecosystem and the residential/commercial landscape. To achieve this target, WSP relied upon:

1. A reference database and draft hydrogeomorphic guidebook for 3rd and 4th order riverine waters/wetlands of the central California coast (NWSTC 1996) developed to assist in the design, permitting and monitoring of riverine restorations within this reference domain (biogeographic province),
2. Relevant literature, reports, flora documentation, and
3. Cumulative 60+ years of professional experience of the lead WSP scientists working in waters/wetlands ecosystems along the central coast of California.

This 90% restoration design is based upon a suite of activities that would increase waters/wetlands ecosystem functions and develop a native, diverse, and aesthetically pleasing landscape. Elements of the restoration design are focused around five phases of work, including earthwork, (mass and fine grading), installation of large wood, planting and irrigation, weed management, and monitoring and adaptive management.

Our rationale for implementation of each technique is described in the following text.

1. Earthwork

Natural transitions within the landscape will need to be restored as a result of historic land uses and the integration of wild and urban environments. Mass grading can restore landscape hydrologic connectivity creating smooth transitions within and between wetland and upland habitat. In addition, mass grading is extremely effective at removing weeds through eliminating standing biomass and elimination of a viable seed bank in the upper soil horizon(s). Earthwork also decreases competition from well-established weeds and, with standard grading techniques such as ripping and/or disking, helps loft soil, blend top and sub-soil horizons, and prepare a successful planting environment.

Fine grading involves the use of directed time to grade microtopographic features within the riverine and riparian environments. Finish grading also involves the placement of large wood structures, and will thus provide an essential element of an ecosystem (detritus). These wood structures will mimic dead and decomposing features of a woody riparian ecosystem, including

snags (standing dead), decadent/decaying logs, and log jam features of floodplains and fluvial systems, as described in the following paragraph.

2. Installation of large wood and log structures

Prior to agriculture, grazing, clearing, industrial uses, and intense water management in California, large wood was a part of natural ecosystems. Log structures can be placed above and/or below ground. Large wood provides numerous ecosystem functions, for example log structures create roughness (*i.e.,* increase Manning's *n*) that slows water flow and spreads it out to promote maximum contact of water with the floodplain surface. Log structures can be strategically placed in order to deflect flood waters away from civil structures including roadways, bridges, *etc.* Large wood creates hydraulic complexity within a reach through dissipation, focusing, and/or adding complexity to the riverine ecosystem and thereby provide habitat for aquatic invertebrates and vertebrates, including fish. Placement of large wood and log structures creates microtopographic variation with abrupt gradients in site water balance which allows for increased plant diversity and variety of habitat microsites.

3. Planting and Irrigation

Planting will be conducted to maintain fidelity to native plant community structure, function, and composition for the Project Site. A native plant nursery will be established on site for the project to provide nursery stock, to hold for planting, and to generate replacement stock should replacement planting become necessary after the project is completed. Collection of seed will be conducted as close to the project site as possible to ensure reestablishment of a suite of locally adapted native plants. An irrigation system will be installed to increase likelihood for planting success. Restoring native plants also will increase the detrital pool (in this case, primarily quickly decomposing carbon sources) that has been removed due to intensive farming. Native plant community restoration improves hydrologic and biogeochemical functioning on the site and provides habitat for native fauna by offering hiding, resting, escape, breeding, and foraging habitats. Establishment of native plants will lead to relative exclusion of non-native and invasive weeds and will provide vertical and horizontal structure within the landscape.

4. Weed Management Strategy

Several aggressive, non-native plant species are present at or near the Project Site, including Himalayan blackberry (*Rubus discolor*) and German ivy (*Delairea odorata*). Invasive weed species not only degrade the plant community functions, but also threaten the success of a restoration project. Therefore, an integrated weed/pest management strategy should be developed and implemented in tandem with the restoration project. The weed management strategy begins with control of existing weeds adjacent to the restoration area through hand pulling, approved localized chemical application, and/or mowing. Installing native plants species with rapid growth rates and/or at high densities will help to quickly develop a canopy which excludes weed recruitment. Continued maintenance including hand weeding and replanting of plants which suffer mortality should be conducted following restoration.

5. Maintenance, Monitoring and Adaptive Management

To ensure that restoration is a success and that appropriate adaptive management/contingency measures are used, the Project Site will be monitored following restoration for a minimum of 5 years. Project targets and standards articulated in the monitoring plan will be established at the beginning of the restoration project and based on the assessment of the path that will achieve stated goals. The monitoring design will include methods to quantify and document each project target and standard and will identify criteria for success. Monitoring protocols will include some combination of photo points, topographic surveys, soil profiles, invertebrate surveys, and/or assessment of vegetation cover and composition. In case project standards and/or success criteria are not met, an adaptive management strategy with contingency measures will be included as part of the monitoring plan. In the event of failure to achieve a project standard, recommended contingency measure(s) will be outlined (*e.g.,* weeding, grading, planting) and implemented as soon as possible.

D. Construction Sequencing

The various tasks associated with the Project Site restoration plan are described in general terms in the following text, which will be used to guide the development of construction plans and specifications.

1. Earthwork (mass and finish grading)

a) Grade to create a smooth transition to the surrounding landscape
b) Grade surrounding landscape to increase rugosity in the surrounding landscape. Rugosity is a measure of small-scale variations and complexity or surface roughness. Increased rugosity offers a relatively more diverse array of sites for planting.
c) Using directed time, construct and link microtopographic depressions and small scale swales, rain gardens, and storm water features.

2. Log Structures

Large wood on and within the active channel and on the adjacent floodplain and associated stream terraces is an integral structural variable of fluvial systems, and an equally important link for plant and animal support ecosystem functions. As such, large wood structures will be constructed across the wetland/riparian buffer.

a) Using directed time, install large wood structures as articulated in the planting plan and other construction documents. These structures shall consist of single logs or piles of log on and beneath final grade (Figure 11).

3. Planting and Irrigation

a) Through mass grading remove all existing weeds and where possible, seed source in the upper 6 inches of soil.
b) Lay out (*i.e.,* stake) planting plan as designed (see Figure 4, 5, 8-10)

c) Install native nursery stock according to planting plan using a suite of plant community types suited to microsite conditions and with fidelity to reference system conditions (Figure 6).
d) Mulch entire planted and seeded areas with minimum 4" lift of sterile (weed-free) straw
e) Install temporary irrigation system. Following grading activities, install a temporary irrigation system to provide irrigation water to all planted areas across the wetland and riparian buffer. A temporary irrigation plan will be designed prior to project implementation.

4. Weed Control

After initial establishment of restored riparian/wetland ecosystem area and functioning, management of weeds/invasive species will become a high priority. Implementation of weed management must address (i) re-emergence of weeds from onsite seed banks, (ii) establishment of existing populations of weeds that were not removed in the initial clearing effort, and (iii) colonization of restored area from offsite exotic seeds sources. Weed control efforts should be adapted with an integrated program which includes mowing, hand weeding, and re-planting or interplanting additional plants as necessary. Weed control will be required as part of the monitoring, maintenance and adaptive management activities.

5. Monitoring Maintenance and Adaptive Management

a) Assume a ten year monitoring interval with monitoring reports completed at Year 0 (baseline), 1, 2, 5, and 10.
b) Conduct two site visits per monitoring year, wet and dry season. During each visit, characterize the site through the collection of site data referencing project standards including hydrologic, biogeochemical, plant community and faunal support/habitat functions.
c) Prepare annual monitoring report due by December 15 each monitoring year. Based on observations, recommend any necessary maintenance and/or adaptive management measures.
d) Implement maintenance and adaptive management measures, including weeding, as necessary.

E. Sediment and Erosion Control

Restoration construction should be initiated and completed during the dry season (May to November). All construction activities must adhere to the project-specific Storm Water Pollution and Prevention Plan (SWPPP) and associated Temporary Erosion and Sediment Control (TESC) plan, both of which must be prepared and submitted by the Big Wave LLC or its consultants to the regulatory community prior to project implementation.

The first step will be to install sediment and erosion control measures according to the SWPPP and TESC. Upon completion of earthwork and log structure installation (*e.g.*, creating

microdepressions, creating windthrow mounds, installing log jams, *etc.*), temporary irrigation must be installed to ensure successful post-construction planting. In addition, Big Wave Group or its consultants may be required to prepare and submit a water quality monitoring plan to regulatory agencies, as part of the monitoring agreement with regulatory agencies.

F. Proposed Design Success Criteria

Specific project standards and associated success criteria (*i.e.*, field indicators/measurements) have been developed for this riparian/wetland ecosystem restoration project. The proposed restoration design places emphasis on the following four project targets.

Project Target 1: ***Increase waters/wetlands habitat patch size for native wetland and riparian animal species typical of the central California coast.***

Project Standard: Success Criteria

1. Increase Patch Size: One hundred percent coverage by native plant communities in the 100 foot buffer.

Project Target 2: ***Establish and maintain diverse native plant communities, with nursery stock genetically adapted to the restored wetland and riparian ecosystem restoration project site.***

Project Standard: Success Criteria

1. Percent cover of native tree species in riparian forest communities: Greater than or equal to 95%.
2. Percent cover of native shrub species in riparian forest and scrub-shrub communities: Greater than or equal to 40% and less than or equal to 75%.
3. Percent cover of native shrub species in riparian scrub-shrub communities: Greater than or equal to 95%.
4. Percent cover of native forbs, graminoids, ferns, and fern allies in palustrine persistent and non-persistent emergent community types: Greater than or equal to 80%.
5. Percent cover of native forbs, graminoids, ferns, and fern allies in forest and scrub shrub communities: Greater than or equal to 20% and less than or equal to 75%.
6. Percent of native species cover in each stratum: Greater than or equal to 85%.
7. Vigor of planted stock: Greater than or equal to 80% survival.

Project Target 3: ***Increase microtopographic complexity (i.e., microdepressions, windthrow mounds) within the restored riparian and waters/wetlands ecosystem restoration project site***

Project Standard: Success Criteria

1. Structural features: Large wood (windthrow mounds) remain structurally stable.
2. Microtopographic roughness: Constructed microtopotraphic features remain intact.

Project Target 4: ***Increase the faunal support/habitat function for native species within the restored riparian and waters/wetlands ecosystem restoration project site***

Project Standard: Success Criteria

1. *Vegetative strata*: Forest communities- three or more strata (*i.e.*, trees, shrubs, herbs, with sapling/seedling and/or vines as additional stratum); Scrub-shrub communities - greater than or equal to two strata (*i.e.*, shrubs, herbs, with sapling/seedling and/or vines as additional stratum)
2. *Faunal diversity*: Restoration site continues to attract a diversity of native wildlife
3. *Canopy cover*: Greater than 80% cover by two or three strata in forest and scrub-shrub communities.

G. Expected Changes in Ecosystem Functions Following Restoration

The proposed riparian/wetland ecosystem restoration plan is expected to result in the increase in ecosystem functioning as considered by four types of wetland functions: (1) hydrologic, (2) biogeochemical, (3) plant community, and (4) faunal support/habitat functions. Comparisons between current (existing) conditions on the site and wetland conditions expected five years after restoration were assessed using best professional judgment. It should be noted that the riparian restoration will result in an increase of approximately 5.3 acres of wetlands under jurisdiction of the California Coastal Commission, but is not expected to add any increase in federal jurisdiction.

Factors affecting the ability of the wetlands at the Project Site to perform ecosystem functions include, but are not limited to (1) degradation from historical land use, (2) intensity of cropping practices, (3) historic modifications to hydrologic features of the site, (4) non-native species, and (5) urbanization in surrounding landscape.

1. Hydrologic Functions

Energy Dissipation. Energy dissipation is defined as *the transformation and/or reduction of the kinetic energy of water as a function of the roughness of the landscape and channel morphology, and vegetation.*

Existing conditions at the Project Site do not allow for significant energy dissipation because the site is cleared and farmed. However, installation of large wood, establishment of complex microtopography, and a diverse plant community including trees will promote an increase in this function.

Surface & Subsurface Storage of Water. Surface & Subsurface Storage of Water is defined as *the presence of soil and/or geologic materials within the creek ecosystem, including the hyporheic zone, that have physical characteristics suitable for detention, retention, and transmission of water.*

The Project Site currently is leveled and degraded by agricultural activities. However, this wetland function is recoverable with the proposed restoration through establishment of sinuous storm water swales hydrologically linked to microtopographic depressions, installation of large wood above and below ground, and development of a native plant community with complex vertical structure.

Landscape Hydrologic Connections. Landscape Hydrologic Connections is defined as *the maintenance of the natural hydraulic connectivity among source areas of surface and subsurface flow to riverine waters/wetlands and other downgradient waters/wetlands.*

This hydrologic function at the Project Site is degraded due to ditching associated with road construction both upstream and downstream and the agricultural activities on the property. The down gradient connection is culverted under and interrupted by West Point Avenue. This function is only modestly recoverable with the proposed wetland and riparian ecosystem restoration.

2. Biogeochemical Functions

Cycling of Elements & Compounds. Cycling of Elements & Compounds is defined as *the short- and long-term transformation of elements and compounds through abiotic and biotic processes that convert chemical species (e.g., nutrients and metals) from one form, or valence, to another.*

The Project Site is not functioning at a high level in its existing conditions because the original slope wetlands and associated hyporheic zone have been filled, drained, and degraded by agricultural activities. However, this function is recoverable with the proposed restoration due to increased microtopographic variation, installation of large wood, and establishment of a diverse native plant community.

Removal of Imported Elements & Compounds. Removal of Imported Elements & Compounds is defined as *the removal of imported nutrients, contaminants, and other elements and compounds in surface and groundwater.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled and degraded as a result of agriculture and road building activities. This function is recoverable with the proposed restoration.

Retention and Detention of Particulates. Retention and Detention of Particulates is defined as *the deposition and retention of inorganic and organic particulates (>0.45μm) from the water column, primarily through physical processes.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled, degraded, and invaded by a large number of non-native species as a result of agriculture and road building activities. This function is recoverable with the proposed restoration.

Organic Matter Export. Organic Matter Export is defined as *the export of dissolved and particulate organic carbon from a wetland.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled and degraded as a result of agriculture and road building activities. This function is recoverable with the proposed restoration.

3. Plant Functions

Characteristic Native Plant Communities. Characteristic Plant Communities is defined as *the physical characteristics and ecological processes that maintain the indigenous living plant biomass.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled, degraded, and invaded by a large number of non-native species as a result of agriculture and road building activities. This function is recoverable with the proposed restoration. The Project Site should be expected to achieve a reference condition after a period of time that exceeds the expected five-year monitoring program.

Characteristic Detrital Biomass. Characteristic Detrital Biomass is defined as *the process of production, accumulation, and dispersal of dead plant biomass of all sizes.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled, degraded, and invaded by a large number of non-native species as a result of agriculture and road building activities. This function is recoverable with the proposed restoration and will likely achieve reference standard functioning after ten years or more, i.e., after the conclusion of the anticipated five-year monitoring program.

4. Faunal Support Habitat Functions

Spatial Structure of Habitat. Spatial Structure of Habitat is defined as *the capacity of waters/ wetlands to support animal populations and guilds through the heterogeneity of structure of vegetative communities.*

The Project Site currently is functioning at a low level because the original riparian zone has been leveled, degraded, and invaded by a large number of non-native species as a result of agriculture and road building activities. This function is recoverable with the proposed restoration and will likely achieve reference standard functioning after ten years or more, *i.e.*, after the conclusion of the anticipated five-year monitoring program.

Habitat Interspersion & Connectivity. Habitat Interspersion & Connectivity is defined as *the capacity of waters/wetlands to permit aquatic, semi-aquatic, and terrestrial organisms to enter and leave a riverine ecosystem via large, contiguous plant communities to meet life history requirements.*

The Project Site currently is functioning at a low level because the original characteristic physical complexity of an associated riparian community is not present nor is it juxtaposed in a mosaic of coastal scrub, sage scrub, perennial grasslands, vernal swales, and depressions characteristic of the central Coast Ranges. This function is recoverable with the proposed restoration, and possible reference standard functioning after ten years or more, largely through the restoration of the riverine vegetative structure and adjacent plant communities.

Distribution & Abundance of Vertebrates. Distribution & Abundance of Vertebrates is defined as *the capacity of waters/wetlands to maintain characteristic density and spatial distribution of vertebrates (aquatic, semi-aquatic and terrestrial).*

The Project Site currently is functioning at a low level because the original characteristic physical complexity of an associated riparian community is not present nor is it juxtaposed in a mosaic of perennial grasslands, vernal swales and depressions characteristic of the central Coast Ranges. This function is recoverable with the proposed restoration, and possible reference standard functioning after ten years or more, largely through the restoration of the wetland and riparian vegetative structure and adjacent plant communities.

Distribution & Abundance of Invertebrates. Distribution & Abundance of Invertebrates is defined as *the capacity of waters/ wetlands to maintain the density and spatial distribution of invertebrates (aquatic, semi-aquatic and terrestrial).*

The Project Site currently is functioning at a low level because the original characteristic physical complexity of an associated riparian community is not present nor is it juxtaposed in a mosaic of coastal scrub, sage scrub, perennial grasslands, vernal swales and depressions characteristic of the central Coast Ranges. This function is recoverable with the proposed restoration, and possible reference standard functioning after ten years or more, largely through the restoration of the wetland and riparian vegetative structure and adjacent plant communities.

VII. BEST MANAGEMENT PRACTICES FOR STORMWATER TREATMENT

San Mateo County (County) has established best management procedures for the treatment of storm water because federal and state laws require municipalities to reduce pollution to waters of the United States by storm waters. According to the San Mateo County's website (http://www.flowstobay.org/p2business/bestmanagementpractices.html), cities within the County are governed under the *San Mateo Countywide Water Pollution Prevent Program* as part of the City/County Associate of Governments of San Mateo County. As such, the County has published procedures, guidelines, *etc.* to reduce and prevent pollution to the adjacent waters. The storm water treatment system proposed for the Big Wave Project incorporates the County's overall approach and practices for storm water management.

Design features for storm water pollution prevention by the Project include separate storm water retention and detention ponds for relatively dirty storm water (*e.g.*, water from parking lots) and relatively clean water (*e.g.*, roof water runoff). Separate water delivery systems for clean and dirty storm water will be constructed at each of the developments (*i.e.*, office park and wellness center). Comparatively dirty storm water will be filtered through a series of grit removal, oil/water separators, and then directed to a retention/detention "rain gardens" (Figures 8 and 9) within the riparian restoration zone. Stormwater will flow through a swale prior to overland flow into the existing wetlands. Similarly, clean storm water will be directed to a separate series of retention/detention microdepressions (rain gardens) via a similar storm water swales (Figure 10). A portion of the clean storm water will be directed to an infiltration basin (one at each development) to recharge ground water. In short, the bioswale/microdepression system will serve to improve water quality in the adjacent existing waters/wetlands ecosystems by treating storm water in a series of treatments as described above.

VIII. CONCLUSIONS

As presented in this *90% Design Report*, the Big Wave Wellness Center and Office Park Project consists of the construction of a residential village and an adjacent commercial property/office park complex. The proposed wetland and riparian ecosystem restoration project also includes restoration of the waters of the U.S., including wetlands, California Coastal Commission wetlands that currently exist as agricultural land. Specifically the Project will restore a complex mosaic within a 100 ft buffer adjacent to existing federal and state waters/wetlands to provide significant benefits to waters/wetlands ecosystem functions, particularly the native plant and animal communities relative to existing conditions. A total of ten plant community types, primarily native forest, scrub shrub, and perennial sedge/rush meadows, composed over approximately 75 native plant species arrayed in 54 planting polygons represent the riparian/wetland ecosystem restoration design. Of particular importance is the restoration of potential breeding habitat for the California red-legged frog, and potential foraging habitat for the San Francisco garter snake, two native vertebrates not known to utilize the Project Site, but which may be able to establish viable populations as a result of the restoration effort.

If implemented as designed, the riparian/wetland ecosystem will result an increase in the hydrologic, biogeochemical, native plant community, and faunal support/habitat functions of the currently farmed wetlands. Equally importantly, the project represents a state-of-the art integration of the natural and built environments through the restoration of the immediate landscape immediately surrounding the Office Park and Wellness Center, and through the utilization of native species for landscaping, locally adapted plant stock, and propagules obtained from the Project Site and adjacent landscape.

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X. FIGURES

Figure 1. The Project Site is located along the central coast of California south of San Francisco and east of the city of Santa Cruz (Map Reference: http://cwp.resources.ca.gov)

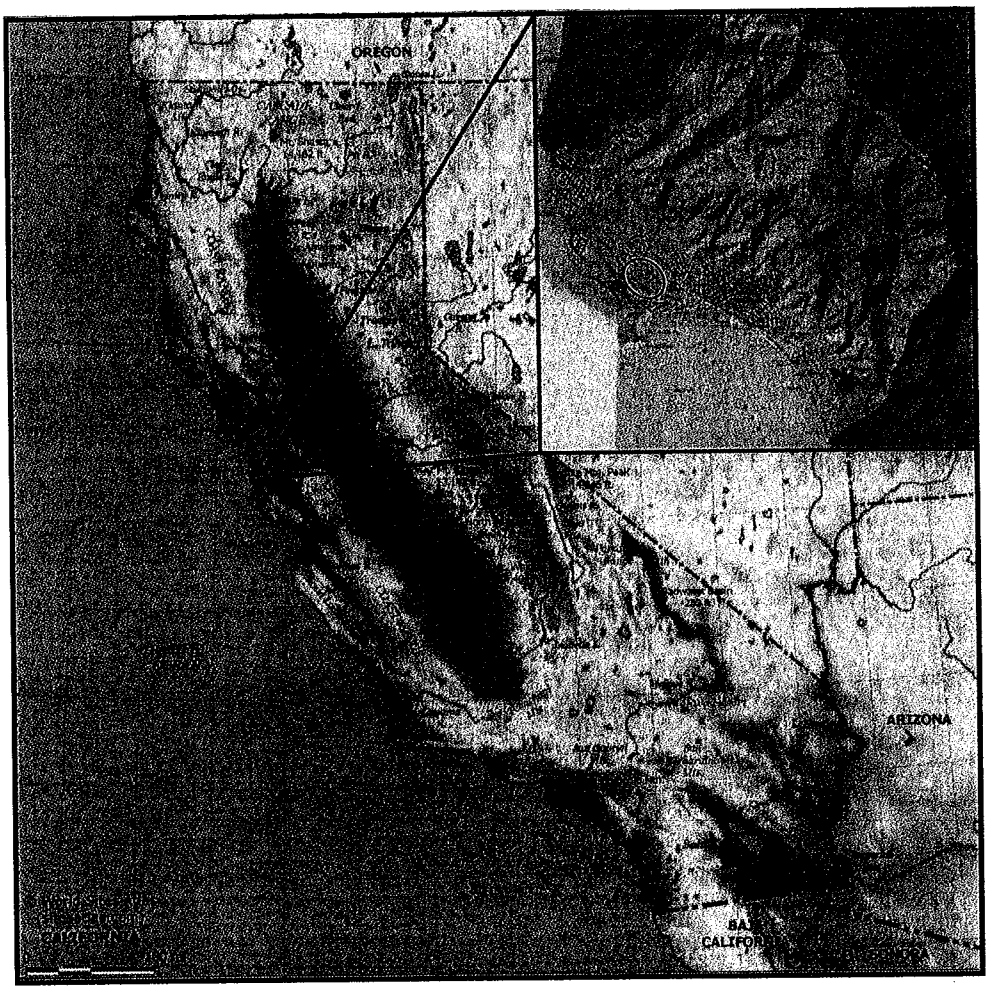
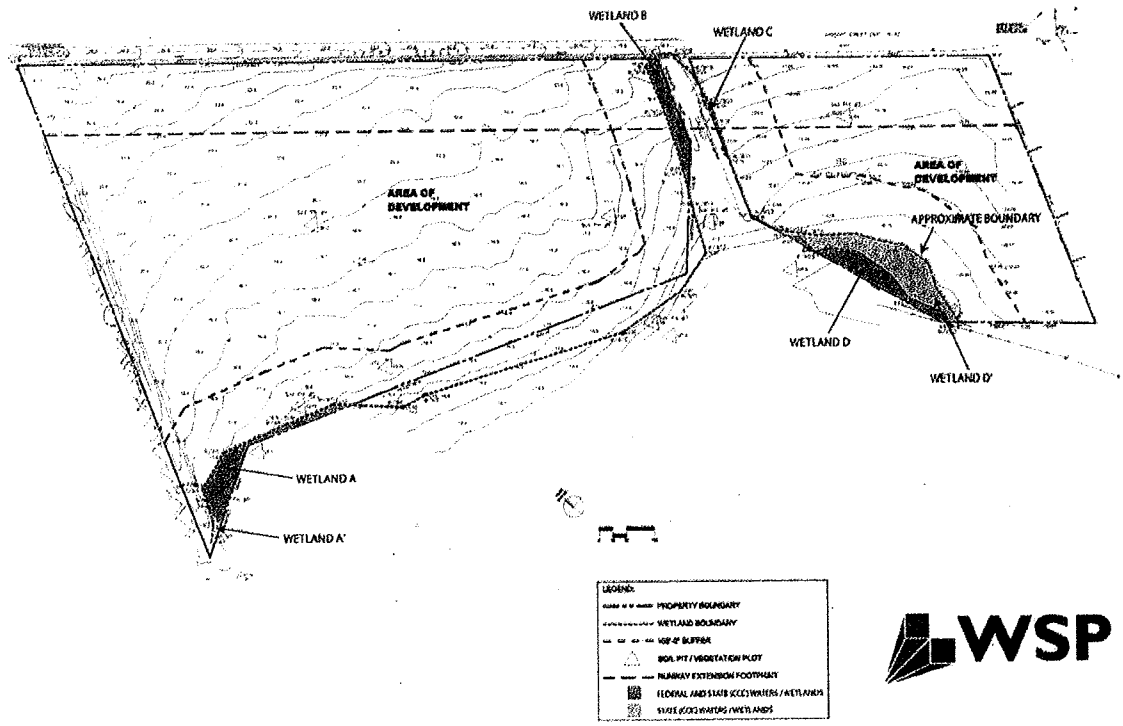
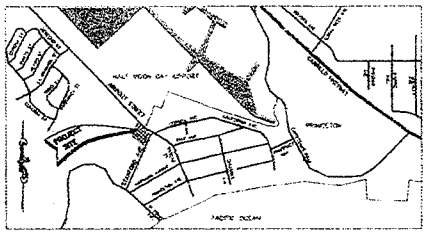


Figure 2. Approximate location of the Big Wave Project Site in unincorporated San Mateo County, California.



Figure 3. Geographic extent of waters of the U.S., including wetlands consistent with definitions provided at 33 CFR 328.3(a)(1-8), and of wetlands as defined by the California Coastal Act (Public Resources Code Division 20 California Coastal Act Section 30121).





LOCATION MAP

SCALE: NOT TO SCALE

UTILITY NOTE:

THE UTILITIES EXISTING ON THE SURFACE AND SHOWN ON THIS DRAWING HAVE BEEN LOCATED BY FIELD SURVEY. ALL UNDERGROUND UTILITIES SHOWN ON THIS DRAWING ARE FROM RECORDS OF THE VARIOUS UTILITY COMPANIES AND THE SURVEYOR-ENGINEER DOES NOT ASSUME RESPONSIBILITY FOR THE WORK LOCATIONS, SHOWN TO BE IN ON OR SELL RECORD UTILITY LOCATION SHOULD BE DEEMED TO EXPONSE THE UTILITY

GENERAL NOTES:

1. ELEVATIONS AND LOCATIONS OF ALL UTILITY CROSSINGS SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO THE START OF ANY CONSTRUCTION AFFECTING SAID LINES. CONTACT USA AT (800) 642-2444 AT LEAST TWO WORKING DAYS PRIOR TO EXCAVATION.
2. ALL APPLICABLE WORK SHALL BE DONE IN ACCORDANCE WITH THE COUNTY OF SAN MATEO STANDARD TECHNICAL SPECIFICATIONS AND DETAILS PREPARED IN THE OFFICE OF THE ENGINEERING DIVISION, INCLUDING MODIFICATIONS CONTAINED HEREIN.
3. THE CONTRACTOR SHALL RESTORE ALL DAMAGED, REMOVED OR OTHERWISE DISTURBED WALLS, FENCES, STRUCTURES, UTILITIES, IMPROVEMENTS OR FEATURES OF WHATEVER NATURE, DUE TO CONTRACTOR'S WORK.
4. THE CONTRACTOR SHALL COORDINATE HIS WORK WITH THE INSTALLATION OF FACILITIES BY PG&E, PACIFIC BELL AND CABLE TV INSTALLATION. VALVE BOXES AND STRUCTURES TO BE SET TO GRADE IN CONCRETE AFTER PAVING.
5. THE CONTRACTOR SHALL GIVE THE COUNTY AT LEAST TWO WORKING DAYS ADVANCE NOTICE FOR INSPECTION (650) 363 – 4100.
6. FOR LANE CLOSURES, THE CONTRACTOR SHALL PREPARE A TRAFFIC CONTROL PLAN AND SHALL OBTAIN APPROVAL FROM THE COUNTY BEFORE COMMENCING WORK. THE CONTRACTOR SHALL PROVIDE FLAGMEN, CONES AND BARRICADES, AS NECESSARY TO CONTROL TRAFFIC AND PREVENT HAZARDOUS CONDITIONS.
7. PEDESTRIAN PUBLIC ACCESS(S) SHALL BE MAINTAINED DURING THE CONSTRUCTION TO THE SATISFACTION OF THE COUNTY.
8. NO TRENCHES OR HOLES SHALL BE LEFT OPEN OVERNIGHT. USE STEEL PLATING OR HOT MIX ASPHALT AS REQUIRED TO PROTECT OPEN TRENCHES OVERNIGHT.
9. THE CONTRACTOR SHALL CONTROL DUST AT ALL TIMES AND SWEEP STREETS AS OFTEN AS NECESSARY DURING CONSTRUCTION AS REQUIRED BY THE CITY/COUNTY.
10. THE GEOTECHNICAL REPORT PREPARED BY BAY AREA GEOTECHNICAL GROUP, PROJECT NO. HOCH-01-02, DATED JUNE 12, 2002 SHALL BE MADE A PART OF THIS PLAN.

WETLAND / RIPARIAN PLANTING PLAN

UP I	Upland I - Coastal Scrub (54)	PE II	Palustrine Emergent II - Rush Meadow (34, 42)
PF I	Palustrine Forest I - Arroyo Willow Riparian Forest (25, 32, 51)	PE III	Palustrine Emergent III - Rain Garden (27, 36, 45)
PF II	Palustrine Forest II - Live Oak Riparian Forest (36, 40, 47, 53)	SWS	Stormwater Swale
PF III	Palustrine Forest III - Rain Garden (31, 46)		Western Sycamore
PSS I	Palustrine Scrub Shrub I - Mixed Willow Scrub Shrub (37, 39, 45, 48, 52)		Windthrow
PSS II	Palustrine Scrub Shrub II - Arroyo Willow Scrub Shrub (26, 29, 35, 41, 50)	14	Planting Polygon
PE I	Palustrine Emergent I - Sedge Meadow (30, 33, 43)		

LANDSCAPING PLAN

	Live Oak
	Madrone
	California Buckeye
	Big Leaf Maple
	Red Alder / Leopard Rush / Santa Barbara Sedge / Lily Perimeter Alley



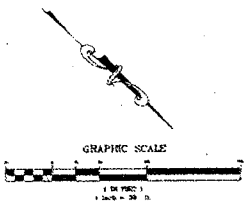


FIGURE 4

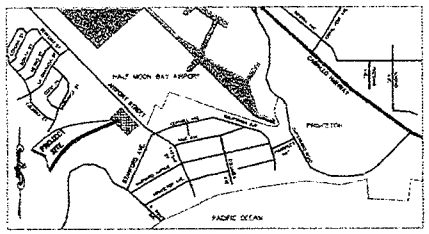
RUGLEOD AND ASSOCIATES
CIVIL ENGINEERING · LAND SURVEYING
835 CENTER STREET · SAN CARLOS · CA 94070 · (650) 593-8586

WSP

PREPARED FOR:
BIG WAVE, LLC

DRAFT PLANTING PLAN
BOWMAN WELLNESS CENTER
PILLAR POINT BLUFFS
SAN MATEO COUNTY, CALIFORNIA

DRAWN BY: KLR
DESIGNED BY: KRG
CHECKED BY: DMR
SCALE: 1" = 30'
DATE:
DRAWING NO: 1584-00
SHEET: P-2



LOCATION MAP
NOT TO SCALE

GENERAL NOTES:

1. ELEVATIONS AND LOCATIONS OF ALL UTILITY CROSSINGS SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO THE START OF ANY CONSTRUCTION AFFECTING SAID LINES. CONTACT USA AT (800) 642-2444 AT LEAST TWO WORKING DAYS PRIOR TO EXCAVATION.
2. ALL APPLICABLE WORK SHALL BE DONE IN ACCORDANCE WITH THE COUNTY OF SAN MATEO STANDARD TECHNICAL SPECIFICATIONS AND DETAILS, DATED MAY 1991 IN THE OFFICE OF THE ENGINEERING DIVISION, INCLUDING MODIFICATIONS CONTAINED HEREIN.
3. THE CONTRACTOR SHALL RESTORE ALL DAMAGED, REMOVED OR OTHERWISE DISTURBED WALLS, FENCES, SURFACES, UTILITIES, IMPROVEMENTS OR FEATURES OF WHATEVER NATURE DUE TO CONTRACTORS WORK.
4. THE CONTRACTOR SHALL COORDINATE HIS WORK WITH THE INSTALLATION OF FACILITIES BY PG&E, PACIFIC BELL AND CABLE TV INSTALLATION. VALVE BOXES AND STRUCTURES TO BE SET TO GRADE IN CONCRETE AFTER PAVING.
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9. THE CONTRACTOR SHALL CONTROL DUST AT ALL TIMES AND SWEEP STREETS AS OFTEN AS NECESSARY DURING CONSTRUCTION AS REQUIRED BY THE COUNTY ENGINEER.
10. THE GEOTECHNICAL REPORT PREPARED BY BAY AREA GEOTECHNICAL GROUP, PROJECT NO. SIGRA-01-03, DATED MAY 7, 2003 SHALL BE MADE A PART OF THIS PLAN.

UTILITY NOTE:

THE UTILITIES EXISTING ON THE SURFACE AND SHOWN ON THIS DRAWING HAVE BEEN LOCATED BY FIELD SURVEY. ALL UNDERGROUND UTILITIES SHOWN ON THIS DRAWING ARE FROM RECORDS OF THE VARIOUS UTILITY COMPANIES AND THE SURVEYOR/ENGINEER DOES NOT ASSUME RESPONSIBILITY FOR THE THEIR COMPLETENESS, NOR DOES LOCATION OF SAID RECORD UTILITY LOCATION SHOULD BE CONFIRMED BY EXPOSING THE UTILITY.

WETLAND / RIPARIAN PLANTING PLAN

UP I	Upland I - Coastal Scrub (17)	PE II	Palustrine Emergent II - Rush Meadow (3, 5, 6)
PF I	Palustrine Forest I - Arroyo Willow Riparian Forest (1, 15)	PE III	Palustrine Emergent III - Rain Garden (21, 22, 24, 25)
PF II	Palustrine Forest II - Live Oak Riparian Forest (8, 11, 14)	SWS	Stormwater Swale (18, 20, 23)
PF III	Palustrine Forest III - Rain Garden (18)		Western Sycamore
PSS I	Palustrine Scrub Shrub I - Mixed Willow Scrub Shrub (2, 7, 13)		Wingstem
PSS II	Palustrine Scrub Shrub II - Arroyo Willow Scrub Shrub (10, 12)	14	Planting Polygon
PE I	Palustrine Emergent I - Sedge Meadow (4, 9, 16)		

LANDSCAPING PLAN

	Live Oak
	Madrone
	California Buckeye
	Big Leaf Maple
	Red Alder / Leopard Rush - Santa Barbara Sedge / Lily Pasmelear Alley

GRAPHIC SCALE

FIGURE 5

DRAFT PLANTING PLAN
HIGHWAY 1/FOSTER PARK
FOSTER STREET
SAN MATEO COUNTY

PREPARED FOR:
BIG WAVE LLC

WSP
WSP USA ENVIRONMENT & INFRASTRUCTURE INC.
ENVIRONMENTAL SERVICES
SOLUTIONS FOR ENERGY, INDUSTRY & INFRASTRUCTURE
617 FRANKLIN STREET SUITE 300, OAKLAND, CA 94607 (510) 893-3600

MACRO AND ASSOCIATES
CIVIL ENGINEERING LAND SURVEYING
950 CENTER STREET - SAN CARLOS, CA 94070 - (650) 593-8582

DRAWN BY	MM
DESIGNED BY	MPS
CHECKED BY	DSH
SCALE	1"=40'
DATE	07/2004
DRAWING NO.	1008-00
SHEET	P-1

Upland I - Coastal Scrub Polygons #17, 54

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Unit Total
Shrubs and Vines					
Baccharis pilularis	70	25	11293.39	0.26	29
Ceanothus gloriosus var. gloriosus	27	40	11293.39	0.26	7
Ceanothus thyrsiflorus	222	14	11293.39	0.26	58
Eriophyllum staechadifolium	460	10	11293.39	0.26	119
Lupinus variicolor	222	14	11293.39	0.26	58
Marah fabaceus	27	40	11293.39	0.26	7
Mimulus aurantiacus	426	10	11293.39	0.26	111
Rosa californica	184	15	11293.39	0.26	48
Ribes sanguineum var. glutinosum	70	25	11293.39	0.26	18
Symphoricarpos mollis	38	30	11293.39	0.26	10
Grasslands					
Bromus carinatus	10	65	11293.39	0.26	3
Chlorogalum pomeridianum var. pomeridianum	9	70	11293.39	0.26	2
Iris douglasiana	34	34 ft. clumped	11293.39	0.26	9
Lotus pictus	49	30	11293.39	0.26	12
Forbs					
Aster chilensis	34	34 ft. clumped	11293.39	0.26	9
Scrophularia californica	70	25	11293.39	0.26	18
Eriogonum gloriosus	426	10	11293.39	0.26	111
Horkelia californica var. californica	426	10	11293.39	0.26	111
Lotus formosissimus	70	25	11293.39	0.26	18
Potentilla glandulosa ssp. glandulosa	426	10	11293.39	0.26	111
Ferns and Fern Allies					
Polystichum munitum	18	50	11293.39	0.26	72

Palustrine Scrub-Shrub I - Mixed Willow Scrub-Shrub Polygons #2, 7, 13, 37, 39, 44, 46, 48, 52

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Shrubs and Vines					
Salix lasiolepis	430	10 ft. clumped	55090.47	1.26	541
Salix nigra	430	10 ft. clumped	55090.47	1.26	541
Artemisia douglasiana	894	7'	55090.47	1.26	1125
Clematis lasiantha	70	25	55090.47	1.26	88
Lonicera involucrata var. ledebourii	232	14	55090.47	1.26	293
Marah fabaceus	56	28	55090.47	1.26	71
Ribes sanguineum var. glutinosum	70	25	55090.47	1.26	88
Sambucus racemosa var. racemosa	49	30	55090.47	1.26	61
Grasslands					
Iris douglasiana	34	34 ft. clumped	55090.47	1.26	43
Lotus pictus	49	30	55090.47	1.26	61
Forbs					
Aster chilensis	34	34 ft. clumped	55090.47	1.26	43
Chlorogalum pomeridianum var. pomeridianum	64	30	55090.47	1.26	81
Horkelia californica	64	30	55090.47	1.26	81
Scrophularia californica	70	25	55090.47	1.26	89
Ferns and Fern Allies					
Polystichum munitum	43	32	55090.47	1.26	55

Palustrine Scrub-Shrub II - Arroyo Willow Scrub-Shrub Polygons #10, 11, 26, 29, 35, 41, 42 43, 36, 29, 35, 41, 50

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Shrubs and Vines					
Salix lasiolepis	430	10 ft clumped	52417.79	1.20	515
Clematis lasiantha	109	20	52417.79	1.20	131
Lonicera involucrata var. ledebourii	194	15	52417.79	1.20	233
Marah fabaceus	56	28	52417.79	1.20	67
Ribes sanguineum var. glutinosum	70	25	52417.79	1.20	84
Sambucus racemosa var. racemosa	46	30	52417.79	1.20	56
Grasslands					
Iris douglasiana	34	34 ft. clumped	52417.79	1.20	41
Lotus pictus	49	30	52417.79	1.20	58
Elymus multisetis	9	70	52417.79	1.20	11
Forbs					
Aster chilensis	34	34 ft. clumped	52417.79	1.20	41
Scrophularia californica	109	20	52417.79	1.20	131
Ferns and Fern Allies					
Polystichum munitum	49	30	52417.79	1.20	58

Palustrine Forest I - Arroyo Willow Riparian Forest Polygons #2, 14, 28, 32, 34

Species	per acre	Spacing (ft)	Area (sq ft)	Area (acres)	Total
Trees					
Alnus rhombifolia	436	10 ft clumped	44537.21	1.02	446
Salix lasiolepis var. lasiolepis	663	8 ft clumped	44537.21	1.02	678
Shrubs and Vines					
Cornus sericea ssp. sericea	681	8	44537.21	1.02	696
Lonicera hispidula var. ledebourii	30	60	44537.21	1.02	31
Marah fabaceus	5	90	44537.21	1.02	5
Ribes sanguineum var. glutinosum	9	70 ft. clumped	44537.21	1.02	9
Salix lasiolepis	325	12 ft clumped	44537.21	1.02	320
Salix sitchensis	325	12 ft clumped	44537.21	1.02	320
Sambucus racemosa var. racemosa	1	90	44537.21	1.02	1
Grasslands					
Carex divulsa	232	14	44537.21	1.02	237
Lotus pictus	194	15	44537.21	1.02	198
Sorghum halepense	858	20 ft. clumped	44537.21	1.02	466
Herbs					
Aristolochia californica	10	65	44537.21	1.02	10
Aster chilensis	24	45 ft. clumped	44537.21	1.02	25
Calliarrhoe involucrata	39	60	44537.21	1.02	40
Convolvulus arvensis	430	10	44537.21	1.02	440
Scrophularia californica	45	30	44537.21	1.02	46
Stachys ajugoides var. ajugoides	76	24	44537.21	1.02	78
Ferns, horse, and fern Allies					
Polystichum munitum	30	55	44537.21	1.02	60

Palustrine Forest II - Live Oak Riparian Forest Polygons #4, 31, 33, 36, 40, 47, 53

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Trees					
Aesculus californica	9	65 ft clumped	33634.33	0.77	6
Quercus agrifolia	194	33 ft clumped	33634.33	0.77	150
Shrubs and Vines					
Heteromeles arbutifolia	23	42	33634.33	0.77	29
Lonicera involucrata var. ledebourii	99	21	33634.33	0.77	76
Marah fabaceus	12	60	33634.33	0.77	9
Oemleria cerasiformis	40	33	33634.33	0.77	31
Rhamnus californica	30	65	33634.33	0.77	24
Ribes sanguineum var. glutinosum	10	65 ft. clumped	33634.33	0.77	8
Rosa californica	70	25	33634.33	0.77	54
Symphoricarpos mollis	70	25	33634.33	0.77	54
Grasslands					
Bromus carinatus	1210	10	33634.33	0.77	934
Chlorogalum pomeridianum var. dreve	52	53	33634.33	0.77	40
Elymus glaucus	109	20	33634.33	0.77	84
Iris douglasiana	209	23 ft. clumped	33634.33	0.77	84

Palustrine Forest III - Rain Garden Polygons #18, 30, 45

Species	per acre	Spacing (ft)	Area (sq ft)	Area (acres)	Total
Trees & Shrubs					
Salix lasiolepis and laevigata	697	8' ac	4264.56	0.10	65
Shrubs					
Dendrene corneobrevis	76	24 clumped	4264.56	0.10	7
Cornus sericea ssp. sericea	76	24 clumped	4264.56	0.10	7
Grasslands					
Deschampsia cespitosa	1742	5' ac	4264.56	0.10	167
Carex amplifolia	1742	5' ac	4264.56	0.10	167
Carex densa	1742	5' ac	4264.56	0.10	167
Carex obnupta	1742	5' ac	4264.56	0.10	136
Juncus patens	1218	6' clumped	4264.56	0.10	116
Juncus effusus var. brunneus	302	12' clumped	4264.56	0.10	29
Lilium pardalinum	30	36' clumped	4264.56	0.10	3
Leersia oryzoides	1218	6' ac	4264.56	0.10	116
Scirpus microcarpus	1218	6' ac	4264.56	0.10	116
Scirpus validus	1218	6' ac	4264.56	0.10	116
Forbs					
Aruncus californica	303	12' ac	4264.56	0.10	29
Aster chilensis	1218	6' clumped	4264.56	0.10	116
Helenium bigelovii	302	12' clumped	4264.56	0.10	29
Scutellaria californica	1218	6' ac	4264.56	0.10	116
Ferns and Fern Allies					
Polystichum munitum	209	12' clumped	4263.37	0.09	19

Palustrine Emergent I - Sedge Meadow Polygons #6, 9, 16, 20, 23, 45

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Grasslands					
Carex obnupta	2353	5.3	6093.56	0.14	217
Juncus balticus	665	8	6093.56	0.14	93
Juncus effusus var. pacificus	665	8	6093.56	0.14	93
Scirpus microcarpus	1210	6	6093.56	0.14	169
Forbs					
Hydrocotyle prolifera	170	16	6093.56	0.14	24
Oenanthe sarmentosa	709	7.6	6093.56	0.14	99
Sparganium eurycarpum ssp. eurycarpum	109	20	6093.56	0.14	15

Palustrine Emergent II - Rush Meadow Polygons #3, 5, 8, 24, 42

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Grasslands					
Juncus balticus	665	8	7854.63	0.18	120
Juncus effusus var. pacificus	868	7	7854.63	0.18	156
Juncus patens	1210	6	7854.63	0.18	218
Scirpus microcarpus	869		7854.63	0.18	156
Forbs					
Hydrocotyle prolifera	170	16	7854.63	0.18	31
Oenanthe sarmentosa	709	20	7854.63	0.18	128
Potentilla anserina var. pacifica	209	29	7854.63	0.18	38
Mimulus guttatus	70	25	7854.63	0.18	13
Veratrum californicum var. californicum	170	16	7854.63	0.18	31

Palustrine Emergent III - Rain Garden Polygons #21, 22, 24, 25, 27, 36 45

Species	Density (# per acre)	On Center Spacing (ft)	Area (sq ft)	Area (acres)	Total
Grasslands					
Carex densa	2723	4' oc	3094.13	0.14	386
Carex obnupta	2723	4' oc	3094.13	0.14	386
Carex barbarae	2723	4' oc	3094.13	0.14	386
Festuca rubra	2723	4' oc	3094.13	0.14	386
Juncus effusus var. brunneus	1210	6' clumped	3094.13	0.14	171
Lilium pardalinum	302	12' clumped	3094.13	0.14	43
Scirpus microcarpus	1210	6' oc	3094.13	0.14	171
Forbs					
Aster chilensis	302	12' oc	3094.13	0.14	43
Helenium bigelovii	1210	6' clumped	3094.13	0.14	171
Oenanthe sarmentosa	685	8' oc	3094.13	0.14	171
Ferns and Fern Allies					
Polystichum munitum	302	12' clumped	3094.13	0.14	43

Streams and Swales Polygons #19, 20, 23

Species	per acre	Spacing (ft)	Area (sqft)	Area (acres)	Total
Grasslands					
Carex barbarae ssp. barbarae	436	10' clumped	7798.54	0.18	78
Carex densa	4360	3' oc	7798.54	0.18	660
Carex tumulicola	8540	3' oc	7798.54	0.18	660
Deschampsia elongata	1742	5' oc	7798.54	0.18	313
Juncus effusus	2723	4' oc	7798.54	0.18	487
Juncus patens	1232	6' oc	7798.54	0.28	217
Hordeum brachyantherum	2723	4' oc	7798.54	0.28	487
Leersia oryzoides	1742	5' oc	7798.54	0.28	313
Juncus patens	1742	5' oc	7798.54	0.28	313
Juncus phaeocephalus	1232	6' clumped	7798.54	0.28	217
Iris douglasiana Pacific Coast hybrids	436	7' clumped	7798.54	0.18	156
Lilium pardalinum	302	12' clumped	7798.54	0.18	54
Sparganium eurycarpum	436	10' clumped	7798.54	0.18	78
Forbs					
Aster chilensis	849	7' clumped	7798.54	0.18	152
Eumecanthus simplex	na	seed	7798.54	0.28	lbs
Eumecanthus prostratus	na	seed	7798.54	0.28	lbs
Ferns and Fern Allies					
Woodwardia fimbriata	685	8' clumped	7798.54	0.28	122

McLEOD AND ASSOCIATES
CIVIL ENGINEERING · LAND SURVEYING
985 CHIEF STAFF · SAN CARLOS · CA 94070 · (650) 593-8560

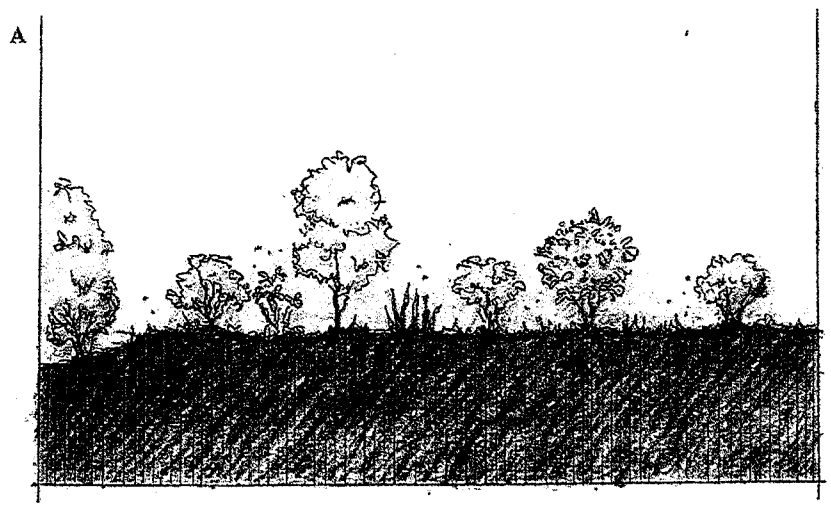
WSP
WSP ENVIRONMENT & ENERGY
ECOLOGISTS, SCIENTISTS, ENGINEERS, PLANNERS & ARCHITECTS
2550 SAND HILL ROAD, MENLO PARK, CA 94025 · TEL: (650) 329-3775

PREPARED FOR
BIG WAVE LLC

DRAFT PLANTING PLAN
BIG WAVE PLANT TAKE OFFS
ABBOTT STREET
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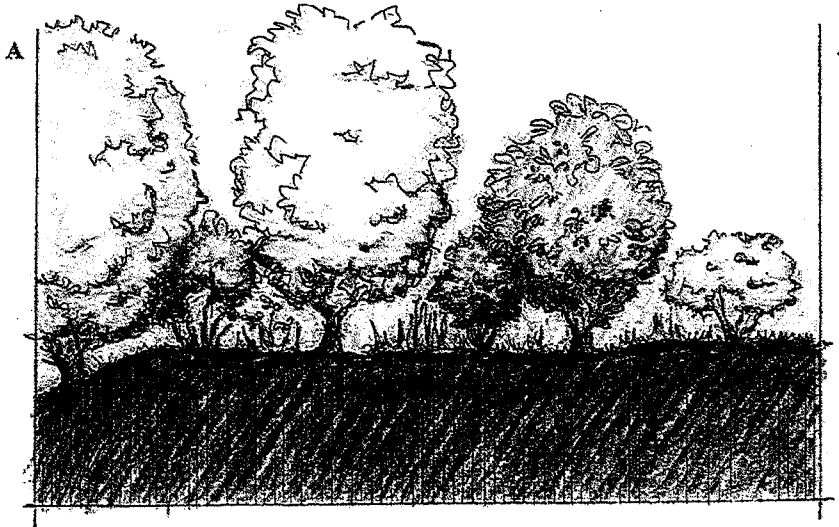
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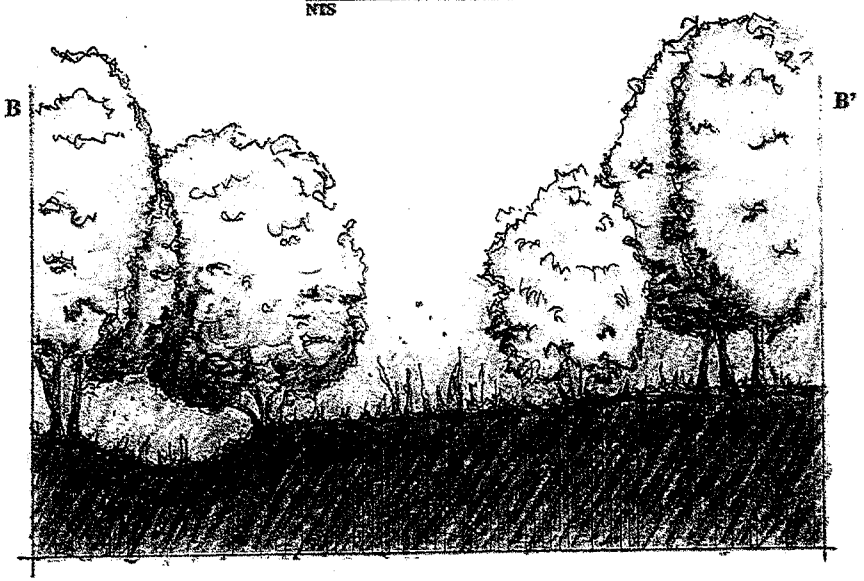
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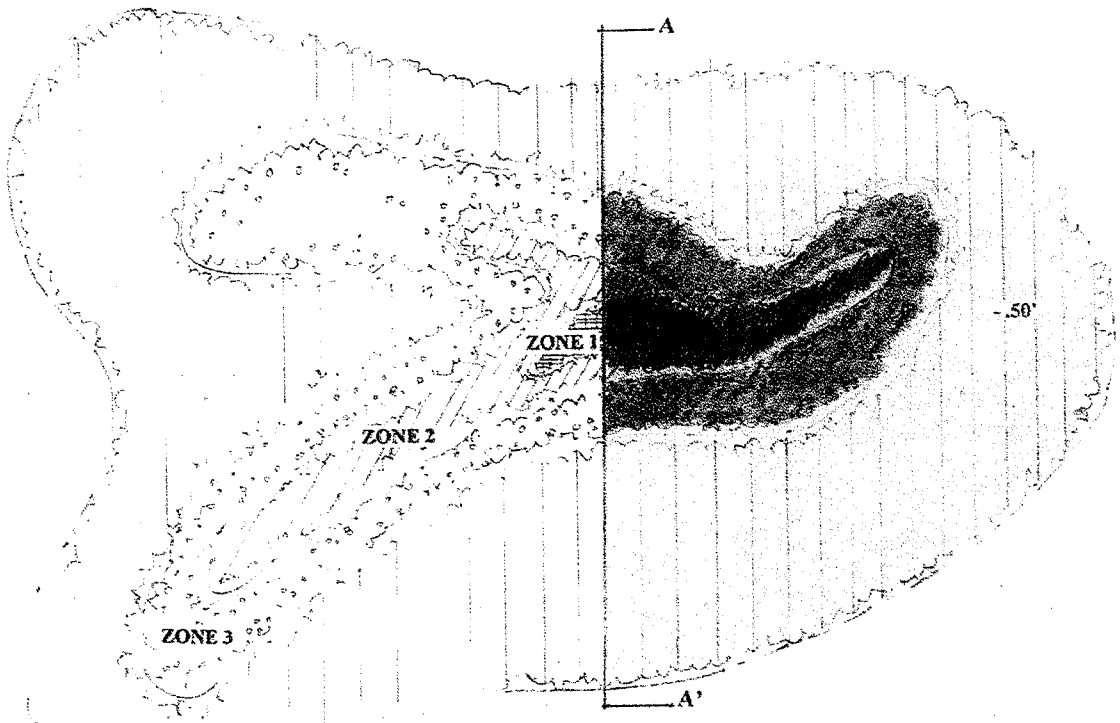
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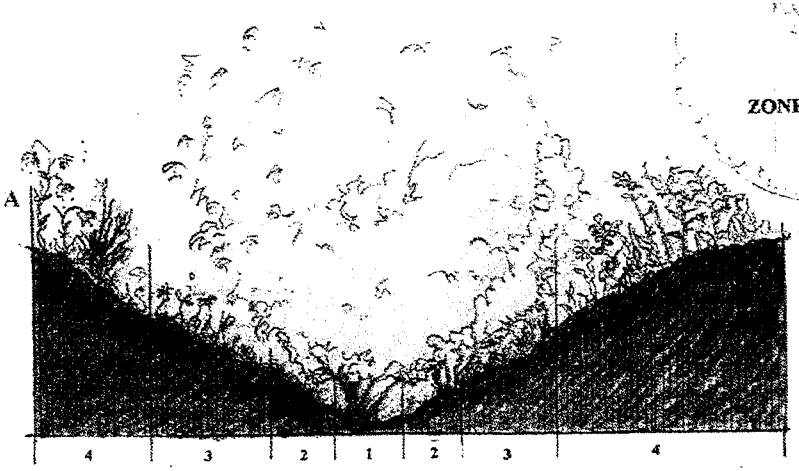
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FIGURE 7



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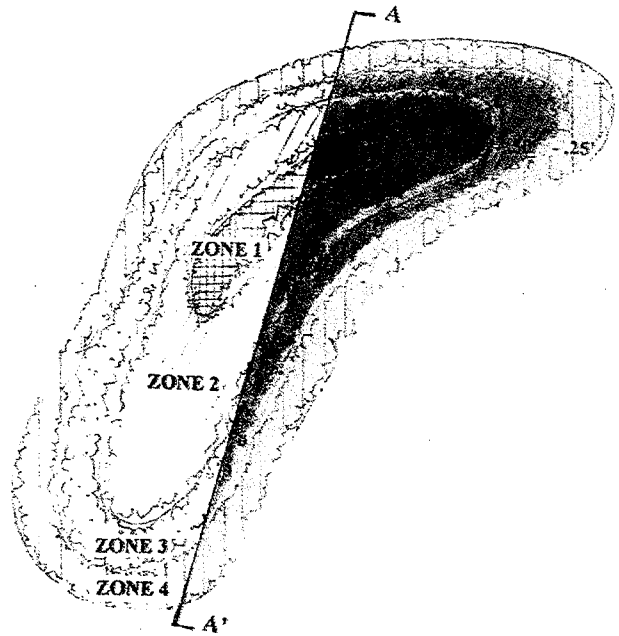
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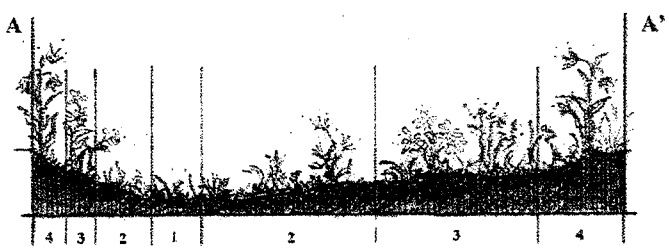
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FIGURE 8



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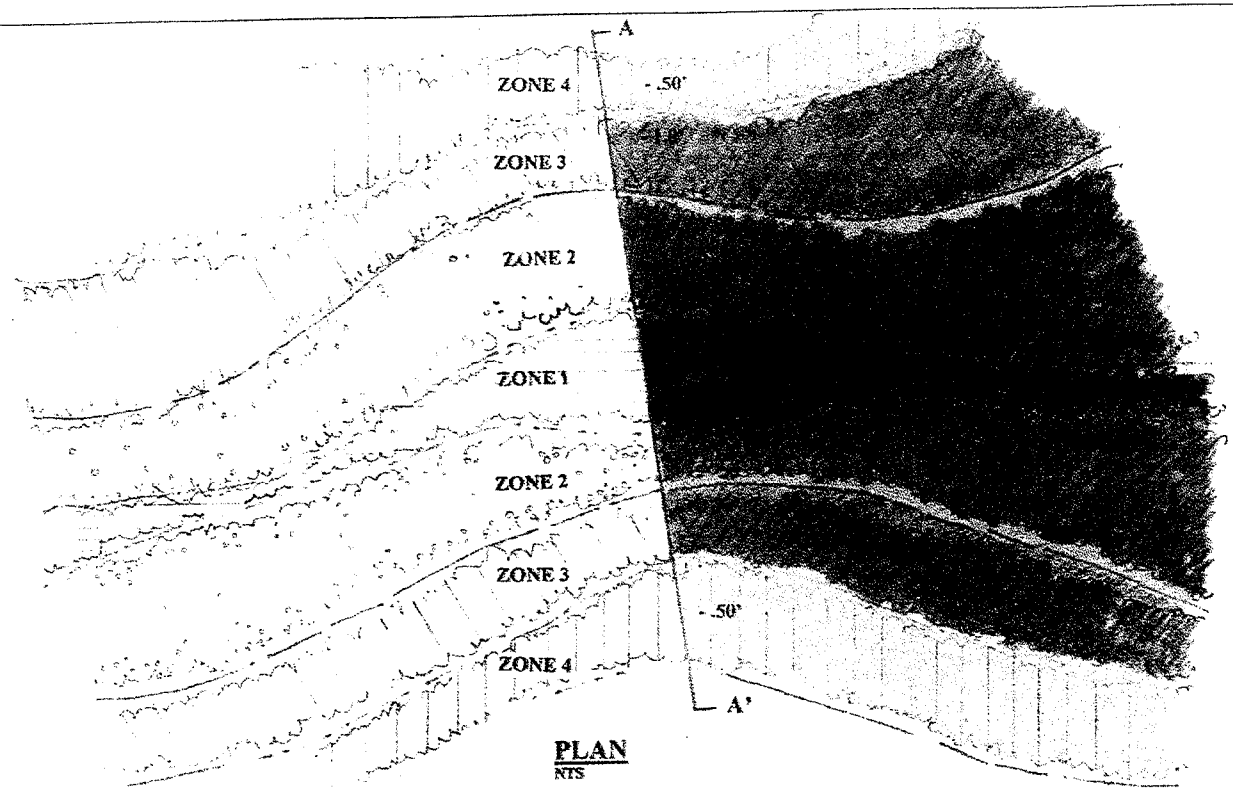
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SHEET TITLE:
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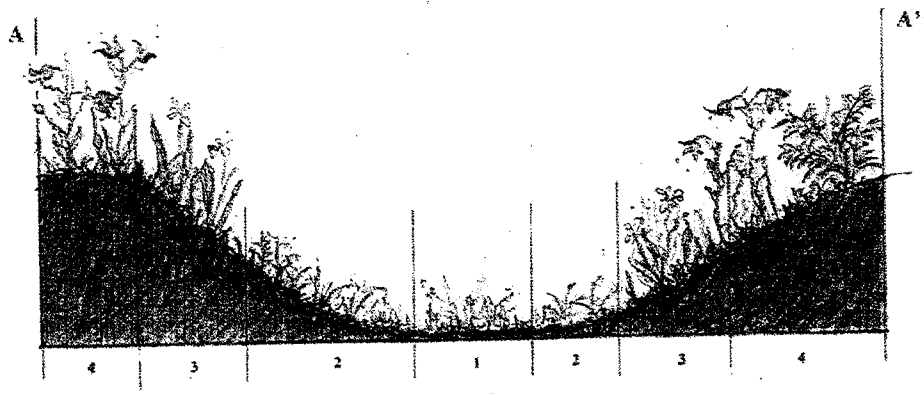
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FIGURE 9



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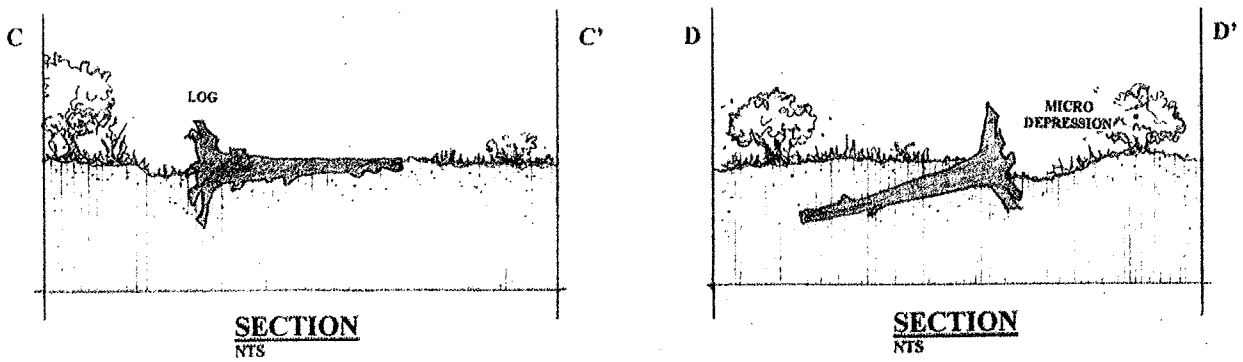
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Stormwater Swales

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FIGURE 10

Figure 11. Typicals for installation of above and below ground wood.



APPENDIX D

ATTACHMENTS TO COMMENT LETTER 205 FROM SHUTE, MIHALY & WEINBERGER, LLP., WINTER KING, DATED DECEMBER 23, 2009



Wildlife Hazard Management at Airports

A Manual for Airport Personnel



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Second Edition, July 2005

The Federal Aviation Administration, in cooperation with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, produced the second edition of this manual. The first edition was published December 1999.

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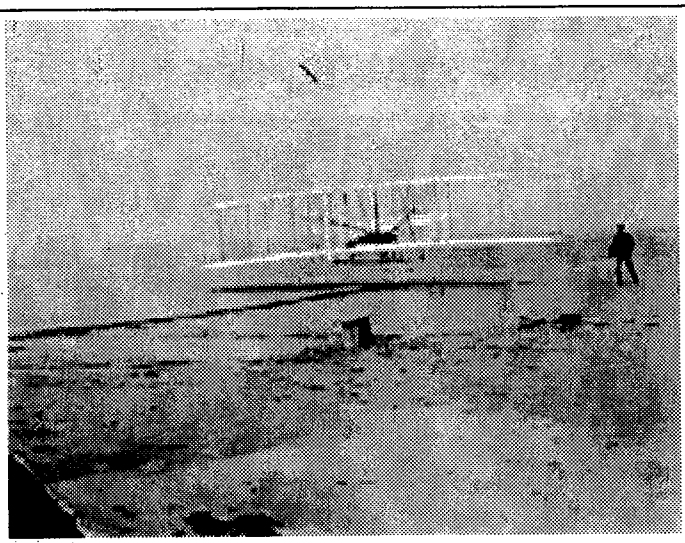
CHAPTER 1:
INTRODUCTION TO THE WILDLIFE STRIKE PROBLEM



Birds and aircraft are increasingly competing for airspace in crowded skies, as demonstrated over the threshold of runway 31R at Ferihegy Airport, Budapest, Hungary, 15 June 2004 (photo © Adam Samu, used with permission).

Throughout history, humans have been intrigued and inspired by the beauty of birds and their ability to fly. Birds first took to the air about 150 million years ago. Humans first began to share their airspace only 100 years ago. Unfortunately, when aircraft and birds attempt to use the same airspace at the same time, collisions occur.

Birds are not the only wildlife problem for aircraft. Deer, coyotes, and even alligators wandering onto runways can create serious problems for departing and landing aircraft. Aircraft collisions with wildlife, also commonly referred to as wildlife strikes, annually cost the civil aviation industry in the USA at least $500 million in direct damage and associated costs and over 500,000 hours of aircraft down time. Although the economic costs of wildlife strikes are extreme, the cost in human lives lost when aircraft crash as a result of strikes best illustrates the need for management of the wildlife strike problem. This manual is designed to inform airport personnel about the scope of the wildlife strike problem and to serve as a ready reference on legal authority, regulations, and the development, implementation, and evaluation of Wildlife Hazard Management Plans for airports.



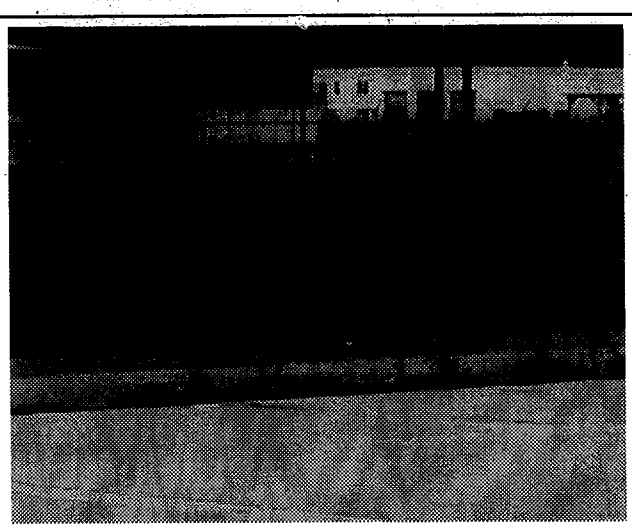
Oliver Wright recorded the first bird strike in 1905 in Ohio, less than 2 years after the Wright Brothers' first powered flight.

The first powered flight by the Wright Brothers occurred in December 1903, and the wildlife strike problem began shortly thereafter. On 7 September 1905, the first reported bird strike, as recorded by Oliver Wright in his diary, occurred when his aircraft hit a bird (probably a red-winged blackbird) as he flew over a cornfield near Dayton Ohio. The first reported mammal strike occurred on 25 July 1909 at the start of Louis Bleriot's historic first flight across the English Channel from Les Baraques, France. During engine warm-up of his Bleriot XI aircraft, a farm dog ran into the propeller. On 3 April 1912 Calbraith Rodgers, the first person to fly across the continental USA, was also the first to die as a result of a wildlife strike when his aircraft struck a gull along the coast of Southern California. Since those first wildlife strikes, aircraft designs and performance have changed radically, and wildlife populations and air traffic have increased. As a result, at least 122 civil aircraft have been destroyed and over 255 civilian lives have been lost worldwide due to wildlife strikes from 1960 to 2004. During this same period, wildlife strikes have resulted in at least 333 military aircraft destroyed and over 150 military personnel killed.

The onset of the jet age revolutionized air travel, but magnified the wildlife strike problem. Early piston-powered aircraft were noisy and relatively slow. Wildlife could usually avoid these aircraft, and strikes that did occur typically resulted in little or no damage. However, modern jet aircraft are fast and relatively quiet, and their engine fan blades are often more vulnerable than propellers to wildlife-strike damage. When turbine-powered aircraft collide with birds or other wildlife, serious structural damage and engine failure can occur. Multiple-engine damage from the ingestion of flocks of birds is of particular concern as the fleet of two-engine passenger aircraft increases in the USA. In 1969, 75% of the 2,100 passenger aircraft had 3 or 4 engines. In 1998, the fleet had grown to 5,400 primarily turbine-powered aircraft, of which only 30% had three or four engines. By 2008, the fleet will consist of about 7,000 aircraft, and less than 10% will have three or four engines.

Air travel has become commonplace in the USA. Aircraft have also assumed a vital role in tactical and logistical military operations. These factors have resulted in increased air traffic. For example, commercial air movements in the USA increased about 3% per year between 1985 and 2004. Coincidentally, human use of the skies has increased during an extremely successful period of wildlife management in North America. Aggressive natural resource and environmental protection programs by public and private wildlife management groups have contributed to impressive increases in

populations of many large-bodied species such as alligators, cormorants, cranes, deer, geese, gulls, herons, pelicans, raptors (falcons, hawks, eagles, and owls), vultures, and wild turkeys. At the same time, many of these species (e.g., Canada geese, coyotes, deer, and turkeys), have expanded into suburban and urban areas, including airports, and are thriving in response to protection and changes to habitats in these areas. Almost all of these species have body masses over 4 pounds (1.8 kg), which exceed the airframe and engine certification standards for wildlife strikes. These concurrent increases in air traffic and wildlife populations contribute to an increased probability of damaging wildlife strikes. These two factors, combined with the increased speed, quietness, and vulnerability of modern aircraft, interact to form the basis of the wildlife strike problem that airport managers face. As a final factor, airport managers also face increased concerns about airport liability in the aftermath of damaging wildlife strikes (see Appendix N).

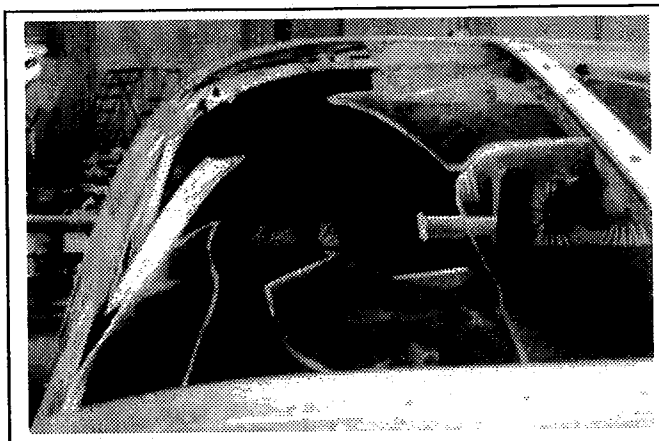


The resident Canada goose population in the USA increased at an annual rate of 8% per year between 1980 and 2004. Notice that the tall grass does not deter Canada geese from grazing and loafing at the airport (photo by M. Begier, USDA).

Wildlife strike problems at individual airports result from these above-described factors interacting at the local level. The nature and magnitude of the problem an individual airport faces will depend on many factors, including air traffic type and volume, local and migratory wildlife populations, and local wildlife habitat conditions. Wildlife is attracted to an airport environment because desirable food, water, or habitat is present. The majority of wildlife strikes occur within the immediate airport environment: 74% of all strikes occur at or below 500 feet above ground level (AGL). Eighteen of the 19 civil and military large-transport aircraft destroyed because of bird strikes between 1960 and 2004 resulted from strikes that occurred on the airport. Therefore, most wildlife involved in strikes is using the airport or its immediate vicinity, and the most logical place to begin correcting the problem is on and near the airport.

Airport sponsors and managers have a legal responsibility under federal regulations (Title 14 Code of Federal Regulations, part 139 [14 CFR, part 139]) to ensure the airport maintains a safe operating environment. As part of this responsibility, they must assess the risk and magnitude of the wildlife strike problem for their airport (14 CFR, part 139.337). This assessment must include accurate and complete reporting of all strike incidents, assessment of wildlife using the airport environment, and assessment of wildlife habitat available to wildlife on the airport. Based on airport conditions and assessed strike risk, airport personnel might need to devise a Wildlife Hazard Management Plan for reducing strike risk and occurrence. Airport personnel must then act to implement and periodically evaluate the plan.

This manual contains a compilation of information to assist airport personnel in conducting Wildlife Hazard Assessments and in the development, implementation, and evaluation of Wildlife Hazard Management Plans. This manual includes specific information on the nature of wildlife strikes, legal authority, government agency roles and responsibilities, regulations, wildlife management techniques, Wildlife Hazard Assessments, Wildlife Hazard Management Plans, and sources of help and information. It is emphasized that this manual provides only a starting point for addressing wildlife hazard issues on airports. Wildlife management is a complex, evolving, and public-sensitive discipline, and ecological conditions vary widely across the USA. Therefore, the assessment of wildlife hazards, the development of Wildlife Hazard Management Plans, and the implementation of management actions by airport personnel must be under consultation by qualified wildlife biologists trained in wildlife damage control.



While on approach to a southern USA airport in March 2003, this PA-34 aircraft struck a pair of red-breasted mergansers at 800 feet AGL. The birds penetrated both windshields. The pilot was not hurt.

CHAPTER 2:
THE FAA NATIONAL WILDLIFE STRIKE DATABASE FOR CIVIL AVIATION



Each autumn, clouds of greater snow geese arrive at Chincoteague National Wildlife Refuge, Virginia, and elsewhere along the Atlantic coast of USA from their Arctic breeding grounds in Canada and Greenland. The greater snow goose population increased from about 50,000 birds in 1966 to over 700,000 birds in 2004 (photo © Brian Kennedy/briankennedy.net, used with permission).

2.1 INTRODUCTION

Before a problem can be solved, the problem must first be understood. A necessary first step toward understanding the complex problem of aircraft collisions with wildlife is the collection and analysis of data from actual wildlife strike events. This chapter provides an overview of the structure and management of the Federal Aviation Administration (FAA) National Wildlife Strike Database for Civil Aviation. The chapter emphasizes the need for accurate reporting of wildlife strikes and the methods for reporting strike events. A statistical summary of reported wildlife strikes for civil aircraft (1990—2003) is also presented to demonstrate the types of information obtained from the database. Finally, a list of selected individual strike cases provides an overview of the nature and magnitude of the wildlife strike problem in the USA.

2.2 REPORTING WILDLIFE STRIKES

The FAA has a standard form (Form 5200-7, Bird/Other Wildlife Strike Report [see Appendix I]) for the voluntary reporting of bird and other wildlife strikes with aircraft. To improve the ease of reporting, strikes can also be reported via the Internet (http://wildlife-mitigation.tc.faa.gov).

Pilots, airport operations, aircraft maintenance personnel, or anyone else who has knowledge of a strike should report strikes. It is important to include as much information as possible on Form 5200-7. The identification of the species of wildlife struck is particularly important. Bird strike remains that cannot be identified by airport personnel can often be identified by a local biologist or, by sending feather remains (with Form 5200-7) to—

For Material Sent via Express Mail Service:	For Material Sent via U.S. Postal Service:
Feather Laboratory Smithsonian Institution NHB, E610, MRC 116 10th & Constitution Ave. NW Washington DC 20560-0116	Feather Laboratory Smithsonian Institution, Div. of Birds PO Box 37012 NHB, E610, MRC 116 Washington DC 20013-7012
(Identify as "safety investigation material")	(Not recommended for priority cases)
The Smithsonian does not charge for feather identification services when the feathers are accompanied by an FAA Bird/Other Wildlife Strike Report (FAA Form 5200-7). Please send whole feathers if available, as diagnostic characteristics are often found in downy barbules at feather base. If available, include wings, breast, and tail feathers. Beaks, feet, bones, and talons are also useful diagnostic materials. Do not send entire bird carcasses through the mail.	

Chapter 7 and Appendix I provide more details on strike reporting.

Analyses of wildlife strike data have proven invaluable in determining the magnitude, nature, and severity of the wildlife strike problem. The database provides a scientific basis for identifying risk factors; justifying, implementing, and defending corrective actions at airports; and judging the effectiveness of those corrective actions. The database is also of critical value to engine manufacturers and aeronautical engineers.

2.3 MANAGEMENT OF THE DATABASE

The FAA National Wildlife Strike Database is managed by the Wildlife Services program of the U.S. Department of Agriculture (USDA) under terms of an Interagency Agreement with the FAA. All strike reports are sent to Wildlife Services for entry into the database after review by the staff Wildlife Biologist at the FAA, Office of Airport Safety and Standards. At the Wildlife Services office, a database manager edits each strike report and consolidates multiple reports for the same strike before entering the data.

Contacts with persons making reports are sometimes made for clarification of details. In addition to FAA Form 5200-7, strike reports are also obtained from other sources (Table 2-1). After entry into the database, the original reports are filed chronologically for future reference if necessary. There are approximately 52,500 strike records for civil aircraft in the database for 1990 through 2003.

Table 2-1. Source of information for reported wildlife strikes to civil aircraft, USA, 1990–2003.

Source	14-year total	% of total known
FAA Form 5200-7[1] (Paper)	31,497	60
FAA Form 5200-7E (Electronic)[2]	2,948	6
Airline report	7,003	13
Multiple[3]	4,704	9
Airport report	2,861	5
Other[4]	1,059	2
Engine manufacturer	793	2
Aircraft Incident Report	720	1
Preliminary Aircraft Incident Report	628	1
Aviation Safety Reporting System	152	<1
Aircraft Incident Preliminary Notice	60	<1
National Transportation Safety Board	57	<1
U.S. Air Force BASH program	11	<1
Total	52,493	100

[1] Bird/Other Wildlife Strike Report.
[2] Electronic filing of reports (http://wildlife-mitigation.tc.faa.gov) began in April 2001. In 2001, <1% of reports were filed electronically compared to 21% in 2002 and 29% in 2003.
[3] More than one report was filed for the same strike.
[4] Various sources, such as news media and Commercial Incident Reports.

In addition to the civil aviation strike reports, strike reports for military aircraft in the U.S. Air Force (USAF) database (where the strike occurred at joint use civil/military airports) have been merged into the FAA database (approximately 6,000 from 1990 to 2003). Civil and military strikes are labeled so analyses can be done with data combined or separated.

2.4 USE OF AND ACCESS TO INFORMATION IN THE DATABASE

Maintaining a consistent record of wildlife strikes at an airport is essential for defining the wildlife hazard level and for evaluating the airport's Wildlife Hazard Management Plan, as discussed in Chapter 7. In addition to their internal use at the airport, the strike reports, when incorporated into the National Wildlife Strike Database, provide a means for engineers, biologists, and safety analysts to better understand national and regional trends in strikes and thereby develop, justify, and defend more effective management programs and wildlife-resistant aircraft and engines. For example, the database has been extremely useful in identifying which wildlife species are most commonly involved in strikes, the seasonal pattern of strikes for various species, the extent and types of damage resulting from strikes, and which aircraft types and components are most vulnerable. It is emphasized that for annual reports and other publicly released analyses, the strike records in the national database are summarized statistically at the regional or national level for trends. Comparisons among individual airports, commercial air carriers, or engine manufacturers are not made.

Selected strike records and data fields are available to the public and aviation industry online at http://wildlife-mitigation.tc.faa.gov. The general public can access information on the number of strikes by year, state, and species of wildlife. Engine manufacturers, commercial airlines, and airports, with a password supplied by the FAA, can access strike reports involving their company or airport. USDA Wildlife Services biologists and FAA Airport Certification Safety Inspectors can access strike reports for airports in the state or region, respectively, where they work.

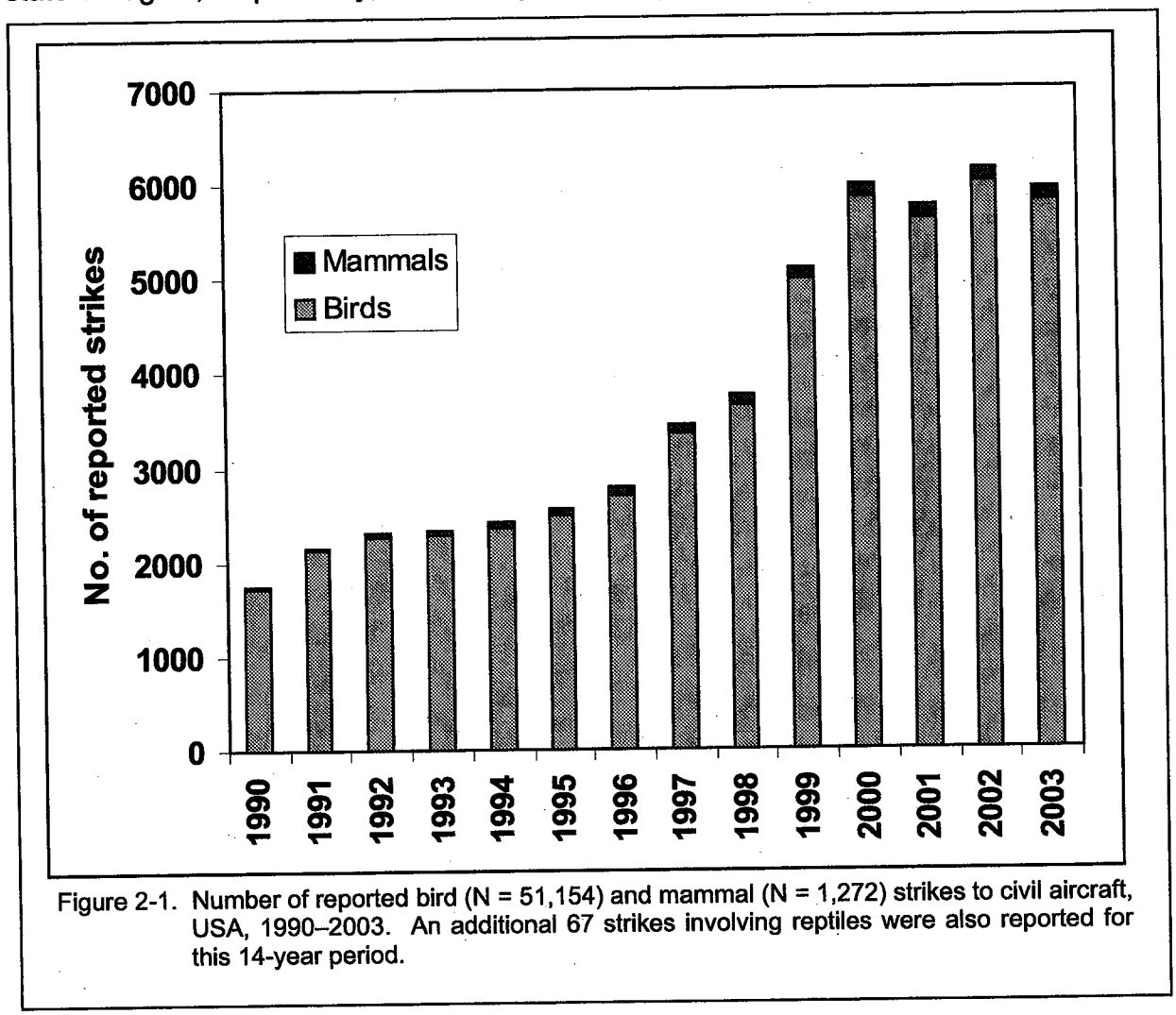


Figure 2-1. Number of reported bird (N = 51,154) and mammal (N = 1,272) strikes to civil aircraft, USA, 1990–2003. An additional 67 strikes involving reptiles were also reported for this 14-year period.

2.5 SUMMARY OF WILDLIFE STRIKE RECORDS, 1990–2003

The FAA's Office of Airport Safety and Standards, in cooperation with USDA Wildlife Services, publishes an annual report, *Wildlife Strikes to Civil Aircraft in the United States*. This report contains a detailed analysis of strike data from 1990 to the most recent year. Copies of the annual report can be downloaded from the FAA's Wildlife Hazard Mitigation Website at http://wildlife-mitigation.tc.faa.gov.

Table 2-2. Person filing report of wildlife strike to civil aircraft, USA, 1990–2003.

Person filing report	14-year total	% of total known
Airline operations	11,313	28
Pilot	10,762	27
Tower	6,672	17
Carcass found[1]	5,809	15
Airport operations	3,971	10
Other	1,520	4
Total known	40,047	100
Unknown	12,446	
Total	52,493	

[1] Airport operations personnel found wildlife remains within 200 feet of a runway centerline that appeared to have been struck by aircraft and no strike was reported by pilot, tower, or airline.

The following section presents a summary analysis of reported wildlife strikes to civil aircraft in the USA for 1990 through 2003 to provide an overview of the types of information obtained from the database. Reports were received from 1,212 airports encompassing all 50 states and some U.S. territories and from 170 foreign airports when U.S. registered aircraft were involved in a strike. Because less than 20% of all strikes have been reported to the FAA and many reports received by the FAA did not include cost or damage data or were filed before aircraft damage was fully assessed, the number of strikes and associated cost data compiled from the voluntary reporting program greatly underestimate the magnitude of the problem.

2.5.A STRIKE FREQUENCY

For the 14-year period (1990–2003), 52,493 strikes were reported to the FAA. Birds were involved in 97.4% of the reported strikes, mammals in 2.4%, and reptiles in less than 0.2% (Figure 2-1).

The number of strikes annually reported tripled from 1990 (1,739) to 2000 (5,979). From 2000 to 2003, reported strikes plateaued at about 6,000 per year with 5,940 strikes reported in 2003 (Figure 2-1). We suggest that the steady increase in reports for 1990 to 2000 was the result of several factors: an increased awareness of the wildlife strike issue, an increase in aircraft operations, an increase in populations of hazardous wildlife species, and an increase in the number of strikes. The plateau in reported strikes from 2000 to 2003 might be related to a slight (<6%) decline in air traffic after the events of September 2001 and to more aggressive wildlife hazard management programs at airports.

Table 2-3. Number of reported wildlife strikes to civil aircraft by type of operator, USA, 1990–2003.

Type of operator	14-year total	% of total known
Commercial	38,005	84
Business	5,596	12
Private	1,567	4
Government/Police	266	<1
Total known	45,434	100
Unknown	7,059	
Total	52,493	

Most (66%) of the 52,493 strike reports filed during the 14-year period were submitted using the paper (60%) or electronic (6%) version of FAA Form 5200-7, *Bird/Other Wildlife Strike Report*. Since the online version of this form became available in April 2001, use of the electronic reporting system has climbed dramatically. Almost 28% of the strike reports filed in 2003 were done using this system (Table 2-1).

Table 2-4. Number of reported bird, mammal, and reptile strikes to civil aircraft by USA state, including the District of Columbia (DC), Puerto Rico (PR), USA-possessed Pacific Islands (PI), and the U.S. Virgin Islands (VI), 1990–2003.

	Reported strikes					Reported strikes			
State	Birds	Mammals	Reptiles	Total	State	Birds	Mammals	Reptiles	Total
AK	393	14	0	407	NC	997	20	0	1,017
AL	489	12	0	501	ND	121	3	0	124
AR	222	13	0	235	NE	461	13	0	474
AZ	712	51	0	763	NH	297	10	0	307
CA	4,325	54	0	4,379	NJ	1,427	67	7	1,501
CO	1,290	59	0	1,349	NM	94	2	0	96
CT	561	16	0	577	NV	248	3	0	251
DC	1,307	30	0	1,337	NY	2,903	96	10	3,009
DE	36	1	0	37	OH	1,626	53	0	1,679
FL	3,622	49	40	3,711	OK	470	19	2	491
GA	866	15	0	881	OR	810	8	0	818
HI	1,047	4	0	1,051	PA	1,962	63	0	2,025
IA	335	12	0	347	PI	80	0	0	80
ID	102	5	0	107	PR	85	0	5	90
IL	2,521	71	1	2,593	RI	209	7	0	216
IN	527	11	0	538	SC	248	12	0	260
KS	148	5	0	153	SD	82	6	0	88
KY	1,203	12	0	1,215	TN	1,328	15	0	1,343
LA	949	18	1	968	TX	3,416	60	0	3,476
MA	684	12	0	696	UT	535	10	0	545
MD	556	40	0	596	VA	735	42	0	777
ME	157	8	0	165	VI	67	0	0	67
MI	1,248	70	0	1,318	VT	41	1	0	42
MN	435	13	0	448	WA	785	11	0	796
MO	1,040	26	0	1,066	WI	437	43	0	480
MS	171	4	0	175	WV	123	45	0	168
MT	61	5	0	66	WY	39	4	0	43
					Total known[1]	44,633	1,243	66	45,942
					Foreign[2]	983	8	0	991
					Unknown	5,538	21	1	5,560
					Total	51,154	1,272	67	52,493

[1] Strikes were reported at 1,212 airports in the USA.
[2] Strikes to USA air carriers were reported at 170 foreign airports.

Table 2-5. Number of reported strikes, strikes with damage, and strikes having a negative effect-on-flight (EOF) for the five most commonly struck bird species groups and two most commonly struck mammal groups, USA, 1990–2003.

	Reported strikes		Strikes with damage		Strikes with EOF	
Species group	14-year total	% of total known	14-year total	% of total known	14-year total	% of total known
Birds						
Gulls	5,323	25	891	28	710	30
Doves/pigeons	2,966	14	245	8	264	11
Raptors	2,666	12	537	17	351	15
Waterfowl	2,217	10	1,023	32	477	20
Blackbirds/starlings	2,210	10	131	4	156	7
All other known	6,302	29	390	12	406	17
Total known	21,684	100	3,217	100	2,364	100
Unknown	29,470		3,483		1,952	
Total birds	51,154		6,700		4,316	
Mammals						
Artiodactyls[1]	643	51	524	94	339	85
Carnivores[2]	312	25	23	4	48	12
All other known	305	24	11	2	10	3
Total known	1,260	100	558	100	397	100
Unknown	12		6		6	
Total mammals	1,272		564		403	

[1] Deer and elk, respectively, comprised 614 and 8 of the 643 strikes with artiodactyls.
[2] Coyotes and foxes, respectively, comprised 150 and 59 of the 312 strikes with carnivores.

Pilots and airline personnel filed 28% and 27% of these 52,493 reports, respectively (Table 2-2). About 84% of the reported strikes involved commercial aircraft; the remainder involved business, private, and miscellaneous aircraft (Table 2-3). California, Florida, and Texas had the most (3,416–4,325) bird strike reports (Table 2-4). Twelve other states each had over 1,000 bird strikes reported. New York, Illinois, Michigan, New Jersey, Pennsylvania, and Texas each had 60 or more mammal strikes.

Table 2-6. Number of reported bird and mammal strikes to civil aircraft by month, USA, 1990–2003[1].

	All birds		All mammals		Deer only[2]	
Month	14-year total	% of total known	14-year total	% of total known	14-year total	% of total known
Jan	1,969	4	60	5	27	4
Feb	1,806	4	50	4	21	3
Mar	2,712	5	73	6	31	5
Apr	3,537	7	83	7	40	7
May	4,729	9	65	5	27	4
Jun	3,806	7	102	8	45	7
Jul	5,678	11	127	10	50	8
Aug	6,845	13	154	12	50	8
Sep	6,919	14	150	12	64	10
Oct	6,685	13	171	13	85	14
Nov	4,100	8	168	13	126	21
Dec	2,368	5	69	5	48	8
Total	51,154	100	1,272	100	614	100

[1] In addition, 67 strikes with reptiles were reported, of which 16 (24%) occurred in September.
[2] Deer strikes were comprised of 574 white-tailed deer, 24 mule deer, and 16 deer not identified to species. Other wild ungulates reported struck (but not included in this column of table) were 8 elk, 7 pronghorns, 7 moose, and 1 caribou.

Table 2-7. Reported time of occurrence of wildlife strikes to civil aircraft, USA, 1990–2003.

	Birds		Mammals	
Time of day	14-year total	% of total known	14-year total	% of total known
Dawn	1,567	4	23	3
Day	22,632	63	200	24
Dusk	1,922	5	81	10
Night	9,562	27	536	64
Total known	35,683	100	840	100
Unknown	15,471		432	
Total[1]	51,154		1,272	

[1] In addition, 67 strikes with reptiles were reported: 56 for which the time was not reported, 6 during the day, 3 at night, 1 at dawn, and 1 at dusk.

2.5.B TYPES OF WILDLIFE INVOLVED

Gulls (25%), doves (14%), raptors (12%), and waterfowl (10%) were the most frequently struck bird groups (Table 2-5). Gulls were involved in more than twice as many strikes as waterfowl (5,323 and 2,217, respectively). Waterfowl, however, were involved in more damaging strikes (1,023 or 32% of all damaging strikes in which the bird type was identified) than were gulls (891 or 28% of all damaging strikes in which the bird type was identified). Gulls were responsible for the greatest number of bird strikes (710 or 30%) that had a negative effect-on-flight.

The most frequently struck mammals were Artiodactyls—primarily deer (51%)—and Carnivores—primarily coyotes (25%, Table 2-5). Artiodactyls were responsible for 94% of the mammal strikes that resulted in damage and 85% of the mammal strikes that had a negative effect-on-flight. In all, 38 identified species of mammals were reported struck; 17 identified species caused damage.

2.5.C CHARACTERISTICS OF STRIKES

Most bird strikes (51%) occurred between July and October (Table 2-6); 63% occurred during the day (Table 2-7); 58% occurred during the landing (descent, approach, or landing roll) phase of flight; and 39% occurred during takeoff and climb (Table 2-8). About 61% of the bird strikes occurred when the aircraft was at a height of 100 feet or less above ground level (AGL), 74% occurred at 500 feet or less AGL, and 92% occurred at or below 3,000 feet AGL (Table 2-9).

Table 2-8. Reported phase of flight at time of wildlife strikes to civil aircraft, USA, 1990–2003.

	Birds		Mammals	
Phase of flight	14-year total	% of total known	14-year total	% of total known
Parked	24	<1	0	0
Taxi	161	<1	24	3
Takeoff run	7,810	20	318	33
Climb	7,327	19	26	2
En route	1,148	3	1	<1
Descent	1,463	4	4	<1
Approach	15,065	38	82	8
Landing roll	6,461	16	498	52
Total known	39,459	100	953	100
Unknown	11,695		319	
Total[1]	51,154		1,272	

[1] In addition, 67 strikes with reptiles were reported.

Most mammal strikes (50%) occurred between August and November with 35% of deer strikes concentrated in October and November (Table 2-6). Most mammal strikes (64%) occurred at night (Table 2-7), 52% occurred during the landing roll, and 33% occurred during the takeoff run. About 10% of the reported mammal strikes occurred while the aircraft was in the air, e.g., when the aircraft struck deer with the landing gear or encountered bats (Table 2-8).

2.5.D AIRCRAFT COMPONENTS STRUCK AND DAMAGED

The aircraft components most commonly reported as struck by birds were the nose/radome, windshield, engine, wing/rotor, and fuselage (Table 2-10). Aircraft

engines were the component most frequently reported as being damaged by bird strikes (33% of all damaged components). Of the 7,511 aircraft engines reported as being struck by birds, 34% (2,591) were damaged (Table 2-10).

There were 6,761, 350, 10, and 5 incidents in which one, two, three, and four engines, respectively, were struck by birds on a single aircraft. There were 2,424, 80, 1, and 1 incidents in which one, two, three, and four engines, respectively, were damaged by birds on a single aircraft.

Table 2-9. Number of reported bird strikes to civil aircraft by height (feet) above ground level (AGL), USA, 1990–2003.

Height of strike (feet AGL)	14-year total	% of total known	% cumulative total
0	14,471	41	41
1-100	6,716	19	61
101-200	1,704	5	65
201-300	1,126	3	69
301-400	682	2	71
401-500	1,204	3	74
501-600	333	1	75
601-700	262	1	76
701-800	561	2	77
801-900	186	1	78
901-1,000	1,002	3	81
1,001-2,000	2,570	7	88
2,001-3,000	1,517	4	92
3,001-4,000	776	2	95
4,001-5,000	575	2	96
5,001-10,000	1,062	3	99
10,001-20,000	237	<1	99
20,001-30,000	11	<1	99
>30,000	1	<1	100
Total known	34,996	100	
Unknown	16,158		
Total	51,154		

Aircraft components most commonly reported as struck by mammals were the landing gear, propeller, and wing/rotor. These same components ranked highest for the parts most often reported as damaged by mammals (Table 2-10).

2.5.E EFFECTS OF WILDLIFE STRIKES ON AIRCRAFT AND FLIGHTS

For the 14-year period, 7,265 reports (17% of known total) indicated the strike damaged one or more aircraft components (Table 2-9), and 4,726 reports (15% of known total) indicated the strike had a negative effect on the flight (Table 2-11). Only 2,630 strike reports provided an estimate of the aircraft down time (total = 455,931 hours, average = 173 hours/incident), and 1,759 reports provided an estimate of the direct or other costs (total = $195,034,000, average = $147,000/incident). Of the 1,759 reports providing a damage cost estimate, 1,637 provided an estimate of direct aircraft damage (total = $169,045,000, average = $103,000/incident), and 595 provided an estimate of other monetary losses (total = $25,989,000, average = $44,000/incident).

Assuming all reported wildlife-aircraft strikes that had an adverse effect on the aircraft and/or flight engendered similar amounts of down time and/or monetary losses and that these reports are all of the damaging strikes that occurred, wildlife strikes cost the U.S. civil aviation industry a minimum of 118,663 hours per year of aircraft down time and

$100.58 million in monetary losses ($70.68 million per year in direct costs and $29.90 million per year in associated costs). Further, assuming a 20% reporting rate, the annual cost of wildlife-aircraft strikes to the U.S. civil aviation industry is estimated to be in excess of 593,317 hours of aircraft downtime and $502.91 million in monetary losses ($353.42 million per year in direct costs and $149.49 million per year in associated costs).

Table 2-10. Civil aircraft components reported as being struck and damaged by wildlife, USA, 1990–2003.

	Birds (14-year total)				Mammals (14-year total)			
Aircraft component	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Radome/nose	12,044	26	1,201	15	69	6	65	6
Windshield	8,145	18	482	6	16	1	11	1
Engine(s)	7,511[1]	16	2,591[1]	33	98	8	95	9
Wing/rotor	6,243	14	1,751	22	144	12	141	14
Fuselage	5,726	12	275	3	82	7	91	9
Landing gear	2,252	5	249	3	452	37	239	24
Propeller	1,415	3	153	2	169	14	157	15
Tail	693	2	305	4	37	3	45	4
Light	386	1	305	4	15	1	22	2
Other	1,675	4	631	8	146	12	148	14
Total[2]	46,090	100	7,943	100	1,228	100	1,014	100

[1] There were 7,126 bird-strike incidents in which a total of 7,511 engines were reported as struck (6,761 incidents with one engine struck, 350 with two engines struck, 10 with three engines struck, and five with four engines struck). In 2,506 (35%) of these 7,126 strike incidents, a total of 2,591 engines were damaged (2,424 incidents with one engine damaged, 80 with two engines damaged, one with three engines damaged, and one with four engines damaged).

[2] In addition, 67 strikes with reptiles were reported; 15 indicated the part struck and 5 indicated the strike damaged an aircraft component: Windshield (1 struck, 1 damaged), Wing/rotor (1 struck, 1 damaged), Fuselage (1 struck, 1 damaged), Landing gear (10 struck, 0 damaged), Tail (1 struck, 1 damaged), Other (1 struck, 1 damaged).

Table 2-11. Number of civil aircraft with reported damage resulting from wildlife strikes, USA, 1990–2003.

	Reported strikes					
	Birds		Mammals		Total[1]	
Damage category[2]	14-year total	% of total known	14-year total	% of total known	14-year total	% of total known
None	36,122	84	348	38	36,481	83
Damage	6,700	16	564	62	7,265	17
Minor	3,659	9	262	29	3,921	9
Uncertain	1,184	3	39	4	1,223	3
Substantial	1,845	4	247	27	2,093	5
Destroyed	12	<1	16	2	28	<1
Total known	42,822	100	912	100	43,746	100
Unknown	8,332		360		8,747	
Total	51,154		1,272		52,493	

[1] Included in totals are 67 strikes involving reptiles in which 11 reports indicated no damage, 55 failed to report damage (if any), and 1 reported substantial damage.

[2] The damage codes and descriptions follow the *International Civil Aviation Organization Bird Strike Information System (1989):* Minor = the aircraft can be rendered airworthy by simple repairs or replacements and an extensive inspection is not necessary; Uncertain = the aircraft was damaged, but details as to the extent of the damage are lacking; Substantial = the aircraft incurs damage or structural failure that adversely affects the structure strength, performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component (specifically excluded are bent fairings or cowlings; small dents or puncture holes in the skin; damage to wing tips, antenna, tires, or brakes; and engine blade damage not requiring blade replacement); Destroyed = the damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

Table 2-12. Reported effect-on-flight (EOF) of wildlife strikes to civil aircraft, USA, 1990–2003.

	Reported strikes					
	Birds		Mammals		Total[1]	
Effect-on-flight[2]	14-year total	% of total known	14-year total	% of total known	14-year total	% of total known
None	26,493	86	315	44	26,821	85
Negative effect	4,316	14	403	56	4,726	15
Precautionary landing	2,235	7	63	9	2,299	7
Aborted takeoff	1,072	4	130	18	1,202	4
Engine shutdown	251	1	22	3	273	1
Other	758	3	188	26	952	3
Total known	30,809	100	718	100	31,547	100
Unknown	20,345		554		20,946	
Total	51,154		1,272		52,493	

[1] Included in totals are 67 strikes involving reptiles in which 13 reports indicated no effect-on-flight, 47 failed to report on effect-on-flight (if any), 1 reported a precautionary landing, and 6 reported "other".

[2] Effect-on-flight: None = flight continued as scheduled, although delays and other cost caused by inspections or repairs may have been incurred after landing; Aborted takeoff = pilot aborted the takeoff; Precautionary landing = pilot landed at other-than-destination airport after strike; Engine shut down = pilot shut down the engine or the engine stopped running because of strike; Other = miscellaneous effects, such as reduced speed because of shattered windshield, emergency landing at destination airport, or crash landing; Unknown = report did not give sufficient information to determine an effect-on-flight (Dolbeer et al. 2000).

2.6 SELECTED EXAMPLES OF WILDLIFE STRIKES

Below are descriptions of some wildlife strikes that are either of historic interest, have influenced flight safety, or are typical of damaging strikes in recent years in the USA.

7 September 1905. From the Wright Brothers diaries, "Orville ... flew 4,751 meters in 4 minutes 45 seconds, four complete circles. Twice passed over fence into Beard's cornfield. Chased flock of birds for two rounds and killed one which fell on top of the upper surface and after a time fell off when swinging a sharp curve." This was the first reported bird-aircraft strike. Because of the location near Dayton, Ohio, and time of year, the bird struck was probably a red-winged blackbird.



Calbraith Rogers and his aircraft the Vin Fizz following his fatal encounter with a gull (photo courtesy National Air and Space Museum, Smithsonian Institution, SI Neg. No. A-43520-E).

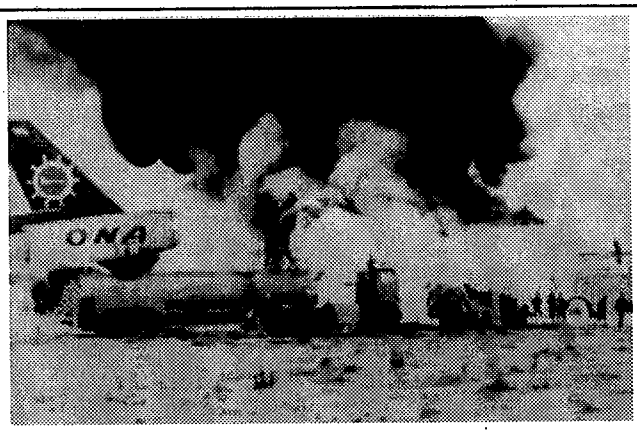
25 July 1909. During engine warm-up for Louis Bleriot's historic first flight across the English Channel from Les Baraques, France, a farm dog ran into the propeller of the Bleriot XI aircraft. This was the first reported terrestrial wildlife (mammal) strike.

3 April 1912. Calbraith Rogers, the first person to fly across the continental USA, was also the first to die as a result of a wildlife strike. On 3 April 1912, Rodgers' Wright Pusher struck a gull, causing the aircraft to crash into the surf at Long Beach, California. Rodgers was pinned under the wreckage and drowned.

4 October 1960. A Lockheed Electra turbo-prop ingested European starlings into all four engines during takeoff from Boston Logan Airport (Massachusetts). The plane crashed into Boston Harbor, killing 62 people. Following this accident, the FAA initiated action to develop minimum bird ingestion standards for turbine-powered engines.

26 February 1973. On departure from Atlanta's Peachtree-Dekalb Airport (Georgia), a Lear 24 jet struck a flock of brown-headed cowbirds attracted to a nearby trash disposal area. Engine failure resulted. The aircraft crashed, killing seven people and seriously injuring one person on the ground. This incident prompted the FAA to develop guidelines for the location of solid waste disposal facilities on or near airports.

12 November 1975. On departure roll from John F. Kennedy International Airport (New York), the pilot of a DC-10 aborted takeoff after ingesting gulls into one engine. The plane ran off runway and caught fire as a result of engine fire and overheated brakes. The resultant fire destroyed the aircraft. All 138 people on board, airline personnel trained in emergency evacuation, evacuated safely (see photo page 18). Following this accident, the National Transportation Safety Board recommended the FAA evaluate the effect of bird ingestion on large, high-bypass, turbofan engines and the adequacy of engine certification standards. The FAA initiated a nationwide data collection effort to document bird strike and engine ingestion events.



This DC-10 was destroyed by fire when several herring gulls were ingested into an engine during takeoff from JFK International Airport, November 1975 (see story on page 17; photo courtesy Port Authority New York and New Jersey).

25 July 1978. A Convair 580 departing Kalamazoo Airport (Michigan) ingested one American kestrel into an engine on takeoff. The aircraft auto-feathered and crashed in a nearby field, injuring 3 of the 43 passengers.

18 June 1983. The pilot of a Bellanca 1730, landing at Clifford, Texas, saw two "buzzards" on final approach. He added power and maneuvered to avoid them, then continued approach. This resulted in a landing beyond the intended point. The middle of the runway was higher than either end; therefore, the pilot was unable to see a large canine moving toward the landing area until aircraft was halfway down the runway. A go-around was initiated, but the lowered landing gear hit some treetops causing the pilot to loose control. The aircraft came to rest in a milo field about 250 yards from initial tree impact after flying through additional trees. The aircraft suffered substantial damage, and two people in the aircraft were seriously injured.

6 January 1985. A Beechcraft King Air 90 departing Smith Reynolds Airport (North Carolina) at dusk hit a large feral dog on the runway just at rotation. The aircraft suffered substantial damage.

17 March 1987. A Boeing-737 struck an 80-pound deer at Chicago O'Hare (Illinois) airport. The aircraft suffered over $114,000 in damage.

5 November 1990. During takeoff at Michiana Regional Airport (Indiana), a BA-31 flew through a flock of mourning doves. Several birds were ingested in both engines, and takeoff was aborted. Both engines were destroyed. Cost of repairs was $1 million, and time out of service was 60 hours.

30 December 1991. A Citation 550, taking off from Angelina County Airport (Texas), struck a turkey vulture. The strike caused major damage to the #1 engine and resulting shrapnel caused minor damage to the wing and fuselage. Cost of repairs was $550,000 and time out of service was 2 weeks.

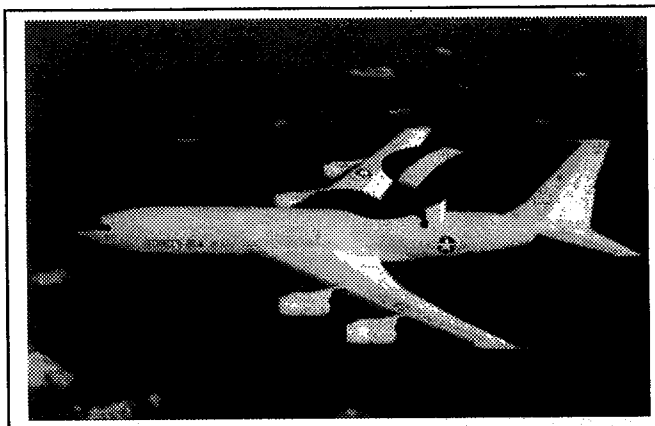
2 February 1992. A Piper Cherokee struck a deer at rotation during takeoff from Sandstone Municipal Airport (MN). The pilot attempted to turn back to the airport but collided into trees just south of airport. The aircraft was destroyed and the pilot seriously injured.

3 December 1993. A Cessna 550 struck a flock of geese during the initial climb out of DuPage County Airport (Illinois). The pilot heard a loud bang, and the aircraft yawed to the left and right. Instruments showed loss of power to the #2 engine and a substantial fuel leak on the left side. An emergency was declared, and the aircraft landed at

Midway Airport. The cost to repair two engines was $800,000, and time out of service was about 3 months.

21 October 1994. A Cessna 210 struck a coyote during the landing roll at Higginsville Industrial Municipal Airport (Missouri) at night. The nose gear collapsed and the propeller hit the runway, resulting in major damage to the engine and crankshaft.

3 June 1995. An Air France Concorde, at about 10 feet AGL while landing at John F. Kennedy International Airport (New York), ingested one or two Canada geese into the #3 engine. The engine suffered an uncontained failure. Shrapnel from the #3 engine destroyed the #4 engine and cut several hydraulic lines and control cables. The pilot was able to land the plane safely, but the runway was closed for several hours. Damage to the Concorde was estimated at over $7 million. The French Aviation Authority sued the Port Authority of New York and New Jersey and eventually settled out of court for $5.3 million.



A USAF AWACS aircraft similar to this was lost in 1995 and 24 airmen were killed when Canada geese were struck just after rotation. The USAF was aware of geese living on the airbase, yet had taken no direct action to eliminate the birds (photo courtesy USAF).

22 September 1995. A U.S. Air Force Airborne Warning and Control System (AWACS) aircraft (modified Boeing 707) crashed, killing all 24 on board, after ingesting four Canada geese into the #1 and #2 engines during takeoff from Elmendorf Air Force Base (Alaska). This was the first crash of an AWACS plane since the Air Force began using them in 1977.

5 October 1996. A Boeing-727 departing Washington Reagan National Airport (District of Columbia) struck a flock of gulls just after takeoff, ingesting at least one bird. One engine began to vibrate and was shut down. A burning smell entered the cockpit. An emergency was declared, and the aircraft, carrying 52 passengers, landed at Washington Reagan National. Several engine blades were damaged.

7 January 1997. An MD-80 aircraft struck over 400 blackbirds just after takeoff from Dallas-Fort Worth International Airport (Texas). Almost every part of the plane was hit. The pilot declared an emergency and returned to land without event. Substantial damage was found on various parts of the aircraft, and the #1 engine had to be replaced. The runway was closed for 1 hour. The birds had been attracted to an un-harvested wheat field on the airport.

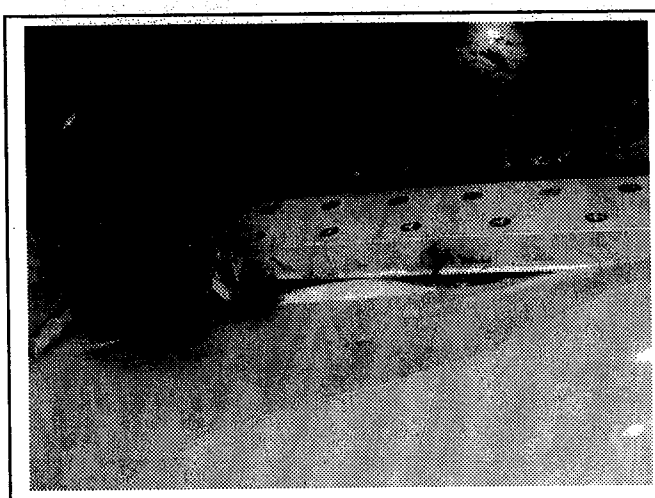
9 January 1998. While climbing through 3,000 feet, following takeoff from Houston Intercontinental Airport (Texas), a Boeing-727 struck a flock of snow geese with three to five birds ingested into one engine. The engine lost all power and was destroyed. The radome was torn from aircraft and leading edges of both wings were damaged. The pitot tube for the first officer was torn off. Intense vibration was experienced in the airframe and the noise level in the cockpit increased to the point that communication

among crewmembers became difficult. An emergency was declared. The flight returned safely to Houston with major damage to aircraft.

22 February 1999. A Boeing-757 departing Cincinnati/Northern Kentucky International Airport (Kentucky) had to return and make an emergency landing after hitting a large flock of starlings. Both engines and one wing received extensive damage. About 400 dead starlings were found on the runway area.

7 February 2000. An American-owned cargo company's DC-10-30 departing Subic Bay, Philippines, ingested a fruit bat into one engine at 250 feet AGL. The aircraft returned to the airport. Five damaged fan blades had to be replaced. Time out of service was 3 days. Total repair and related costs exceeded $3 million.

21 January 2001. An MD-11 departing Portland International Airport (Oregon) ingested a herring gull into the #3 engine during the takeoff run. The engine stall blew off the nose cowl that was sucked back into the engine and shredded. The engine had an uncontained failure. The pilot aborted takeoff and blew two tires. The 217 passengers were safely deplaned and rerouted to other flights. Smithsonian Feather Lab identified bird.



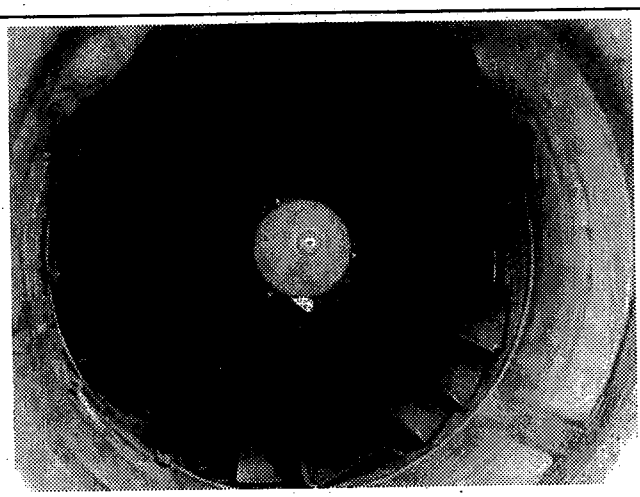
One of the two turkeys that penetrated a Canadair RJ 200 fuselage below the windshield; parts of the bird entered the cockpit.

09 March 2002. A Canadair RJ 200 at Dulles International Airport (Virginia) struck two wild turkeys during the takeoff roll. One shattered the windshield spraying the cockpit with glass fragments and remains. Another hit the fuselage and was ingested. There was a 14-by 4-inch section of fuselage skin damaged below the windshield seal on the flight officer's side. The cost of repairs was estimated at $200,000. Time out of service was at least 2 weeks.

19 October 2002. A Boeing 767 departing Logan International Airport (Massachusetts) encountered a flock of over 20 double-crested cormorants. At least 1 cormorant was ingested into the #2 engine. There were immediate indications of engine surging followed by compression stall and smoke from the engine. The engine was shutdown. An overweight landing with one engine was made without incident. The nose cowl was dented and punctured. There was significant fan blade damage with abnormal engine vibration. One fan blade was found on the runway. The aircraft was towed to the ramp. Hydraulic lines were leaking, and several bolts were sheared off inside engine. Many pieces fell out when the cowling was opened. The aircraft was out of service for 3 days. The cost of repairs was $1.7 million.

8 January 2003. A Bombardier de Havilland Dash 8 collided with a flock of lesser scaup at 1,300 feet AGL on approach to Rogue Valley International Airport (Oregon). At least one bird penetrated the cabin and hit the pilot who turned control over to the first officer for landing. Emergency power switched on when the birds penetrated the

radome and damaged the DC power system and instruments systems. The pilot was treated for cuts and released from the hospital.



This picture shows a close-up of the #2 engine from the Fokker-100 that ingested Canada geese on 4 September 2004.

4 September 2003. A Fokker 100 struck a flock of at least five Canada geese over the runway shortly after takeoff at LaGuardia Airport (New York), ingesting one or two geese into the #2 engine. Engine vibration occurred. The pilot was unable to shut the engine down with the fuel cutoff lever, so the fire handle was pulled and the engine finally shut down, but the vibration continued. The flight was diverted to nearby JFK International Airport where a landing was made. The NTSB found a 20- by 36-inch wide depression on the right side of nose behind radome. Maximum depth was 4 inches. Impact marks were found on the right wing. A fan blade separated from the disk and penetrated the fuselage. Several fan blades were deformed. Holes were found in the engine cowling. Bird remains were recovered and identified by Wildlife Services.

17 February 2004. A Boeing 757 during a takeoff run from Portland International Airport (Oregon) hit five mallards and returned with one engine out. At least one bird was ingested, and parts of five birds were collected from the runway. Engine damage was not repairable, and the engine had to be replaced. The cost was $2.5 million, and time out of service was 3 days.



This is the #1 engine of the MD-80 after ingesting at least 1 double-crested cormorant on 16 September 2004. (See story on page 22.)

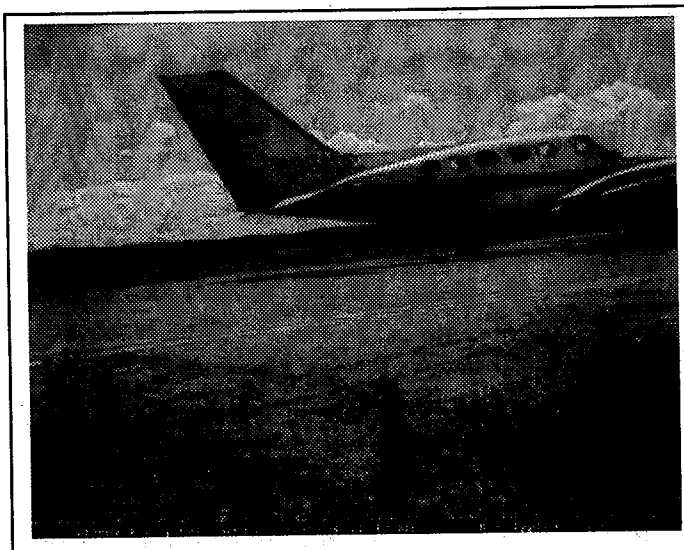
15 April 2004. An Airbus 319 climbing out of Portland International Airport (Oregon) ingested a great blue heron into the #2 engine, causing extensive damage. The pilot shut the engine down as a precaution and made an emergency landing. The runway was closed 38 minutes for cleaning. The flight was cancelled. The engine and nose cowl were replaced. Time out of service was 72 hours. The damage totaled $388,000.

14 June 2004. A Boeing 737 struck a great horned owl during a nighttime landing roll at Greater Pittsburgh International Airport (Pennsylvania). The bird severed a cable in the front main gear. The steering

failed, and the aircraft ran off the runway and became stuck in mud. Passengers were bused to the terminal. Two nose wheels, two main wheels, and brakes were replaced. The aircraft was out of service 24 hours. The cost was estimated at $20,000.

16 September 2004. A MD 80 departing Chicago O'Hare (Illinois) hit several double-crested cormorants at 3,000 feet AGL and 4 miles from airport. The #1 engine caught fire and failed, sending metal debris to the ground in a Chicago neighborhood. The aircraft made an emergency landing back at O'Hare with no injuries to the 107 passengers. (See photo on page 21.)

24 October 2004. A Boeing 767 departing Chicago O'Hare (Illinois) hit a flock of birds during the takeoff run. A compressor stall caused the engine to flame out. A fire department got calls from local residents who reported seeing flames coming from the plane. The pilot dumped approximately 11,000 gallons of fuel over Lake Michigan before returning to land. Feathers found in engine were sent to the Smithsonian, Division of Birds, for identification.

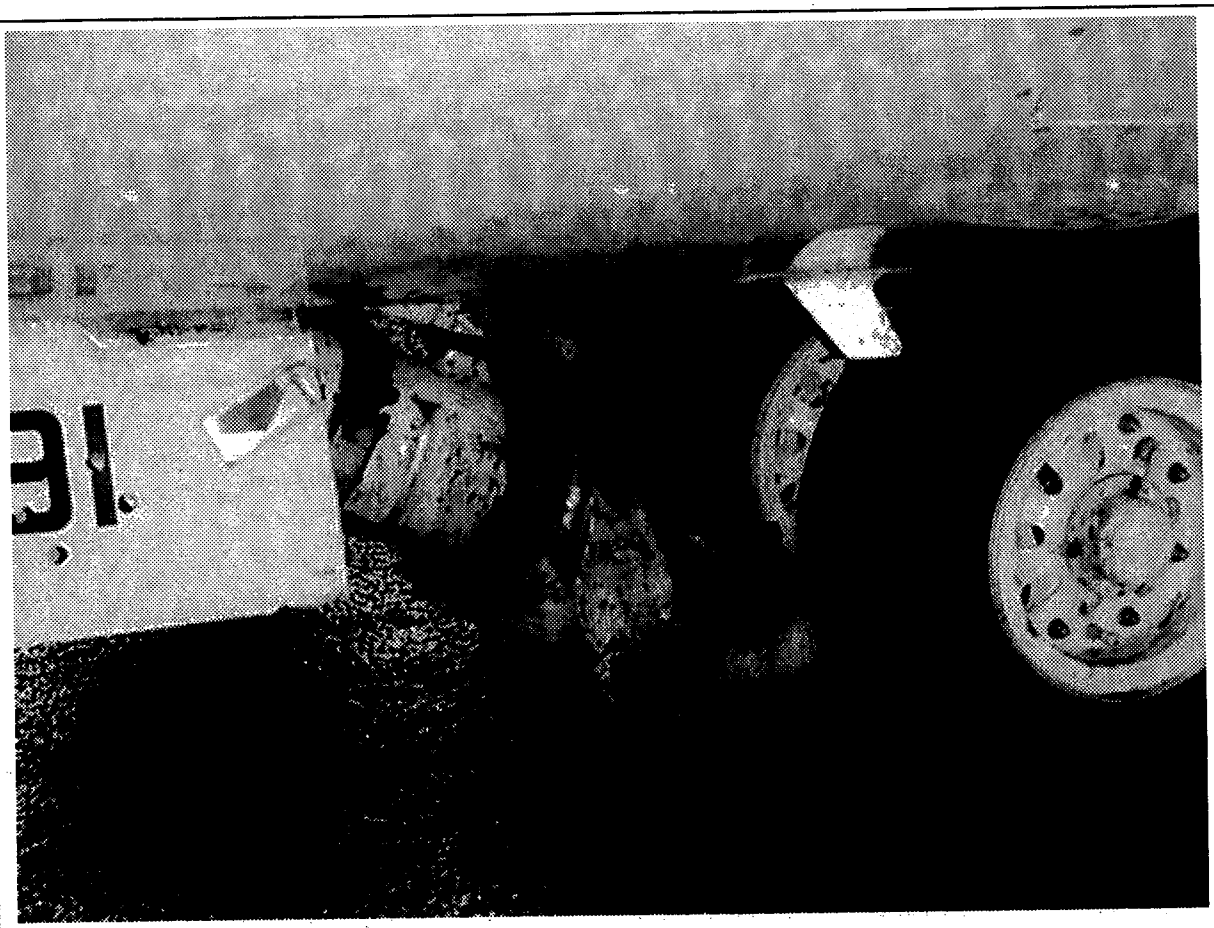


Besides having the potential to cause damaging strikes, small mammals, such as this prairie dog at a southwestern USA airport, can create problems by burrowing, gnawing on wiring, and serving as a food attractant for large birds of prey.

2.7 CONCLUSIONS

Wildlife strikes can cause serious damage to aircraft and the occasional loss of human life. Because most strikes occur on or near airports, airports are the logical locations to place emphasis in addressing the problem. The following chapters and appendices, coupled with guidance from professional wildlife biologists trained in wildlife damage management, provide the information needed to develop, implement, and evaluate wildlife hazard management programs to minimize the likelihood of wildlife strikes on airports.

CHAPTER 3:
AGENCIES AND ORGANIZATIONS IMPACTING WILDLIFE HAZARD MANAGEMENT ON AIRPORTS



In December 2002, this Dash-8 struck a deer while landing at a southeastern USA airport. The impact caused the nose gear to collapse. The white-tailed deer population in the USA increased from a low of about 350,000 in 1900 to at least 24 million in 2004.

3.1 INTRODUCTION

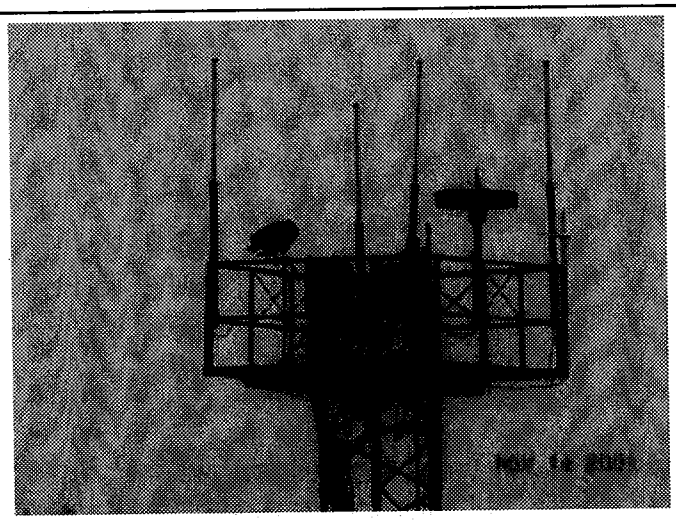
Wildlife management is a complex mixture of science, experience, and art, regulated and implemented by various federal, state, and local governmental agencies. Overlapping federal, state, and local regulations enforced by various governmental organizations protect wildlife and associated wildlife habitat. This chapter provides an overview of the roles and responsibilities of various agencies and organizations that influence wildlife management on or near airports.

3.2 FEDERAL AGENCIES

3.2.A U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION

3.2.A.I MISSION

The mission of the Federal Aviation Administration (FAA) is to provide a safe, secure, and efficient global aviation system that contributes to national security and the promotion of U.S. aviation. As the leading authority in the international aerospace community, the FAA is responsive to the dynamic nature of customer needs, economic conditions, and environmental concerns.



High-profile species such as bald eagles present special problems for airport managers (photo by E. Cleary, FAA).

3.2.A.II AUTHORITY

Since 1970, Section 612 of the Federal Aviation Act of 1958, as amended (49 U.S.C. 1432), has empowered the FAA Administrator to issue airport operating certificates to airports serving certain air carriers and to establish minimum safety standards for the operation of those airports. Some of these regulations and policies directly involve the management of wildlife and wildlife hazards on and/or near airports.

3.2.A.III ROLE AND RESPONSIBILITY

Among its other responsibilities, the FAA is responsible for enforcement of Title 14 Code of Federal Regulations, part 139 (14 CFR 139). To carry out this role, the FAA has responsibilities for various aspects of aviation that include air navigation, air traffic control, aviation certification and regulation, aviation security, environmental impact minimization, and aviation research and development.

The FAA roles and responsibilities relating to wildlife hazards and their associated human health and safety concerns are addressed in 14 CFR 139.337. The FAA's Office of Airport Safety and Standards' 150/5200 series Advisory Circulars (AC), Program Policy and Guidance, and Certalerts further clarify this information.

3.2.A.III.A OFFICE OF AIRPORT SAFETY AND STANDARDS

A staff wildlife biologist is assigned to the Office of Airport Safety and Standards, Washington, DC. The biologist works with airport operators and certificate holders through the FAA regional and district offices in matters related to wildlife hazards on airports. Responsibilities of the staff wildlife biologist include reviewing development plans of all certificated airports to minimize wildlife hazards; managing the wildlife aircraft strike database designed to document the history of reported strikes at airports

throughout the USA and its territories; and serving as an internal consultant to the FAA on the appropriateness of Wildlife Hazard Management Plans, wildlife hazard research, and other wildlife management issues of concern to the FAA.



Airport operators are required to conduct a Wildlife Hazard Assessment when wildlife capable of causing substantial aircraft damage are observed to have access to the aircraft movement area (photo courtesy USDA).

The FAA staff wildlife biologist examines all wildlife aircraft strike reports submitted to the FAA. Copies of major strike reports (14 CFR 139.337(b)(1-4)), together with the strike history for the particular airport, are forwarded to the appropriate FAA regional personnel. See also FAA Office of Airport Safety and Standards' Policies and Program Guidance Policy No. 79, *Review of Airport Wildlife Hazard Management Plans* (Appendix D).

3.2.A.III.B WILDLIFE HAZARD ASSESSMENTS

Operators of certificated airports are required by regulation to conduct a Wildlife Hazard Assessment when specific wildlife events occur, as discussed in Chapter 6 (14 CFR 139.337(b)(1-4), see Appendix P). FAA Office of Airport Safety and Standards' Program Policy and Guidance No. 77, *Initiation of Wildlife Hazard Assessments at Airports* (Appendix D), establishes the procedures followed by FAA Airport Certification Safety Inspectors when it is determined that an airport needs to conduct a Wildlife Hazard Assessment. Under terms of the Memorandum of Understanding between the FAA and U.S. Department of Agriculture, Wildlife Services (USDA/WS, Appendix G), the USDA/WS program can provide assistance with the conduct of Wildlife Hazard Assessments and the development of Wildlife Hazard Management Plans. FAA Office of Airport Safety and Standards' Certalert No. 04-09, Relationship Between FAA and WS (Appendix E), further clarifies the roles of, and relationship between, the FAA and USDA/WS with regard to wildlife hazards on or near airports. See Chapter 6 for a discussion of the contents of a Wildlife Hazard Assessment.

3.2.A.III.C WILDLIFE HAZARD MANAGEMENT PLANS

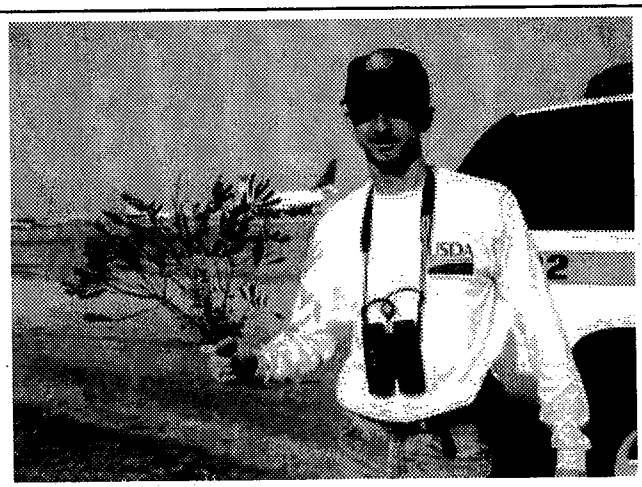
The FAA Administrator considers the Wildlife Hazard Assessment, aeronautical activity at the airport, views of the airport operator and its users, and other pertinent factors in determining whether a Wildlife Hazard Management Plan is needed (14 CFR 139.337(d)(1-6), see Appendix P). See Chapter 6 for a discussion of the contents of a Wildlife Hazard Management Plan.

3.2.A.III.D ADVISORY CIRCULARS (150/5200 SERIES)

The FAA issues Advisory Circulars (AC) to systematically inform the aviation public of nonregulatory material of interest. The standards, practices, and suggestions contained

in AC are recommended by the FAA for use by the operators and sponsors of all public-use airports. An AC provides guidance and information in its designated subject area and/or shows methods acceptable to the FAA Administrator for complying with 14 CFR 139. Unless incorporated into regulation by reference, the contents of an AC are not binding on the public. FAA Advisory Circulars germane to airport wildlife issues can be found in Appendix C.

3.2.B U.S. Department of Agriculture, Wildlife Services



Bayberry bushes produce fruits that often attract large flocks of tree swallows along the east coast of the USA during fall migration. Identifying and removing such preferred food plants is an important part of a wildlife hazard management control program (photo by R. A. Dolbeer, USDA).

3.2.B.I Mission

The mission of the U.S. Department of Agriculture/Wildlife Services (USDA/WS) is to provide federal leadership in managing problems caused by wildlife. USDA/WS helps manage wildlife to reduce damage to agriculture, natural resources, and property; minimizes potential threats to human health and safety; and assists in the protection of threatened and endangered species.

3.2.B.II Authority

The primary statutory authority for the USDA/WS program is the Animal Damage Control Act of March 2, 1931, as amended (7 U.S.C. 426-426c; 46 Statute 1468)(See Appendix B).

USDA/WS has the authority to manage migratory bird damage only as specified in the Code of Federal Regulations and under permits issued by the U.S. Fish and Wildlife Service (USFWS) (50 CFR 21). USDA/WS does not have the authority to issue migratory bird depredation permits.

3.2.B.III Role and Responsibility

Wildlife is a public resource greatly valued by the citizens of the USA. However, wildlife can cause damage to agricultural and industrial resources, pose risks to human health and safety, and impact other natural resources. USDA/WS has the federal responsibility to help resolve conflicts that occur when human activity and wildlife are in proximity to one another. USDA/WS has primary responsibility of responding to threats caused by migratory birds.

Wildlife Services Directive 2.305, Wildlife Hazards to Aviation (Appendix F), provides guidance for USDA/WS wildlife biologists in providing technical assistance or direct control to airport managers, state aviation agencies, the aviation industry, the FAA, and the Department of Defense (DOD) on hazards caused by wildlife to airport safety.

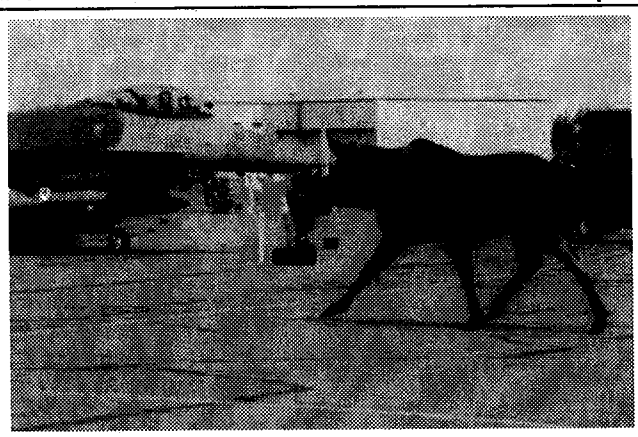
USDA/WS assists federal, state, and local agencies; airport managers; the aviation industry; and the military in reducing wildlife hazards on and in the vicinity of airports

and air bases according to the Memoranda of Understanding with the FAA (Appendix G) and Department of Defense and guidelines published elsewhere.

In addition, it is the responsibility of USDA/WS personnel that observe existing or potential wildlife hazards at airports or air bases to immediately notify the appropriate aviation authorities.

USDA/WS may enter into cooperative agreements to develop Wildlife Hazard Assessments and Wildlife Hazard Management Plans and to conduct direct wildlife hazard reduction programs. These activities are performed pursuant to agreements that are funded by cooperating entities.

USDA/WS biologists may provide training for airport and air base personnel in wildlife and hazard identification and the safe and proper use of wildlife control equipment and techniques.



Birds are not the only wildlife that pilots must watch out for. Proper fencing would have prevented this incident.

USDA/WS biologists may provide recommendations and assistance to airport managers and air base commanders in obtaining federal, state, and local permits to remove protected wildlife species.

3.2.C U.S. DEPARTMENT OF DEFENSE

3.2.C.I MISSION

The U.S. Department of Defense (USDOD) is responsible for providing the military forces needed to deter war and protect the security of the USA.

3.2.C.II AUTHORITY

The USDOD is the successor agency to the National Military Establishment created by the National Security Act of 1947 (50 U.S.C. 401). It was established as an executive department of the Government by the National Security Act Amendments of 1949 with the Secretary of Defense as its head (5 U.S.C. 101). The USDOD's primary authority is established under 32 CFR 1-2900.

3.2.C.III ROLE AND RESPONSIBILITY

Each military department (Department of the Navy includes the U.S. Marine Corps) is separately organized under its own Secretary and functions under the authority, direction, and control of the Secretary of Defense. The commanders of unified and specified combat commands are responsible to the President and the Secretary of Defense for accomplishing the military missions assigned to them and exercising command authority over forces assigned to them.

The U.S. Air Force (USAF) Bird Aircraft Strike Hazard (BASH) Team, HQ Air Force Safety Center, Kirtland Air Force Base, New Mexico, oversees the USAF wildlife strike reduction efforts. The BASH team maintains a wildlife strike database for strikes

involving USAF aircraft (http://afsafety.af.mil/afsc/Bash/home.html) similar to the database maintained by the FAA for civil aircraft (Chapter 2).

3.2.D U.S. ARMY CORPS OF ENGINEERS

3.2.D.I MISSION

The U.S. Army Corps of Engineers (COE) is charged with a wide range of functions related to water resources. Among these is the protection of navigation and safeguarding the nation's water resources.

3.2.D.II AUTHORITY

Regulatory authorities of the COE include Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403), which prohibits the obstruction or alteration of navigable waters of the U.S. without a COE permit; Section 404 of the Clean Water Act (33 U.S.C. 1344), which regulates the excavation and discharge of dredged or fill materials into waters of the U.S.; and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, which regulates deposition of fill material into ocean waters.



Recognizing that landfills can attract hazardous birds, the USEPA requires municipal solid waste landfills to be operated in a manner that does not pose a hazard to aviation safety (photo by E. Cleary, FAA).

3.2.D.III ROLE AND RESPONSIBILITY

The COE regulatory branch administers a permit system under Section 404 of the Clean Water Act. All proposed management actions involving any wetland habitat modification or excavation of fill material from or discharged into waters of the USA must be evaluated for Section 404 applicability and permit requirements. Projects requiring permits might require mitigation of impacted resources.

3.2.E U.S. ENVIRONMENTAL PROTECTION AGENCY

3.2.E.I MISSION

The mission of the U.S. Environmental Protection Agency (USEPA) is to safeguard the nation's environment.

3.2.E.II AUTHORITY

The USEPA was established in 1970 in response to concerns about polluted air and rivers, unsafe drinking water, endangered species, and waste disposal. The USEPA's primary regulatory responsibilities are established under 40 CFR 1-799.

3.2.E.III ROLE AND RESPONSIBILITY

USEPA functions include setting and enforcing environmental standards and

regulations related to air and water pollution, hazardous wastes, pesticides, and toxic substances. The USEPA's mission is accomplished through partnerships with state and local governments. USEPA responsibilities include pesticide registration and regulation and siting and construction of wastewater treatment and solid waste disposal facilities, which are permitted through state and local agencies. The FAA and USDA/WS may be consulted by airport authorities or state and local agencies to review impacts of proposed USEPA-regulated projects on aviation safety.

3.2.E.III.A LANDFILLS

Approval or disapproval of a landfill site is the responsibility of the USEPA, state and local governing bodies, and zoning boards. Other federal agencies, such as the FAA and USDA/WS, may only comment as to whether they would consider the proposed landfill to be compatible or non-compatible with their mission requirements.

3.2.E.III.B PESTICIDES



As one facet of an integrated hazardous wildlife management program, licensed falconers may occasionally use trained raptors, such as this peregrine falcon, at airports to repel other birds (photo by E. Cleary, FAA).

Before any pesticide may be used, it must be registered with the USEPA and with the appropriate state pesticide regulating authority. Pesticides are generally classified as either restricted use or general use. Restricted-use pesticides may only be sold to and used by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification. There are few restrictions on who may purchase or use general-use pesticides. Persons who want to use restricted-use pesticides, apply any pesticide to the land of another, or apply any pesticides for hire must be a Certified Applicator or working under the direct supervision of a Certified Applicator, and then only use pesticides covered by the Certified Applicator's certification (see state EPA below).

3.2.F U.S. DEPARTMENT OF INTERIOR, U.S. FISH AND WILDLIFE SERVICE

3.2.F.I MISSION

The mission of the U.S. Fish and Wildlife Service (USFWS) is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of all people.

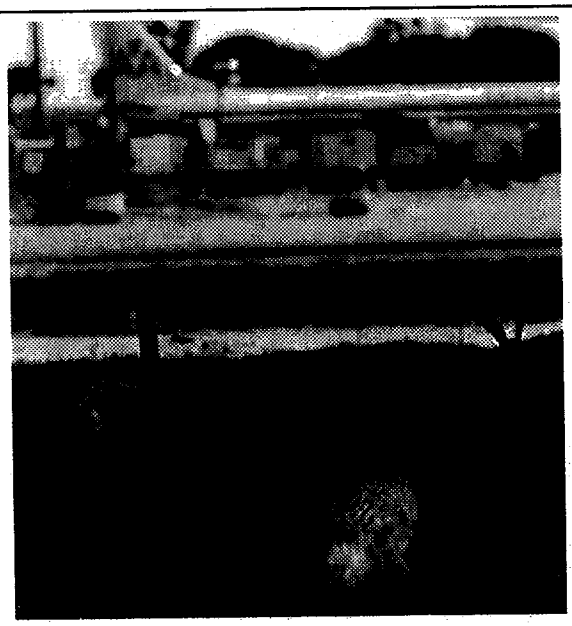
3.2.F.II AUTHORITY

The USFWS has management authority for migratory birds and federally listed

threatened and endangered wildlife species. The USFWS primary regulatory responsibilities are established under 50 CFR 1-199.

3.2.F.III ROLE AND RESPONSIBILITY

The USFWS is responsible for the conservation and enhancement of migratory birds, threatened and endangered species, certain marine mammals, anadromous fishes, and wetlands. The USFWS also manages the National Wildlife Refuge System, enforces federal wildlife laws, and conducts biological reviews of the environmental impacts of development projects.



Most mammals are protected by state wildlife agencies, and it is generally necessary to obtain a State Depredation Permit before taking these species on an airport. The first step in obtaining such a permit is to contact the nearest office of USDA Wildlife Services (see Appendix A).

The USFWS renders biological opinions on proposed federal activities that might impact federally listed or proposed endangered or threatened species or result in the destruction or adverse modification of designated or proposed critical habitat. These opinions are solicited through a "Section 7 consultation", as required under the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Statute 884, as amended).

3.3 STATE AGENCIES

Specific state regulations and their enforcement are not addressed in this manual because of their wide variability. The following general comments are provided as background information.

Consult state and local regulatory agencies having jurisdiction over wildlife and natural resources, environmental protection, health, law enforcement, transportation, and others as applicable, when working with airport wildlife issues.

3.3.A STATE WILDLIFE MANAGEMENT AGENCIES

Wildlife management authority for resident nonmigratory birds, terrestrial mammals, freshwater fish, reptiles, and other taxa rest with state wildlife management agencies. These agencies establish the take and possession regulations for all state-protected species. States set their migratory game-bird hunting seasons and bag limits within the guidelines established by the USFWS. States also may list certain wildlife and plant species as threatened or endangered that are not considered as such at the federal level.

Persons needing to take state-protected species outside of the legal hunting season or beyond the established bag limits to promote airport safety must first secure a state

depredation permit. Contact the nearest USDA/WS office (Appendix A) for assistance in obtaining any necessary state depredation permits.

3.3.B STATE ENVIRONMENTAL PROTECTION AGENCIES

3.3.B.I LANDFILL SITING PERMITS AND INSPECTIONS

With concurrence from the USEPA, state EPAs, local governing bodies, and zoning boards have the final responsibility for issuing landfill permits. It is also a state responsibility to inspect all landfills to ensure compliance with all applicable federal and state regulations.

3.3.B.II PESTICIDE REGISTRATION

Before a pesticide may be sold or used, it must be registered with the USEPA and with the respective state's pesticide regulatory agency. Special Local Need (SLN) registered pesticides may only be used in the state—and in some cases, the specific geographical location—for which the SLN registration has been issued.

3.3.B.III PESTICIDE APPLICATOR LICENSING

With USEPA concurrence, each state is responsible for establishing pesticide applicator licensing requirements and applicator training procedures. The retail sale and use of restricted-use pesticides is limited to Certified Applicators or persons working under their direct supervision and only for those uses covered by the Certified Applicator's certification.



Within 2 weeks of completion, starlings and pigeons had started roosting in this canopy constructed over the passenger drop-off area at a major USA airport (photo by S. Gordon).

Anyone who uses restricted-use pesticides, applies any pesticides for hire, or applies any pesticide to the land of another must be a Certified Applicator or working under the direct supervision of a Certified Applicator, and may only use pesticides covered by the Certified Applicator's certification.

3.4 AIRPORTS

3.4.A AIRPORT OPERATOR

The operator of a certificated airport[1] must demonstrate that the airport is properly and adequately equipped and programs are in place to provide a safe airport-operating environment in accordance with all sections of 14 CFR 139 subpart D. Included in this regulation is the need to address

[1] Airports that have received an Airport Operating Certificate from the FAA, issued under 14 CFR 139, to operate a Class I, II, III, or IV airport.

wildlife hazard issues, conduct Wildlife Hazard Assessments, and develop Wildlife Hazard Management Plans, as conditions dictate.

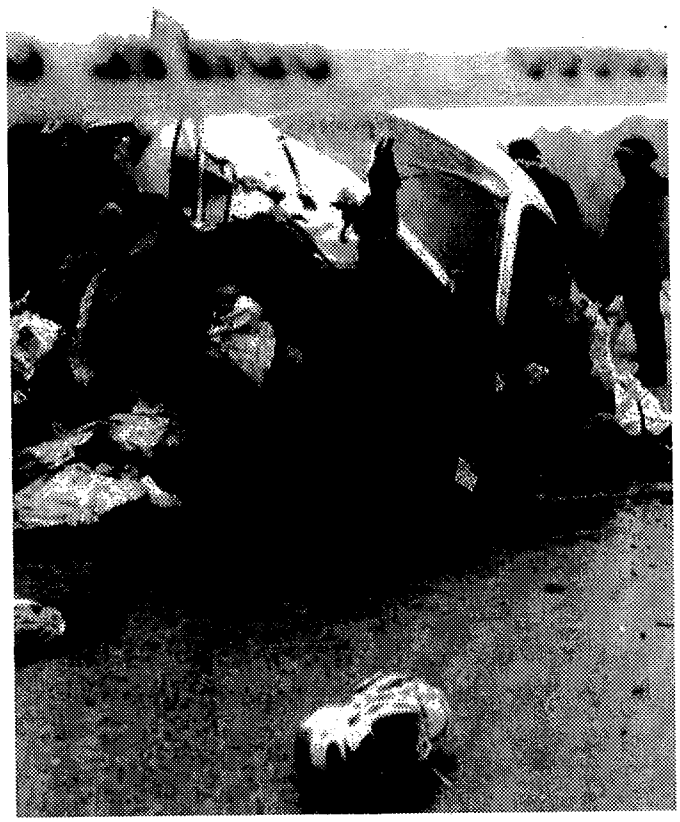
In accordance with its Airport Certification Manual and the requirements of section 139.337(a), each certificate holder must take immediate action to alleviate wildlife hazards whenever they are detected. An important part of this process is establishing procedures for airport employees or tenants to report hazardous wildlife on or near the air operation areas (AOA) to the appropriate airport personnel.

3.4.B AIR TRAFFIC CONTROL

Air traffic control personnel must report any unsafe conditions, including hazardous wildlife on or near the AOA, to the appropriate airport personnel anytime they are observed.

Also, to the extent permitted by higher priority duties and other circumstances, air traffic controllers are required to—

- Issue advisory information on pilot-reported, tower-reported, or radar-observed and pilot-verified bird activity;
- Relay bird activity information to adjacent facilities and to Flight Service Stations (FSS) whenever it appears the wildlife hazard will become a factor in the area (FAA Order 7110.65, 2-1-22).



Pilots using uncontrolled airports need to be alert to the possibility of wildlife on the runway. This Learjet was destroyed when it struck two deer on landing at a southern USA airport, January 2001. In 2004, there were 3,344 airports in the FAA's National Plan of Integrated Airport Systems; less than 650 had an air traffic control tower.

3.4.C PILOTS

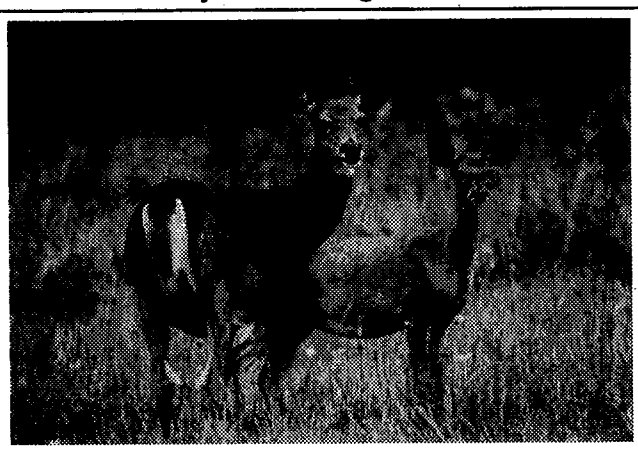
Pilots have a responsibility to report all unsafe conditions on or near an airport, including birds or other wildlife that could pose a threat to aircraft safety. Pilots and other airline or airport personnel should report all known wildlife strikes. Strikes can be reported electronically at http://wildlife-mitigation.tc.faa.gov. Wildlife strikes can also be reported by completing and mailing FAA Form 5200-7 *Bird/Other Wildlife Strike Report* (Appendix I). No postage is required if this form is mailed within the USA. This form can be downloaded and printed from the above website and duplicated as needed. All strike reports are closely screened and edited to prevent duplicate entries in the

database.

3.5 BIRD STRIKE COMMITTEE–USA

Bird Strike Committee–USA (BSC–USA) was formed in 1991 to facilitate the exchange of information, promote the collection and analysis of accurate wildlife strike data, promote the development of new technologies for reducing wildlife hazards, promote professionalism in wildlife management programs on airports through training and advocacy of high standards of conduct of airport biologists and bird patrol personnel, and serve as a liaison to similar organizations in other countries.

Bird Strike Committee USA is directed by a 9- to 12-person steering committee consisting of two to three members each from the FAA, USDA/WS, DOD, and the aviation industry. The organization meets annually, in conjunction with Bird Strike Committee Canada, at an airport in the USA or Canada. There are generally four parts to a BSC–USA meeting. Part 1 is classroom and field training sessions on wildlife control at airports, which cover both civil and military aviation. Part 2 consists of the presentation of technical papers and posters. Part 3 comprises exhibits and demonstrations with vendors. Part 4 is a field trip that generally covers the host airport and surrounding areas to observe management programs and habitat issues related to wildlife and aviation safety. Participation in the annual meetings is open to any person interested in reducing wildlife hazards to aviation and in environmental and land-use issues related to airports. BSC–USA does not charge membership fees; however, a registration fee is charged for attendance at annual meetings.



Between 1990 and 2003, deer were responsible for 16 (76 percent) of the mammal strikes that resulted in injury or death and for 23 (77 percent) of the 30 deaths or injuries resulting from wildlife strikes with civil aircraft in the USA (photo by S. Wright, USDA).

Additional information about BSC–USA can be found at BSC–USA's website: http://www.birdstrike.org.

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CHAPTER 4:
FEDERAL REGULATIONS AND DEPARTMENTAL POLICIES IMPACTING AIRPORT WILDLIFE MANAGEMENT



Four men escaped unhurt when their Learjet 36 struck an elk and caught fire during takeoff at a western USA airport in December 2002. The pilot was able to bring the plane to a stop in a marsh just off the end of the runway and evacuate the aircraft before it was destroyed by fire.

4.1 INTRODUCTION

Wildlife is often protected by overlapping federal, state, and local laws, regulations, and ordinances, enforceable by a diversity of governmental organizations. Chapter 3 provided an overview of the roles and responsibilities of the various agencies. This chapter will discuss some of the more important federal regulations and departmental policies that influence wildlife management on or near airports.

4.2 SUMMARY OF APPLICABLE FEDERAL REGULATIONS

4.2.A TITLE 14, CODE OF FEDERAL REGULATIONS, PART 139

14 CFR 139 governs the certification and operation of land airports that serve any scheduled or unscheduled passenger operation of an air carrier that is conducted with an aircraft having a seating capacity of more than 9 passengers. Part 139.337 (Appendix P) speaks specifically to the airport operator's responsibilities when dealing with the reduction of wildlife strike hazards on and around airports. A detailed discussion of Part 139.337 can be found in Chapter 6.

4.2.B TITLE 40, CODE OF FEDERAL REGULATIONS, PART 258.10

The U.S. Environmental Protection Agency (USEPA), recognizing that birds can be attracted in large numbers to municipal solid waste landfills (MSWLF) and recognizing the potential threat posed by birds to aircraft safety, requires owners or operators of new MSWLF units—or lateral expansions of existing MSWLF units that are located within 10,000 feet of any airport runway used by turbojet aircraft or within 5,000 feet of any airport runway used only by piston-type aircraft—to demonstrate successfully that such units do not create hazardous conditions for aircraft.



Because of conservation efforts by government agencies and private organizations, many wildlife species once on the brink of extinction are now on the road to recovery. This juvenile bald eagle, hatched in New York, was rescued after a storm in Indiana. Management of migratory bird species is the responsibility of the USFWS (photo by E. Cleary, FAA).

The USEPA also requires any operator proposing a new or expanded waste disposal operation within 5 statute miles of a runway end to notify the appropriate FAA Regional Airports Division Office and the airport operator of the proposal.

4.2.C TITLE 50, CODE OF FEDERAL REGULATIONS, PARTS 1 TO 199

These regulations govern the management of federally protected wildlife within the United States and its territories based on the authority established in the Migratory Bird Treaty Act (see below). These regulations also establish procedures for issuing permits to take federally protected species. In general, a federal depredation permit, issued by the U.S. Fish and Wildlife Service (USFWS), must be obtained before any non-game migratory birds may be taken, or before any migratory game birds may be taken outside of the normal hunting season or beyond established bag limits.

Federal law protects all migratory birds, including their nests and eggs:

"A migratory bird [is]...any bird whatever its origin and whether or not raised in captivity,

which belongs to a species listed in sect. 10.13 [of 50 CFR] or which is a mutation or a hybrid of any such species, including any part, nest, or egg of any such bird, or any product, whether or not manufactured, which consist, or is composed in whole or part, of any such bird, or any part, nest, or egg there of." (50 CFR 10.12). This list includes almost all native bird species in the United States, with the exception of nonmigratory game birds, such as turkeys and grouse, and some introduced game birds, such as pheasants and chukars. Exotic and feral species, such as graylag geese, muscovy ducks, European starlings, house (English) sparrows, and rock doves (pigeons), are not listed in 50 CFR 10.13 and are therefore not protected by federal law.

In addition to federal protection, all states protect migratory birds as well as game birds, such as pheasants, turkeys, grouse, and partridges. States might or might not protect exotic or feral species.

With the exception of federally listed or proposed threatened or endangered species, federal law does not protect terrestrial mammals, reptiles, or other wildlife taxa (e.g., deer, coyotes, raccoons, groundhogs, snakes, turtles, and freshwater fish). Protection of these wildlife groups is left to the individual states.



Blackbirds traveling to and from roosting sites near an airport can create hazardous conditions for aircraft. A federal permit is not required to control blackbirds when "concentrated in such numbers and manner as to constitute a health hazard or other nuisance" (photo by R. A. Dolbeer, USDA).

4.2.C.I DEPREDATION PERMITTING REQUIREMENTS AND PROCEDURES

Persons wishing to take migratory birds, nests, or eggs as part of an airport wildlife management program must first secure a depredation permit from the USFWS. Some state wildlife management agencies may require that a state permit be obtained also. Persons wishing to take state-protected species must first secure a permit from their respective state wildlife management agency. For assistance in obtaining federal and state depredation permits, contact the local U.S. Department of Agriculture, Wildlife Services (USDA/WS) office (Appendix A).

4.2.C.II STANDING DEPREDATION ORDERS

Federal law allows people to protect themselves and their property from damage caused by migratory birds. Provided no effort is made to kill or capture the birds, a depredation permit is not required to merely scare or herd depredating migratory birds other than endangered or threatened species or bald or golden eagles (50 CFR 21.41).

In addition, certain species of migratory birds may be killed or captured without a federal permit under specific circumstances, most of which relate to agricultural situations. A Standing Depredating Order that has applicability at airports relates to blackbirds and related species:

"A federal permit shall not be required to control yellow-headed, red-winged, rusty and Brewer's blackbird, cowbirds, all grackles, crows, and magpies, when found committing or about to commit depredation upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or when concentrated in such numbers and manner as to constitute a health hazard or other nuisance ..." (50 CFR 21.43).



This Navy T-44A suffered a turkey vulture strike to the right horizontal stabilizer during a routine training flight in October 2002 in Texas. The T-44A is the U.S. Navy's version of a Beechcraft King Air 90, a twin turboprop corporate and utility transport aircraft. The turkey vulture population in the USA increased at a mean annual rate of over 2% from 1980–2004.

However, state laws may not mirror federal law in this respect. For example, in Ohio, crows may not be killed in any circumstances, outside of the state crow-hunting season, without a state-issued depredation permit, and blackbirds may not be killed on Sundays.

Persons wishing to take any other migratory birds, or to take migratory birds in situations other than those described above, must first secure a federal Migratory Bird Depredation Permit from the USFWS, and in some case a State Depredation Permit. The first step in obtaining the necessary permits is to contact the nearest USDA/WS state office (Appendix A).

4.2.D The Migratory Bird Treaty Act of 1918, as amended (U.S. Code 603–711; 40 Statute 755)

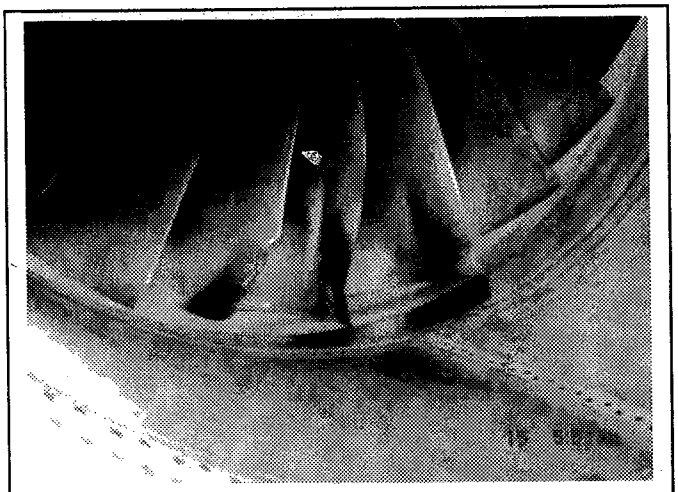
The United States of America, Canada, the United Mexican States, Russia and Japan are signatories to the Migratory Bird Treaty Act (MBTA). This act provides the statutory foundation for the federal protection and management of migratory birds in the United States (50 CFR, Parts 1–199).

4.2.E The Animal Damage Control Act of 1931, as amended (7 U.S. Code 426–426c; 46 Statute 1468)

This act authorizes and directs the Secretary of Agriculture to manage wildlife injurious to agricultural interests, other wildlife, or human health and safety, including wildlife hazards to aviation (Appendix B). The U.S. Department of Agriculture's Wildlife Services (USDA/WS) is the agency that carries out this mandate. USDA/WS, because of the experience, training, and background of its personnel, is recognized throughout the world for expertise in dealing with wildlife damage management issues. USDA/WS has an active presence in all U.S. states and territories. USDA/WS also has a National Wildlife Research Center in Colorado and eight regional research field stations.

4.2.F FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT, AS AMENDED (7 U.S. CODE 136; PUBLIC LAW 104.317)

This act, administered by USEPA, governs the registration, labeling, classification, and use of pesticides. Any substance used as a pesticide must be registered with the USEPA and with the respective state pesticide-regulatory agency. Anyone wishing to use restricted-use pesticides, applying any pesticides to the land of another, or applying any pesticides for hire, must be a Certified Applicator, or working under the direct supervision of a Certified Applicator, and then may only use pesticides covered by the Certified Applicator's certification.



This engine on an A320 ingested a great blue heron on departure from a western USA airport in 2002. The pilot observed the bird just prior to impact. The aircraft made an emergency landing with the engine out. The engine and nose cowl were replaced. The runway was closed for 38 minutes while fire trucks washed the debris from the runway (photo courtesy S. Gordon).

4.3 DEPARTMENTAL POLICIES

4.3.A FAA ADVISORY CIRCULARS

The FAA recommends that public-use airport operators implement the standards and practices contained in all applicable Advisory Circulars (AC). Holders of Airport Operating Certificates issued under Title 14, Code of Federal Regulations (CFR), Part 139, Certification of Airports, Subpart D (Part 139), may use the standards, practices, and recommendations contained in an AC to comply with the airport management requirements of Part 139. In general, airports that have received federal grant-in-aid assistance must use the standards presented in an AC. See Appendix C for copies of the current version (as of July 2005) of AC mentioned in this Manual. AC are revised on an irregular schedule. Copies of revised AC can be accessed at: http://www.faa.gov/arp/

4.3.A.I 150/5200-32A. REPORTING WILDLIFE AIRCRAFT STRIKES.

This AC explains the importance of reporting wildlife strikes. It also examines recent improvements in the FAA's Bird/Other Wildlife Strike Reporting system, how to report a wildlife strike, what happens to the wildlife strike report data, how to access the FAA National Wildlife Aircraft Strike Database, and the FAA's Feather Identification Program.

4.3.A.II 150/5200-33A. HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS.

This AC provides guidance on locating certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. It also provides guidance on the placement of new airport development projects (including airport construction, expansion, and renovation) pertaining to aircraft movement in the vicinity of hazardous

wildlife attractants.

4.3.A.III 150/5200-34. CONSTRUCTION OR ESTABLISHMENT OF LANDFILLS NEAR PUBLIC AIRPORTS.

This AC provides guidance on meeting the requirements of Section 503 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (Public Law 106–181) (AIR 21), which prohibits the construction or establishment of a new Municipal Solid Waste Landfill within 6 statute miles of certain public-use airports. Before these prohibitions apply, both the airport and the landfill must meet very specific conditions. These restrictions do not apply to airports or landfills located within the state of Alaska (see § 5.3.A.I of this manual).



Between 1990 and 2003, vultures were involved in 374 reported wildlife strikes to US civil aircraft; 219 (59%) of those strikes caused damage to the aircraft. Vultures readily feed at landfills (photo by M. Colunga, Aeropuertos y Servicios Auxiliares).

4.3.B FAA, AIRPORTS: AIRPORT CERTIFICATION PROGRAM POLICIES AND GUIDANCE

Program Policies and Guidance documents provide FAA personnel with interpretations of and directions for applying various aspects of federal regulations related to aviation safety. See Appendix D for Program Policies and Guidance related to airport wildlife management.

4.3.B.I POLICY NO. 77. INITIATION OF WILDLIFE HAZARD ASSESSMENTS AT AIRPORTS.

This policy establishes the procedures for FAA Airport Certification Safety Inspectors to follow when it is determined that an airport needs to conduct a Wildlife Hazard Assessment to address an airport wildlife hazard.

4.3.B.II POLICY NO. 78. SECTION 7 CONSULTATION ON ENDANGERED OR THREATENED SPECIES.

This policy establishes the procedures for coordinating and documenting FAA compliance with the Endangered Species Act when requiring an airport operator to develop, submit for approval, and implement a Wildlife Hazard Management Plan.

4.3.B.III POLICY NO. 79. REVIEW OF AIRPORT WILDLIFE HAZARD MANAGEMENT PLANS.

This policy establishes the procedures to be followed when an incident occurs that would initiate a Wildlife Hazard Assessment under 14 CFR 139.337(b)(1-4), and directs Airport Certification Safety Inspectors to review an airport's Wildlife Hazard Management Plan to ensure that it meets all requirements of 14 CFR 139.337(e) and (f), as part of their preparation for a certification inspection.

4.3.B.IV POLICY NO. 82. WASTE DISPOSAL FACILITY COORDINATION.

This policy establishes the procedures for coordinating and documenting FAA determinations on developing new, or expanding existing, waste disposal sites within 5 miles of a public-use airport.



This retention pond, located less than 2,000 feet from the main runway at a major USA airport, had 3 duck and 1 Canada goose nests when surveyed in 2002 (photo by E. Cleary, FAA).

4.3.C FAA, AIRPORTS, OFFICE OF AIRPORT SAFETY AND STANDARDS, CERTALERTS RELATING TO AIRPORT WILDLIFE MANAGEMENT

Certalerts provide non-directive advisory or cautionary information dealing with aviation safety to the aviation community. See Appendix E for Certalerts dealing with aviation wildlife hazards.

4.3.C.I CERTALERT NO. 98-05. GRASSES ATTRACTIVE TO HAZARDOUS WILDLIFE.

This Certalert warns airport operators against the use of millet and any other large-seed producing grasses or other plants attractive to hazardous wildlife for revegetation of construction sites or other disturbed areas on the airport

4.3.C.II CERTALERT NO. 04-09. THE RELATIONSHIP BETWEEN FAA AND USDA/WS.

This Certalert clarifies the roles of and relationship between the Federal Aviation Administration (FAA) and the United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (USDA/WS) with regards to wildlife hazards on or near airports.

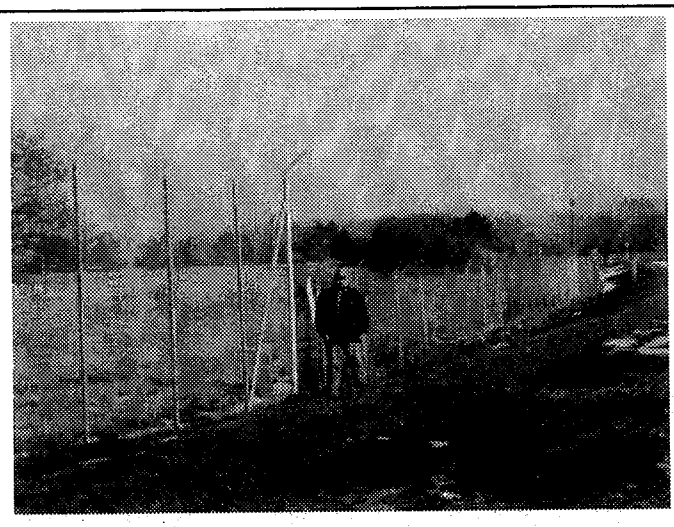
4.3.C.III CERTALERT NO 04-16. DEER HAZARDS TO AVIATION AND DEER FENCING.

In light of recent incidents where a Learjet landing at an airport in Alabama and a Learjet departing an airport in Oregon were destroyed after colliding with deer or elk, airport operators are reminded of the importance of controlling deer and other wild ungulates on and around airfields.

4.3.D USDA, WILDLIFE SERVICES DIRECTIVE 2.305, WILDLIFE HAZARDS TO AVIATION

This directive provides general guidelines for USDA/WS technical and direct control assistance to airport managers, state aviation agencies, aviation industry, FAA, and Department of Defense about hazards caused by wildlife to airport safety (Appendix F).

4.3.E MEMORANDUM OF UNDERSTANDING: FAA AND USDA/WS



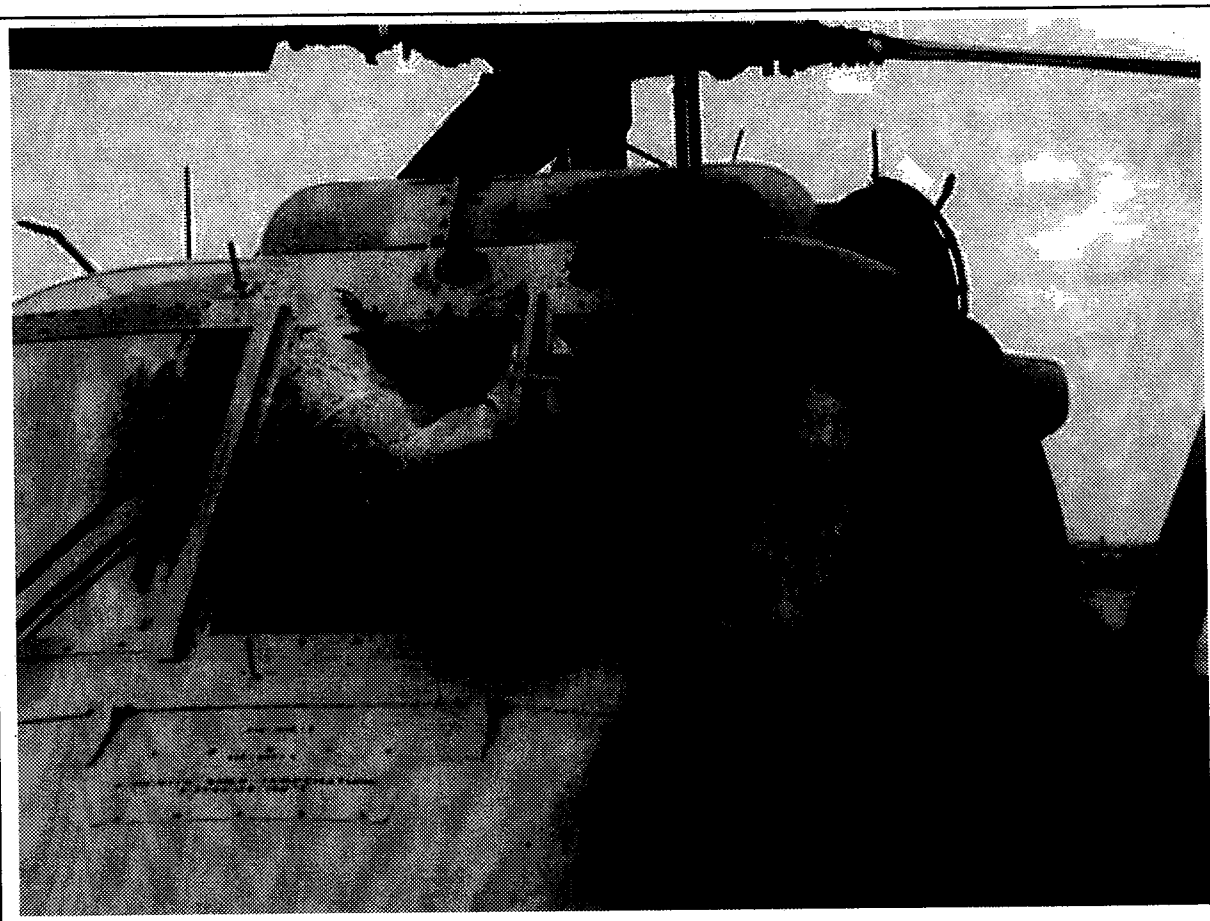
A well-maintained fence, at least 10-feet high with no gaps at the bottom, is the primary defense to keep deer and other large animals off the airport's AOA. Deer can easily jump fences that are only 6 feet high (right) (photo by R. A. Dolbeer, USDA).

A Memorandum of Understanding between the FAA and USDA/WS (No. 12-14-71-0003-MOU), establishing a cooperative relationship between the two agencies, has been in effect since 1989. The FAA relies heavily on the assistance of USDA/WS for resolving problems involving wildlife hazards to aviation at airports (Appendix G).

4.3.F INTERAGENCY MEMORANDUM OF AGREEMENT

The Federal Aviation Administration, the U.S. Air Force, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S Department of Agriculture/Wildlife Services signed a Memorandum of Agreement (MOA) (finalized July 2003) to acknowledge their respective missions in protecting aviation from wildlife hazards. Through the MOA, the agencies established procedures necessary to coordinate their missions to address more effectively existing and future environmental conditions contributing to collisions between wildlife and aircraft (wildlife strikes) throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety while protecting the Nation's valuable environmental resources (Appendix H).

CHAPTER 5:
RECOGNIZING HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS



A Eurasian crane penetrated the windshield of this Israeli helicopter in March 2003. In the USA, vultures and waterfowl have been responsible for the most losses of military aircraft to bird strikes.

5.1 INTRODUCTION

Land-use practices and habitat are the key factors determining the wildlife species and the size of wildlife populations that are attracted to airport environments. The recognition and control of those land-use practices and habitats on or near airports that attract hazardous wildlife are fundamental to effective Wildlife Hazard Management Plans.

The FAA (through Advisory Circular 150/5200-33A, Hazardous Wildlife Attractants on or Near Airports, Appendix C) provides guidance on locating certain land uses that have the potential to attract hazardous wildlife on or near public-use airports. It also discusses airport development projects (including airport construction, expansion, and renovation) affecting aircraft movement near hazardous wildlife attractants.

5.2 SEPARATION CRITERIA FOR HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS

The minimum separation criteria outlined below are recommended for land-use practices that attract hazardous wildlife to the vicinity of airports. Please note that these criteria include land uses that cause movement of hazardous wildlife onto, into, or across the approach or departure airspace, air operation area (AOA), loading ramps, or aircraft parking area of airports.



Piston engines are not as susceptible to bird-strike damage as turbine engines. However, other parts of piston-powered aircraft can be severely damaged. This Rockwell Commander, flying at 1,500 feet AGL and 130 knots, struck a large bird. This was the second damaging bird strike this aircraft had suffered in less than 10 years (photo courtesy B. McKinnon, Transport Canada).

The basis for the separation criteria contained in this section can be found in existing FAA regulations. The separation distances are based on (1) flight patterns of piston-powered aircraft and turbine-powered aircraft, (2) the altitude at which most strikes happen (81 percent occur under 1,000 feet and 92 percent occur under 3,000 feet above ground level), and (3) National Transportation Safety Board (NTSB) recommendations. The recommended separation distances are diagramed in Figure-5-1.

5.2.A AIRPORTS SERVING PISTON-POWERED AIRCRAFT

Airports that do not sell Jet-A fuel normally serve piston-powered aircraft. Notwithstanding more stringent requirements for specific land uses, a minimum separation distance of 5,000 feet is recommended at these airports for known hazardous wildlife attractants or for new airport development projects meant to accommodate aircraft movement. This distance is to be maintained between an airport's AOA, loading ramps, and aircraft parking areas and the hazardous wildlife attractant. Figure 5-1 depicts this separation distance measured from the nearest AOA.

5.2.B AIRPORTS SERVING TURBAN-POWERED AIRCRAFT

Airports selling Jet-A fuel normally serve turbine-powered aircraft. Notwithstanding more stringent requirements for specific land uses, a minimum separation distance of 10,000 feet is recommended at these airports for known hazardous wildlife attractants or for new airport development projects meant to accommodate aircraft movement. This distance is to be maintained between an airport's AOA, loading ramps, and aircraft parking areas and the hazardous wildlife attractant. Figure 5-1 depicts this separation distance measured from the nearest AOA.

5.2.C PROTECTION OF APPROACH OR DEPARTURE AIRSPACE

For all airports, a minimum separation distance of 5 statute miles is recommended between the farthest edge of the airport's AOA and known hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace. Figure 5-1 depicts this separation distance measured from the nearest AOA.

5.3 LAND-USE PRACTICES THAT POTENTIALLY ATTRACT HAZARDOUS WILDLIFE



Because most agricultural crops attract birds at some point during their production cycle, the FAA recommends against allowing farming on airport property (photo by R. DeFusco, BASH, Inc.).

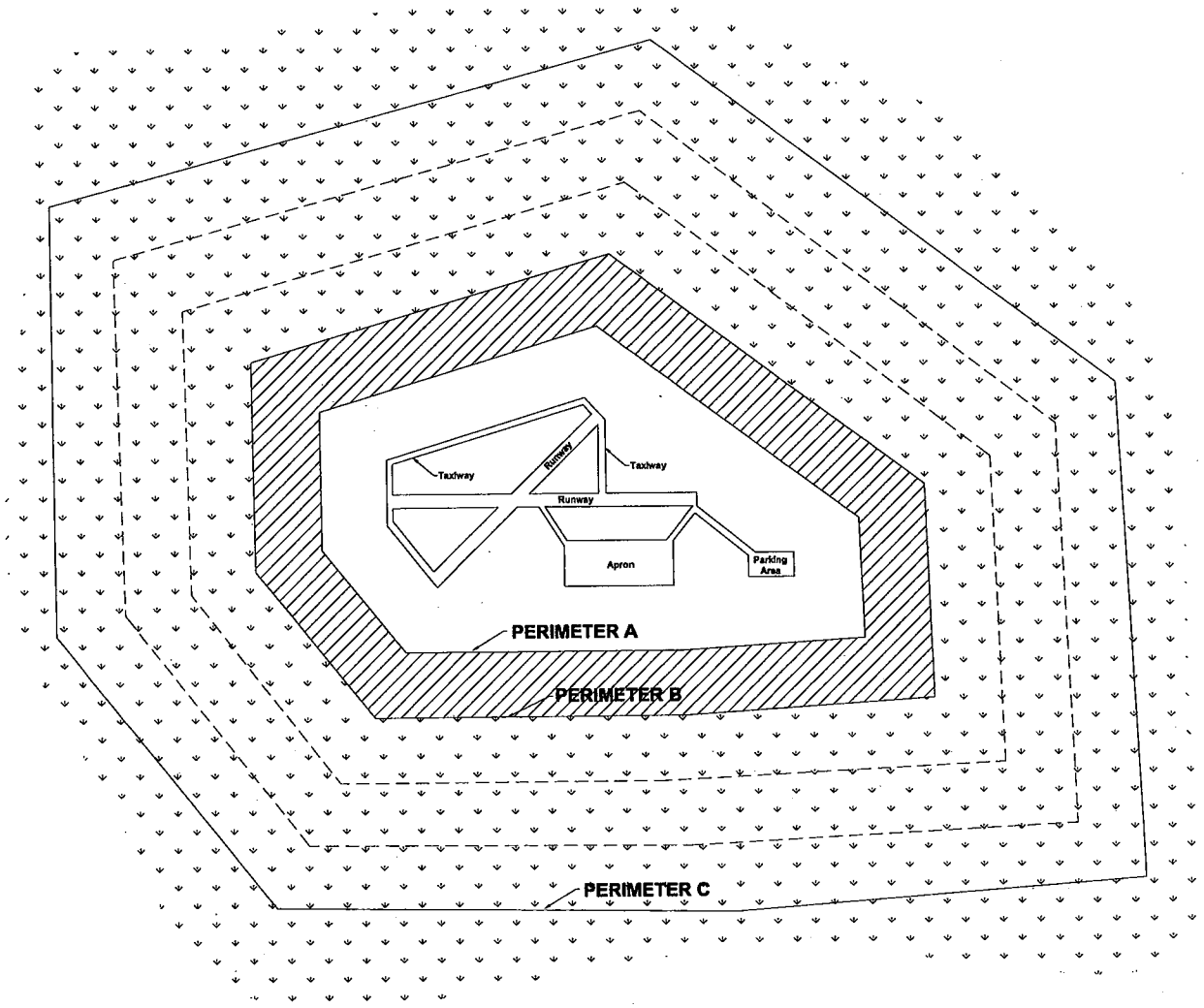
The wildlife species and the size of the populations attracted to the airport environment vary considerably, depending on several factors, including land-use practices on or near the airport. This section discusses land-use practices having the potential to attract hazardous wildlife and threaten aviation safety.

5.3.A WASTE DISPOSAL OPERATIONS

Municipal solid waste landfills (MSWLF) are known to attract large numbers of hazardous wildlife, particularly birds. Because of this, these operations, when located within the separations identified in the siting criteria in AC 150/5200-33A (see above and Appendix C), are considered incompatible with safe airport operations.

5.3.A.1 SITING NEW MUNICIPAL SOLID WASTE LANDFILLS SUBJECT TO AIR 21

Section 503 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (Public Law 106–181) (AIR 21) prohibits the construction or establishment of a new MSWLF within 6 statute miles of certain public-use airports. Before these prohibitions apply, both the airport and the landfill must meet the very specific conditions described below. These restrictions do not apply to airports or landfills located within Alaska.



Perimeter A:

For airports serving piston-powered aircraft, hazardous wildlife attractants must be 5,000 feet from the nearest air operations area.

Perimeter B:

For airports serving turbine-powered aircraft, hazardous wildlife attractants must be 10,000 feet from the nearest air operations area.

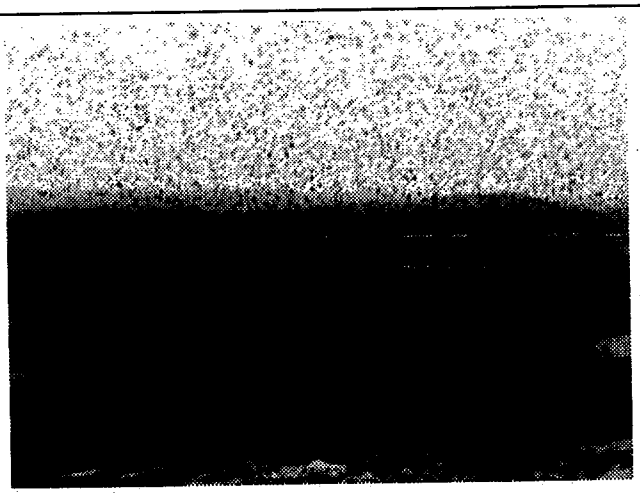
Perimeter C:

5-mile range to protect approach, departure, and circling airspace.

Figure 5-1. Separation distances within which hazardous wildlife attractants should be avoided, eliminated, or mitigated.

The airport must (1) have received a federal grant(s) under 49 U.S.C. § 47101, et. seq.; (2) be under control of a public agency; (3) serve some scheduled air carrier operations conducted in aircraft with less than 60 seats; and (4) have total annual enplanements consisting of at least 51 percent of scheduled air carrier enplanements conducted in aircraft with less than 60 passenger seats.

The proposed MSWLF must (1) be within 6 miles of the airport, as measured from airport property line to MSWLF property line, and (2) have started construction or establishment on or after April 5, 2001. Public Law 106–181 only limits the construction or establishment of some new MSWLF. It does not limit the expansion, either vertical or horizontal, of existing landfills. Consult the most recent version of AC 150/5200-34, *Construction or Establishment of Landfills Near Public Airports* (Appendix C), for a more detailed discussion of these restrictions.



It is widely recognized that open-faced, putrescible waste landfills attract gulls. However, these landfills also attract other birds hazardous to aviation. Over 5,000 starlings were counted at this Midwestern USA landfill (photo by E. Cleary, FAA).

5.3.A.II SITING NEW MUNICIPAL SOLID WASTE LANDFILLS NOT SUBJECT TO AIR 21

If an airport and MSWLF do not meet the restrictions of Public Law 106–181, do not locate new MSWLF within the separation distances identified in AC 150/5200-33A (see above and Appendix C). Measure the separation distances from the closest point of the airport's AOA to the closest planned MSWLF cell.

5.3.A.III CONSIDERATIONS FOR EXISTING WASTE DISPOSAL FACILITIES WITHIN THE LIMITS OF SEPARATION CRITERIA

Do not locate airport development projects that would increase the number of aircraft operations or accommodate larger or faster aircraft near MSWLF operations within the separations identified in AC 150/5200-33A (see above and Appendix C). In addition, in accordance with 40 CFR 258.10, owners or operators of existing MSWLF units that are located within the separations listed in AC 150/5200-33A (see above and Appendix C) must demonstrate that the unit is designed and operated so it does not pose a bird hazard to aircraft.

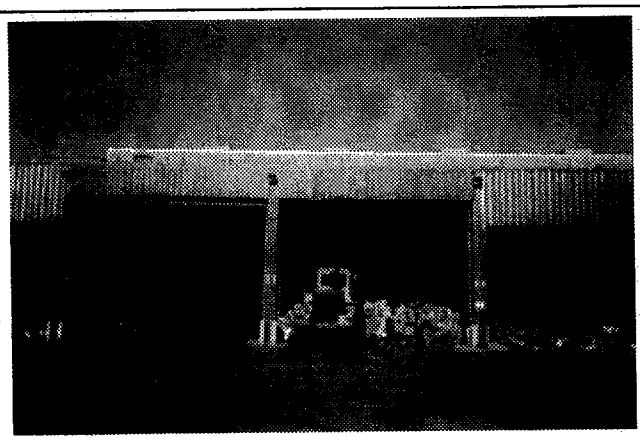
To claim successfully that a waste-handling facility sited within the separations identified in AC 150/5200-33A (see above and Appendix C) does not attract hazardous wildlife and does not threaten aviation, the developer must establish convincingly that the facility will not handle putrescible material other than in fully enclosed transfer stations (see 5.4.b, below).

In their effort to satisfy the EPA requirement, some putrescible-waste facility proponents

might offer to undertake experimental measures to demonstrate that their proposed facility will not be a hazard to aircraft. To date, no such facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife to levels that existed before the putrescible-waste landfill began operating. For this reason, the FAA does not consider the demonstration of experimental wildlife control at putrescible-waste landfills within the separation distances specified in AC 150/5200-33A to be an acceptable alternative to locating the landfill beyond the separation distances.

5.3.B TRASH TRANSFER STATIONS

Enclosed waste-handling facilities that receive garbage behind closed doors; process it via compaction, incineration, or similar manner; and remove all residue by enclosed vehicles generally are compatible with safe airport operations, provided they are not located on airport property or within the Runway Protection Zone (RPZ). Do not handle or store putrescible waste outside or in a partially enclosed structure accessible to hazardous wildlife at these facilities. Trash transfer facilities that leave the main doors open during normal operations, are open on one or more sides, that temporarily store uncovered quantities of municipal solid waste outside, that use semi-trailers that leak or have trash clinging to the outside, or that do not control odors by ventilation and filtration systems (odor masking is not acceptable) do not meet the FAA's definition of fully enclosed trash transfer stations. The FAA considers these facilities incompatible with safe airport operations if they are located closer than the separation distances specified in AC 150/5200-33A (see above and Appendix C).



Open-sided trash transfer stations attract gulls, starlings, and other birds that can pose a hazard to aviation safety. Any waste-management facility that has exposed putrescible waste must not be located closer to an airport than the separation distance specified in AC 150/5200-33A (Appendix C) (photo by L. Henze, USDA).

5.3.C COMPOSTING OPERATIONS ON OR NEAR AIRPORT PROPERTY

Composting operations that accept only yard waste (e.g., leaves, lawn clippings, or branches) generally do not attract hazardous wildlife. Sewage sludge, woodchips, and similar material are not municipal solid wastes and may be used as compost bulking agents. The compost, however, must never include food or other municipal solid waste. Do not locate composting operations on airport property. Do not locate off-airport property composting operations closer than the greater of the following distances: 1,200 feet from any AOA, loading ramp, or aircraft parking space or the distance called for by airport design requirements (see AC 150/5300-13, Airport Design). This spacing is meant to prevent material, personnel, or equipment from penetrating any Object Free Area (OFA), Obstacle Free Zone (OFZ), Threshold Siting Surface (TSS), or Clearway. Monitor composting operations located in proximity to the airport to ensure that steam or

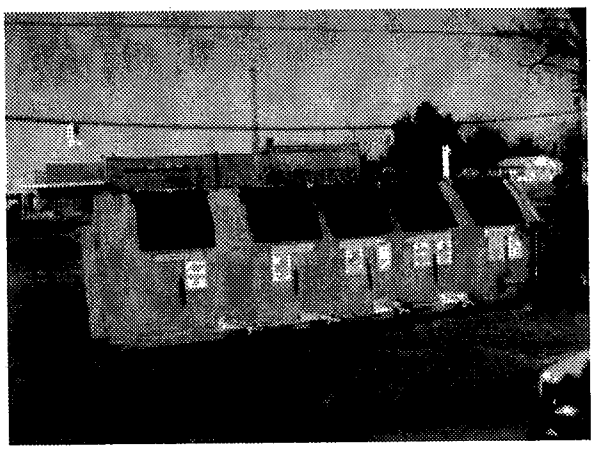
thermal rise does not adversely affect air traffic. On-airport disposal of compost by-products is not recommended.

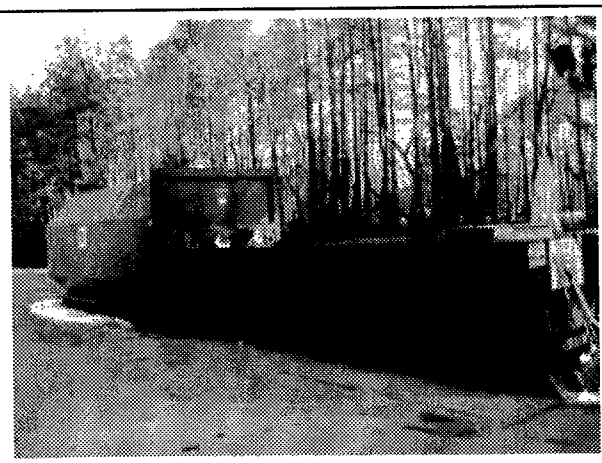
5.3.D UNDERWATER WASTE DISCHARGES

The underwater discharge of any food waste (e.g., fish processing offal) within the separations identified in AC 150/15200-33A (see above and Appendix C) is not recommended because it could attract scavenging hazardous wildlife.

5.3.E RECYCLING CENTERS

Recycling centers that accept previously sorted non-food items, such as glass, newspaper, cardboard, or aluminum, are, in most cases, not attractive to hazardous wildlife and are acceptable.





Small recycling bins and compactor stations, properly maintained so that putrescible waste is covered at all times, are generally not attractive to birds (photos by E. Cleary, FAA).

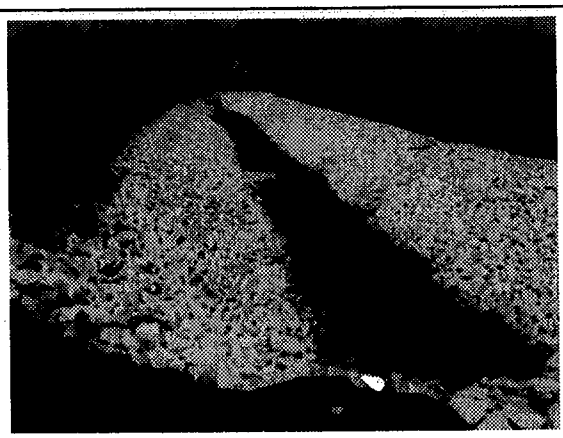
5.3.F CONSTRUCTION AND DEMOLITION DEBRIS FACILITIES

Construction and demolition debris (C&D) landfills do not generally attract hazardous wildlife and are acceptable if maintained in an orderly manner, admit no putrescible waste, and are not co-located with other putrescible waste disposal operations. C&D landfills have similar visual and operational characteristics to putrescible waste disposal sites. When co-located with putrescible waste disposal operations, C&D landfills are more likely to attract hazardous wildlife because of the similarities between these disposal facilities. Site C&D landfills co-located with other putrescible waste disposal operations outside of the separations identified in AC 150/5200-33A (see above and Appendix C).

5.3.G FLY ASH DISPOSAL

The incinerated residue from resource recovery power/heat-generating facilities that are fired by municipal solid waste, coal, or wood is generally not a wildlife attractant because it no longer contains putrescible matter. Landfills accepting only fly ash are generally not considered to be wildlife attractants and are acceptable as long as they are maintained in an orderly manner, admit no putrescible waste of any kind, and are not co-located with other disposal operations that attract hazardous wildlife.

Since varying degrees of waste consumption are associated with general incineration (not resource recovery power/heat-generating facilities), the FAA considers the ash from general incinerators a regular waste disposal by-product and, therefore, a hazardous wildlife attractant if disposed of within the separation criteria outlined in AC 150/5200-33A (see above and Appendix C).



Water detention basins at airports, such as this French-drain system at an eastern USA airport, should be designed to completely drain within 48 hours after the design storm event (photo by R. A. Dolbeer, USDA).

5.4 WATER MANAGEMENT FACILITIES

Drinking water intake and treatment facilities, storm water and wastewater treatment facilities, associated retention and settling ponds, ponds built for recreational use, and ponds that result from mining activities often attract large numbers of potentially hazardous wildlife. To prevent wildlife hazards, land-use developers and airport operators might need to develop management plans, in compliance with local and state regulations, to support the operation of storm water management facilities on or near public-use airports to ensure a safe airport environment.

5.4.A EXISTING STORM WATER MANAGEMENT FACILITIES

On-airport storm water management facilities allow the quick removal of surface water, including discharges related to aircraft deicing, from impervious surfaces, such as pavement and terminal/hangar building roofs. Existing on-airport detention ponds collect storm water, protect water quality, and control runoff. Because they slowly release water after storms, they create standing bodies of water that can attract hazardous wildlife. Using appropriate wildlife hazard mitigation techniques, airport management should take immediate corrective actions to address any wildlife hazards arising from existing storm water or other such facilities located on or near an airport (14 CFR 139.337 (a)). Develop measures to minimize hazardous wildlife attraction in consultation with a wildlife damage management biologist.



This storm water basin was designed to drain within 48 hours following a major storm event (the design storm). The rip-rap lining helps prevent vegetation growth and bird use of the pond (photo courtesy FAA).

Where possible, modify storm water detention ponds to allow a maximum 48-hour detention period for the design storm. Avoid or remove retention ponds and detention ponds featuring long-term storage to eliminate standing water. Design or modify

detention basins to remain totally dry between rainfalls. Where constant flow of water is anticipated through the basin, or where any portion of the basin bottom may remain wet, include a concrete or paved pad and/or ditch/swale in the bottom to prevent vegetation that may provide cover and food for wildlife.

When it is not possible to drain a large detention pond completely, use physical barriers, such as bird balls, wires grids, pillows, or netting, to deter birds and other hazardous wildlife. When physical barriers are used, carefully evaluate their use and ensure they will not adversely affect water rescue. Before installing any physical barriers over detention ponds on Part 139 airports, get approval from the appropriate FAA Regional Airports Division Office.



Floating plastic balls can be used to cover ponds and prevent birds from using the site. FAA approval is required before physical barriers may be used over ponds at certificated airports (photo courtesy Wildlife Materials, Inc.).

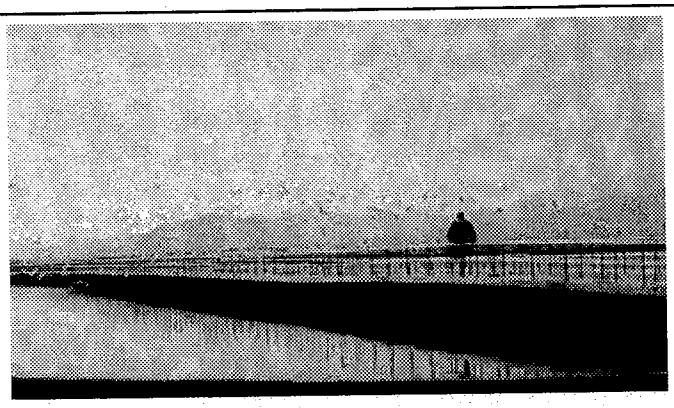
Encourage off-airport storm water treatment facility operators to incorporate appropriate wildlife hazard mitigation techniques into storm water treatment facility operating practices when their facility is located within the separation criteria specified in AC 150/5200-33A (see above and Appendix C).

5.4.B NEW STORM WATER MANAGEMENT FACILITIES

Design and operate off-airport storm water management systems located within the separations identified in AC 150/5200-33A (see above and Appendix C) so as not to create above-ground standing water. Design, engineer, construct, and maintain on-airport storm water detention ponds for a maximum 48–hour detention period for the design storm and so the ponds remain completely dry between storms. Use steep-sided, narrow, linearly shaped water detention basins to facilitate the control of hazardous wildlife. When it is not possible to place these ponds away from the AOA, use physical barriers, such as bird balls, wires grids, pillows, or netting, to prevent access of hazardous wildlife to open water and minimize aircraft-wildlife interactions. When physical barriers are used, carefully evaluate their use and ensure they will not adversely affect water rescue. Before installing any physical barriers over detention ponds on Part 139 airports, get approval from the appropriate FAA Regional Airports Division Office. Eliminate all vegetation in or around detention basins that provides food or cover for hazardous wildlife. If soil conditions and other requirements allow, use underground storm water infiltration systems, such as French drains or buried rock fields, because they are less attractive to wildlife.

5.4.C EXISTING WASTEWATER TREATMENT FACILITIES

Immediately correct any wildlife hazards arising from existing wastewater treatment or similar facilities located on or near the airport (14 CFR 139.337). Encourage wastewater treatment facility operators to incorporate measures, developed in consultation with a wildlife damage management biologist, to minimize hazardous wildlife attractants. Encourage wastewater treatment facility operators to incorporate these mitigation techniques into their standard operating practices. In addition, consider the existence of wastewater treatment facilities when evaluating proposed sites for new airport development projects and avoid such sites when practicable.



In tropical regions, cattle egrets appear to fill the ecological niche occupied by gulls at waste management facilities in North America. Over 13,000 cattle egrets were seen at this sewage treatment and landfill complex near Mexico City (photo by E. Cleary, FAA).

5.4.D NEW WASTEWATER TREATMENT FACILITIES

Do not construct new wastewater treatment facilities or associated settling ponds within the separations identified in AC 150/15200-33A (see above and Appendix C). Wastewater treatment facilities are "any devices and/or systems used to store, treat, recycle, or reclaim municipal sewage or liquid industrial wastes." The definition includes any pretreatment involving the reduction of the amount of pollutants or the elimination of pollutants prior to introducing such pollutants into a publicly owned treatment works (wastewater treatment facility). Consider the potential to attract hazardous wildlife during the site-location analysis for wastewater treatment facilities if an airport is in the vicinity of the proposed site. Oppose such facilities if they are within the separations identified in AC 150/5200-33A (see above and Appendix C).

5.4.E ARTIFICIAL MARSHES

In warmer climates, wastewater treatment facilities sometimes employ artificial marshes and use submergent and emergent aquatic vegetation as natural filters. These artificial marshes may be used by various species of birds, such as blackbirds and waterfowl, for nesting, feeding, or roosting. Do not establish artificial marshes within the separations identified in AC 150/5200-33A (see above and Appendix C).

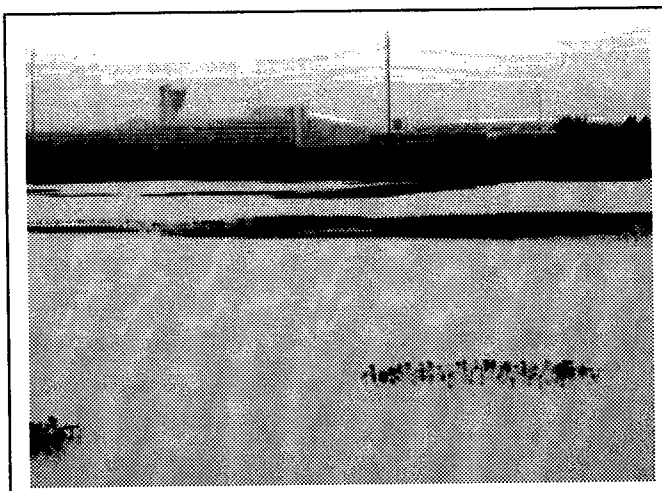
5.4.F WASTEWATER DISCHARGE AND SLUDGE DISPOSAL

Do not discharge of wastewater or sludge on airport property because it may improve soil moisture and quality on unpaved areas and lead to improved turf growth that can be an attractive food source for many species of animals. Also, the turf requires more frequent mowing, which in turn might mutilate or flush insects or small animals and produce thatch, both of which can attract hazardous wildlife. In addition, the improved turf might attract grazing wildlife, such as deer and geese. Problems might also occur when discharges saturate unpaved airport areas. The resultant soft, muddy conditions can severely restrict or prevent emergency vehicles from reaching accident sites in a timely manner.

5.5 WETLANDS

Wetlands provide a variety of functions and can be regulated by local, state, and federal laws. Wetlands typically attract diverse species of wildlife, including many that rank high on the list of hazardous wildlife species (Table 7-1).

If questions exist as to whether an area qualifies as a wetland, contact the local division of the U.S. Army Corps of Engineers, the Natural Resources Conservation Service, or a wetland consultant qualified to delineate wetlands. A MOA among six federal agencies was signed in 2003 (Appendix H) to facilitate, among other things, resolution of wetland management issues at airports without compromising aviation safety related to wildlife hazards.



This photo is from a National Wildlife Refuge located adjacent to a major USA airport (note air traffic control tower in background). These incompatible land uses were established years ago, before the FAA had set minimum separation distances. In this type of situation, both the airport manager and the refuge manager must be extra vigilant and ready to respond to rapidly developing wildlife hazard conditions (photo by E. Cleary, FAA).

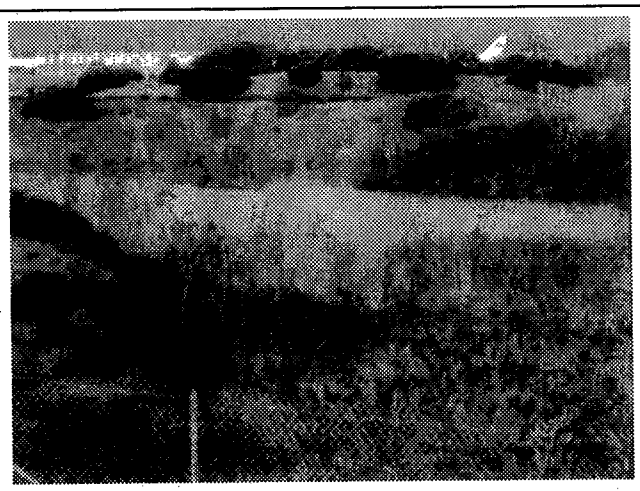
5.5.A EXISTING WETLANDS ON OR NEAR AIRPORT PROPERTY

If wetlands are located on or near airport property, be alert to any wildlife use or habitat changes in these areas that could affect safe aircraft operations. At public-use airports, immediately correct, in cooperation with local, state, and federal regulatory agencies, any wildlife hazards arising from existing wetlands located on or near airports. Where required, a Wildlife Hazard Management Plan (WHMP) will outline appropriate wildlife hazard mitigation techniques. Develop measures to minimize hazardous wildlife attraction in consultation with a wildlife damage management biologist.

5.5.B NEW AIRPORT DEVELOPMENT

Whenever possible, locate new airports using the separations from wetlands identified in AC 150/5200-33A (see above and Appendix C). Where alternative sites are not practicable, or when expanding an existing airport into or near wetlands, in consultation with a wildlife damage management biologist, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the state wildlife management agency, evaluate the wildlife hazards and prepare a WHMP that indicates methods of minimizing the hazards.

5.5.C MITIGATION FOR WETLAND IMPACTS FROM AIRPORT PROJECTS



This water body at a major west coast USA airport should be removed because it provides ideal habitat for waterfowl and wading birds hazardous to aircraft. However, the water has also been designated as critical habitat for the endangered Riverside fairy shrimp. Airports must work closely with multiple federal and state agencies to resolve such conflicts (Photo by T. Pitlik, USDA)

Wetland mitigation might be necessary when wetland disturbances result from new airport development projects or projects required to correct wildlife hazards from wetlands. Wetland mitigation must be designed so it does not create a wildlife hazard. Locate wetland mitigation projects that may attract hazardous wildlife outside of the separations identified in AC 150/5200-33A (see above and Appendix C).

5.5.C.1 ON-SITE MITIGATION OF WETLAND FUNCTIONS

The FAA may consider exceptions to locating mitigation activities outside the separations identified in AC 150/5200-33A (see above and Appendix C) if the affected wetlands provide unique ecological functions, such as critical habitat for threatened or endangered species or ground water recharge, which cannot be replicated when moved to a different location. Using existing airport property is sometimes the only feasible way to achieve the mitigation ratios mandated in regulatory orders and settlement agreements with the resource agencies. Conservation easements are an additional means of providing mitigation for project impacts. Typically the airport operator continues to own the property, and an easement is created stipulating that the property will be maintained as habitat for state or federally listed species.

Mitigation must not inhibit the airport operator's ability to effectively control hazardous wildlife on or near the mitigation site or effectively maintain other aspects of safe airport operations. Avoid enhancing such mitigation areas to attract hazardous wildlife. The FAA may review any onsite mitigation proposals to determine compatibility with safe airport operations. In cooperation with a wildlife damage management biologist, evaluate any wetland mitigation projects that are needed to protect unique wetland functions and that must be located in the separation criteria in AC 150/5200-33A (see

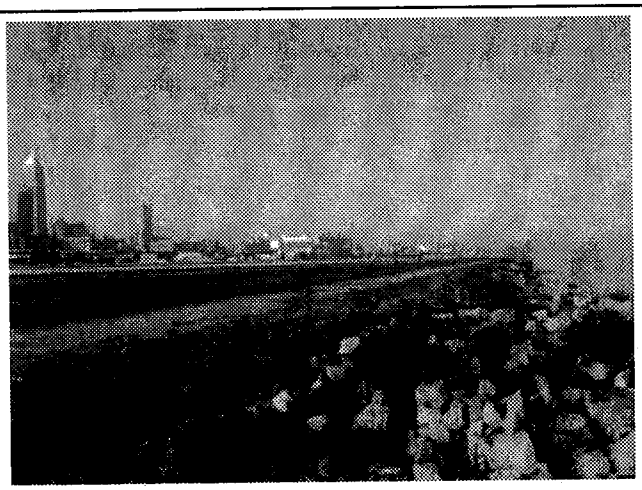
above and Appendix C) before the mitigation is implemented. Develop a WHMP to reduce any identified wildlife hazards.

5.5.C.II OFF-SITE MITIGATION OF WETLAND FUNCTIONS

Site wetland mitigation projects that might attract hazardous wildlife outside of the separations identified in AC 150/5200-33A (see above and Appendix C) unless they provide unique functions that must remain onsite (see 2-4c(1)). Agencies that regulate impacts to or around wetlands recognize that it might be necessary to split wetland functions in mitigation schemes. Therefore, regulatory agencies may, under certain circumstances, allow portions of mitigation to take place in different locations.

5.5.C.III MITIGATION BANKING

Wetland mitigation banking is the creation or restoration of wetlands in order to provide mitigation credits that can be used to offset permitted wetland losses. Mitigation banking benefits wetland resources by providing advance replacement for permitted wetland losses; consolidating small projects into larger, better-designed and managed units; and encouraging integration of wetland mitigation projects with watershed planning. This last benefit is most helpful for airport projects, as wetland impacts mitigated outside of the separations identified in AC 150/5200-33A (see above and Appendix C) can still be located within the same watershed. Wetland mitigation banks meeting the separation criteria offer an ecologically sound approach to mitigation in these situations. Working with local watershed management agencies or organizations, develop mitigation banking for wetland impacts on airport property. See Appendix M for a more detailed discussion of this issue.



During the first winter following its completion, over 20,000 Bonaparte's gulls used this dredge spoil containment area (far right of photo) constructed next to an airport on Lake Erie's shoreline. The airport's main runway can be seen to the left (photo by E. Cleary, FAA).

5.6 DREDGE SPOIL CONTAINMENT AREAS

Do not locate dredge spoil containment areas (also known as Confined Disposal Facilities) within the separations identified in AC 150/5200-33A (see above and Appendix C) if the containment area has standing water or the spoils contain material that would attract hazardous wildlife.

5.7 AGRICULTURAL ACTIVITY

5.7.A CROP PRODUCTION

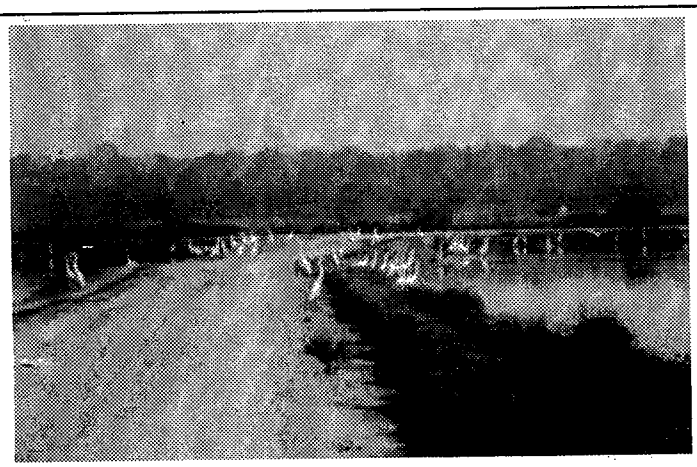
Because most, if not all, agricultural crops can attract hazardous wildlife during some phase of production, do not use airport property for crop production, including hay

crops, within the separations identified in AC 150/5200-33A (see above and Appendix C).

If the airport has no financial alternative to agricultural crops to produce income necessary to maintain the viability of the airport, then the airport must follow the crop distance guidelines listed in the table titled "Minimum Distances between Certain Airport Features and Any On-Airport Agricultural Crops" found in AC 150/5300-13, *Airport Design*, Appendix 19. Avoid production of cereal grains and sunflowers. Weigh the cost of wildlife control and potential accidents against the income produced by the on-airport crops when deciding whether to allow crops on the airport.

5.7.B LIVESTOCK PRODUCTION

Confined livestock operations (i.e., feedlots, dairy operations, hog or chicken production facilities, or egg-laying operations) often attract flocking birds, such as starlings, that pose a hazard to aviation. Therefore, keep such facilities outside of the separations identified in AC 150/5200-33A (see above and Appendix C). Develop a program to reduce the attractiveness of any livestock operation within these separations. Do not graze free-ranging livestock on airport property because the animals might wander onto the AOA. Livestock feed, water, and manure might attract hazardous birds.



Various fish-eating birds are attracted to aquaculture facilities as demonstrated by these great egrets at a southern USA catfish pond complex. Attempts to repel the birds using propane exploders failed because the birds habituated to the sound (photo by D. LeBlanc, USDA).

5.7.C AQUACULTURE

Aquaculture activities (e.g., catfish, trout, bait fish production) conducted outside of fully enclosed buildings are inherently attractive to a variety of birds. Existing aquaculture facilities/activities within the separations listed in AC 150/5200-33A (see above and Appendix C) must have a program developed to reduce the attractiveness of the sites to species that are hazardous to aviation safety. Oppose the establishment of new aquaculture facilities/activities within the separations listed in AC 150/5200-33A (see above and Appendix C).

5.7.D ALTERNATIVE USES OF AGRICULTURAL LAND

Some airports are surrounded by vast areas of farmed land within the distances specified in AC 150/5200-33A (see above and Appendix C). Seasonal uses of these agricultural lands for activities such as waterfowl hunting can create a hazardous wildlife situation. Rice farmers, for example, might flood their land during waterfowl hunting season and obtain additional revenue by renting out duck blinds. The duck hunters,

using decoys and calls, draw in large numbers of birds, creating a threat to aircraft safety. It is recommended that a wildlife damage management biologist review, in coordination with local farmers and airport management, these types of seasonal land uses. Restrictions to seasonal land uses that are incompatible with aviation safety should be incorporated into the WHMP.

5.8 GOLF COURSES, LANDSCAPING, AND OTHER LAND-USE CONSIDERATIONS

5.8.A GOLF COURSES

The large grassy areas and open water found on most golf courses are attractive to hazardous wildlife, particularly Canada geese, mallards, and gulls. These species can pose a threat to aviation safety. Do not site new golf courses within the separations identified in AC 150/5200-33A (see above and Appendix C). Existing golf courses located within these separations must develop a program to reduce the attractiveness of the sites to species that are hazardous to aviation safety. Ensure these golf courses are monitored on a continuing basis for the presence of hazardous wildlife. If hazardous wildlife is detected, take corrective actions immediately.



Trees and shrubs that produce fruits that are attractive to birds, such as these pyracanthas at a western USA airport, should not be used in landscape designs on airport property. Dense stands of evergreen trees also should be avoided as they provide ideal roosting sites for flocks of starlings and blackbirds (photo by R. A. Dolbeer, USDA).

5.8.B LANDSCAPING AND LANDSCAPE MAINTENANCE

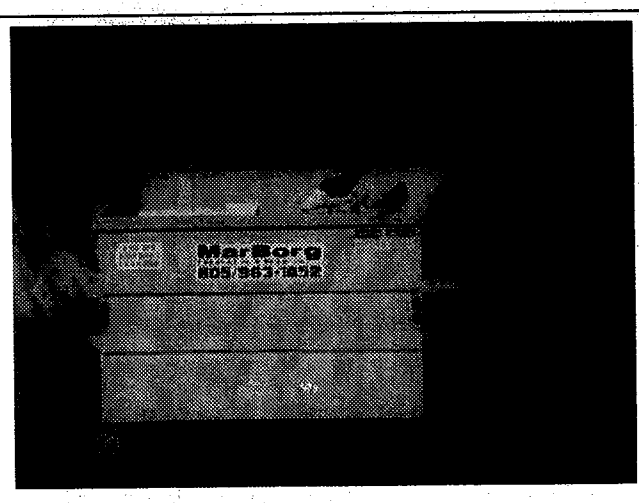
Depending on geographic location and plant selection and spacing, airport landscaping can attract hazardous wildlife. Approach landscaping with caution, and confine it to airport areas not associated with aircraft movements. In cooperation with a wildlife damage management biologist, review all landscaping plans. Monitor all landscaped areas on a continuing basis for the presence of hazardous wildlife. If hazardous wildlife is detected, take corrective actions immediately.

Turf grass areas can be highly attractive to a variety of hazardous wildlife species. Research conducted by the USDA/WS National Wildlife Research Center has shown that no one grass management regime will deter all species of hazardous wildlife in all situations. In cooperation with a wildlife damage management biologist, develop airport turf grass management plans on a prescription basis, depending on the airport's geographic location and the type of hazardous wildlife likely to frequent the airport. See Chapter 9 and Appendix O for more information on vegetation management.

Ensure that plant varieties attractive to hazardous wildlife are not used on the airport. Do not plant disturbed areas or areas in need of re-vegetating with seed mixtures containing millet or any other large-seed producing grass. Prevent plant maturation and seed head production on airport property already planted with seed mixtures containing millet, rye grass, or other large-seed producing grasses by the use of disking, plowing, or another suitable agricultural practice. Follow the specific recommendations for grass management and seed and plant selection made by the State University Cooperative Extension Service, the local office of USDA/Wildlife Services, or a qualified wildlife damage management biologist. Consider developing and implementing a preferred/prohibited plant species list, reviewed by a wildlife damage management biologist, which has been designed for the geographic location to reduce the attractiveness to hazardous wildlife for landscaping airport property. Avoid installation of ponds, fountains, reflecting pools, and other water bodies as part of an airport's landscaping scheme.

5.8.c OTHER HAZARDOUS WILDLIFE ATTRACTANTS

Other specific land uses or activities (e.g., sport or commercial fishing, shellfish production or harvesting), perhaps unique to certain regions, have the potential to attract hazardous wildlife. Regardless of the source of the attraction, when hazardous wildlife is noted on a public-use airport, airport operators must take prompt remedial action to protect aviation safety.



This open dumpster at a park 0.5 mile from a west coast USA airport served as a strong attractant for gulls, pigeons, and crows. Airports must work with surrounding landowners and local governments to prevent bird attractants near airports (photo by R. A. Dolbeer, USDA).

5.9 SYNERGISTIC EFFECTS OF SURROUNDING LAND USES

There might be circumstances where two (or more) different land uses that would not, by themselves, be considered hazardous wildlife attractants or that are located outside of the separations identified in AC 150/5200-33A (see above and Appendix C) that are in such an alignment with the airport as to create a wildlife corridor directly through the airport and/or surrounding airspace. An example of this situation might involve a lake located outside of the separation criteria on the east side of an airport and a large hayfield on the west side of an airport—land uses that together could create a flyway for Canada geese directly across the airspace of the airport. There are numerous examples of such situations; therefore, airport operators and the wildlife damage management biologist must consider the entire surrounding landscape and community when developing the WHMP.

CHAPTER 6:
DEVELOPING WILDLIFE HAZARD MANAGEMENT PROGRAMS AT AIRPORTS



The pilot of this Cessna 172 made a Mayday call to a nearby Air Traffic Control Tower in Texas after hitting a bird (likely a vulture) with the left wing at 800 feet AGL on 8 July 2003. The pilot attempted to make an emergency landing in a field but lost control and crashed, killing him and his passenger (photo courtesy of FAA).

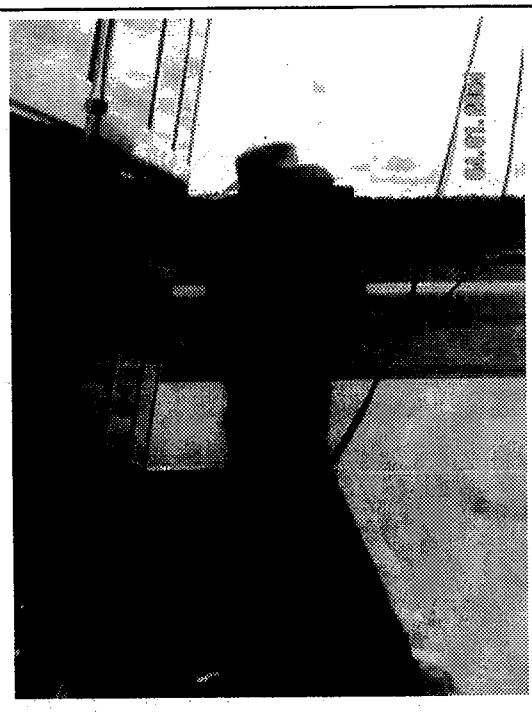
6.1 INTRODUCTION

In recognition of the increased risk of serious aircraft damage or the loss of human life that can result from a wildlife strike, greater emphasis is being placed on preparing airport Wildlife Hazard Management Plans that effectively deal with the problem. This heightened awareness and increased effort has raised many questions about the preparation and content of an FAA-approved Wildlife Hazard Management Plan for an airport. The specific events that trigger a Wildlife Hazard Assessment and the specific issues that a Wildlife Hazard Management Plan must address for FAA approval and inclusion in the airport's Airport Certification Manual (ACM)

are described in 14 CFR 139.337 (Appendix P).

It is important to note that regardless of whether a Wildlife Hazard Assessment has ever been required or a Wildlife Hazard Management Plan has been developed, airport operators must be ready to deal with hazardous wildlife on or near the airport. The airport operator must be prepared to take immediate action to deal with unexpected incursions of hazardous wildlife into the AOA, loading ramps, or parking areas (14 CFR 139.337(a)).

14 CFR 139.337	Comments
(a). In accordance with its Airport Certification Manual and the requirements of this section, each certificate holder shall take immediate action to alleviate wildlife hazards whenever they are detected.	Public-use airport operators need to be aware of any hazardous wildlife attractants on or near their airport, even if a wildlife strike has never been reported from the airport. Airport personnel need at least a minimal understanding of wildlife hazard control issues.



The Air Traffic Control (ATC) Tower is a good place to start a Wildlife Hazard Assessment. The tower presents an excellent overview of the airport and provides an opportunity to talk to ATC personnel about wildlife they have seen on the airport (photo by A. Gosser, USDA).

6.2 WILDLIFE HAZARD ASSESSMENT

The first step in preparing an airport Wildlife Hazard Management Plan is to conduct a Wildlife Hazard Assessment. The Wildlife Hazard Assessment, conducted by a wildlife damage management biologist, provides the scientific basis for the development, implementation, and refinement of a Wildlife Hazard Management Plan. Though parts of the Wildlife Hazard Assessment may be incorporated directly into the Wildlife Hazard Management Plan, they are two separate documents.

6.2.A REQUIREMENT FOR WILDLIFE HAZARD ASSESSMENT

Title 14 CFR 139.337(b)(1–4) requires that, in a manner authorized by the Administrator, each certificate holder must ensure that a Wildlife Hazard Assessment is conducted when any of the following events occurs on or near the airport:

1. An air carrier aircraft experiences multiple wildlife strikes;
2. An air carrier aircraft experiences substantial damage from striking wildlife;

3. An air carrier aircraft experiences an engine ingestion of wildlife; or
4. Wildlife of a size, or in numbers, capable of causing an event described in paragraph (b)(1), (2), or (3) of this section is observed to have access to any airport flight pattern or aircraft movement area.

The following provides a point-by-point comment on the regulations concerning the events that trigger a wildlife hazard assessment.

14 CFR 139.337	Comments
(b) In a manner authorized by the Administrator, each certificate holder shall ensure that a Wildlife Hazard Assessment is conducted when any of the following events occurs on or near the airport.	A wildlife hazard assessment, conducted by a qualified wildlife damage management biologist, must be conducted if—
(b) (1) An air carrier aircraft experiences a multiple wildlife strike	Aircraft strikes more than one animal (geese, starlings, bats, deer, coyotes, etc.).
(b) (2) An air carrier aircraft experiences substantial damage from striking wildlife. As used in this paragraph, substantial damage means damage or structural failure incurred by an aircraft that adversely affects the structural strength, performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component	The definition of substantial damage is taken directly form the International Civil Aviation Organization (ICAO) *Manual on the International Civil Aeronautics Organization Bird Strike Information System.*
(b) (3) An air carrier aircraft experiences an engine ingestion of wildlife; or	Wildlife is ingested into a turboprop, turbofan, or turbojet engine. Engine damage does not have to result from the ingestion.
(b) (4) Wildlife of a size, or in numbers, capable of causing an event described in paragraph (b)(1), (2), or (3) of this section is observed to have access to any airport flight pattern or aircraft movement area.	Airports with a standing Notice to Airmen (NOTAM), announcements on their Automatic Terminal Information Service (ATIS), or comments in Airport/Facility Directory (A/FD) warning pilots of wildlife hazards on or near the airport meet this condition.

6.2.B NECESSARY ELEMENTS OF A WILDLIFE HAZARD ASSESSMENT

Title 14 CFR 139.337 (c)(1–5) provides specific guidance as to what facts must be addressed in a Wildlife Hazard Assessment. The following is a point-by-point comment

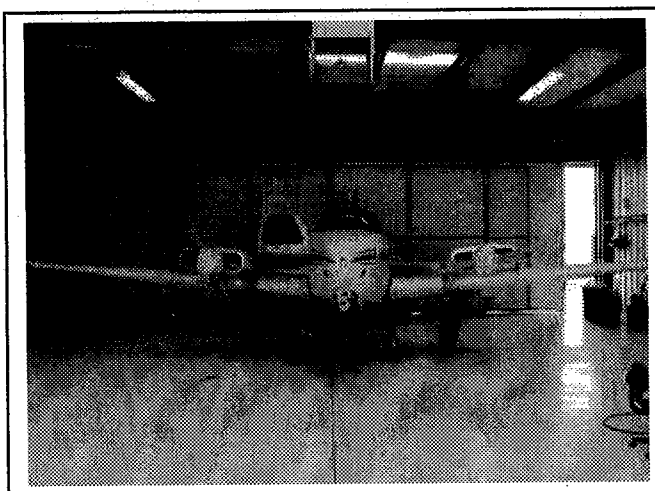
on each section of the regulations concerning the factors to be addressed in a Wildlife Hazard Assessment.

14 CFR 139.337	Comments
(c) The Wildlife Hazard Assessment ... shall be conducted by wildlife damage management biologist ... having training or experience in wildlife hazard management at airports ... or working under the direct supervision ...	The Wildlife Hazard Assessment (WHA) is to be conducted by someone having the following qualifications: Education: Meets U.S. Office of Personal Management standards for GS-486 Wildlife Biologist. Work experience: Has prepared a WHA acceptable to the FAA. Has prepared a Wildlife Hazard Management Plan acceptable to the FAA. Or, is working under the direct supervision of someone who meets the above requirements.
(c) cont. ... the Wildlife Hazard Assessment shall contain:	
(c) (1) Analysis of the event or circumstances that prompted the study.	Who, what, when, where, why of the situation prompting the WHA.
(c) (2) Identification of the wildlife species observed and their numbers, locations, local movements, and daily and seasonal occurrences.	What wildlife species have access to the airport? What are their legal status, movement patterns, and seasonal patterns? Refer to Table 7-1 for a ranked listing of hazardous species. Pay particular attention to those species considered the most hazardous occurring on or near the airport.
(c) (3) Identification and location of features on and near the airport that attract wildlife.	Wildlife are attracted to an airport because something exists on or near the airport that they desire, such as large open areas where they can loaf in relative safety; abundant food or water; and escape, loafing, or nesting cover. These attractants need to be identified and evaluated.

14 CFR 139.337	Comments
(c) (4) Description of the wildlife hazards to air carrier operations.	This is a judgment call best made by a professional wildlife management biologist trained in dealing with airport issues. Hitting 3-4 swallows is much less hazardous than hitting one 12-pound Canada goose (see Table 7-1).
(c) (5) Recommended actions for reducing identified wildlife hazards to air carrier operations.	The biologist preparing the WHA must provide prioritized recommendations for mitigating the hazardous wildlife attractants identified in (c)(3).

6.2.C DURATION OF WILDLIFE HAZARD ASSESSMENT AND BASIC SURVEY TECHNIQUES

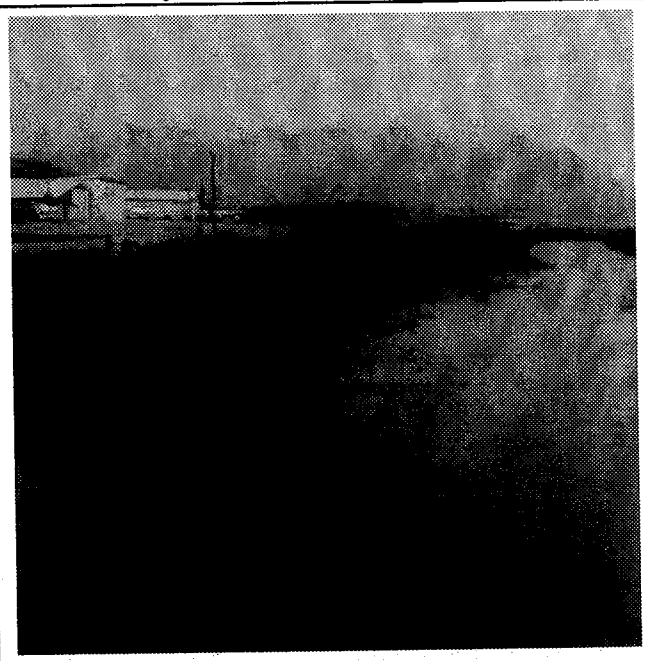
In conducting a Wildlife Hazard Assessment 14 CFR Part 139.337 (c)(2) requires the "identification of the wildlife species observed and their numbers, locations, local movements, and daily and seasonal occurrences." In most cases, this requirement dictates that a 12-month assessment be conducted so the seasonal patterns of birds and other wildlife using the airport and surrounding area during an annual cycle can be properly documented. Most regions of the USA have dramatic seasonal differences in numbers and species of migratory birds. Even for non-migratory wildlife, such as deer and resident Canada geese, behavior and movement patterns can change significantly among seasons. Observations of wildlife at an airport and surrounding areas limited to a few days in a single season generally cannot adequately assess hazardous wildlife issues and associated habitat attractants.



During the WHA, special attention must be paid to the presence of domestic animals on the airport. This Beachcraft Baron struck an 80-pound dog (chow) during a night departure. The center landing gear collapsed and both propellers struck the ground.

In order to adequately identify "the wildlife species observed and their numbers, locations, local movements, and daily and seasonal occurrences" during a Wildlife Hazard Assessment, the FAA and USDA/WS recommend that standardized survey procedures be used. These standardized procedures should provide an objective assessment of hazardous wildlife in the airport environment that can be repeated in future years for comparative purposes. One objective procedure for assessing bird populations, based on North American Breeding Bird Survey methodology, is the establishment of standardized survey points about ½ mile apart throughout the AOA (10-20 survey points are generally recommended depending on

size of airport). Assigning each bird or bird flock observed during a point count to a grid location can be useful in further refining spatial distributions of birds on the airport. Additional survey points may be established in nearby off-airport areas (e.g., taxicab lot, golf course, or city park) suspected of attracting hazardous birds that move across the AOA. Standardized counts of birds should be made at each of these survey points at least twice monthly. In addition, specialized surveys might be needed as part of the overall assessment to document large-to-mid-sized mammals, such as deer or jackrabbits (from vehicle using spotlight or night vision equipment), and small mammals, such as voles and mice (snap traps), on the airport. These specialized mammal surveys should be conducted at least twice during a 12-month WHA.



Bodies of open water adjacent to airports, such as this drainage canal, are often magnets for waterfowl and wading birds. Note the shallow slope that allows birds easy access in and out of the water. Such canals should be covered if possible or diverted away from the airport (photo by E. Cleary, FAA).

6.3 WILDLIFE HAZARD MANAGEMENT PLAN

6.3.A REQUIREMENT FOR WILDLIFE HAZARD MANAGEMENT PLAN

When complete, the Wildlife Hazard Assessment is submitted to the FAA for evaluation and determination whether a Wildlife Hazard Management Plan needs to be developed for the airport. In reaching this decision, the FAA will consider the Wildlife Hazard Assessment, the aeronautical activity at the airport, the views of the certificate holder and airport users, and any other pertinent information (14 CFR 139.337 (d)(1–6)). At a minimum, it is recommended that the airport manager develop and implement a plan to deal with any hazardous wildlife attractants or situations identified in the Wildlife Hazard Assessment.

If the FAA determines that a Wildlife Hazard Management Plan is needed, the airport operator must then formulate and implement a Wildlife Hazard Management Plan, using the Wildlife Hazard Assessment as the basis for the plan (14 CFR 139.337 (e)(1–3)). At the same time, the FAA regional coordinator will contact the local U.S. Fish and Wildlife Service (USFWS), Ecological Services Field Office and request information about the presence of federally listed or proposed endangered or threatened species or designated or proposed critical habitat on or near the airport. (See FAA Airport Certification Program, Program Policy and Guidance No. 78, Section-7 Consultation on Endangered or Threatened Species, Appendix D.) The USFWS response will be forwarded to the airport operator to be taken into account when preparing the required plan.

If federally listed or proposed endangered or threatened species or designated or proposed critical habitat are present, the airport operator must prepare a Biological Assessment (50 CFR 402.13) assessing the impacts of the Wildlife Hazard Management Plan on these species or habitats. The Biological Assessment and draft Wildlife Hazard Management Plan must be submitted to the FAA for review and approval.

Airport management may request the wildlife biologist who prepared the Wildlife Hazard Assessment to assist with the preparation of the Wildlife Hazard Management Plan and to review the finished plan. However, only the airport operator can commit airport resources (time, money, personal), and the ultimate responsibility for the development and implementation of the plan rests with the airport operator. When the plan is completed the airport operator must submit the draft plan, together with a copy of the Biological Assessment, to the FAA for approval. The FAA will conduct any needed Section 7 consultations with the USFWS.



The presence of a threatened or endangered species on an airport, such as this nesting California least tern, would constitute extraordinary circumstances and require preparation of either an Environmental Assessment or an Environmental Impact Statement before the Wildlife Hazard Management Plan could receive FAA approval (photo courtesy of USFWS, NTCT Image Library).

6.3.B. National Environmental Policy Act Review

The FAA's approval of a draft Wildlife Hazard Management Plan is covered by the categorical exclusion in FAA Order 1050.1E, paragraph 308e. Before the FAA approves a draft Wildlife Hazard Management Plan, the FAA must determine whether or not the draft Wildlife Hazard Management Plan involves extraordinary circumstances (see FAA Order 1050.1E, paragraphs 303c and 304).

- If a draft Wildlife Hazard Management Plan does not involve extraordinary circumstances, the FAA may categorically exclude the Wildlife Hazard Management Plan under FAA Order 1050.1E, paragraph 308e.
- If a draft Wildlife Hazard Management Plan involves extraordinary circumstances, the FAA may require the airport sponsor to prepare an EA, or the FAA may prepare an EIS.

Once a draft Wildlife Hazard Management Plan is approved, the plan is returned to the airport sponsor for inclusion in the airport's Airport Certification Manual and is enforceable.

6.3.C NECESSARY ELEMENTS OF A WILDLIFE HAZARD MANAGEMENT PLAN

The goal of an airport's Wildlife Hazard Management Plan is to minimize the risk to aviation safety, airport structures or equipment, or human health posed by populations of hazardous wildlife on and around the airport.



As part of the Wildlife Hazard Management Plan, pilots should be reminded to conduct a pre-flight inspection of their aircraft for bird nesting material, especially if the aircraft is parked outside or has not been used for some time (photo courtesy USDA).

The Wildlife Hazard Management Plan must accomplish the following:

- Identify personal responsible for implementing each phase of the plan,
- Identify and provide information on hazardous wildlife attractants on or near the airport,
- Identify appropriate wildlife management techniques to minimize the wildlife hazard,
- Prioritize appropriate management measures,
- Recommend necessary equipment and supplies,
- Identify training requirements for the airport personnel who will implement the Wildlife Hazard Management Plan, and
- Identify when and how the plan will be reviewed and updated.

It is often helpful for the airport manager to appoint a Wildlife Hazards Working Group that periodically reviews the airport's Wildlife Hazard Management Plan and the plan's implementation to make recommendations for further refinements or modifications (see Chapter 7).

14 CFR 139.337 (f)(1–7) provides specific guidance as to what facts must be addressed in a Wildlife Hazard Management Plan. The following table details how the requirements of Part 139.337 (f) (1–7) are to be addressed in an FAA-approved Wildlife Hazard Management Plan (see also Appendix E).

14 CFR 139.337	Comments
(f). The Wildlife Hazard Management Plan shall include at least the following :	
(f) (1) A list of the individuals having authority and responsibility for implementing each aspect of the plan.	Assign or delegate specific responsibilities for various sections of the Wildlife Hazard Management Plan to various airport departments, such as— • Airport Director • Operations Dept. • Maintenance Dept. • Security Dept. • Planning Dept. • Finance Dept. • Wildlife Coordinator • Wildlife Hazards Working Group • Local law enforcement authorities that might provide wildlife law enforcement and other support include — o U.S. Fish and Wildlife Service o State Wildlife Agency o City Police o County Sheriff

14 CFR 139.337	Comments
(f) (2) A list prioritizing the following actions identified in the wildlife hazard assessment and target dates for their initiation and completion:	Provide a prioritized list of problem wildlife populations and wildlife attractants (food, cover, and water) identified in the WHA, proposed mitigation actions, and target starting and completion dates. A list of completed wildlife population management projects and habitat modification projects designed to reduce the wildlife strike potential can be included to provide a history of work already accomplished. It is helpful to group attractants by areas and ownership. Airport property: • Air Operations Area (AOA) • Within 2 miles of AOA • Airport structures Non-airport property • Within 2 miles of AOA • Within 5 miles of AOA
(f) (2) (i) Wildlife population management;	Address species-specific population management plans (e.g., deer, gulls, geese, and coyotes): • Habitat modification • Resource protection • Repelling/exclusion • Removal Chapter 9 provides a discussion of the various wildlife control methods.

14 CFR 139.337		Comments
(f) (2) (ii)	Habitat modification; and	Food/prey management: • Rodents • Earthworms • Insects • Grain/seeds • Garbage –handling, storage • Handouts (feeding wildlife) Vegetation management: • AOA vegetation • Drainage ditch vegetation • Landscaping • Agriculture Water management: • Permanent Water • Wetlands • Canals/ditches/streams • Holding ponds • Sewage (glycol) treatment ponds • Other water areas • Ephemeral water o Runways, taxiways, aprons o Other wet areas Airport buildings: • Airfield structures • Abandoned structures • Terminal • Airport construction

14 CFR 139.337	Comments
(f) (2) (ii) [cont.] [and] land use changes.	i.e., Elimination of agricultural activities on or near the airport, surface mining, urban development, creation of off-airport storm water management systems.
(f) (3) Requirements for and, where applicable, copies of local, state, and federal wildlife control permits.	Certain species of wildlife might be protected at all levels of government—local, state, and federal—or might not be protected at all, depending on location and species. Address the specific species involved and their legal status in this section. Describe the wildlife management permitting requirements and procedures for all levels of government having jurisdiction, i.e.— • Federal – 50 CFR, Parts 1 to 199. • State – Fish and Game Code (or equivalent) • City, county – ordinances • If pesticides are to be used, the following are also needed: o Pesticide-use regulations: o Federal: Federal Insecticide, Fungicide, and Rodenticide Act. o State (varies by state) o Pesticide-use licensing requirements o State regulations Summaries are generally adequate. It is not necessary to quote chapter and verse of federal, state, and local laws and regulations.

14 CFR 139.337	Comments
(f) (4) Identification of resources that the certificate holder will provide to implement the plan.	Provide information identifying what resources the airport will supply in terms of— • Personal • Time • Equipment (e.g., radios, vehicles, guns, traps, propane cannons, etc.) • Supplies (e.g., pyrotechnics) • Pesticides (restricted/non-restricted use) • Application equipment • Sources of supply for equipment and supplies
(f) (5) Procedures to be followed during air carrier operations that at a minimum includes—	
(f) (5) (i) Designation of personnel responsible for implementing the procedures;	Who, when, what circumstances: • Wildlife Control Personnel • Wildlife Coordinator • Operations Dept. • Maintenance Dept. • Security Dept. • Air Traffic Control
(f) (5) (ii) Provisions to conduct physical inspections of the aircraft movement areas and other areas critical to successfully manage known wildlife hazards before air carrier operations begin;	Who, when, how, what circumstances: • Runway, taxiway sweeps • AOA monitoring • Other areas attractive to wildlife

14 CFR 139.337	Comments
(f) (5) (iii) Wildlife hazard control measures; and	Who, what circumstances, when, and how are Wildlife Control Personnel contacted? What methods are to be used to— • Repel • Capture • Kill
(f) (5) (iv) Ways to communicate effectively between personnel conducting wildlife control or observing wildlife hazards and the air traffic control tower.	Training in communication procedures Equipment needed Radios, cellular phones, lights
(f) (6) Procedures to review and evaluate the wildlife hazard management plan annually or following an event described in paragraphs (b)(1), (2), and (3) of this section, including:	At a minimum, hold annual meetings, or meet after an event described in 139.337(a)(1–3) with representatives from all airport departments involved in wildlife hazard management efforts and the wildlife damage management biologist who did the original Wildlife Hazard Assessment.
(f) (6) (i) The plans effectiveness in dealing with known wildlife hazards on and in the airport's vicinity and:	Input from all airport departments, Air Traffic Control, and the wildlife biologist as to effectiveness of the plan. Good records are required for evaluating the effectiveness of a program (see Chapter 7).
(f) (6) (ii) Aspects of the wildlife hazards described in the wildlife hazard assessment that should be reevaluated.	For example— • Number of times wildlife seen on AOA. • Requests for wildlife dispersal from air traffic control, pilots, or others. • Increased number of strikes.

14 CFR 139.337	Comments
(f) (7) A training program conducted by a qualified wildlife damage management biologist to provide airport personnel with the knowledge and skills needed to successfully carry out the wildlife hazard management plan required by paragraph (d) of this section.	Training for— • Wildlife control personnel • Other airport personnel • Pesticide user training and certification (See Chapter 8)
(g) FAA Advisory Circulars contain methods and procedures for wildlife hazard management at airports that are acceptable to the Administrator.	AC 150/5200-33A, *Hazardous Wildlife Attractants on or Near Airports*

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Table 6-1. Airport Wildlife Hazard Review Worksheet. Page 1 of 5

Airport Name (LOCID)			
City:	State:	FAA Region:	
Wildlife Hazard Assessment Evaluation			
Elements	Reference 14 CFR 139.337	Complete	Comments
The wildlife hazard assessment ... shall contain at least the following:	(c)		
Analysis of event(s) or circumstances that prompted the assessment.	(c) (1)		
Identification of the wildlife species observed, and	(c) (2)		
description of species numbers,	(c) (2)		
description of species local movements,	(c) (2)		
description of daily occurrences,	(c) (2)		
description of seasonal occurrences.	(c) (2)		
Identification and location of features on and near the airport that attract wildlife.	(c) (3)		
Description of wildlife hazard to air carries operations.	(c) (4)		
Recommendations for mitigation of identified wildlife attractants.	(c) (5)		

Table 6-1. Airport Wildlife Hazard Review Worksheet. Page 2 of 5

Airport Name (LOCID)			
City:	State:	FAA Region:	
Determination of Need for Wildlife Hazard Management Plan			
Elements	Reference 14 CFR 139.337	Complete	Comments
Review of Wildlife Hazard Assessment.	(d)		
Wildlife Hazard Assessment.	(d) (1)		
Actions recommended in WHA.	(d) (2)		
Aeronautical activity.	(d) (3)		
Certificate holder's views.	(d) (4)		
Airport users' views.	(d) (5)		
Other factors.	(d) (6)		
Development of Wildlife Hazard Management Plan to be required by FAA.	Yes	No	
Endangered Species Act, Section 7 consultation needed.	Yes	No	
Letter sent to USFWS.	Yes	No	Date sent
USFWS response received.	Yes	No	Date received
USFWS response forwarded to airport sponsor, if positive.	Yes	No	Date sent
FAA Official making this determination:	Signature		Date

Table 6-1. Airport Wildlife Hazard Review Worksheet. Page 3 of 5

Airport Name (LOCID)			
City: State: FAA Region:			
Wildlife Hazard Management Plan Evaluation			
Elements	Reference 14 CFR 139.337	Complete	Comments
The plan shall include at least the following:	(f)		
A list of the individuals having authority and responsibility for implementing each aspect of the plan (Airport and non-airport personnel).	(f) (1)		
A list prioritizing the following actions identified in the wildlife hazard assessment and, target dates for their initiation and completion:	(f) (2)		
Wildlife population management;	(f) (2) (i)		
Habitat modification; and	(f) (2) (ii)		
Land-use changes.	(f) (2) (iii)		
Requirements for and, where applicable, copies of local, state, and federal wildlife control permits (Including pesticide use, where applicable).	(f) (3)		
Identification of resources that the certificate holder will provide to implement the plan.	(f) (4)		
Procedures to be followed during air carrier operations that at a minimum includes:	(f) (5)		

Table 6-1. Airport Wildlife Hazard Review Worksheet. Page 4 of 5

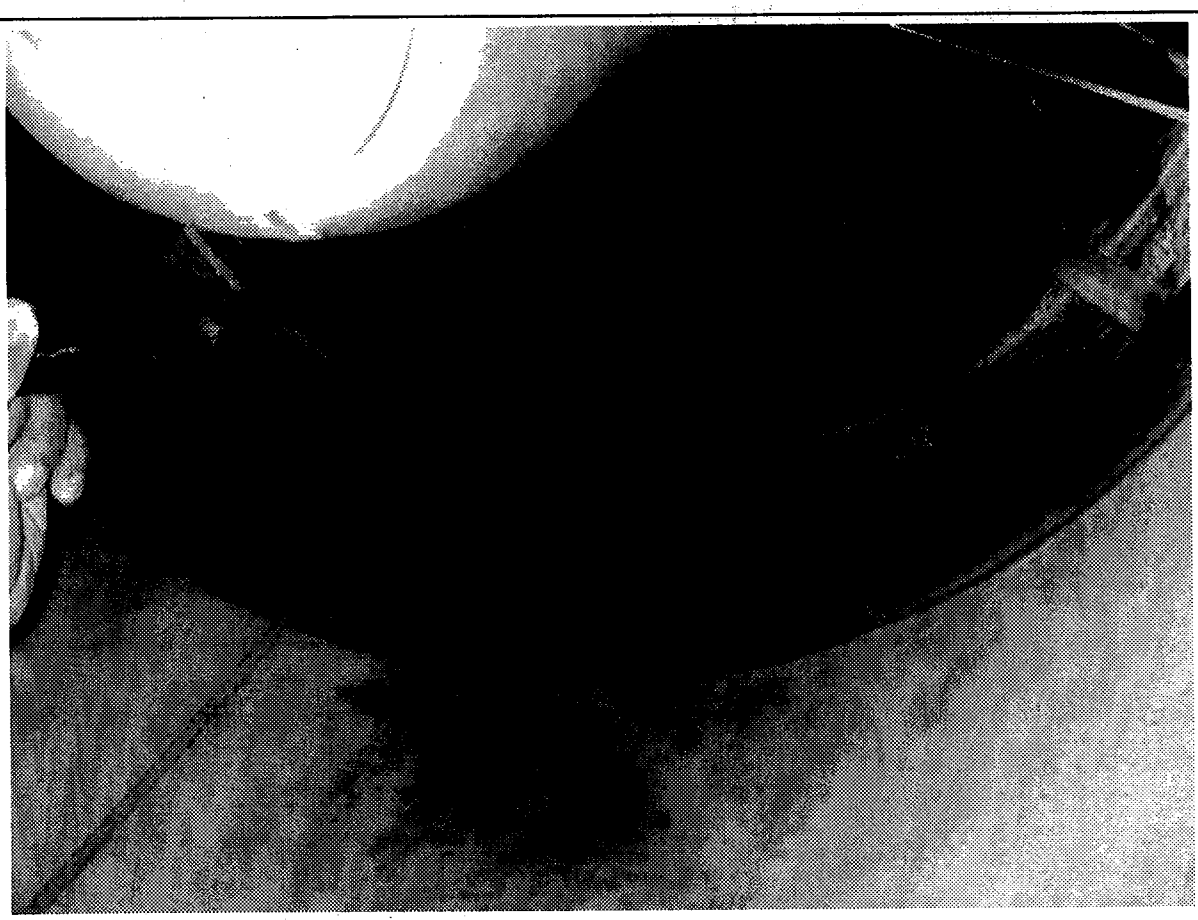
Airport Name (LOCID)			
City:	State:	FAA Region:	
Wildlife Hazard Management Plan Evaluation (Continued)			
Elements	Reference 14 CFR 139.337	Complete	Comments
Designation of personnel responsible for implementing the procedures;	(f) (5) (i)		
Provisions to conduct physical inspections of the aircraft movement areas and other areas critical to successfully manage known wildlife hazards before air carrier operations begin;	(f) (5) (ii)		
Wildlife hazard control measures; and	(f) (5) (iii)		
Ways to communicate effectively between personnel conducting wildlife control or observing wildlife hazards and the air traffic control tower.	(f) (5) (iv)		
Procedures to review and evaluate the wildlife hazard management plan annually or following an event described in paragraphs (b)(1), (2), and (3) of this section, including:	(f) (6)		
The plans effectiveness in dealing with known wildlife hazards on and in the airport's vicinity and:	(f) (6) (1)		

Table 6-1. Airport Wildlife Hazard Review Worksheet. Page 5 of 5

Airport Name (LOCID)			
City:	State:	FAA Region:	
Wildlife Hazard Management Plan Evaluation (Continued)			
Elements	Reference 14 CFR 139.337	Complete	Comments
Aspects of the wildlife hazards described in the wildlife hazard assessment that should be reevaluated.	(f) (6) (ii)		
A training program conducted by a qualified wildlife damage management biologist to provide airport personnel with the knowledge and skills needed to successfully carry out the wildlife hazard management plan required by paragraph (d) of this section.	(f) (7)		
FAA Advisory Circulars contain methods and procedures for wildlife hazard management at airports that are acceptable to the Administrator.	(g)		
Section 7 Consultation completed with USFWS.	Yes	No	Date completed
NEPA coordination.	Yes	No	
Categorical exclusion.	Yes	No	
EA/EIS required.	Yes	No	
Wildlife Hazard Management Plan approved by:			
	Signature		Date

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CHAPTER 7:
EVALUATING WILDLIFE HAZARD MANAGEMENT PROGRAMS AT AIRPORTS



This engine suffered major damage after ingesting a large bird on departure from a midwestern USA airport. A UV emitting "black light" flashlight can be useful in detecting organic remains from birds in the engine.

7.1 INTRODUCTION

Wildlife populations on and in the vicinity of airports are constantly changing in response to changes in land use, state and federal management policies, and environmental factors. In addition, wildlife might adapt or habituate to control strategies that were once effective, or they might develop new behavioral or feeding patterns on or near the airport. New wildlife control technologies might become available, or established products or techniques might be withdrawn or banned. Finally, there might be changes in wildlife control and management personnel at an airport. Once a Wildlife Hazard Management Plan is in place, develop a process to evaluate the plan at least annually.

Update the plan as needed, based on the annual evaluation (14 CFR 139.337 [f][6]). This chapter outlines a means of conducting such evaluations.

7.2 MONITORING AND RECORD KEEPING

The importance of accurate monitoring and record keeping cannot be overemphasized. Without consistently maintained records of wildlife activity, wildlife strikes, and wildlife management actions, the proper evaluation of a program is impossible. Without evaluation, no assessment of the effectiveness of a program can be made. Furthermore, without accurate records and proper evaluation, it might be difficult to justify and defend certain management actions, such as wildlife removal, or to defend the airport during litigation in the aftermath of a damaging wildlife strike (see Appendix N).

7.2.A HAZARD ASSESSMENTS, PLANS, AND STUDIES

As discussed in Chapter 8, to facilitate access and reduce losses, keep all reference books, such as wildlife field guides, videos, posters, and other training and educational materials, in a specific location. For ready reference, have copies of Wildlife Hazard Assessments, Wildlife Hazard Management Plans, and other relevant wildlife studies conducted at the airport available at this site. Ideally, locate the wildlife library at the site where information on wildlife control activities and wildlife strikes is entered into logs, files, and databases.



Sweep nets can be used to monitor and identify insect populations, such as Japanese beetles, that attract gulls and other birds to an airport so pesticide applications and other control strategies can be implemented in a timely manner (photos by T. W. Seamans, USDA).

7.2.B DAILY LOG OF WILDLIFE CONTROL ACTIVITIES

Maintain a daily log of wildlife activity and management actions; important factors to record include—

- Date, time, and location on airport where wildlife is observed.
- Species of wildlife and approximate numbers.

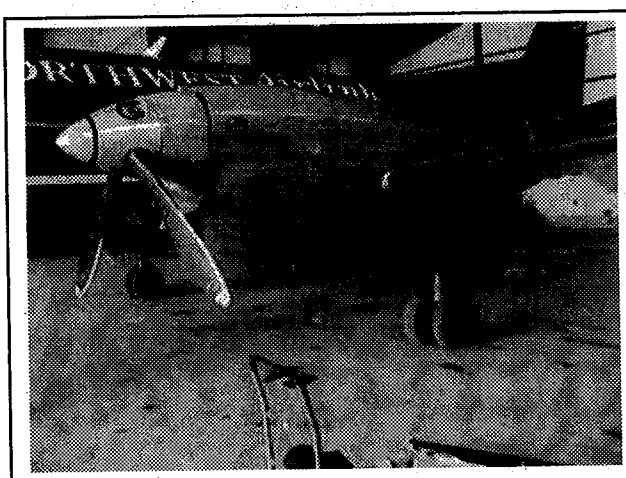
- Control actions taken and response of wildlife.

Record this information on a standard form (see Table 7-1 for an example of a daily log form) that can be used by wildlife control personnel at the site where the activity takes place. If a form is not available, record the information in a log book kept at the operations base.

The use of a standardized form or recording format, such as that presented in Table 7-1, is strongly recommended. The information recorded will be most useful if it is summarized into monthly and annual statistics (see below). Use of a standardized format allows this summarization to be easily done. The use of computerized database systems customized to provide summaries of wildlife control activities is recommended.

7.2.C DAILY LOG OF WILDLIFE STRIKES

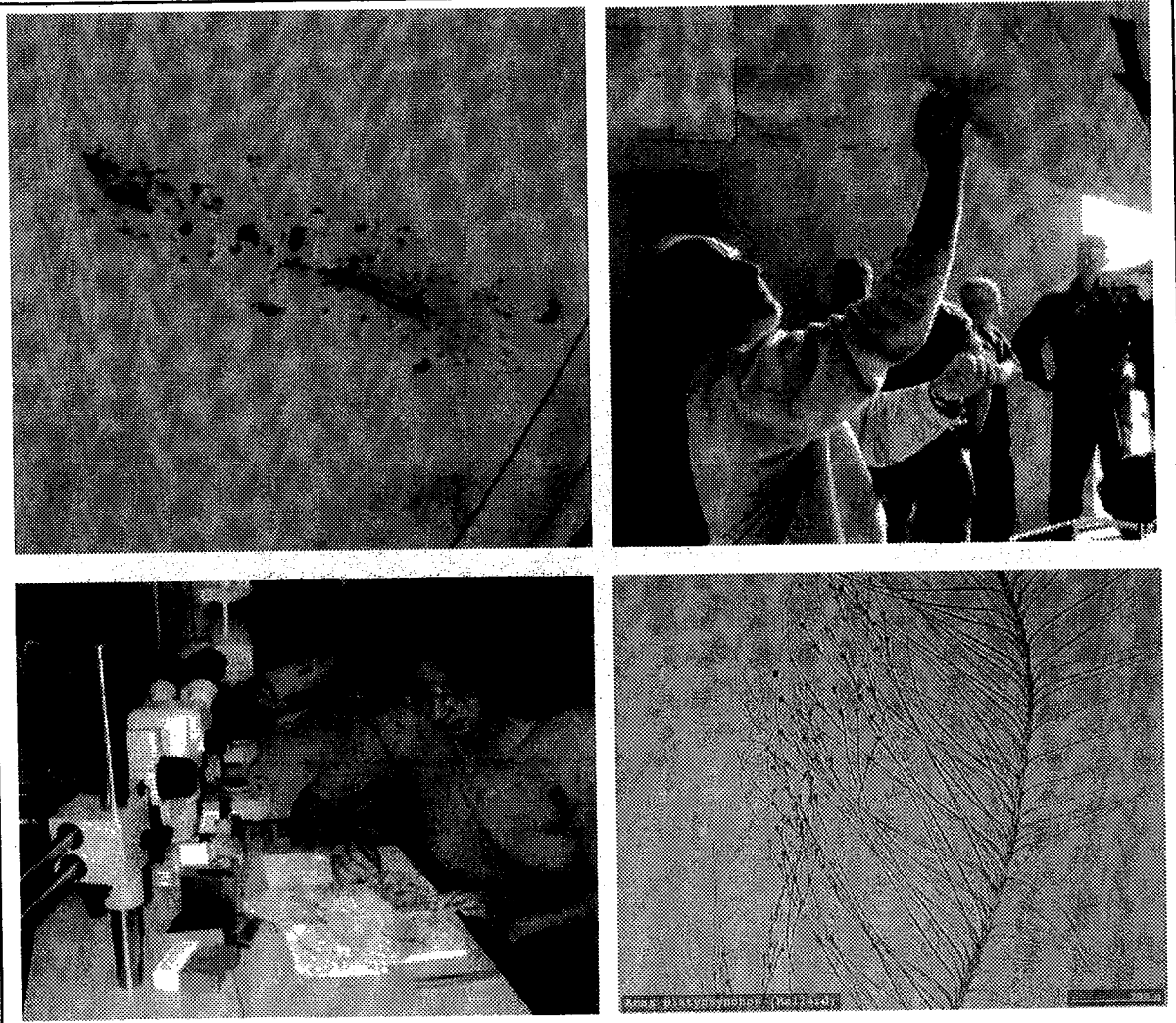
Maintaining a consistent record of wildlife strikes is essential for defining the wildlife hazard level for an airport and for evaluating the airport's Wildlife Hazard Management Plan. In addition to maintaining these strike records for internal use at the airport, surface-mail (using FAA Form 5200-7) or electronically submit strike reports to the FAA (http://wildlife.mitigation.tc.faa.gov). The FAA will incorporate the information into the National Wildlife Strike Database (Chapter 2).



This Saab 340 hit a deer on landing at a Midwest USA airport in April 2000, ripping the engine from its mountings (photo courtesy Northwest Airlines).

As defined in the glossary, a wildlife strike has occurred when—

1. A pilot reports striking one or more birds or other wildlife;
2. Aircraft maintenance personnel identify aircraft damage as having been caused by a wildlife strike;
3. Personnel on the ground report seeing an aircraft strike one or more birds or other wildlife;
4. Bird or other wildlife remains are found within 200 feet of the centerline of a runway, unless another reason for the animal's death is identified;
5. The animal's presence on the airport had a significant negative effect on a flight (e.g., aborted takeoff or landing, high-speed emergency stop, aircraft left pavement area to avoid collision with animal).



Top Left. Bird strike remains on an aircraft. **Top Right.** Strike remains being collected. (Smithsonian feather identification specialists refer to the collected material as "snarge.") **Lower Left.** Smithsonian feather identification specialist preparing snarge to identify the bird. **Lower Right.** Micrograph of a downy feather recovered from the snarge. The feather belongs to a mallard (photos by: Top – M. Begier, USDA; Bottom – C. Dove, Smithsonian Institution).

Record each strike event under categories 1-3 or 5 (reported strike) on FAA Form 5200-7 (Appendix I) and mail (the form is pre-addressed and franked on the back side) or transmit electronically to the FAA. Send photocopies of the form that do not have the address and frank on the back to—

Federal Aviation Administration
Office of Airport Safety and Standards, AAS-310
800 Independence Avenue, SW
Washington, DC 20591

Copies of this form (with the address and frank) can be downloaded and printed from http://wildlife-mitigation.tc.faa.gov. The form also can be filled out and filed electronically at this site.

When filling out Form 5200-7, include as much of the information requested as is available. Typically, not all information requested on the form will be available or known, but the report is valuable even if some information is missing.

For category 4 strikes (wildlife remains found but no report of strike), a log of these incidents should be maintained with the date, location, number, and species of animals struck recorded (Table 7-2). A copy of this log should also be mailed monthly to the FAA at the above address, or these strikes should be reported individually on FAA Form 5200-7 with a notation that a carcass was found but no strike was reported.

For all strike reports, make every effort to have the wildlife correctly identified to species. Freeze specimens that cannot be readily identified in a labeled bag until a local wildlife expert can be consulted. If only feather remains are available, mail them to the Smithsonian Institution Feather Lab for identification (see instructions and address in Chapter 2, and in Advisory Circular 150/5200-32A *Reporting Wildlife Aircraft Strikes*, Appendix C). There is no charge for this identification service. Please include a copy of the strike report or other relevant information with the bird remains to assist the feather experts in identifying the bird.



One approach to controlling rodent populations at airports is the periodic treatment of grass areas with zinc phosphide-treated bait. The application must be under the supervision of a person certified in vertebrate pest control (Photo by R. A. Dolbeer, USDA).

7.2.D RECORDS OF SIGNIFICANT MANAGEMENT ACTIONS TAKEN

In addition to maintaining a daily log of wildlife control activities and wildlife strikes, it is important to keep records of other preventative management actions that might not be part of the daily routine of wildlife control. Examples of such actions might be installing or repairing fencing, thinning trees, clearing construction debris, applying pesticides or repellents, conducting grass-height management, installing netting in hangers or wires over ponds, and regrading pavement or grass areas to eliminate standing water. In addition, activities such as writing letters to catering services about proper storage of food waste are also important management actions. Documenting these activities in some type of summary file or table can aid in determining the total cost and effectiveness of the wildlife control program.

7.2.E SUMMARY REPORTS BY MONTH AND YEAR

Periodically summarize information from the Daily Wildlife Control Activities log and from wildlife strikes records to provide baseline data for analyzing and evaluating the

wildlife control program. A logical approach is to conduct monthly summaries that are then incorporated into an annual report. These summaries do not need to be complex but must reflect the level of activity for the common control techniques deployed. For example, monthly summaries of pyrotechnics fired, runway sweeps to clear birds, distress call deployments, birds and mammals removed by species, and wildlife strikes by species would be useful (Table 7-3). Prepare a short paragraph outlining other significant activities during the month, such as repairing a fence, meetings with airport tenants about wildlife issues (e.g., feeding birds in taxi stand area), or regrading an area to remove standing water. Prepare an annual report (Table 7-4) by combining data from the monthly reports. It is emphasized that Tables 7-3 and 7-4 are only presented as examples to provide guidance in developing a format to summarize data. A particular airport might use methods not listed in Tables 7-3 and 7-4, such as falconry, radio-controlled model airplanes, dogs, or propane cannons. The important point is that there must be an objective, numerical documentation of wildlife control methods deployed and wildlife strikes occurring on the airport. The use of a computer database program can be extremely helpful in producing these summary reports.



All airport management, as well as airport operations and maintenance personnel, need a basic understanding of wildlife aircraft strike issues on their airport. Specialized courses in managing wildlife hazards at airports, taught by recognized experts, provide a practical way of doing this. The FAA and USDA/WS can provide this type of training (photo by C. Steves, FAA).

7.2.F TRAINING

Maintain and annually summarize a record of all training that wildlife control personnel have received. Include attendance at conferences, courses and workshops (e.g., firearms safety), self-study courses, and specialized on-the-job training.

7.3 ASSESSMENT OF WILDLIFE HAZARD MANAGEMENT PLAN

All FAA approved Wildlife Hazard Management Plans must be reviewed at least annually or following an event that would normally trigger a Wildlife Hazard Assessment (see 14 CFR 139.337 (b)(1-4) and 139.337 (f)(6)). The review must include: the plan's effectiveness in dealing with known wildlife hazards on and in the vicinity of the airport, and aspects of the wildlife hazards described in the Wildlife Hazard Assessment that should be reevaluated (14 CFR 139.337 (f)(6)). The wildlife damage management biologist that helped prepare the plan and a sub-group from the Airport's Wildlife Hazard Working Group should conduct this review.

Appendix K describes a simple system (modified from Seubert 1994) for assessing a Wildlife Hazard Management Plan at an airport. Five assessment categories are used to indicate the adequacy of a Wildlife Hazard Management Plan and how well the plan is being implemented:

Category 1. Management functions related to wildlife hazards on or in the vicinity of the airport.

Category 2. Bird control on or in the vicinity of the airport.

Category 3. Mammal control on or in the vicinity of the airport.

Category 4. Management of habitat and food sources on airport property related to wildlife hazards.

Category 5. Land uses and food sources off of the airport potentially related to wildlife hazards on airport.

Within Categories 1-4 (activities on the airport), a series of elements are listed that are evaluated as either "Satisfactory", "Unsatisfactory", "Needs Improvement", or "Not Applicable". For Category 5 (off-airport attractants), the elements are scored on a scale of 0 (not present) to 3 (site creates significant wildlife hazard for airport; action should be taken). Those elements deemed "Unsatisfactory" or "Needs Improvement" (in Categories 1-4) or that are scored 2 or 3 (in Category 5) are then commented on in a summary form. The elements listed within each category are not intended to cover every possibility at every airport. The elements can be modified or expanded to meet situations unique to an airport.



Wetlands on airport provide both habitat and food for wildlife. Such areas can be eliminated through wetland mitigation programs (photo by E. Cleary, FAA).

7.4 AIRPORT WILDLIFE HAZARDS WORKING GROUP

7.4.A FUNCTION

Wildlife hazard management on an airport often requires communication, cooperation, and coordination among various groups on the airport and with various local, state, and federal agencies and private entities. For many airports, the establishment of a Wildlife Hazards Working Group (WHWG) will greatly facilitate this communication, cooperation, and coordination.

7.4.B MEMBERSHIP

Include a representative from each of the key groups and agencies that have a significant involvement or interest in wildlife issues on the airport in the WHWG. Airport groups might include representatives from security, maintenance, operations, and air traffic control. From government, representatives from the state wildlife agency, the U.S. Fish and Wildlife Service and USDA/WS might be appropriate. Include representatives from any facility near the airport that significantly attracts wildlife (such

as a landfill or wildlife refuge).

In general, do not exceed 10 people in the core WHWG. This will keep meetings from becoming unwieldy. In addition to regular members, invite people with specialized knowledge, interest, or concerns to the meetings as appropriate. Typically, someone from airport management chairs the WHWG. The chair can be rotated among various airport departments.



Airports should establish a Wildlife Hazards Working Group (WHWG) that meets at least annually to facilitate communication, cooperation, and coordination among the various agencies and airport departments. The WHWG also provides a forum to review and update the airport's Wildlife Hazard Management Plan (photo by R. A. Dolbeer, USDA).

7.4.C MEETINGS

At least annually hold a meeting of the WHWG to conduct a general review of the overall wildlife hazard management program for the airport and to discuss special issues or problems as needed. Include the following in the general discussion:

- Strike trends and significant strike events (based on data summarized using formats in Tables 7-3 and 7-4).
- Source of wildlife causing strike problems.
- Wildlife control activities (based on data and commentary summarized using formats in Tables 7-3 and 7-4.
- Wildlife Hazard Management Plan evaluation (based on most recent assessment using format in Appendix K).

Special issues to be discussed might include projected impacts of land-use changes on or near the airport, trends in populations or behavior of various species of wildlife, wildlife removal permits, evaluation of new wildlife control technologies, and clarification of roles and responsibilities. A good way to end the meeting might be with a field demonstration of a wildlife management activity on the airport or a site visit to a nearby wildlife attractant (e.g., sewage treatment facility) that might need addressing.

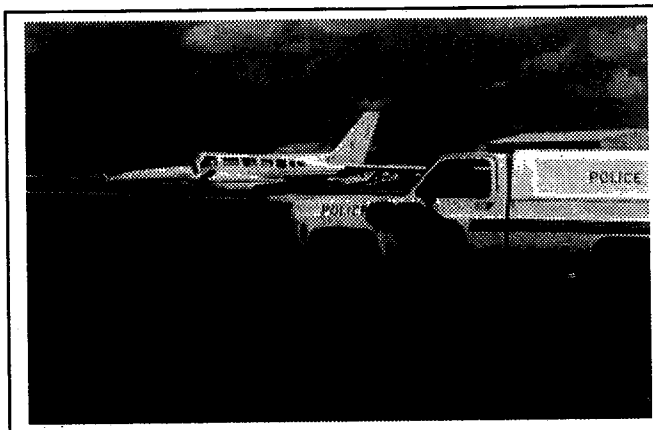
Special meetings of the entire WHWG or a subgroup might be needed after significant strike events or other developments affecting wildlife hazards if a regular meeting is not scheduled for the near future.

7.4.D MEETING REPORTS

Make arrangements to have minutes taken and a summary report written for each meeting. Include in the report a list of attendees, decisions made by the group, deadlines and responsible parties for task assignments, and a list of critical issues that were not resolved.

7.5 SUMMARY AND CONCLUSIONS

Periodic evaluations of an airport's Wildlife Hazard Management Plan and the activities undertaken to implement the plan are critical because of the dynamic nature of wildlife hazards and control technologies. The foundation for these evaluations is the maintenance of consistent records of wildlife control activities and wildlife strikes. The use of standardized formats for keeping these records, such as those presented in Tables 7-1 to 7-4, permits easy compilation of events and activities into monthly and annual statistical and narrative summaries. Once these summaries are available, objective examinations and comparisons can be made of trends in strikes, wildlife activities, control methods deployed, and other factors.



All wildlife carcasses found during aircraft movement area inspections should be removed immediately. Unless another reason for the animal's death can be determined, the incident should be reported as a wildlife strike and recorded in the airport's wildlife strike database (photo courtesy USDA).

An objective, standardized format for assessing a Wildlife Hazard Management Plan and its implementation is presented in Appendix K. This format allows an outside biologist or evaluation group to systematically review the actions being taken and make recommendations in areas where improvement is needed. The availability of summary statistics, such as provided through records maintained in Tables 7-1 to 7-4, is essential for this assessment.

Finally, the establishment of a WHWG provides an excellent means of improving communication, coordination, and cooperation among the diverse groups involved in wildlife hazard management on an airport. The WHWG also can provide an important forum for reviewing, evaluating, and improving an airport's wildlife hazard management program.

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Table 7-1. Example of a daily log of wildlife control activities.

Airport					Month	Year	
		Location (Grid)	Wildlife		Control method	Results/comments	Initials
Date	Time		Species	No.			

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Table 7-2. Example of a Wildlife Strike Log for recording bird or other wildlife remains found within 200 feet of runway centerline that, in the judgment of wildlife control personnel, were killed as a result of interacting with an aircraft.

Airport				Month		Year
Date	Time found	Species	Runway	Location on runway	Was strike reported[1]?	Comments

[1]If strike was reported, complete FAA Form 5200-7.

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Table 7-3. Example of a form to provide monthly summary of wildlife control activities.

Airport			Month	Year
Control activity (modify list as appropriate)	This month	Same month last year	Comments (list wildlife dispersed or removed by species and method)	
No. of pyrotechnics fired				
No. of times distress calls deployed				
No. of runway sweeps to clear birds				
No. of wildlife removed				
Miles driven by wildlife patrol				
No. of reported strikes				
No. of reported strikes with damage				
No. of carcasses found (no strike reported)				

Summary paragraph of other wildlife control activities:

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Table 7-4. Example of a form to provide annual summary of wildlife control activities derived from monthly reports (Table 7-3). Modify each airport's form to reflect the common control activities undertaken during the year. The data may also be presented graphically.

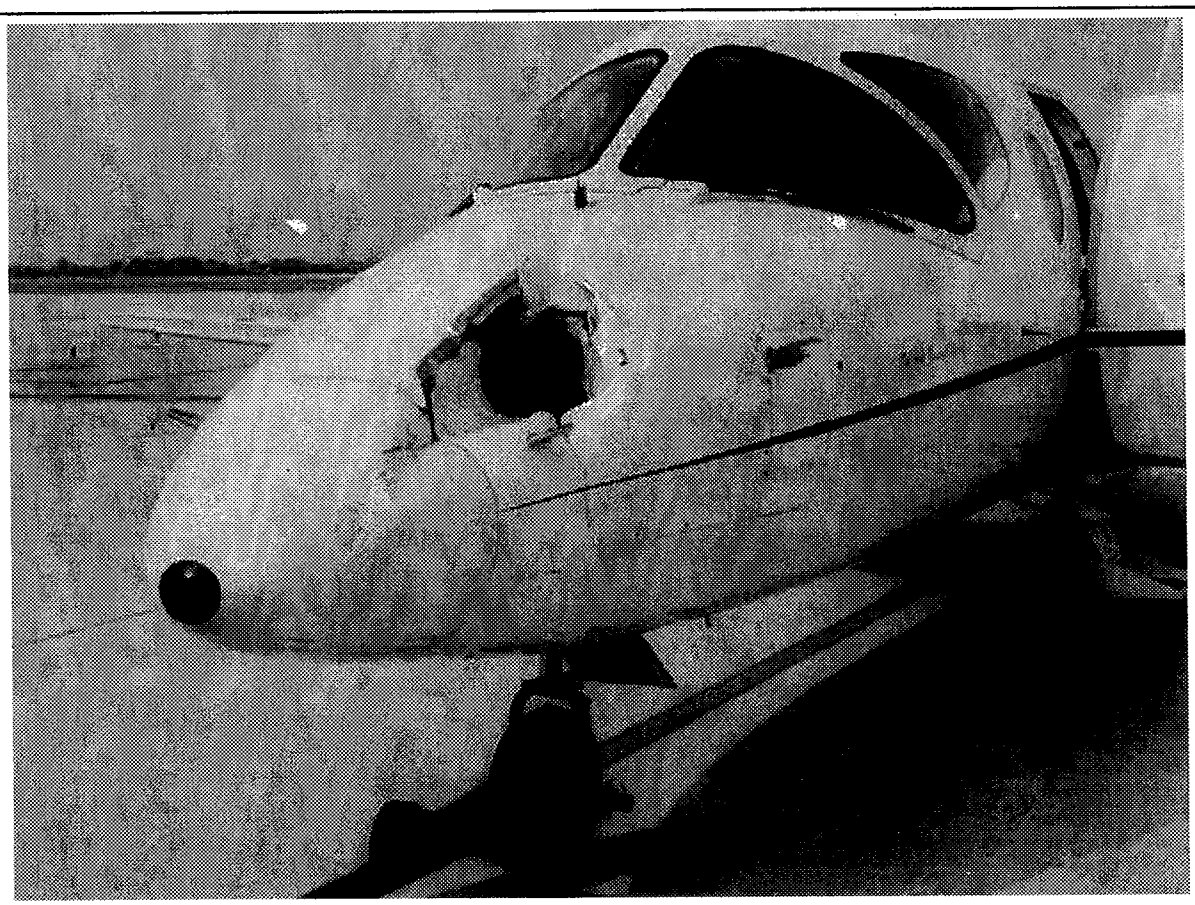
Airport				Year					
	Number of:								
Month	Pyro-technics fired	Times distress calls deployed	Runway sweeps to clear birds	Wildlife dispersed	Wildlife removed[1]	Miles driven by wildlife patrol	Reported strikes[2]	Reported strikes with damage	Carcasses found (no strike reported)[2]
Jan									
Feb									
Mar									
Apr									
May									
Jun									
Jul									
Aug									
Sep									
Oct									
Nov									
Dec									
Total									

[1]Provide separate list by species and method.

[2]Provide separate list by species.

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CHAPTER 8:
WILDLIFE HAZARD MANAGEMENT TRAINING FOR AIRPORT PERSONNEL



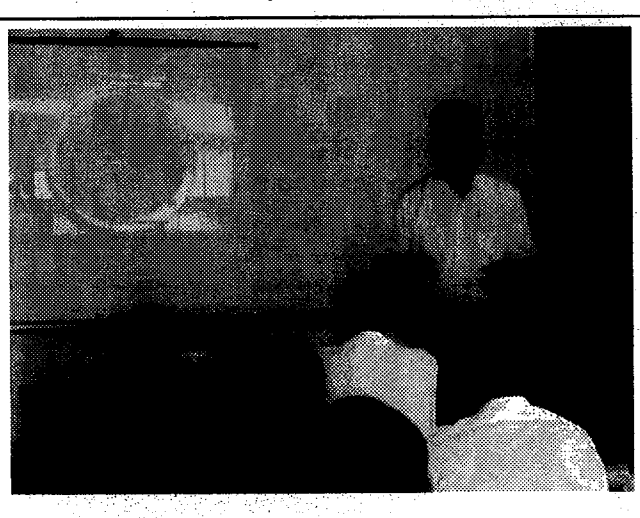
Populations of most bird species weighing over 4 pounds have increased dramatically in the USA since 1980. These large birds can cause substantial damage when struck by aircraft (photo courtesy USAF).

8.1 INTRODUCTION

The management of wildlife is a complex endeavor that often attracts public interest. Once an assessment of hazards has been completed and a Wildlife Hazard Management Plan has been developed, the plan must be implemented by well-trained and knowledgeable individuals if it is to be successful in reducing wildlife strikes and accepted by the public.

Depending on the size of an airport and the level of wildlife hazard, the Wildlife Hazard Management Plan may be implemented by a single airport employee undertaking wildlife control activities on an occasional "as needed" basis or by a full-time wildlife biologist with a staff of operations personnel providing continuous bird patrols.

Some of the personnel involved in these control activities, hereafter referred to as wildlife control personnel (WCP), might not have formal education in wildlife biology. All WCP must have sufficient training to be knowledgeable in the basic principles of wildlife management and in the identification, behavior, general life history, and legal status of the hazardous species in the area. WCP also must be trained in the proper implementation or deployment of various control strategies and techniques outlined in the Wildlife Hazard Management Plan. Finally, an awareness of endangered and threatened wildlife species that might visit or reside on the airport is critical.



Training, provided by recognized experts, should include classroom instruction, fieldwork, and attendance at conferences, such as Bird Strike Committee USA/Canada (photo by C. Steves, FAA).

8.2 TRAINING

The following areas of training and levels of skill are suggested for WCP implementing control activities on airports under a Wildlife Hazard Management Plan. It is emphasized that, once a plan is in place, in addition to the training provided to WCP, there must be periodic oversight and review of the plan and its implementation by a professional biologist trained in wildlife damage control (14 CFR 139.337 (f)(7)).

8.2.A BIRD IDENTIFICATION

There are over 600 species of birds that reside in or migrate through the USA. Many of these species, such as gulls, have quite different plumage patterns and bill colors as subadults (year of hatching up to 3 years in some species) than as adults (as an example, see Appendix J for a fact sheet on North American gulls). Some birds, such as laughing gulls, European starlings, and black-bellied plovers, have different summer and winter plumage patterns and bill colors. In other species, such as northern harriers and red-winged blackbirds, males and females appear quite different. Some species are present in an area all year, others only in migration (spring, fall), and others only in winter or in summer. All species have unique vocalizations, behaviors, and habitat preferences that are useful in field identification. Thus, to become an expert in field identification of all bird species at a location requires many years of training and practice. WCP require basic training so they can identify, in all plumages, commonly seen hazardous birds, as well as those rarer species that are considered hazardous when present or are of concern because of endangered- or threatened-species status. Table 8-1 provides a list of the relative hazard of various species groups based on the percent of reported strikes that cause damage or an effect-on-flight.

Table 8-1. Ranking of 25 species groups as to relative hazard to aircraft (1=most hazardous) based on three criteria (damage, major damage, and effect-on-flight), a composite ranking based on all three rankings, and a relative hazard score. Data were derived from the FAA National Wildlife Strike Database, January 1990–April 2003[1].

Species group	Ranking by criteria			Composite ranking[5]	Relative hazard score[6]
	Damage[2]	Major damage[3]	Effect on flight[4]		
Deer	1	1	1	1	100
Vultures	2	2	2	2	64
Geese	3	3	6	3	55
Cormorants/pelicans	4	5	3	4	54
Cranes	7	6	4	5	47
Eagles	6	9	8	6	41
Ducks	5	8	10	7	39
Osprey	8	4	8	8	39
Turkey/pheasants	9	7	11	9	33
Herons	11	14	9	10	27
Hawks (buteos)	10	12	12	11	25
Gulls	12	11	13	12	24
Rock pigeon	13	10	14	13	23
Owls	14	13	20	14	23
Horned lark/snow bunting	18	15	15	15	17
Crows/ravens	15	16	16	16	16
Coyote	16	19	5	17	14
Mourning dove	17	17	17	18	14
Shorebirds	19	21	18	19	10
Blackbirds/starling	20	22	19	20	10
American kestrel	21	18	21	21	9
Meadowlarks	22	20	22	22	7
Swallows	24	23	24	23	4
Sparrows	25	24	23	24	4
Nighthawks	23	25	25	25	1

[1] Excerpted from the *Special Report for the FAA, Ranking the Hazard Level of Wildlife Species to Civil Aviation in the USA: Update #1, July 2, 2003.* Refer to this report for additional explanations of criteria and method of ranking.

[2] Aircraft incurred at least some damage (destroyed, substantial, minor, or unknown) from strike.

[3] Aircraft incurred damage or structural failure that adversely affected the structure strength, performance, or flight characteristics and that would normally require major repair or replacement of the affected component, or the damage sustained makes it inadvisable to restore aircraft to airworthy condition.

[4] Aborted takeoff, engine shutdown, precautionary landing, or other.

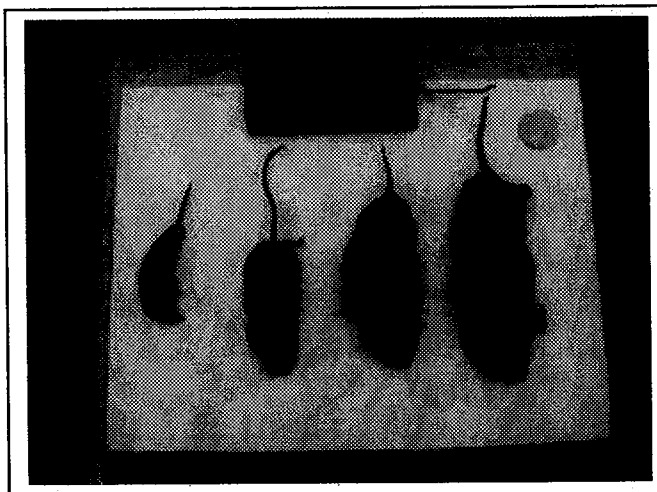
[5] Relative rank of each species group was compared with every other group for the three variables, placing the species group with the greatest hazard rank for $\geq$ 2 of the 3 variables above the next highest ranked group, then proceeding down the list.

[6] Percentage values, from Tables 3 and 4 in Footnote 1 of the *Special Report*, for the three criteria were summed and scaled down from 100, with 100 as the score for the species group with the maximum summed values and the greatest potential hazard to aircraft.

Binoculars are essential for detailed, close-up observations sometimes necessary for identification as well as for the detection and identification of birds or other wildlife at a distance. Provide WCP with a quality pair of binoculars, and train WCP in their use.

Equip each WCP with his or her own bird identification field guide, to be carried in the vehicle while on patrol. As a learning aid, encourage WCP to make annotations in their field guides regarding behavior or appearance next to identified birds.

There are a number of excellent field guides available from bookstores, some of which are listed at the end of this chapter. There are also bird identification guides available on CDs that provide useful life history information and vocalizations.



Grass areas at airports often contain several species of small mammals that are an attractive food for hawks, owl, herons, and egrets. Vagrant shrews, deer mice, gray-tailed voles, and Townsend's voles (left to right) were all captured during one night of trapping at a western USA airport in September 2003 (photo by R. A. Dolbeer, USDA).

8.2.B MAMMAL IDENTIFICATION

Unlike birds, there are typically only a few mammal species of importance on an airport. Train WCP to identify, not only by sight but also by sign (e.g., tracks, burrows, and fecal material), the common large and mid-sized mammals (e.g., deer, raccoons, woodchucks, coyotes) that live around the airport. Train WCP to identify signs (e.g., trails in grass, burrows) indicative of a population eruption of field rodents, such as voles, deer mice, or rats. A survey by a biologist using snap traps might be necessary to identify the species and relative abundance of rodents occupying various airport habitats. In addition, rodent species can be identified by examination of skull remains in pellets (boluses) regurgitated by hawks and owls. These pellets are often found on the ground beneath perching sites used by raptors.

Citations for field guides covering mammals and their tracks throughout the USA are provided at the end of this chapter. In addition, there are many state and regional field guides for identifying mammals and their signs. A good field guide to mammals is a necessary part of any airport's hazardous wildlife control library.

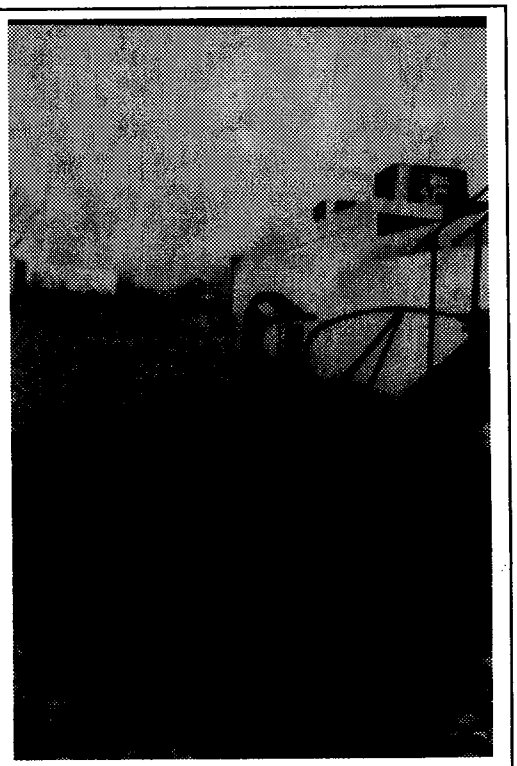
8.2.C BASIC LIFE HISTORIES AND BEHAVIOR OF COMMON SPECIES

In addition to learning to identify the hazardous birds and mammals on the airport, WCP should have some understanding of the biology and behavior of these species. This information will make the job of wildlife hazard management more interesting and be useful in anticipating problems and deploying control measures more effectively.

For each species of bird, it is important to know if it is present year round or only in summer, in winter, or during migration. For example, in which habitats and at what time

of year do locally breeding bird species nest and when are young fledged from nests? What are the daily movement patterns between roosting, feeding and loafing areas in relation to the airport? What are the feeding behaviors and food preferences of each species on the airport? Which habitats does each species prefer? How does weather influence the presence and behavior of various species on the airport? How does each species react to approaching aircraft and to various repellent devices? By being observant and noting the behavior of these hazardous species, useful insights can be gained that will lead to more effective habitat management or repellent strategies.

Most bird and mammal field guides provide information on geographic range, feeding habits, and habitat preferences for each species. Alsop (2001), Sibley (2001), and Ehrlich et al. (1988) provide concise summaries of life history information (nesting, feeding, habitat preferences) for most birds in North America. Appendix J provides some life history facts for various gull species in the USA. Such books and fact sheets provide an excellent starting point for knowledge about a species. However, the most useful information will come from careful observation of what the birds and mammals are doing on your airport.



Canada geese have adapted to nesting on rooftops, often well away from water (photo courtesy USDA).

8.2.D WILDLIFE AND ENVIRONMENTAL LAWS AND REGULATIONS

As presented in Chapter 4, there is a complexity of federal and state laws protecting wildlife and regulating the issuance of permits to take (capture or kill) individuals causing problems. In addition, environmental laws and regulations regarding pesticide applications, drainage of wetlands, and endangered species must be considered in implementing Wildlife Hazard Management Plans. All WCP should have a basic understanding of the federal Migratory Bird Treaty Act (MBTA) whereby almost all native migratory birds are protected regardless of their abundance (see Chapter 4). WCP must understand that federal and often state permits must be issued before protected species can be taken on an airport. WCP must know that wild mammals are regulated at the state level, which may require permits for activities involving removal (killing or trapping/relocating). Non-native birds, such as pigeons, house sparrows, and starlings, and gallinaceous game birds, such as turkeys, grouse, and pheasants, are not protected by the MBTA but often have state protection. WCP involved in taking any wildlife species must have a clear understanding of which species have no legal protection and, for all others, the species and numbers allowed to be taken under permits issued. Permits also will list the methods of removal allowed and acceptable procedures for disposing of removed wildlife. Detailed records must be maintained of wildlife taken under permit.

8.2.E WILDLIFE CONTROL TECHNIQUES

Chapter 9 provides a brief description of most wildlife control techniques used on airports. WCP will need training to deploy these techniques safely and effectively.





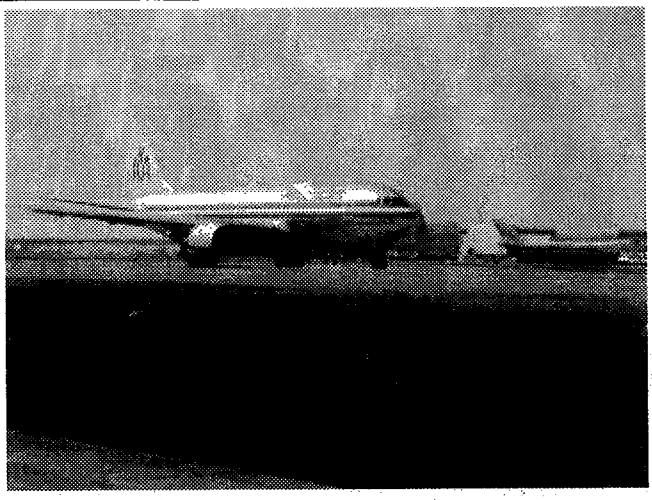
The use of pyrotechnics, such as cracker shells fired from a 12-gauge shotgun (left) or screamers fired from a pistol launcher, should be part of an airport's integrated management program to disperse hazardous birds. Occasional lethal control by shooting might be necessary to reinforce pyrotechnics and other nonlethal dispersal techniques used against common species such as gulls and Canada geese. Permits and proper training must be in place before lethal control is implemented (photos by R. A. Dolbeer, USDA).

Firearms. It is critical that only personnel trained in the use of firearms, authorized under depredation permit, and knowledgeable in field identification of the target and similar-looking non-target species are allowed to use firearms on the airport. Skill, experience, and the proper equipment are needed to be safe and to maximize the effectiveness of a shooting program, whether it is to remove specific problem animals or to kill one or more individuals to reinforce repellent techniques. All discharged shell casings are potential Foreign Object Debris (FOD) and must be picked up.

Pyrotechnics. Pyrotechnics can cause injury or damage if discharged incorrectly or carelessly. For example, serious injuries have occurred when pyrotechnics were accidentally discharged inside vehicles. Proper equipment (safety glasses, ear protection) and training is essential for safe use of pyrotechnics. In addition, training is needed to deploy the correct pyrotechnic for each situation and wildlife species and to minimize habituation. It is critical that pyrotechnics (and other repellent devices) not be deployed in situations where the birds or mammals might be flushed into the path of departing or arriving aircraft.

Pesticide application. WCP applying restricted-use pesticides, applying pesticides for hire, or applying pesticides to the land of another must be Certified Applicators or

working under the direct supervision of a Certified Applicator and then may only use pesticides covered by the Certified Applicator's certification. Proper application equipment and safety clothing must be used. Detailed records of pesticide applications must be maintained.



Propane cannons can be used as part of an integrated program to disperse birds from airports. However, birds quickly habituate to the loud bangs if the cannons are used continuously and not integrated with other frightening devices (photo by R. A. Dolbeer, USDA).

For information on the training requirements for becoming a Certified Pesticide Applicator, contact the State University Cooperative Extension Service.

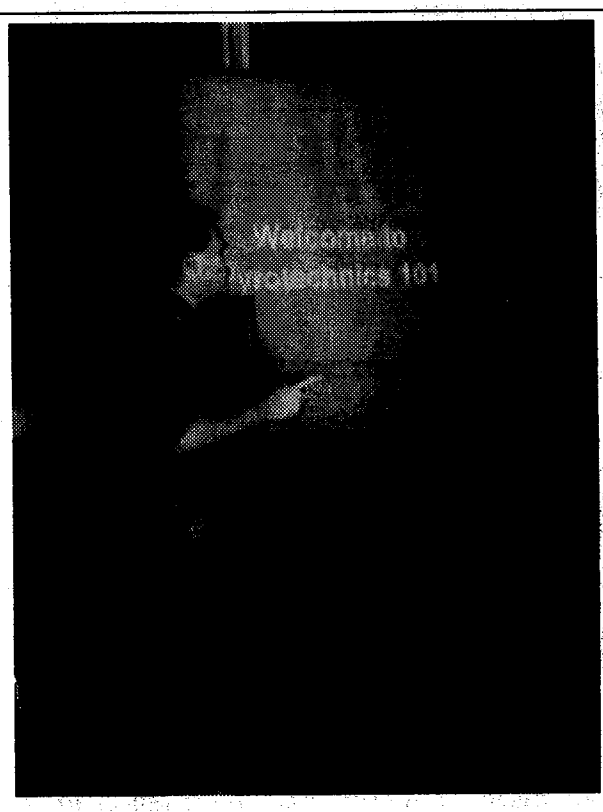
Distress call tapes, propane cannons, and miscellaneous techniques. As emphasized in Chapter 9, a major problem in the use of repellent techniques or devices is habituation of the wildlife species to the threats. These techniques all require training for their proper deployment. The most critical factor for most repellent devices is that they be deployed sparingly and appropriately when the target wildlife is present and be reinforced occasionally by a real threat such as shooting. More detailed information on the use of various repellent devices is presented in Chapter 9 and Hygnstrom et al. (1994).

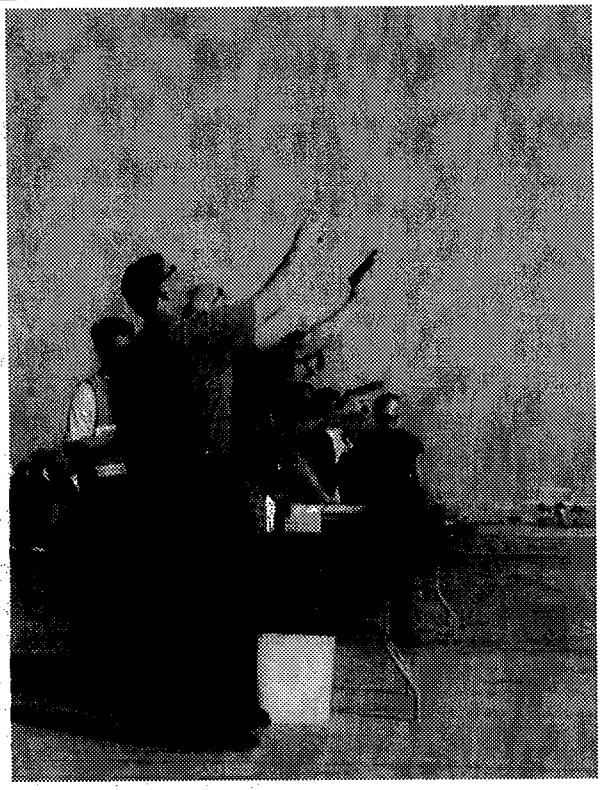
8.2.F RECORD KEEPING AND STRIKE REPORTING

A key component of a Wildlife Hazard Management Plan is developing a system to (1) document the daily activities of WCP, (2) log information about wildlife numbers and behavior on the airport, and (3) record all wildlife strikes with aircraft. This information is essential to document the effort being made by the airport in reducing wildlife hazards. The information is also extremely useful during periodic evaluations of the Wildlife Hazard Management Plan and when revisions to the plan are proposed. Instruct WCP on the importance of record keeping and train them to record this information in a standardized format. Chapter 7 provides more details about record keeping and wildlife strike reporting.

8.3 SOURCES OF TRAINING

Wildlife control workshops at airports. Books, manuals, and videos can provide a starting point for building skills to manage hazardous wildlife on airports. However, hands-on training is essential to develop the necessary skills and confidence to successfully and safely carry out wildlife control activities. Workshops on airport wildlife control offered by the USDA/WS or other entities are an excellent means of obtaining training in wildlife identification, legal issues, and the deployment of various control techniques specific for a given airport or region of the country. These workshops can be held for all WCP at a single airport or at a centralized airport with participants coming from airports throughout the state or region.





A special classroom and field training program in the proper and safe use of pyrotechnics to disperse birds was provided at the 2002 and 2004 meetings of Bird Strike Committee–USA/Canada (photos by R. DeFusco).

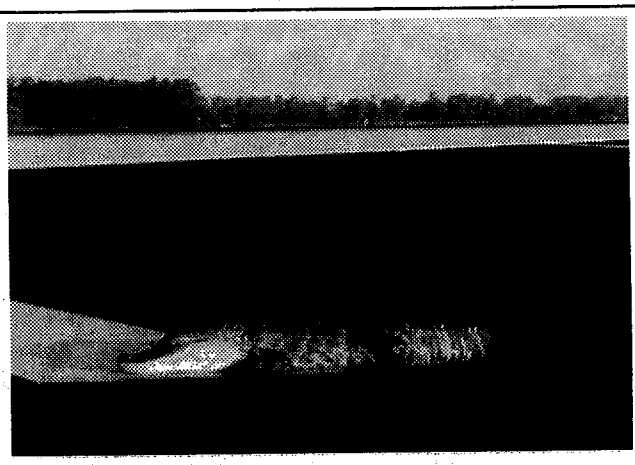
Contact the Wildlife Services office in your state (Appendix A) for more information.

Bird Strike Committee USA meetings. Bird Strike Committee–USA (BSC–-USA) holds joint meetings annually with Bird Strike Committee Canada at a USA or Canadian airport. This annual meeting provides an excellent forum to discuss the latest issues and techniques in wildlife control for airports. The meeting includes a field trip to the host airport with demonstrations by vendors and wildlife specialists of various wildlife

control equipment and techniques. Chapter 3 provides more information on BSC–USA. Information on annual meetings, as well as information on various aspects of wildlife hazard management for airports, can be found at BSC–USA's web site: www.birdstrike.org.

Hunter safety and firearms courses. Require airport personnel who will be using firearms to complete a hunter safety or firearms safety course. The state wildlife agency can provide information on these courses.

Miscellaneous courses and activities. Many universities and some community colleges offer courses in ornithology, principles of wildlife management, principles of wildlife damage control, or other related topics. Local Audubon Society chapters or park districts sometimes offer workshops or short courses in field identification of birds. Participation in conservation organization activities, such as Christmas Bird Counts and spring migration counts, is an excellent means of building bird identification skills and developing contacts with local wildlife experts.



Birds and mammals are not the only wildlife groups that can cause problems on airports. This 7-foot alligator wandered onto the runway at a southern USA airport in September 2002, threatening both aircraft and personnel. The alligator was relocated unharmed. For the 14-year period 1990–2003, reports of 15 alligator-aircraft strikes with civil aircraft were received by the FAA (photo by J. Metcalf).

8.4 WILDLIFE HAZARD MANAGEMENT LIBRARY

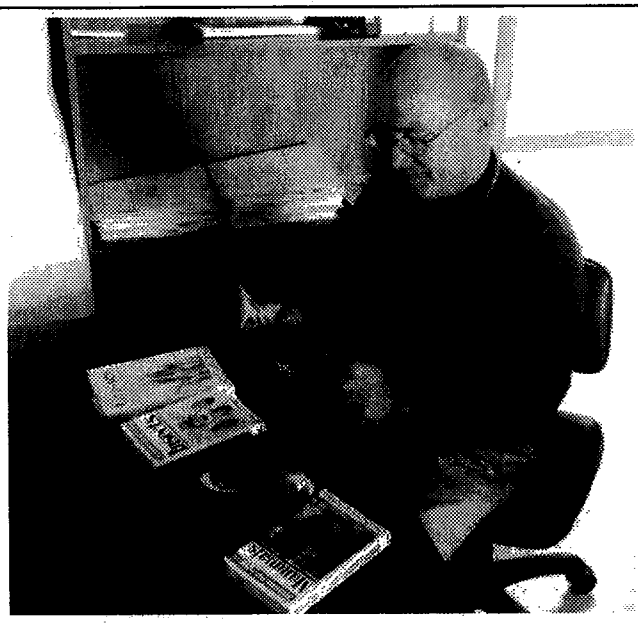
Establish a designated location for reference books, such as wildlife field guides, videos, posters, and other training and educational materials and the airport's Wildlife Hazard Management Plan if one has been developed. Ideally, locate this wildlife library at the site where information on wildlife control activities and wildlife strikes is entered into logs, files, and databases.

8.5 FIELD GUIDES AND REFERENCE BOOKS

There are many excellent field guides and reference books for learning about wildlife. To provide examples, a selection of books that cover North America or large regions of the USA is listed below. This list is not intended as an endorsement of these books to the exclusion of others. There are also many field guides for individual states and specialized books for various wildlife species or species groups.

Field Guides–Birds

Bull, J., J. Farrand, Jr., and, L. Hogan. 1994. *National Audubon Society field guide to North American birds: Eastern region.* Alfred Knopf, New York, New York. 796 pages. 2nd edition.



Airports should maintain a small library of field guides that can be referenced by biologists and operations personnel to identify and learn about birds, mammals, plants, and insects found on the airport. These field guides should be located with the Wildlife Hazard Management Plan and other related documents (photo by B. Washburn, USDA).

National Geographic Society. 2002. *Field guide to the birds of North America.* National Geographic Society, Washington, District of Columbia. 480 pages. 4th edition.

Griggs, J. L. 1997. *All the birds of North America: American Bird Conservancy's field guide.* Harper Collins, New York, New York. 172 pages.

Peterson, R. T. 1998. *A field guide to the birds: a completely new guide to all the birds of Eastern and Central North America.* Houghton Mifflin Company, New York, New York. 384 pages. 4th edition.

Peterson, R. T. 1990. *A field guide to Western birds: a completely new guide to field marks of all species found in North America west of the 100th meridian and north of Mexico.* Houghton Mifflin Company, New York, New York. 431 pages. Reissue edition.

Robbins, C. S., B. Bruun, and H. S. Zim. 1983. *Birds of North America.* Golden Press, New York, New York. 360 pages.

Field Guides - Mammals

Burt, W. H., and R. P. Grossenheider. 1998. *A field guide to the mammals: North America north of Mexico.* Houghton Mifflin Company, New York, New York. 3rd edition. 289 pages.

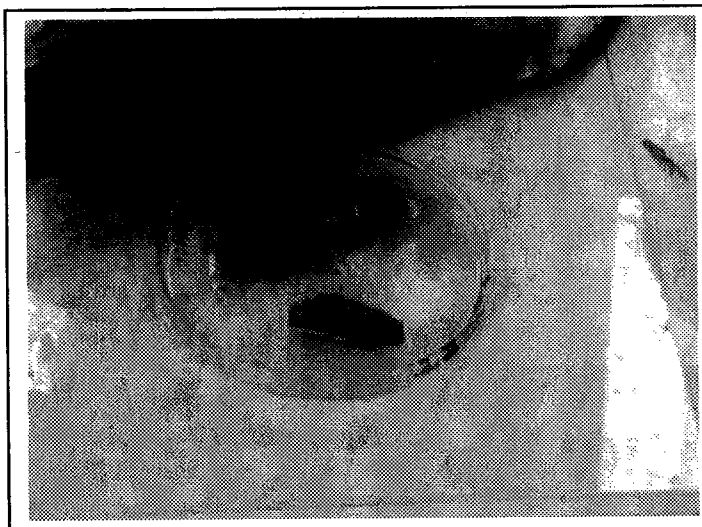
National Audubon Society. 2000. N*ational Audubon Society field guide to North American mammals* (revised and expanded). Alfred Knopf, New York, New York. 937 pages.

Elbroch, M. 2003. *Mammal tracks and sign: A guide to North American species.* Stackpole Books, Mechanicsburg, Pennsylvania. 792 pages.

Murie, O. J. 1954. *A field guide to animal tracks.* Houghton Mifflin Company, New York, New York. 374 pages.

Life Histories

Alsop, F. J., III. 2001. *Birds of North America, Eastern Region* (751 pages), *Western Region* (752 pages). DK Publishing, Inc., New York, New York.



An examination of the stomach contents of aircraft-struck birds found on runways can often identify food sources that are attracting the birds to the airport. A chicken neck and undigested French-fried potato found in this laughing gull stomach indicated a nearby source of uncovered garbage (photo by G. E. Bernhardt, USDA).

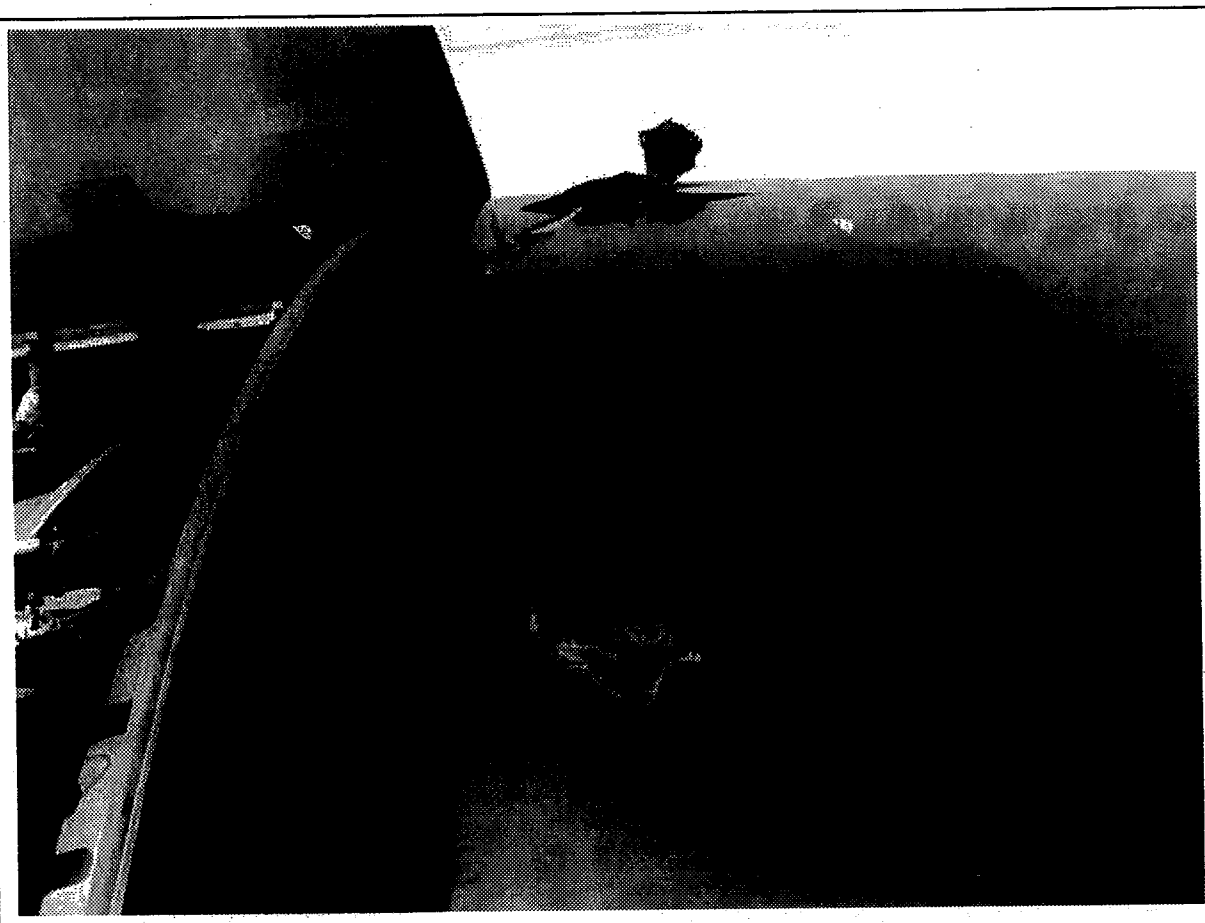
Ehrlich. P. R., D. S. Dobkin, and D. Wheye. 1988. *The birder's handbook: a field guide to the natural history of North American birds, including all species that regularly breed north of Mexico.* Simon and Schuster, New York. 785 pages.

Chapman, J. A., and G. A. Feldhamer (editors). 1982. *Wild mammals of North America.* Johns Hopkins University Press, Baltimore, Maryland. 1,147 pages.

Sibley, D. A. 1991. *The Sibley guide to bird life and behavior.* Alfred A. Knopf, New York, New York. 580 pages.

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CHAPTER 9:
WILDLIFE CONTROL STRATEGIES AND TECHNIQUES AT AIRPORTS



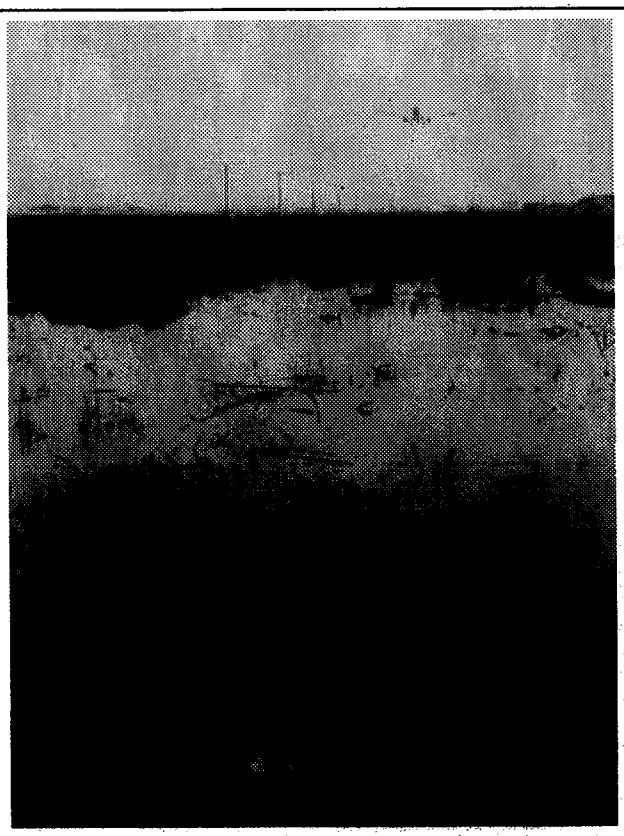
A B-767 departing an east coast USA airport in October 2002 ingested at least one double-crested cormorant into the #2 engine. Parts of the engine broke loose and penetrated the engine casing, resulting in an uncontained engine failure. The strike also damaged the landing light and leading edge of the right wing. The cormorant population increased at an annual rate of 7% in the USA from 1980–2004.

9.1 INTRODUCTION

No airport or aircraft type is immune from the hazards of wildlife strikes. Many species of birds and mammals have been involved in damaging strikes (Chapter 2). A flock of starlings suddenly rising from the ground, a lone kestrel hovering in search of prey, a pair of Canada geese taking flight after grazing in the infield, or a deer bounding across a runway—all can result in significant aircraft damage or in extreme cases, a crash and loss of human lives. In addition to strikes, wildlife that are roosting, nesting, or burrowing on airports can cause structural damage to buildings, equipment, and aircraft as well as nuisance and health problems for workers and passengers.

As discussed in Chapters 5 and 6 about the conduct of Wildlife Hazard Assessments and development of Wildlife Hazard Management Plans, the first step in solving any wildlife damage problem is to answer the following nine questions for each species:

1. What are the wildlife doing that make the control of their numbers or damage necessary? The type of activity that needs to be controlled will determine both the severity of the problem and the type of control methods used.



There should be zero tolerance for nesting by Canada geese and other large birds at airports. Permits should be in place so any nests discovered can be destroyed immediately and adult nesting birds dispersed or removed (photo by R. White, USDA).

2. Which species of wildlife are causing the problem? Accurate identification of the exact species is critical because different species often require different management techniques.
3. Why are the wildlife on the airport? Are they attracted to the airport for food, water, or shelter; or are they just flying over the airport from nighttime roosting sites to daytime feeding sites? The answer to this question will determine, to a large extent, the most appropriate control methods to use.
4. What are the daily and seasonal movement patterns of the wildlife among feeding, loafing, and roosting/nesting areas? Try to identify the times of day and seasons of year, as well as locations on airport, where the wildlife pose the most critical threat to aviation safety and where they are most vulnerable to management actions.
5. What is the legal status at the federal, state, and local levels of the problem species? All wildlife species are not afforded equal legal protection by all levels of government.
6. What effective and legal management methods are available? In wildlife hazard management, effective and legal are not necessarily synonymous.
7. How selective are these control methods? The objective is to control only the target wildlife, not every species in the area.
8. How much will it cost to apply the selected control methods? The cost of control might dictate which methods are practical, given the seriousness of the threat caused by the species.

9. What are public attitudes toward the problem wildlife species and the hazards that these species pose? Public opinion also may influence the type of management actions taken.



Elimination of wildlife habitat and attractants on or near airports will reduce wildlife strikes. Exposed I beams, such as used in the canopy over the passenger pick-up area at a Midwestern USA airport, make ideal roosting habitat for flocks of European starlings (photo by R. White, USDA).

This chapter presents the overall approach to be taken when managing wildlife hazards on airports. Once the overall approach is established, the chapter outlines the strengths and weaknesses of various wildlife control methods recommended for use on airports, as well as certain methods that should not be used. This chapter is not the final word on this subject. Wildlife damage control is a dynamic field, and new products, technologies, and innovations are continuously being introduced. In addition, changes in the legal status of control techniques, chemical registrations, and wildlife species occur at the federal and state level. Thus, this chapter is only a starting point for information on wildlife control techniques.

It is recommended that this chapter be used in conjunction with the two-volume manual *Prevention and Control of Wildlife Damage* published in 1994 by Cooperative Extension, University of Nebraska at Lincoln (see full citation at end of this chapter). This manual, written by various experts in the field of wildlife damage control, provides detailed information on the techniques, equipment, chemical registrations, species-specific management recommendations, and sources of supply for the various control strategies presented in this chapter. This manual is also available online in a periodically updated version at: ianrwww.unl.edu/wildlife/solutions/handbook/.

9.2 WILDLIFE CONTROL STRATEGIES

Four basic control strategies are available to solve wildlife problems on airports:

1. Aircraft flight schedule modification;
2. Habitat modification and exclusion;
3. Repellent and harassment techniques; and
4. Wildlife removal.

Integrate all four control strategies into the Wildlife Hazard Management Plan as appropriate.

9.2.A AIRCRAFT FLIGHT SCHEDULE MODIFICATION

Although not generally practical for regularly scheduled commercial traffic on larger airports, there may be various situations when flight schedules of some aircraft can be adjusted to minimize the chance of a strike with a wildlife species that has a predictable pattern of movement. For example, pilots could be advised not to depart during a 20-minute period at sunrise or sunset during winter when large flocks of blackbirds cross an airport going to and from an off-airport roosting site. In situations such as at Midway Atoll where albatrosses and other seabirds are abundant during parts of the year, scheduling nighttime arrivals and departures, when birds are not flying, might be the only means of avoiding strikes. Finally, air traffic controllers on occasion might need to temporarily close a runway with unusually high bird activity or a large mammal (e.g., deer) incursion until wildlife control personnel can disperse the animals.



Poles and other structures that are no longer in use should be removed from airport property. Such structures make ideal perching sites for hawks and owls searching for prey. The pellets at the base of this pole are undigested fur and bones of rodents that were regurgitated by red-tailed hawks (photo by R. A. Dolbeer, USDA).

9.2.B HABITAT MODIFICATION AND EXCLUSION

Habitat modification means changing the environment to make it less attractive or inaccessible to the problem wildlife. All wildlife require food, cover, and water to survive. Any action that reduces, eliminates, or excludes one or more of these elements will result in a proportional reduction in the wildlife population at the airport. Habitat modifications to make the airport and surrounding area as unattractive as possible to hazardous wildlife must be the foundation of every airport's Wildlife Hazard Management Plan.

Initially, management actions to reduce food, cover, and water on an airport might be expensive. However, when costs are amortized over several years, these actions might be the least expensive approach to reducing wildlife populations on the airport. Once a habitat modification is done correctly, it is generally not necessary to go back and do it again. Also, these control methods are generally well accepted by the public and minimize the need to harass or kill wildlife on the airport.

9.2.B.I FOOD

Some of the more common urban food sources for birds on and near airports include handouts from people in taxi stands and parks, grain elevators, feed mills, sewer treatment plants, and improperly stored food waste around grocery stores, restaurants, and catering services. Rural food sources attractive to birds include sanitary landfills, feedlots, certain agricultural crops (especially cereal grains and sunflower), and spilled grain along road and rail rights-of-way.

Be aware of food attractants for birds that exist on and in proximity to the airport. On the airport, require bird-proof storage of food waste, prohibit bird feeding, and promote good sanitation and litter control programs.



Gulls and other birds concentrate at locations where people regularly provide food such as bread and seeds. Feeding birds should be prohibited on and in the vicinity of airports (photo by R. White, USDA).

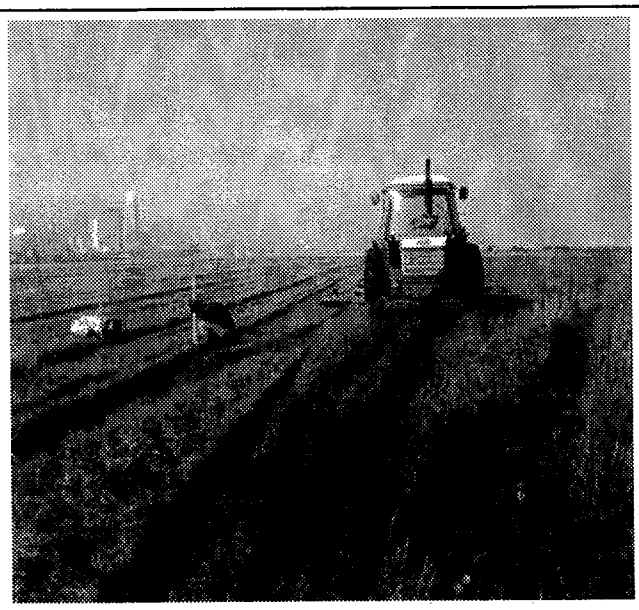
Because most, if not all, agricultural crops can attract hazardous wildlife during some phase of production, the FAA recommends against the use of airport property for agricultural production, including hay crops, within the separations identified in Chapter 5, § 5.2. If the airport has no financial alternative to agricultural crops to produce income necessary to maintain the viability of the airport, then the airport must follow the crop distance guidelines listed in the table titled "Minimum Distances between Certain Airport Features and Any On-Airport Agricultural Crops" found in AC 150/5300-13, *Airport Design*, Appendix 19 (see Appendix C). Weigh the cost of wildlife control and potential accidents against the income produced by the on-airport crops when deciding whether to allow crops on the airport (AC 150/5200-33A) (see Chapter 5 and Appendix C). For nearby off-airport areas, work closely with local governmental entities and landowners to discourage land-use practices and activities that provide food sources for problem bird species.

Do not use trees and other landscaping plants for the street side of airports that produce fruits or seeds attractive to birds. On airside areas, the large expanses of grass and forbs can sometimes provide ideal habitat for rodent and insect populations that attract raptors, gulls, other bird species, and mammalian predators such as coyotes. In addition, grasses allowed to produce seed heads can provide a desirable food source for doves, blackbirds, and other flocking species. The management of airside vegetation to minimize rodents, insects, and seeds might be complex, requiring insecticide, herbicide, and rodenticide applications; changes in vegetation cover; and adjustments in mowing schedules (e.g., mowing at night to minimize bird feeding on insects exposed by the mowing). Such management plans will need to be developed in conjunction with professional wildlife biologists and horticulturists knowledgeable with the local wildlife populations, vegetation, and growing conditions (see below).

9.2.B.II COVER

All wildlife require cover for resting, roosting, escape, and reproduction. Non-migratory Canada geese in urban areas, left undisturbed, will establish territories on corporate lawns, golf courses, and even building roofs associated with nearby ponds. Pigeons, house sparrows, and European starlings use building ledges, abandoned buildings, open girders and bridge work, and dense vegetation for cover. Blackbirds use marsh

vegetation, such as cattails, for nesting and roosting. Many bird problems can be solved by eliminating availability of such areas either through removal or by exclusion.



The maintenance of monotypic, uniform stands of tall (e.g., 10-inch) grass is difficult and expensive at most airports, requiring fertilizer, herbicides, and water (photo by R. A. Dolbeer, USDA).

Take care when selecting and spacing plants for airport landscaping. Avoid plants that produce fruits and seeds desired by birds. Also avoid the creation of areas of dense cover for roosting, especially by European starlings and blackbirds. Thinning the canopy of trees, or selectively removing trees to increase their spacing, can help eliminate bird roosts that form in trees on airports.

The management of an airport's airside ground cover to minimize bird activity is a controversial subject in North America. The general recommendation, based on studies in England in the 1960s and 1970s, has been to maintain a monoculture of grass at a height of 6-10 inches (Transport Canada) or 7-14 inches (U.S. Air Force). Tall grass, by interfering with visibility and ground movements, is thought to discourage many species of birds from loafing and feeding. However, the limited studies conducted in North America have not provided a consensus of opinion on the utility of tall-grass management for airports. For example, Canada geese do not appear to be discouraged by tall grass. In addition, maintenance of tall grass can result in increased rodent populations, a food source for raptors. Finally, maintenance of monotypic, uniform stands of tall grass is difficult and expensive on many airports because of varying soil conditions and the need for fertilizer and herbicide applications. Arid regions in the western USA cannot maintain tall grass without irrigation.

A promising approach to reducing wildlife attraction to airport ground cover, irrespective of the height, is the use of vegetation that is undesirable or mildly toxic to wildlife. For example, there are varieties of fescue grass that contain fungal endophytes. Some of these endophytes are unpalatable to grazing birds, such as geese, as well as to rodents and deer. These endophytic grasses might also support fewer insect numbers. Other ground cover, such as wedelia or Bermuda grass, might be appropriate for subtropical airfields. Finally, artificial (synthetic) turf in selected areas might be useful in providing a more sterile environment for wildlife at airports.

Until more research is completed, no general guidelines on grass height or vegetation type for airside ground cover will be made. See Appendix O, Summary of Studies on Vegetation Management for North American Airfields, for a literature review of the current state of knowledge on airport grass management. Consult with professional

wildlife hazard management biologists and horticulturists to develop a vegetation type and mowing schedule appropriate for the growing conditions and wildlife at the location. The main principles to follow are to use a vegetation cover and mowing regime that do not result in a build-up of rodent numbers or the production of seeds, forage, or insects desired by birds.

Finally, dense stands of trees and undergrowth on airport property can provide excellent cover for deer, coyotes, nesting geese and raptors, roosting blackbirds, rodents, and other wildlife. In general, clear or at least sufficiently thin these habitats to eliminate the desired cover and to allow easy visual and physical access by wildlife control personnel. Remove all unnecessary posts, fences, and other structures that can be used as perches by raptors and other birds. Piles of construction debris and discarded equipment, unmowed fence rows, and other unmanaged areas are not only esthetically unpleasing but typically provide excellent cover for commensal rodents (rats and house mice) and den sites for woodchucks, feral dogs and coyotes. Eliminate such areas on airports.



Standing water is a strong attractant to waterfowl, gulls, and wading birds such as egrets and herons. Airport managers should strive to eliminate all standing water (photo by R. A. Dolbeer, USDA).

9.2.B.III WATER

Water acts as a magnet for birds; therefore, eliminate all standing water on an airport to the greatest extent possible. Fill or modify to allow rapid drainage of depressions in paved and vegetated areas, and disturbed areas at construction sites that accumulate standing water after rain. This is particularly important at coastal airports where fresh water is highly attractive to birds for drinking and bathing. Do not establish retention ponds, open drainage ditches, outdoor fountains and other wetland sites on or adjacent to airports.

Where possible, modify storm water detention ponds to allow a maximum 48-hour detention period for the design storm. Avoid or remove retention ponds and detention ponds featuring dead storage to eliminate standing water. Design detention basins to remain totally dry between rainfalls. Where constant flow of water is anticipated through the basin, or where any portion of the basin bottom might remain wet, design the detention facility to include a concrete or paved pad and/or ditch/swale in the bottom to prevent vegetation that might provide nesting habitat.

When it is not possible to drain a large detention pond completely, use physical barriers, such as bird balls, wires grids, pillows, or netting, to deter birds and other hazardous wildlife. Evaluate the use of physical barriers and ensure they will not adversely affect water rescue. Before installing any physical barriers over detention ponds on Part 139

certificated airports, obtain approval from the appropriate FAA Regional Airports Division Office.

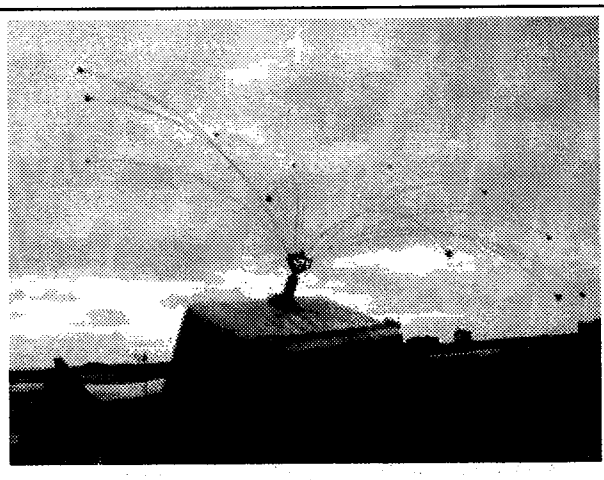


Birds are permanently excluded from this storm water detention facility through the use of a floating permeable barrier (Photo courtesy Industrial & Environmental Concepts, Inc.).

Encourage off-airport storm water treatment facility operators to incorporate appropriate wildlife hazard mitigation techniques into their operating practices when the facility is located within the separation criteria specified in AC 150/15200-33A (see 5-2 above and Appendix C).

9.2.B.IV EXCLUSION TECHNIQUES

If food, water, or cover cannot be eliminated by habitat modification, then actions can sometimes be taken to exclude the wildlife from the desired resource. Exclusion involves the use of physical barriers to deny wildlife access to a particular area. As with habitat modification, exclusion techniques, such as installing a covered drainage ditch instead of an open ditch, can initially be costly. However, exclusion provides a permanent solution that is not only environmentally friendly, but when amortized over many years, might actually be the least expensive solution.



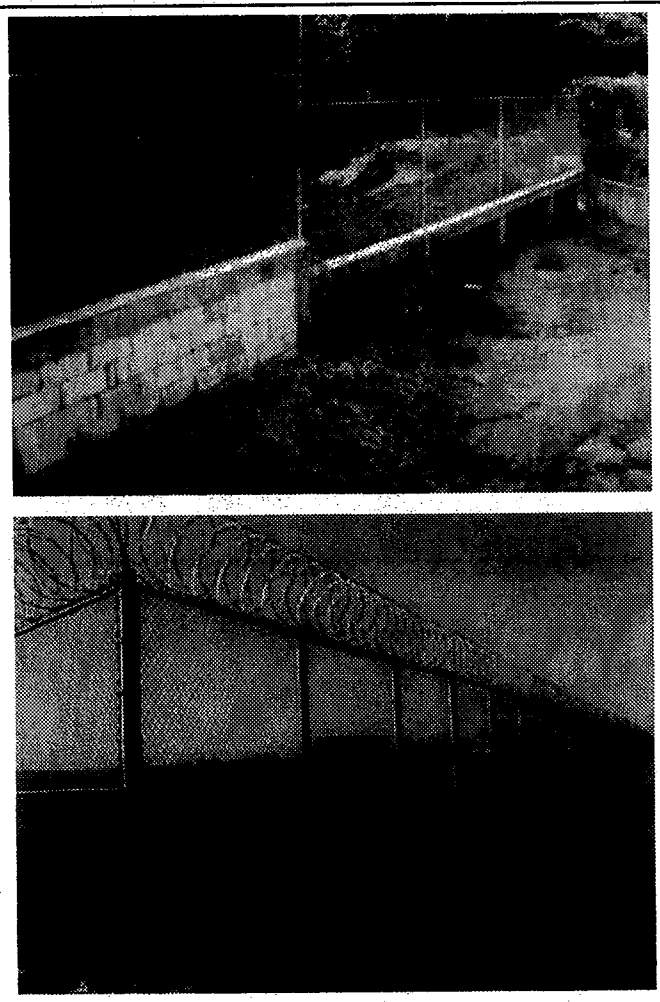
Light posts and other structures in taxicab lots at airports can be fitted with anti-perching devices to discourage gulls and other birds from using the area. Feeding of birds should also be prohibited on airport property.

9.2.B.IV.A EXCLUSION OF BIRDS

Architects should consult biologists during the design phase of buildings, hangers, bridges, and other structures at airports to minimize exposed areas that birds can use for perching and nesting. For example, tubular steel beams are much less attractive as perching sites for starlings and pigeons than are I-beams. If desirable perching sites are present in older structures, access to these sites (such as rafter and girded areas in hangers, warehouses, and under bridges) often can be eliminated with netting. Curtains made of heavy-duty plastic sheeting, cut into 12-inch strips, and hung in warehouse or hanger doorways, can discourage birds from entering these openings. Anti-perching devices, such as spikes, can be installed on ledges, roof peaks, rafters, signs, posts, and other roosting and perching areas to keep certain birds from using them. Changing the angle of building ledges to 45 degrees or

more will deter birds. However, it is emphasized that incorporating bird exclusion or deterrence into the design of structures is the most effective, long-term solution.

Gull and waterfowl use of retention ponds and drainage ditches can be reduced with over-head wire systems. A system of wires spaced 10 feet apart or in a 10- x 10-foot grid will discourage most gulls and waterfowl from landing. Similar wire systems have been successfully used to keep gulls off roofs and out of landfills and crows out of electrical substations. When it is desirable to eliminate all bird use, netting can be installed over small ponds and similar areas. However, birds are sometimes tangled in the netting and maintenance problems arise with high winds and freezing weather. Complete coverage of ponds with plastic, 3-inch diameter "bird balls" or floating mats will completely exclude birds and yet allow evaporation of water. Designing ponds with steep slopes will discourage wading birds such as herons. Use of culverts to totally cover water in drainage ditches is recommended whenever possible.



A well-maintained fence, at least 10-feet high with no gaps at the bottom, is the primary defense to keep deer and other large animals off of the AOA at airports. Gates must also be close-fitting, and water drains under the fence must be equipped with exclusion devices (top photo by E. Cleary, FAA).

9.2.B.IV.B EXCLUSION OF MAMMALS

Institute a "zero tolerance" policy for deer, livestock, and other large mammals in the AOA because of their severe threat to aviation safety (see Table 8-1). The best, albeit most costly, procedure for excluding these animals off the AOA is proper fencing. The FAA recommends a 10-12 foot chain link fence with 3-strand barbed wire outriggers. In some cases, an airport might be able to use an 8-foot chain link fence with 3-strand barbed outriggers, depending on the amount of deer activity in the area (see Certalert No. 04-16, Appendix E). A 4-foot skirt of chain-link fence material, attached to the bottom of the fence and buried at a 45° angle on the outside of the fence will prevent animals from digging under the fence and reduce the chance of washouts. This type of fencing also greatly increases airport security. There are also numerous electric-fence designs for excluding deer, discussed in Hygnstrom et al. (1994), that are not as costly as permanent fencing but have drawbacks in safety

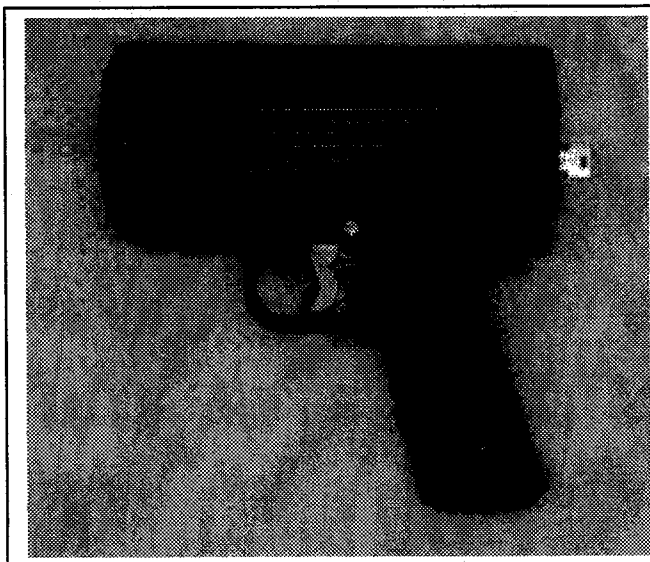
and maintenance.

Properly install and maintain all fencing. Keep the fence line right-of-way free of excess vegetation. Patrol the fence line at least daily, and fix any washouts, breaks, or other holes in the fence as soon as they are discovered. Take immediate action to remove any deer or other large mammals observed on or near the AOA.

Cattle Guards are widely used to prevent hoofed livestock from traversing across fenced areas through permanent openings maintained for vehicular access. These devices, if at least 15 feet in length perpendicular to the fence, will prevent deer from entering through gated areas on airports.

9.2.c REPELLENT TECHNIQUES

Repellent and harassment techniques are designed to make the area or resource desired by wildlife unattractive or to make the wildlife uncomfortable or fearful. Long term, the cost-effectiveness of repelling wildlife usually does not compare favorably with habitat modification or exclusion techniques. No matter how many times wildlife are driven from an area that attracts them, they or other individuals of their species will return as long as the attractant is accessible. However, habitat modifications and exclusion techniques will never completely rid an airport of problem wildlife; therefore, repellent techniques are a key component of any wildlife hazard management plan.



Under low-light conditions, specially designed lasers can be effective in dispersing geese, cormorants, and other bird species.

Repellents work by affecting the animal's senses through chemical, auditory, or visual means. Habituation or acclimation of birds and mammals to most repellent devices or techniques is a major problem. When used repeatedly without added reinforcement, wildlife soon learn that the repellent devices or techniques are harmless. The devices become a part of their "background noise", and they ignore them.

Critical factors to be recognized in deploying repellents are—

1. There are no "silver bullets" that will solve all problems;
2. Likewise, there is no standard protocol or set of procedures that is best for all situations. Repelling wildlife is an art as much as a science. The most important factor is having motivated, trained, appropriately equipped personnel who understand the wildlife situation on their airport;
3. Each wildlife species is unique and will often respond differently to various repellent techniques. Even within a group of closely related species, such as gulls, the

various species will often respond differently to various repellent techniques; and

4. Habituation to repellent techniques can be minimized by—
   a) using each technique sparingly and appropriately when the target wildlife is present,
   b) using a variety of repellent techniques in an integrated fashion, and
   c) reinforcing repellents with occasional lethal control (with necessary permits in place) directed at abundant problem species such as gulls or geese.

Advances in electronics, remote sensing capabilities, and computers are resulting in the development of "intelligent" systems that can automatically deploy repellent devices (e.g., noisemakers, chemical sprays) when targeted wildlife enter a designated area. These devices might help reduce habituation and increase effectiveness of repellents in some situations. However, these devices will never replace the need for trained people on the ground to respond appropriately to incursions by a variety of highly adaptable, sentient wildlife species.

9.2.C.I WILDLIFE PATROLS AND RUNWAY SWEEPS IN VEHICLES

Regular patrols of airside areas to disperse birds and other hazardous wildlife are a critical component of an integrated program of wildlife hazard management on airports. Often, driving a vehicle toward the wildlife will be enough to cause the wildlife to disperse, especially if the driver has been deploying repellent and removal techniques and strategies as outlined below. Regular patrols and sweeps also permit wildlife control personnel to learn the daily movement patterns, habitat preferences, and behavior of wildlife on the airport. This information can be useful in determining wildlife attractants on the airport that need to be removed (e.g., low areas that gather standing water after rains) and in anticipating problem situations. All wildlife carcasses found during runway sweeps should be removed, identified to species, and documented on a wildlife strike log for carcass remains (Table 7-2).



Chemical repellents, such as methyl anthranilate, can be applied to temporary pools of standing water on airports to repel birds until the water evaporates. The preferred long-term solution is to improve drainage to avoid standing water after significant rain events (photo courtesy USDA).

9.2.C.II CHEMICAL REPELLENTS FOR BIRDS

Chemical repellents, toxicants, and capturing agents must be registered with the U.S. Environmental Protection Agency (USEPA) or Food and Drug Administration (FDA) before they can be used to manage wildlife on airports. Products must also be registered in each state. Hygnstrom et al. (1994) provides a listing of chemical products, by active ingredient and by company

name, registered for birds and mammals. The following chemical repellents, listed by active ingredient, are presently available for use on airports.

Perching structures (polybutenes). Several commercial products are available in liquid or paste form. These sticky formulations make birds uncomfortable when they alight on them, encouraging the birds to look elsewhere to perch or roost. To be effective, all perching surfaces in a problem area must be treated, or the birds will move a short distance to an untreated surface. Under normal conditions, the effective life of these materials is 6 months to 1 year. Dusty environments can substantially reduce the life expectancy. Once the material loses effectiveness, it is necessary to remove the old material and apply a fresh coat. Applying the material over duct tape, rather than directly to the building ledge or rafter surface, will facilitate clean up.

Turf feeding (methyl anthranilate, anthraquinone). There are two chemicals presently (2005) registered as bird repellents for turf (grass). One repellent is an anthraquinone formulation for repelling geese from turf. Anthraquinone apparently acts as a conditioned-aversion repellent with birds. Birds ingesting food treated with anthraquinone become slightly ill and develop a post-ingestion aversion to the treated food source. Birds visually identify anthraquinone in the UV light spectrum and become conditioned to avoid the treated food source. Because of its conditioned-aversion properties, anthraquinone use does not require treatment of the entire airfield, but only areas where birds are grazing and/or higher risk areas such as runway approaches.

The other repellent is methyl anthranilate, an artificial grape flavoring commonly used in foods and beverages. Birds have a taste aversion to methyl anthranilate, apparently reacting to it in much the same way that mammals react to concentrated ammonia (smelling salts). Methyl anthranilate is registered under formulations as a feeding repellent for geese and other birds on turf.



A recent study showed that predator urines (coyote, bobcat) had no influence on deer movements along established trails or at feeding sites (photo by T. Seamans, USDA).

Both anthraquinone and methyl anthranilate products are liquid formulations applied by sprayer to the vegetation. Effectiveness of these sprays in repelling geese can be variable, depending on growing conditions, rainfall, mowing, and availability of alternate feeding areas. In general, repellency based on conditioned aversion is longer lasting than repellency based on taste.

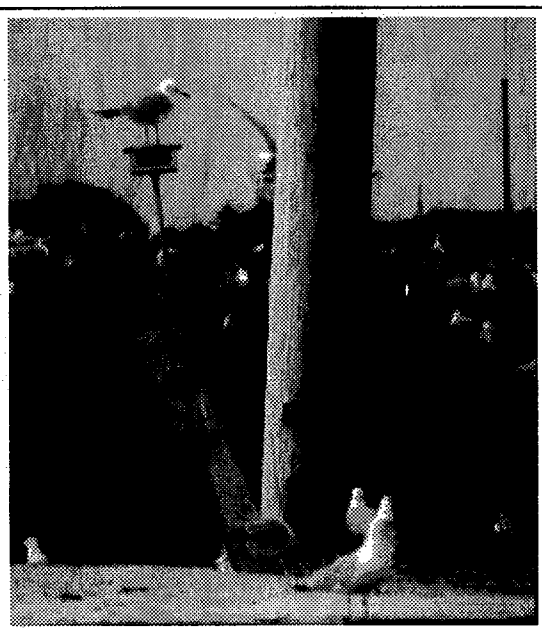
Water (methyl anthanilate). Methyl anthranilate formulations are also available for application to pools of standing water on airports and at other locations to repel birds from drinking and bathing. This application is probably best for temporary pools of water after rainfall, where repellency of only a few days is needed.

General area (fogging with methyl anthanilate). A methyl anthranilate formulation is

also available for use in fogging machines (thermal or mechanical) to disperse birds from hangers, lawns, and other areas.

Frightening agent (Avitrol [4-Aminopyridine]). Avitrol is registered for repelling pigeons, house sparrows, black-birds, grackles, cowbirds, starlings, crows, and gulls from feeding, nesting, loafing, and roosting sites. Birds eating Avitrol-treated baits react with distress symptoms and calls, behaviors that frighten away other birds in the flock. Avitrol, although registered as a "frightening agent", is lethal to the birds that eat treated baits. Therefore, recognize that Avitrol is a toxic to the birds that consume treated bait. Avitrol-treated bait is diluted with untreated bait so most birds in the flock do not ingest treated bait. The primary use of Avitrol at airports has been in pigeon control around buildings. The use of Avitrol requires knowledge of the feeding patterns of the birds, proper prebaiting procedures to ensure bait acceptance and avoidance of non-target species, and removal of dead birds after treatment.

9.2.C.III CHEMICAL REPELLENTS FOR MAMMALS



In most cases, birds rapidly adapt to and then ignore recorded distress calls and other noises produced by electronic auditory devices. Such devices, as shown on the pole in the photo, can be useful only if used sparingly as part of an integrated program of bird dispersal (photo by R. A. Dolbeer, USDA).

There are a number of taste and odor repellents marketed to repel deer, rabbits, and other mammals from browsing on vegetation (Hygnstrom et al. 1994). These include products that are applied directly to the vegetation and general area (odor) repellents (e.g., predator urine). Some of these products might be appropriate for short-term protection of valuable landscaping plants and fruit trees. However, their use on airports to repel or discourage deer or other mammals is not recommended because they are unlikely to have any influence on wildlife movements in the airport operating area.

9.2.C.IV AUDIO REPELLENTS FOR BIRDS

Propane cannons. Propane cannons (exploders) generate a shotgun-sounding blast. In general, birds quickly habituate to cannons that detonate at systematic or random intervals throughout the day. Thus, to ensure they remain effective, use cannons sparingly and only when birds are in the area. Reinforcement by occasional killing a few birds (of common species such as gulls and Canada geese under an appropriate permit) with a shotgun might also enhance effectiveness. Systems designed so cannons placed around an airport can be detonated remotely on demand by radio signal when birds are in the area are a useful means of reducing habituation.

Distress-call and electronic noise-generating systems. Recorded distress calls are available for common birds on airports, such as gulls, crows, and starlings. Such calls,

broadcast from speakers mounted on a vehicle, will often initially draw the birds toward the sound source to investigate the threat. The birds then can be dispersed by pyrotechnics or by using a shotgun to shoot an occasional bird. As with propane cannons, distress calls routinely broadcast from stationary speakers, with no associated follow-up stimuli that provide additional fear or stress, have little utility. Birds also habituate rapidly to other electronic sound systems that generate a variety of synthetic sounds from stationary speakers.

Shell crackers and other pyrotechnics. There are a variety of projectiles that can be fired from breech-loaded shotguns or from specialized launchers to provide an auditory blast or scream, as well as smoke and flashing light, to frighten birds. Some of the newer cartridges have ranges of up to 300 yards. These pyrotechnics, when used skillfully in combination with other harassment techniques and limited lethal control (shooting via shotgun), can be very useful in driving birds off of an airport. An advantage of these pyrotechnic devices is that they require a person to fire the projectile, thus ensuring that they are deployed directly at the target birds and that the birds associate the pyrotechnic with a threat (person).



Taxidermy mounts of coyotes deployed to move in the wind might be useful as part of an integrated program to disperse Canada geese and other birds from airports. Such effigies must be used sparingly and moved to various locations to prevent habituation. Permanently mounted effigies have little deterrent effect (photo by R. A. Dolbeer, USDA).

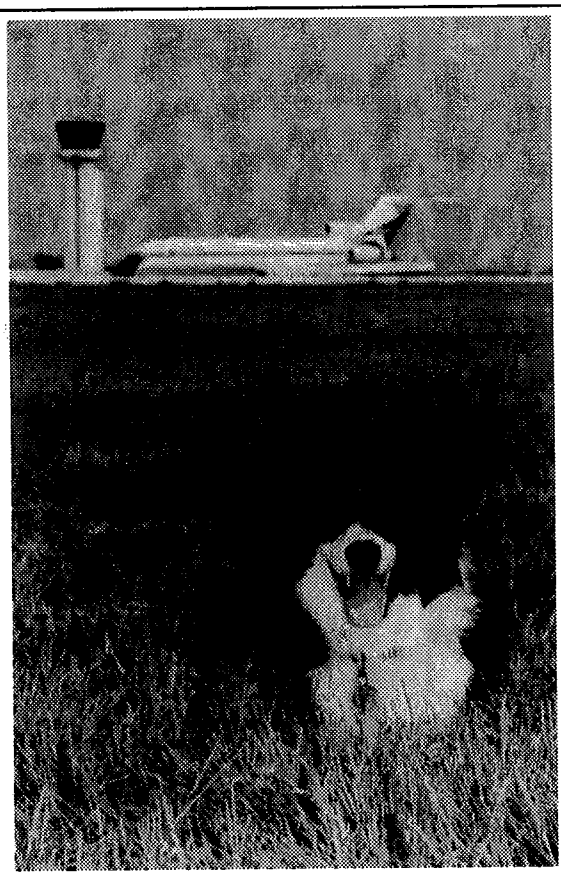
Ultrasonic devices. Ultrasonic (i.e., above the sound range detected by humans) devices have not proven to be effective bird repellents. In fact, most birds do not detect frequencies as high as humans can detect, much less frequencies above the level of human detection. During tests conducted by the U.S. Department of Agriculture's National Wildlife Research Center, pigeons showed no response when exposed within 10 feet to a fully functional, high-frequency sound generating device. Do not deploy these devices in hangers or other airport settings to deter birds.

9.2.C.V AUDIO REPELLENTS FOR MAMMALS

Probably the most commonly used audio scaring device for deer is the propane cannon. However, deer rapidly habituate to propane cannons. Their use on airports to repel deer and other mammals from runways is not recommended except for short-term (i.e., several days), emergency situations until a more permanent solution (fencing or deer removal) can be achieved. Other electronic noise-generating devices also have proven ineffective in repelling deer or other mammals for more than a few days. Pyrotechnics also provide only short-term repellency for mammals.

9.2.C.VI VISUAL REPELLENTS FOR BIRDS

Most visual repellents are simply a variation on an ancient theme—the scarecrow. In general, visual repellents, such as hawk effigies or silhouettes, eye-spot balloons, flags, and Mylar reflecting tapes, have shown only short-term effectiveness and are inappropriate for use as a long-term solution to bird problems on airports. Most short-term success achieved with these devices is likely attributable to "new object reaction" rather than to any actual frightening effect produced by them. For example, in a test in Ohio, a flag with a large eye-spot was exposed to pigeons in an abandoned building. As soon as the flag was put up, the pigeons left the building, giving the impression that the eye-spot was highly repellent to the birds. However, within 24 hours, the pigeons returned. From then on, the pigeons behaved in a completely normal fashion and showed no interest in, or reaction to, the flag.



The successful use of border collies to repel birds requires a high degree of dedication and commitment by the handlers. Jet was among the first border collies to successfully work at an airport to control birds.

One visual deterrent that has been successfully used in recent years is the display of dead birds in a "death pose." Several experiments and field demonstrations have shown that a dead turkey vulture (freeze-dried taxidermy mount with wings spread), hung by its feet in a vulture roosting or perching area, will cause vultures to abandon the site. Initial trials using dead gulls and ravens suspended from poles have also shown promising results in dispersing these species from feeding and resting sites. The dead bird must be hung in a "death pose" to be effective. Dead birds lying supine on the ground or in the roost are generally ignored or might even attract other birds. Permits must be in place before federally protected migratory birds can be obtained and used as "dead-bird deterrents." Research is under way to determine if artificial "dead-bird effigies" can be developed that will be just as effective as the taxidermy mounts.

Another new concept in visual repellency that has shown utility in recent years is the use of hand-held laser devices that project a 1-inch diameter red beam to disperse birds. These devises have been used successfully to disperse birds such as Canada geese, double-crested cormorants, and crows from nighttime roosting areas in reservoirs and trees. Advantages are effectiveness at long range (over ¼ mile) and lack of noise. Lasers have also shown some effectiveness in dispersing birds from hangers. Effectiveness is diminished or nonexistent in daylight

conditions. As with the use of firearms, the use of lasers in an airport environment obviously requires caution.

9.2.C.VII VISUAL REPELLENTS FOR MAMMALS

For the most part, visual repellents such as flags and effigies have proven ineffective for repelling mammals. Their use is not recommended for keeping deer or other mammals off airports. Red lasers (see above) were ineffective in dispersing deer.

9.2.C.VIII TRAINED FALCONS AND DOGS TO REPEL BIRDS



Radio-controlled aircraft, such as this Robo-Falcon™, can be useful as part of an integrated program in dispersing birds from airports and landfills. Considerable training is required to operate these devices in the airport environment (photo by R. A. Dolbeer, USDA).

Trained falcons and other birds of prey have been used intermittently on various airports in Europe and North America to disperse birds since the late 1940s. The advantage of falconry is that the birds on the airport are exposed to a natural predator for which they have an innate fear. The disadvantage is that a falconry program is often expensive, requiring a number of birds that must be maintained and cared for by a crew of trained, highly motivated personnel. Furthermore, the effectiveness of falconry programs in actually reducing strikes has been difficult to evaluate.

Blokpoel (1976) outlined the following summary of falconry for airports that is still a good overall assessment: (1) properly trained birds of prey of the right species for the job at hand, used regularly and persistently by skilled and conscientious personnel, are effective in clearing birds from airfields during daylight and good weather; (2) for good results, daily operations on a year-round basis are required in most cases, (3) several falcons are required to have at least one bird ready at all times, and (4) to obtain, train, operate, and care for falcons, a staff of at least two full-time, well-trained personnel is required.

The use of trained dogs, especially border collies, to chase geese and other birds from golf courses, airports, and other sites is a recent development. As with falcons, the advantage is exposure to a natural predator. Likewise, the disadvantage is that the dog must be under the control of a trained person at all times, and the dog must be cared for and exercised 365 days a year. A dog will have little influence on birds that are flying over the airport.

9.2.C.IX RADIO-CONTROLLED MODEL AIRCRAFT TO REPEL BIRDS

Radio-controlled (RC) model aircraft, which provide both visual and auditory stimuli, occasionally have been used to harass birds on airports. One advantage is that the RC aircraft is under the control of a person and can be directed precisely to herd the birds

away from the airport runway. A second advantage is that the RC aircraft can be deployed on an "as needed" basis with little maintenance needed between flights. Some RC aircraft have been designed to mimic the appearance of a falcon and even to remotely fire pyrotechnics. The disadvantage is that a trained person is required to operate the RC aircraft in an airport environment. Before using RC aircraft, ensure that the radio frequencies used are compatible with other radio uses in the airfield environment.

9.2.C.X NONLETHAL PROJECTILES TO REPEL BIRDS

Paint balls and rubber or plastic projectiles, fired from paint-ball guns and 12-gauge shotguns, respectively, can be used to reinforce other dispersal techniques employed to repel Canada geese, roosting vultures, and perhaps other species of birds. With paint balls, a high-quality paint-ball gun should be used to provide sufficient accuracy and velocity (typically fired from 20 to 100 feet from bird). There are several types of rubber or plastic projectiles (slugs, buck shot, pellets, beads) for use in a shotgun. The proper distance from the bird for firing varies by projectile and species of bird. Personnel using these techniques need to be trained in firearm use and in the use of the particular projectiles being deployed. The objective is to shoot from a sufficient distance so that the projectile induces temporary pain, but no injury, in the bird struck.



Birds of prey, such as this red-tailed hawk, are captured with bal-chatri traps at some USA airports and relocated 50-100 miles from the airport. Studies have shown that relocated juvenile hawks typically do not return to the airport. Adult territorial birds will often return (photo courtesy of L. Schafer, USDA).

9.2.D WILDLIFE REMOVAL TECHNIQUES

Habitat modification, exclusion, and repellent techniques are the first lines of action in any Wildlife Hazard Management Plan. However, these actions will not solve every problem; therefore, hazardous wildlife sometimes must be removed from an airport. Such removal can be accomplished by capturing and relocating or by killing the target animals. With few exceptions, a federal Migratory Bird Depredation Permit, and in many cases a state permit, is required before any migratory birds may be taken (captured or killed). A state permit is generally necessary before any state-protected birds or mammals may be taken. Any capturing or killing must be done humanely and only by people who are trained in wildlife species identification and the techniques to be deployed.

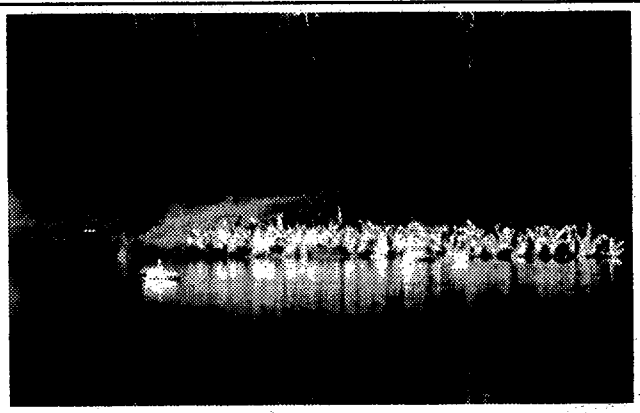
9.2.D.I CAPTURING BIRDS AND MAMMALS

The disposition of live-captured birds and mammals will depend on the legal, political, and social realities of each situation. State wildlife agencies are increasingly restrictive

about the relocation of captured wild animals, particularly for common species, because of disease concerns and the creation of additional wildlife problems at release sites. When practical, euthanize unprotected birds, such as pigeons, house sparrows, and European starlings, using procedures recommended by the American Association of Wildlife Veterinarians (AAWV). Dispose of common mammals, such as raccoons, woodchucks, and coyotes, captured on airports by following state regulations. Resident Canada geese captured during molt or by nets can be euthanized and donated to soup kitchens or food banks, provided the necessary federal and state permits are in place.

9.2.D.I.A CHEMICAL CAPTURE OF BIRDS

Alpha Chloralose (A-C) is registered with the FDA as an immobilizing agent for use in capturing waterfowl, coots, and pigeons. A-C can only be used by people certified to use A-C working under the authority of personnel with the U.S. Department of Agriculture Wildlife Services (USDA/WS). A-C, incorporated into bread baits, is ideal for selectively capturing ducks, geese, and coots that can be hand-fed at urban ponds and parks. Corn baits are recommended for pigeons or groups of waterfowl or coots that cannot be individually baited. Birds ingesting a clinical dose of A-C can be captured in 30- to 90-minutes. Complete recovery normally occurs within 8 hours but can take up to 24 hours.



Cannon or rocket nets are well suited for capturing up to 100 or more waterfowl, pigeons, or gulls in situations where other methods might not be practical. The net must be placed where it can be safely discharged, and the target birds must be trained to feed in front of it. Depending on the situation, prebaiting can take several days. Here, white pelicans are being captured for banding to study migration patterns (photo by T. King, USDA).

9.2.D.I.B LIVE-TRAPPING BIRDS

The major advantage of live trapping is selectivity: any non-target birds can be released unharmed. The major disadvantage is that live trapping is often labor intensive. Traps must be tended frequently to remove captured animals and, in the case of cage traps with decoy birds, to provide food and water. Hygnstrom et al. (1994) provides detailed descriptions of various trap designs.

Trapping is used on some airports to remove raptors (hawks and owls) in the aircraft operating area. Bal-chatri, noose carpets, Swedish goshawk, or sliding padded pole traps are typically used. Because raptors are desirable components of bird communities, most permits for trapping raptors require that the birds be banded and relocated into suitable habitat at least 50 miles from the airport.

Live trapping, using walk-in type traps on roofs or other isolated sites, can be used to remove pigeons at airports. Euthanize captured pigeons following AAWV guidelines. If relocated, pigeons can fly long distances to return to the site of capture.

Net launchers use a blank rifle cartridge to propel a net. Fired from the shoulder much

like a shotgun or rifle, net launchers can capture individual or small groups of problem birds that can be approached within about 50 feet.

9.2.D.I.C CHEMICAL CAPTURE OF MAMMALS

Large mammals, such as deer, can be captured with tranquilizer guns, but this is generally not a practical or desirable option for airports. Live capture and relocation of deer is not recommended or permitted in most states because deer populations are at or near carrying capacity. However, in those situations where the use of firearms is not safe or practical, the use of tranquilizer guns might be appropriate. The use of tranquilizer guns requires personnel with a high degree of skill and experience. If used in an airport environment, safeguards must be in place to ensure partially tranquilized deer do not enter runway areas.

9.2.D.I.D LIVE-TRAPPING MAMMALS

Specialized drop-door traps, drop nets, or rocket net set-ups can be used to live-capture deer, but live-capturing deer generally is not recommended for airport situations for reasons outlined above. However, smaller box-type or basket live-traps can be used to capture medium-sized mammals, such as raccoons, woodchucks, beavers, and feral dogs. Leg-hold traps and snares can be used to capture coyotes, feral dogs and raccoons.



Hunting during the regular deer season should be encouraged in areas adjacent to airports having deer problems to reduce the population in the general area. Archery hunting sometimes can be used in areas closed to firearms (photo by E. Cleary, FAA).

Successful mammal trapping, especially with leg-hold traps and snares, requires a high degree of skill and experience. Once set, traps must be checked frequently (at least once every 24 hours and more frequently in hot or cold weather). Trappers must be knowledgeable in procedures for handling and euthanizing mammals. State and local regulations might restrict the use of some types of traps.

9.2.D.II KILLING BIRDS AND MAMMALS

In general, killing of wildlife on an airport is the last option deployed after habitat modification, exclusion techniques, and repellent actions have been implemented. However, the management of a wildlife hazard situation on an airport might require killing a particular animal or require that a local population of a problem species be reduced by lethal means until a long-term, nonlethal solution is implemented (e.g., erection of deer-proof fence, relocation of nearby gull nesting colony). In addition, lethal control of a few individuals is sometimes necessary to reinforce nonlethal frightening techniques. Some lethal control is usually necessary as part of an integrated Wildlife Hazard Management Plan for an airport.

The following information must be developed to justify lethal control and to minimize

adverse public reaction to a program involving killing:

- Documentation that the wildlife species is an economic, safety, or health threat.
- Justification of why nonlethal options are not adequate to solve the problem.
- An assessment of the impact that the killing will have on local and regional populations of the species (i.e., is the level of killing planned likely to result in a significant reduction in numbers of the species at the local or regional level?).
- Assurance that the killing procedure is appropriate (i.e., safe, effective, and humane) and specific for the target wildlife species.
- Documentation of the effectiveness of the killing program in helping to solve the problem (e.g., reduction in bird strikes).
- Recommended steps to be taken, if any are feasible, to reduce the need for killing in the future.



Canada geese should not be allowed to nest on airports. Nests and eggs should be destroyed after appropriate permits are obtained (photo courtesy of J. Bucknall, USDA).

9.2.D.II.A DESTROYING EGGS AND NESTS

Do not allow Canada geese, mute swans, and gulls to nest on airport property. Provided the correct permits are in place, destroy (break eggs and remove nest material) any goose, mute swan, or gull nests with eggs found on an airport. Egg addling (oiling, shaking, or puncturing), whereby the birds continue to incubate nonviable eggs, is not recommended for airports. Egg addling encourages the nesting birds (and any nonbreeding birds associated with them) to stay on the airport. At the time of nest destruction, harass the adult birds from the airport. Check the nesting area weekly for renesting until the end of the nesting season (generally the end of June). As an alternative to harassment, it may be better to shoot nesting geese and mute swans (see below).

Destroy pigeons, starlings, and house sparrows nests whenever they are encountered in airport buildings and structures. Where practical, install physical barriers, as discussed above, to prevent renesting.

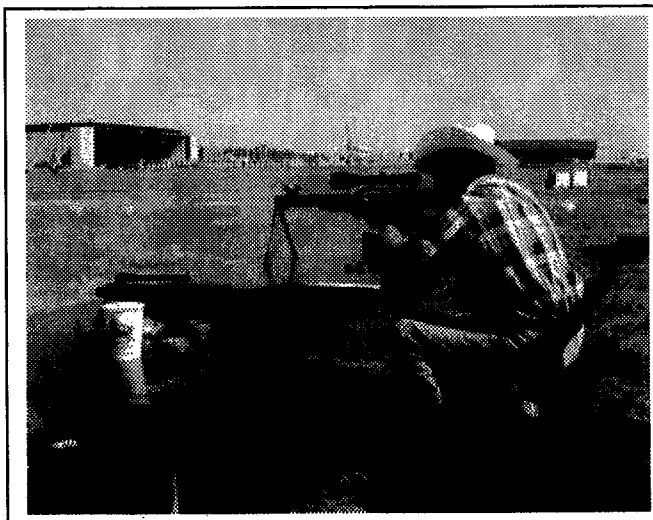
Nests of other birds hazardous to aviation generally also should be destroyed when encountered on airports. Remember that migratory bird nests are protected by federal law and may not be taken without a Depredation Permit. Each situation will have to be addressed on a case-by-case basis, depending on the species of bird and level of threat posed, location from runways, bird movement patterns, and other factors.

9.2.D.II.B SHOOTING BIRDS

Shooting birds in an airport environment generally falls into two main categories. First,

pigeons using hangers, bridge girders, and other sites can be shot at night with an air rifle. This nighttime shooting is done quietly and discretely, with the objective being to disturb the birds as little as possible so that the maximum number can be removed.

In the second category of shooting, common birds, such as gulls and geese, in the AOA that are not responding to various repellent methods can be shot with a 12-gauge shotgun. This shooting is done during daylight in the open so that other birds can witness the action. Shooting a shotgun has several effects on a flock of birds. First, it reinforces other audio or visual repelling techniques. Second, the loud noise, coupled with the death of one or more of the flock members, can frighten the rest of the flock away. Third, the target birds are permanently removed.



Compressed CO_2-powered pellet rifles, with laser pointers and telescopic sights, are an effective means of removing rock doves (pigeons) from hangers and other structures at airports. Personnel must be properly trained in the use of all pyrotechnic devices and firearms, and their use must be coordinated with airport security (photo by R. A. Dolbeer).

Four cardinal rules apply when using shooting as a control method at airports:

1. Use only personnel who are trained in the use of firearms and who have an excellent knowledge of wildlife identification.
2. Use the proper gun and ammunition for the situation.
3. Have necessary federal and state wildlife kill permits in place, and keep accurate records of birds killed by species and date.
4. Notify airport security, air traffic control, and, if appropriate, the local law enforcement authority before instituting a shooting program. Local ordinances against the discharge of firearms within certain distances of buildings, or within the city limits, may need to be waived.

9.2.D.II.C SHOOTING MAMMALS

Adopt a "zero tolerance" for deer on airports. If fencing is inadequate to keep deer off an airport or if deer have gotten inside the airport's fence, shooting is the best procedure for removing the deer. Because of inherent safety considerations and to ensure safe and efficient removal, shooting on airports must be by professional sharpshooters, using non-ricocheting bullets in rifles equipped with night-vision scopes and noise suppressers. Elevated shooting stands can be erected on the ground or on a truck bed to direct shots toward the ground. When practical, donate the meat from deer that are removed from airports to charity. Shooting of deer on airports must be coordinated through the state wildlife agency.

Encourage hunting during the regular deer season in areas adjacent to airports with deer problems to reduce the population in the general area. Archery hunting sometimes can be used in areas closed to firearms.

9.2.D.II.D ORAL TOXICANTS FOR BIRDS

Currently in the USA, only one oral toxicant, DRC-1339 or Starlicide (active ingredient 3-chloro-p-toluidine hydrochloride), is registered with the USEPA for use in bird population management. Starlicide (0.1% active ingredient) is formulated in a pellet bait for use at feedlots to control starlings and blackbirds. DRC-1339 (98% active ingredient) can be formulated with a variety of baits and used to control starlings, pigeons, gulls, ravens, and blackbirds under certain conditions, some of which might be applicable at airports. The control of pigeons around airport buildings and starlings roosting on or near an airport are the situations most likely applicable. Only USDA/WS personnel or persons working under their direct supervision can use DRC-1339.

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicators certification.

ZINC PHOSPHIDE ON WHEAT

FOR MOUSE CONTROL

For the control of meadow voles, prairie voles, pine voles, mountain voles, and white-footed mice in ornamentals, orchards, vineyards, rangelands, forests, lawns, golf courses, parks, nurseries, and highway medians.

ACTIVE INGREDIENT:	
Zinc Phosphide	1.82%
INACTIVE INGREDIENTS:	98.18%
TOTAL	100.00%

This is the center portion of a zinc phosphide rodenticide label showing the restricted use statement, target species, and ingredients list. Other parts of the label provide important information such as the manufacturer, EPA registration number, and the directions for use. Always read the entire label before using any pesticide.

The use of toxic baits to kill target birds without affecting non-target species requires considerable skill and patience. Daily movement patterns of the target birds among feeding, loafing, and roosting sites must be determined so attractive bait sites that are controlled from public access (such as a roof top) can be selected. The proper bait (a highly desired food) must be selected, and the birds then must be prebaited, often for a week or more, to ensure good bait acceptance and that non-target animals are not visiting the bait site. Proper prebaiting is the most critical step of a successful program. During the baiting period, all uneaten bait must be removed daily. With DRC-1339, birds typically die 1 to 3 days after bait ingestion; therefore, areas surrounding bait sites will need to be searched for several days after baiting to remove dead birds.

9.2.D.II.E CONTACT TOXICANTS FOR BIRDS

Hollow metal perches containing a wick treated with the toxicant fenthion previously were used to control pigeons, house sparrows, and starlings in and around buildings. The USEPA has phased out the use of fenthion-treated perches because of concerns for secondary poisoning of raptors and mammalian scavengers feeding on dying birds. No replacement chemical has been registered at this time (2005).

If toxic perches become available, their use outside of buildings is not recommended

because there is no way of preventing non-target birds from landing on them. Even when used inside buildings, careful placement of perches and monitoring must be done to ensure non-target birds such as swallows are not exposed to the toxicant. Pick up and properly dispose of all dead birds.



Anticoagulant rodenticides in covered bait stations are being used to control mice and voles in the AOA of this airport in Mexico. The bait stations are checked regularly and old, moldy bait is removed and properly disposed. This airport also uses falconry as part of its integrated program (photo by R. A, Dolbeer, USDA).

9.2.D.II.F TOXICANTS FOR MAMMALS

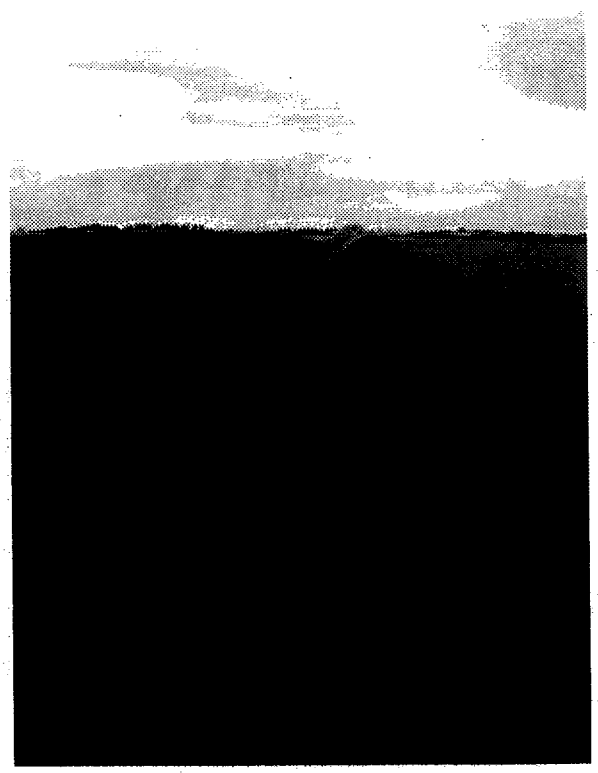
Small rodent populations (e.g., voles, house and deer mice, Norway rats) might erupt in grassy and brushy areas or around construction debris on airports, attracting raptors and creating a hazard to aviation. In general, control rodent populations by habitat management (mowing, sanitation, clean-up of brushy areas and piles of debris). However, there might be situations where the use of a rodenticide is appropriate to reduce rodent populations in airside vegetation. The control of commensal rodents in airport terminal buildings and other facilities will not be discussed here because these jobs are usually handled by private pest control operators.

There are two types of rodenticides that might be available for use in airside vegetation, anticoagulants and acute toxicants. Anticoagulants, of which there are several types registered, cause the rodent to die from internal bleeding. Some anticoagulants require multiple feedings to induce sufficient bleeding for death whereas others require only a single feeding. The only acute toxicant registered for above-ground treatment of field rodents is zinc phosphide, available in pellet and grain-bait formulations and as a concentrate for specialized bait formulations.

Depending on registration label instructions, rodenticide baits can be broadcast in the vegetation or hand-placed in burrows and runways. Anticoagulant baits can also be placed in various types of bait containers placed in areas of high rodent activity. Care must be taken to minimize non-target bird and mammal exposure with broadcast and hand-placed baits.

9.2.D.II.G FUMIGANTS FOR MAMMALS

Burrowing rodents on airports, such as woodchucks (ground hogs) and prairie dogs, can be killed by fumigation of burrows with either gas cartridges or aluminum phosphide tablets. Gas cartridges, ignited from a burning fuse after placement in the burrow, generate carbon monoxide. Aluminum phosphide pellets react with moisture in the burrow to produce phosphine gas. Care must be taken to plug all burrow entrances with sod after placement of the cartridge or pellets in the burrow. Gas cartridges are a general use, over-the-counter pesticide. Aluminum phosphide pellets can only be applied by certified pesticide applicators and might not be available in all states. As with all pesticides, it is critical to make sure the wildlife species you are treating is covered under the registration for your state.



Earthworms crawling onto runways after heavy rains can be a strong attractant to gulls and other birds. This runway in New Zealand uses slit drains to block worms from reaching the runway. Other options include brush-sweeping runway edges to remove worms and deploying extra personnel to disperse gulls. As of 2005, there are no chemicals registered in the USA to control earthworms (photo by R. A. Dolbeer, USDA).

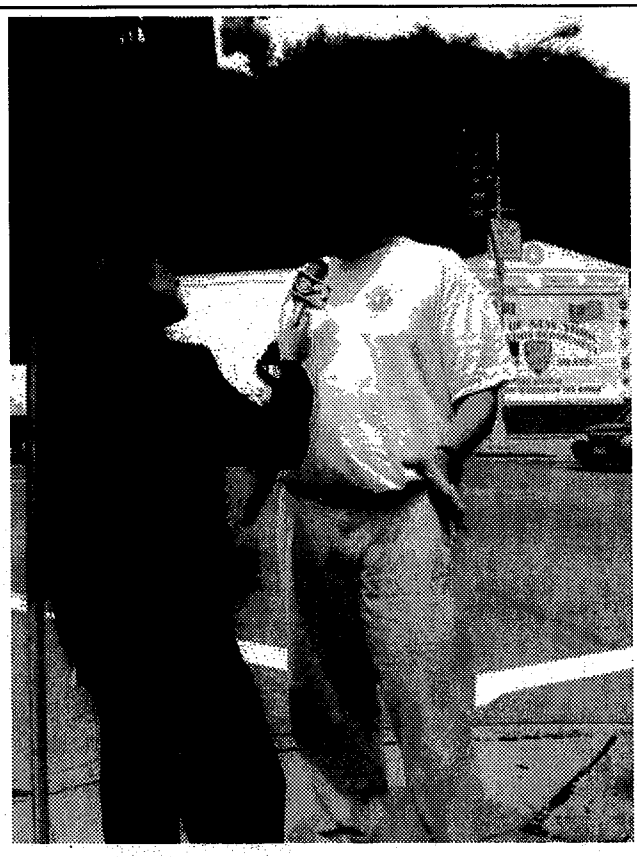
9.2.D.II.H LETHAL TRAPS FOR MAMMALS

Depending on state and local laws, Conibear® (body gripping) traps can be used to remove woodchucks, beaver, and other medium-sized mammals that create problems on airports. Neck snares can be used to capture coyotes, beaver, and certain other mammals. The use of these lethal traps requires a high degree of skill and experience to selectively capture the target animal. Once set, traps must be checked frequently (at least once every 24 hours and more frequently in hot or cold weather) to euthanize any animals that might be captured but not killed. Trappers must be knowledgeable in procedures for handling and euthanizing captured mammals.

9.3 CONCLUSIONS

Habitat modifications to minimize food, cover, and water and physical barriers to exclude wildlife are the foundations of wildlife hazard management programs for airports. In addition, an integrated array of repellent techniques is necessary to disrupt normal behavior and to stress hazardous wildlife that attempt to use the airport. These repellent techniques must be used judiciously and backed by real threats to minimize habituation. To this end, lethal control of selected individuals of common species is sometimes necessary to reinforce repellent actions. Furthermore, the management of a

wildlife hazard situation on an airport might require removal of a particular animal or group of animals or require that a local population of a problem species be reduced by lethal means until a long-term, nonlethal solution is implemented. Finally, the most critical factor for the success of a wildlife hazard management program is to have motivated and trained professionals who are knowledgeable about the wildlife species attempting to use the airport environment and the techniques used to manage the problems these species create.



The management of hazardous wildlife at airports often generates interest from the public and news media. Professional biologists and public relations personnel at airports must be prepared to explain and defend actions taken to protect the flying public from wildlife hazards to aviation (photo by R. A. Dolbeer, USDA).

9.4 OTHER SOURCES OF INFORMATION

For details on techniques, equipment, chemical registrations, species-specific management recommendations, and sources of supply, the reader is referred to—

Hygnstrom, S. C., R. M. Timm, and G. E. Larson, editors. 1994. *Prevention and control of wildlife damage*. University of Nebraska Cooperative Extension Division, Lincoln, Nebraska. (This 2-volume manual is also available online at ianrwww.unl.edu/wildlife/solutions/handbook/.)

In addition, Appendix L provides a list of research publications by the U.S. Department of Agriculture, National Wildlife Research Center (NWRC), documenting results of evaluations of various wildlife control products and strategies. These evaluations were conducted between 1992 and 2004 with support from the FAA under an interagency agreement with NWRC. This is not a complete list of all evaluations that have been done on all wildlife control methods, but it does provide information on many of the control methods discussed in this chapter.



Birds and aircraft will always share the skies, and there will always be the risk of collisions. To minimize that risk, airports must be managed to be as unattractive to birds as possible. Integrating various control strategies offers the maximum long-term effectiveness and immediate relief from a hazardous situation and minimizes the need for the use of lethal control methods (photo by B. Washburn, USDA).

ACKNOWLEDGEMENTS

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SELECTED PUBLICATIONS AND WEB SITES

In addition to these publications and web sites, a list of wildlife field guides and reference books is provided at the end of Chapter 8. Also, a list of publications on wildlife control techniques by the U.S. Department of Agriculture, National Wildlife Research Center, is provided in Appendix L.

Belant, J. L., S. K. Ickes, and T. W. Seamans. 1998. Importance of landfills to urban-nesting herring and ring-billed gulls. Landscape and Urban Planning 43:11-19.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America, third edition. Stackpole Books, Harrisburg, Pennsylvania. 540 pages.

Blokpoel, H. 1974. Bird hazards to aircraft. Canadian Wildlife Service. Ministry of Supply and Services, Ottawa, Ontario, Canada. 236 pages.

Blokpoel, H., and, G. D. Tessier. 1984. Overhead wires and monofilament lines exclude ring-billed gulls from public places. Wildlife Society Bulletin 12:55-53

Cleary, E. C., R. A. Dolbeer, and S. E. Wright. 2004. Wildlife strikes to civil aircraft in the United States, 1990-2003. U.S. Department of Transportation, Federal Aviation Administration, Serial Report No. 10, DOT/FAA/AS/00-6(AAS-310). Washington DC USA. 56 pages. (http://wildlife-mitigation.tc.faa.gov/).

Code of Federal Regulations (CFR): available at http://www.gpoaccess.gov/cfr/index.html

CFR Title 40, Part 258, Criteria for Municipal Solid Waste Landfills, section 258.10, Airport Safety, pages 395-396 (July 2003).

CFR Title 50, Parts 1-100, Wildlife and Fisheries, 494 pages (October 2003).

CFR Title 14, Part 139, Certification and Operations: Land Airports Serving Certain Air Carriers, section 139.337, Wildlife Hazard Management, pages 846-847 (June 2004).

Dolbeer, R. A., J. L. Belant, and J. L. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. Wildlife Society Bulletin 21:442-450.

Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. Ranking the hazard level of wildlife species to aviation. Wildlife Society Bulletin 28:372-378 (updated in special report to Federal Aviation Administration in 2003 that was incorporated into AC 150/5200-7 [Appendix C].

Dolbeer, R. A., and P. Eschenfelder. 2002. Population increases of large birds, airworthiness standards, and high-speed flight: a precarious combination. Pages 273-281 in Proceedings of the 55th International Air Safety Seminar, Dublin, Ireland (Flight Safety Foundation, Alexandria, Virginia).

Dunning, J. B. Jr., editor. 1993. CRC Handbook of Avian Body Masses. CRC Press. Boca Raton, Florida. 371 pages. (Body weights for birds throughout the world)

Gill, F. B. 1990. Ornithology. W. H. Freeman and Company. New York, New York. 660 pages.

Hygnstrom, S. C., R. M. Timm, and G. E. Larson, *editors*. 1994. *Prevention and control of wildlife damage*. University of Nebraska Cooperative Extension Division, Lincoln, Nebraska. (This 2-volume manual is also available online at: ianrwww.unl.edu/wildlife/solutions/handbook/)

Knittle, C. E., and R. D. Porter, 1993. Waterfowl damage and control methods in ripening grain: an overview, US Fish and Wildlife Service, Fish and Wildlife Technical Report 14, Washington, DC. 17 pages.

Linnell, M. A., M. R. Conover, and T. J. Ohashi. 1999. Biases in bird strike statistics based on pilot reports. Journal of Wildlife Management 63:997-1003.

MacKinnon, B., R. Sowden, and S. Dudley (Editors). 2001. Sharing the skies: an aviation guide to the management of wildlife hazards. Transport Canada, Aviation Publishing Division, Tower C, 330 Sparks Street, Ottawa, Ontario, K1A 0N8 Canada. 316 pages.

Seubert, J. L. 1994. Assessing the implementation of wildlife hazard management programs at civil airports. Proceedings Bird Strike Committee Europe 22:275-284.

Smith, A. E., S. R. Craven, and P. D. Curtis. 1999. Managing Canada geese in urban environments. Jack Berryman Institute Publication 16, and Cornell Cooperative Extension, Ithaca, New York.

Transport Canada. 2002. Wildlife Control Procedures Manual. Safety and Security, Aerodrome Safety Branch. TP11500E. Ottawa, Ontario. (www.tc.gc.ca/civilaviation/aerodrome/wildlifecontrol/)

Web Sites:

Bird Strike Committee Canada. www.birdstrikecanada.com/

Bird Strike Committee USA. www.birdstrike.org/

Prevention and control of wildlife damage (2-volume manual). University of Nebraska Cooperative Extension Division, Lincoln, Nebraska. ianrwww.unl.edu/wildlife/solutions/handbook/

Transport Canada. www.tc.gc.ca/civilaviation/aerodrome/wildlifecontrol/

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services. www.aphis.gov.usda.gov/ws

U.S. Department of Defense, U.S. Air Force Bird Aircraft Strike Hazard (BASH) Team. http://afsafety.af.mil/afsc/bash/home.html.

U.S. Department of Interior, Fish and Wildlife Service. www.fws.gov/

U.S. Department of Transportation, Federal Aviation Administration, Airports Division. www.faa.gov/arp/.

U.S. Department of Transportation, Federal Aviation Administration, Wildlife Mitigation and Wildlife Strike Database. http://wildlife-mitigation.tc.faa.gov/.

Wright, S. E., R. A. Dolbeer, and A. J. Montoney. 1998. Deer on airports: an accident waiting to happen. Vertebrate Pest Conference 18:90-95.

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GLOSSARY

Air carrier. A person who holds or who is required to hold an air carrier operating certificate issued under this chapter [Title 14 Code of Federal Regulations, Part 139, Certification and Operation: Land Airports Serving Certain Air Carriers] while operating aircraft having a seating capacity of more than 10 passengers (14 CFR 139.5).

Air carrier aircraft. An aircraft that is being operated by an air carrier and is categorized as either a large air carrier aircraft if designed for at least 31 passenger seats or a small air carrier aircraft if designed for more than 9 passenger seats but less than 31 passenger seats, as determined by the aircraft type certificate issued by a competent civil aviation authority (14 CFR 139.5).

Air carrier operation. The takeoff or landing of an air carrier aircraft and includes the period of time from 15 minutes before until 15 minutes after the takeoff or landing (14 CFR 139.5).

Air operations area (AOA). Any area of an airport used or intended to be used for landing, takeoff, or surface maneuvering of aircraft. An air operations area included such paved areas or unpaved areas that are used or intended to be used for the unobstructed movement of aircraft in addition to its associated runway, taxiways, or apron.

Airport. An area of land or other hard surface, excluding water, that is used or intended to be used for the landing and takeoff of aircraft, including any buildings and facilities (14 CFR 139.5).

Airport operator. The operator (private or public) or sponsor of a public use airport.

Airport Operating Certificate. A certificate, issued under this part [Title 14 Code of Federal Regulations, Part 139, Certification and Operation: Land Airports Serving Certain Air Carriers], for operation of a Class I, II, III, or IV airport.

Approach or departure airspace. The airspace, within 5 statute miles of an airport, through which aircraft move during landing or takeoff.

Bird balls. High-density plastic floating balls that can be used to cover ponds and prevent birds from using the sites.

Bird hazard. See Wildlife hazard.

Bird strike. See Wildlife strike

Carrying capacity. The maximum number of animals of a given species, which a habitat is capable of supporting on a sustained basis. The goal of wildlife management programs on airports is to eliminate or minimize the carrying capacity of habitat for species hazardous to aviation.

Categorical exclusion (NEPA): A category of actions that do not individually or cumulatively have a significant effect on the human environment (40 CFR, 1508.4).

Certificate holder. The holder of an Airport Operating Certificate issued under this part. [Title 14 Code of Federal Regulations, Part 139, Certification and Operation: Land Airports Serving Certain Air Carriers] (14 CFR 139.5).

Class I airport. An airport certificated to serve scheduled operations of large air carrier aircraft that can also serve unscheduled passenger operations of large air carrier aircraft and/or scheduled operations of small air carrier aircraft.

Class II airport. An airport certificated to serve scheduled operations of small air carrier aircraft and the unscheduled passenger operations of large air carrier aircraft. A Class II airport cannot serve scheduled large air carrier aircraft.

Class III airport. An airport certificated to serve scheduled operations of small air carrier aircraft. A Class III airport cannot serve scheduled or unscheduled large air carrier aircraft.

Class IV airport. An airport certificated to serve unscheduled passenger operations of large air carrier aircraft. A Class IV airport cannot serve scheduled large or small air carrier aircraft.

Concurrent use. Aeronautical property used for compatible non-aviation purposes while at the same time serving the primary purpose for which it was acquired; and the use is clearly beneficial to the airport. The concurrent use should generate revenue to be used for airport purposes (see Order 5190.6A, *Airport Compliance Requirements*, sect. 5h).

Construct a new MSWLF. To begin to excavate, grade land, or raise structures to prepare a municipal solid waste landfill as permitted by the appropriate regulatory or permitting agency.

Cover. Vegetation covering a ground surface and serving as shelter for wildlife that are roosting, resting, nesting, or feeding.

Cover types. A descriptive term characterizing vegetative composition and physical characteristics of a plant community.

Detention ponds. Storm water management ponds that hold storm water for short periods of time, generally less than then 48 hours (compare with retentions ponds).

Dump. The actively used and unvegetated part of an area where refuse (garbage) is placed and allowed to accumulate on the ground surface without periodic covering or compacting. This includes both authorized and unauthorized areas.

Establish a new Municipal Solid Waste Landfill. When the first load of putrescible waste is received on-site for placement in a prepared municipal solid waste landfill.

Extraordinary circumstances: Environmental conditions associated with an action that is normally categorically excluded and that: (1) involves one or more of the circumstances listed in FAA Order 1050.1E, paragraph 304a through 304k; and may cause a significant environmental effect.

Fly ash. The fine, sand-like residue resulting from the complete incineration of an

organic fuel source. Fly ash typically results from the combustion of coal or organic waste used to operate a power generating plant.

Hazardous wildlife. Species of wildlife (birds, mammals, reptiles, insects, earth worms), including feral animals and domesticated animals not under control, that are associated with aircraft strike problems, are capable of causing structural damage to airport facilities, or act as attractants to other wildlife that pose a strike hazard (Advisory Circular 150/5200-33A – Hazardous Wildlife Attractants on or Near Airports; 14 CFR 139.3)

Heliport. An airport or an area of an airport used or intended to be used for the landing and takeoff of helicopters (14 CFR 139.3).

Mammal strike. See Wildlife strike.

Migratory Bird. "[A] migratory bird [is] ... any bird whatever its origin and whether or not raised in captivity, which belongs to a species listed in Section 10.13 [of 50 CFR] or which is a mutation or a hybrid of any such species, including any part, nest, or egg of any such bird, or any product, whether or not manufactured, which consist, or is composed in whole or part, of any such bird, or any part, nest, or egg thereof." (50 CFR 10.12). This list includes almost all native bird species in the United States, with the exception of nonmigratory game birds such as pheasants, turkeys and grouse. Exotic and feral species such as graylag geese, muscovy ducks, European starlings, house (English) sparrows, and rock doves (pigeons) also are not listed in 50 CFR 10.13 and are therefore not protected by federal law.

Migration. The periodic movement of a wildlife species from one geographic area to another, usually in correlation with seasonal changes in weather.

Municipal Solid Waste Landfill (MSWLF). A publicly or privately owned discrete area of land or an excavation that receives household waste and that is not a land application unit, surface impoundment, injection well, or waste pile, as those terms are defined under 40 CFR § 257.2. An MSWLF may receive other types wastes, such as commercial solid waste, non-hazardous sludge, small-quantity generator waste, and industrial solid waste, as defined under 40 CFR § 258.2. An MSWLF can consist of either a stand alone unit or several cells that receive household waste.

Movement area. The runways, taxiways, and other areas of an airport which are used for taxiing or hover taxiing, air taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas (14 CFR 139.3).

New MSWLF. A municipal solid waste landfill that was established or constructed after April 5, 2001 (AC 150/5200-34).

Pesticide. (1) Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and (3) any nitrogen stabilizer (7 U.S.C.A. 136[u]).

Piston-powered aircraft. Fixed-wing aircraft powered by piston engines. Such aircraft normally use LL-100 fuel.

Piston-use airport. Any airport that does not sell Jet-A fuel for fixed-wing turbine-powered aircraft, and primarily serves fixed-wing, piston-powered aircraft. Incidental use of the airport by turbine-powered, fixed-wing aircraft would not affect this designation. However, such aircraft should not be based at the airport (AC 150/5200-33A).

Public airport. An airport used or intended to be used for public purposes that is under the control of a public agency; and of which the area used or intended to be used for landing, taking off, or surface maneuvering of aircraft is publicly owned (49 U.S.C. § 47102(16)).

Putrescible waste. Solid waste that contains organic matter capable of being decomposed by micro-organisms and of such a character and proportion as to be capable of attracting or providing food for birds (40 CFR §257.3-8).

Putrescible-waste disposal operation. Landfills, garbage dumps, underwater waste discharges, or similar facilities where activities include processing, burying, storing, or otherwise disposing of putrescible material, trash, and refuse.

Propane cannon/exploder. A hollow cylinder that produces a loud explosion to frighten wildlife by the ignition of a metered amount of propane at timed or random intervals or by remote control.

Pyrotechnics. Various combustible projectiles launched from a shotgun, pistol or other device that produce noise, light and smoke to frighten wildlife.

Retention ponds. Storm water management ponds that hold water for long periods of time, generally more then 48 hours (compare with detentions ponds).

Runway protection zone (RPZ). An area off the runway end to enhance the protection of people and property on the ground (see AC 150/5300-13). The dimensions of this zone vary with the airport design, aircraft, type of operation, and visibility minimum.

Scheduled operation. Any common carriage passenger-carrying operation for compensation or hire conducted by an air carrier for which the air carrier or its representatives offers in advance the departure location, departure time, and arrival location. It does not include any operation that is conducted as a supplemental operation under 14 CFR part 121 or public charter operations under 14 CFR part 380.

Sewage sludge. Any solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment process; and a material derived from sewage sludge. Sewage does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works (40 CFR 257.2). Also, the de-watered effluent resulting from secondary or tertiary treatment of

municipal sewage and/or industrial wastes, including sewage sludge as referenced in USEPA's *Effluent Guidelines and Standards*, 40 CFR Part 401.

Sludge. Any solid, semi-solid, or liquid waste generated form a municipal, commercial or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility or any other such waste having similar characteristics and effect (40 CFR 257.2).

Solid waste. Any garbage, refuse, sludge, from a waste treatment plant, water supply treatment plant or air pollution control facility and other discarded material, including, solid liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved material in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or by product material as defined by the Atomic Energy Act of 1954, as amended (68 Statute 923), (40 CFR 257.2).

Take (of wildlife). To pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect any wild animal (50 CFR 10.12).

Turbine-powered aircraft. Aircraft powered by turbine engines including turbojets and turboprops but excluding turbo-shaft, rotary-wing aircraft. Such aircraft normally use Jet-A fuel (AC 150/5200-33A).

Turbine-use airport. Any airport that sells Jet-A fuel for fixed-wing turbine-powered aircraft.

Wastewater treatment facility. Any devices or systems used to store, treat, recycle, or reclaim municipal sewage or liquid industrial wastes, including Publicly Owned Treatment Works (POTW), as defined by Section 212 of the Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-576) and the Water Quality Act of 1937 (P.L. 100-4). This definition includes any pretreatment involving the reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a POTW (40 CFR 403.3 [o], [p], [q]).

Wildlife. Any wild animal, including without limitation any wild mammal, bird, reptile, fish, amphibian, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, including any part, product, egg, or offspring thereof (50 CFR 10.12, *Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants*). As used in this manual wildlife includes feral animals and domestic animals out of the control of their owners (14 CFR Part 139, Certification of Airports).

Wildlife attractants. Any human-made structure, land-use practice, or human-made or natural geographic feature, that can attract or sustain hazardous wildlife within the landing or departure airspace, AOA, loading ramps, or aircraft parking areas

of an airport. These attractants can include but are not limited to architectural features, landscaping, waste disposal sites, wastewater treatment facilities, agricultural or aquaculture activities, surface mining, or wetlands (AC 150/5200-33).

Wildlife hazard. A potential for a damaging aircraft collision with wildlife on or near an airport (14 CFR 139.3).

Wildlife strike. A wildlife strike has occurred when:

1. A pilot reports striking 1 or more birds or other wildlife;

2. Aircraft maintenance personnel identify aircraft damage as having been caused by a wildlife strike;

3. Personnel on the ground report seeing an aircraft strike 1 or more birds or other wildlife;

4. Bird or other wildlife remains, whether in whole or in part are found within 200 feet of a runway centerline, unless another reason for the animal's death is identified;

5. The animal's presence on the airport had a significant negative effect on a flight (i.e., aborted takeoff, aborted landing, high-speed emergency stop, aircraft left pavement area to avoid collision with animal) (criteria 1-4 adopted from Transport Canada (MacKinnon et al. 2001).

ACRONYMS

AAWV	American Association of Wildlife Veterinarians
AC	Advisory Circular
A-C	Alpha-Chloralose
ADC	Animal Damage Control (former name of USDA/WS)
AGL	Above Ground Level
AOA	Air Operations Area
APHIS	Animal and Plant Health Inspection Service
ATC	Air Traffic Control
BASH	Bird Aircraft Strike Hazard (USAF)
BSCC	Bird Strike Committee Canada
BSC-USA	Bird Strike Committee USA
C&D Landfills	Construction and Demolition Landfills
CFR	Code of Federal Regulations
EA	Environmental Assessment
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOD	Foreign Object Debris, Foreign Object Damage
MBTA	Migratory Bird Treaty Act
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding

MSWLF	Municipal Solid Waste Landfill
NEPA	National Environmental Policy Act
NIPAS	National Integrated Plan of Airport System
NWRC	National Wildlife Research Center (USDA)
OFA	Object Free Area
OFZ	Obstacle Free Zone
RPZ	Runway Protection Zone
TSS	Threshold Siting Service
USAF	United States Air Force
USCOE	United States Army Corps of Engineers
USDOD	United States Department of Defense
USDA/WS	United States Department of Agriculture, Wildlife Services
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WCP	Wildlife Control Personnel
WHA	Wildlife Hazard Assessment
WHMP	Wildlife Hazard Management Plan
WHWG	Wildlife Hazard Working Group
WS	Wildlife Services (USDA)

COUNTY OF SAN MATEO
Inter-Departmental Correspondence

March 9, 1994

To: Patrick Sanchez, Parks and Recreation Division

From: Sam Herzberg, Planner II SH

Subject: Pillar Point Marsh Wetland Delineation

I am writing to brief you on the status of the Army Corps of Engineers' findings regarding the wetland delineation of the Pillar Point Marsh.

On February 8, 1994, I sent you a memo describing the initial findings of the Corps' wetland delineation, as performed by Dan Martell. As you recall when the County initially requested the Corps perform a formal wetland delineation of the Pillar Point Marsh in September 1993, it was assumed the Corps would concur with Charles Pattersen's 1987 Wetland Delineation and Report - Pillar Point Marsh, and facilitate a land appraisal of the marsh and its surrounding areas for the purpose of County acquisition from the current property owners. Mr. Martell indicated that his initial findings of the wetland boundaries identified a wetland considerably smaller than Charles Pattersen's delineation. Due to unexpected delays in the Corps' ability to produce an immediate wetland delineation of Pillar Point Marsh, Mr. Martell recommended the County proceed with its property acquisition based on Charles Pattersen's delineation.

On March 7, 1994, Mr. Martell called to inform me his initial assumptions of the hydrology of the Marsh were incorrect. Pillar Point Marsh is unlike typical coastal wetlands, because it is a perched wetland. Due to shale deposits located upstream the alluvium that collects in the wetland, due to erosion over time, forms a clay sealant which causes the water to stay on the surface and not percolate subsurface. Unlike the Pescadero Marsh, which is wet annually, Pillar Point Marsh holds the water at the surface until it either runs off, or evaporates. Mr. Martell indicated that he has made further inspections of the Marsh, following recent past rainfalls, and performed soil testing. He has determined that with minor exceptions he concurs with Charles Pattersen's wetland delineation of the Marsh. He is currently in the process of acquiring aerial photos from the San Mateo County Harbor District, at 50' scale, for the purposes of mapping the wetland boundaries. This map with a report on his findings regarding the hydrology of the Pillar Point Marsh will be forthcoming within the next several weeks.

If you have any further questions please feel free to contact me at ext. 1823.

SH:cdn - SFHE0479.ACO

cc: Paul Koenig, Director of Environmental Services
Terry Burnes, Planning Administrator
Mike Murphy, Deputy County Counsel
Linda Green, Real Property Division
Bob Emert, Superintendent of Parks
Roman Gankin, Principal Planner
Bill Rozar, Development Review Manager
Janice Jagelski, Planner

CALIFORNIA GEOLOGICAL SURVEY

GUIDELINES FOR EVALUATING THE HAZARD OF SURFACE FAULT RUPTURE

NOTE 49

GUIDELINES FOR EVALUATING THE HAZARD OF SURFACE FAULT RUPTURE
(Similar guidelines were adopted by the State Mining and Geology Board for advisory purposes in 1996.)

These guidelines are to assist geologists who investigate faults relative to the hazard of surface fault rupture. Subsequent to the passage of the Alquist-Priolo Earthquake Fault Zoning Act (1972), it became apparent that many fault investigations conducted in California were incomplete or otherwise inadequate for the purpose of evaluating the potential of surface fault rupture. It was further apparent that statewide standards for investigating faults would be beneficial. These guidelines were initially prepared in 1975 and have been revised several times since then.

The investigation of sites for the possible hazard of surface fault rupture is a deceptively difficult geologic task. Many active faults are complex, consisting of multiple breaks. Yet the evidence for identifying active fault traces is generally subtle or obscure and the distinction between recently active and long-inactive faults may be difficult to make. It is impractical from an economic, engineering, and architectural point of view to design a structure to withstand serious damage under the stress of surface fault rupture. Once a structure is sited astride an active fault, the resulting fault-rupture hazard cannot be mitigated unless the structure is relocated, whereas when a structure is placed on a landslide, the potential hazard from landsliding often can be mitigated. Most surface faulting is confined to a relatively narrow zone a few feet to few tens of feet wide, making avoidance (i.e., building setbacks) the most appropriate mitigation method. However, in some cases primary fault rupture along branch faults can be distributed across zones hundreds of feet wide or manifested as broad warps, suggesting that engineering strengthening or design may be of additional mitigative value (e.g., Lazarte and others, 1994).

No single investigative method will be the best, or even useful, at all sites, because of the complexity of evaluating surface and near surface faults and because of the infinite variety of site conditions. Nonetheless, certain investigative methods are more helpful than others in locating faults and evaluating the recency of activity.

The evaluation of a given site with regard to the potential hazard of surface fault rupture is based extensively on the concepts of recency and recurrence of faulting along existing faults. In a general way, the more recent the faulting the greater the probability for future faulting (Allen, 1975). Stated another way, faults of known historic activity during the last 200 years, as a class, have a greater probability for future activity than faults classified as Holocene age (last 11,000 years), and a much greater probability of future activity than faults classified as Quaternary age (last 1.6 million years). However, it should be kept in mind that certain faults have recurrent activity measured in tens or hundreds of years whereas other faults may be inactive for thousands of years before being reactivated. Other faults may be characterized by creep-type rupture that is more or less ongoing. The magnitude, sense, and nature of fault rupture also vary for different faults or even along different strands of the same fault. Even so, future faulting generally is expected to recur along pre-existing faults (Bonilla, 1970). The development of a new fault or reactivation of a long-inactive fault is relatively uncommon and generally need not be a concern in site development.

As a practical matter, fault investigation should be directed at the problem of locating existing faults and then attempting to evaluate the recency of their activity. Data should be obtained both from the site and outside the site area. The most useful and direct method of evaluating recency is to observe (in a trench or road cut) the youngest geologic unit faulted and the oldest unit that is not faulted. Even so, active faults may be subtle or discontinuous and consequently overlooked in trench exposures (Bonilla and Lienkaemper, 1991). Therefore, careful logging is essential and trenching needs to be conducted in conjunction with other methods. For example, recently active faults may also be identified by direct observation of young, fault-related geomorphic (i.e., topographic) features in the field or on aerial photographs. Other indirect and more interpretive methods are identified in the outline below. Some of these methods are discussed in Bonilla (1982), Carver and McCalpin (1996), Hatheway and Leighton (1979), McCalpin (1996a, b, c), National Research Council (1986), Sherard and others (1974), Slemmons (1977), Slemmons and dePolo (1986), Taylor and Cluff (1973), the Utah Section of the Association of Engineering Geologists (1987), Wallace (1977), Weldon and others (1996), and Yeats and others (1997). McCalpin (1996b) contains a particularly useful discussion of various field techniques. Many other useful references are listed in the bibliographies of the references cited here.

The purpose, scope, and methods of investigation for fault investigations will vary depending on conditions at specific sites and the nature of the projects. Contents and scope of the investigation may also vary based on guidelines and review criteria of agencies or political organizations having regulatory responsibility. However, there are topics that should be considered in all comprehensive

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fault investigations and geologic reports on faults. For a given site some topics may be addressed in more detail than at other sites because of the difference in the geologic and/or tectonic setting and/or site conditions. These investigative considerations should apply to any comprehensive fault investigation and may be applied to any project site, large or small. Suggested topics, considerations, and guidelines for fault investigations and reports on faults are provided in the following annotated outline. Fault investigations may be conducted in conjunction with other geologic and geotechnical investigations (DMG Notes 42 and 44). Although not all investigative techniques need to be or can be employed in evaluating a given site, the outline provides a checklist for preparing complete and well-documented reports. Most reports on fault investigations are reviewed by local or state government agencies. Therefore it is necessary that the reports be documented adequately and written carefully to facilitate that review. The importance of the review process is emphasized here, because it is the reviewer who must evaluate the adequacy of reports, interpret or set standards where they are unclear, and advise the governing agency as to their acceptability (Hart and Williams, 1978; DMG Note 41).

The scope of the investigation is dependent not only on the complexity and economics of a project, but also on the level of risk acceptable for the proposed structure or development. A more detailed investigation should be made for hospitals, high-rise buildings, and other critical or sensitive structures than for low-occupancy structures such as wood-frame dwellings that are comparatively safe. The conclusion drawn from any given set of data, however, must be consistent and unbiased. Recommendations must be clearly separated from conclusions, because recommendations are not totally dependent on geologic factors. The final decision as to whether, or how, a given project should be developed lies in the hands of the owner and the governing body that must review and approve the project.

CONTENTS OF GEOLOGIC REPORTS ON FAULTS

Suggested topics, considerations, and guidelines for investigations and reports

The following topics should be considered and addressed in detail where essential to support opinions, conclusions, and recommendations, in any geologic report on faults. It is not expected that all the topics or investigative methods would be necessary in a single investigation. In specific cases it may be necessary to extend some of the investigative methods well beyond the site or property being investigated. Particularly helpful references are cited parenthetically below.

I. Text

- A. Purpose and scope of investigation; description of proposed development.
- B. Geologic and tectonic setting. Include seismicity and earthquake history.
- C. Site description and conditions, including dates of site visits and observations. Include information on geo logic units, graded and filled areas, vegetation, existing structures, and other factors that may affect the choice of investigative methods and interpretation of data.
- D. Methods of investigation.
  1. Review of published and unpublished literature, maps, and records concerning geologic units, faults, ground-water barriers, and other factors.
  2. Stereoscopic interpretation of aerial photographs and other remotely sensed images to detect fault-related topography (geomorphic features), vegetation and soil contrasts, and other lineaments of possible fault origin. The area interpreted usually should extend beyond the site boundaries.
  3. Surface observations, including mapping of geologic and soil units, geologic structures, geomorphic features and surfaces, springs, deformation of engineered structures due to fault creep, both on and beyond the site.
  4. Subsurface investigations.
     - a. Trenching and other excavations to permit detailed and direct observation of continuously exposed geologic units, soils, and structures; must be of adequate depth and be carefully logged (Taylor and Cluff, 1973; Hatheway and Leighton, 1979; McCalpin, 1996b).
     - b. Borings and test pits to permit collection of data on geologic units and ground water at specific locations. Data points must be sufficient in number and spaced adequately to permit valid correlations and interpretations.
     - c. Cone penetrometer testing (CPT) (Grant and others, 1997; Edelman and others, 1996). CPT must be done in conjunction with continuously logged borings to correlate CPT results with on-site materials. The number of borings and spacing of CPT soundings should be sufficient to adequately image site stratigraphy. The existence and location of a fault based on CPT data are interpretative.
  5. Geophysical investigations. These are indirect methods that require a knowledge of specific geo logic conditions for reliable interpretations. They should seldom, if ever, be employed alone without knowledge of the geology (Chase and Chapman, 1976). Geophysical methods alone never prove the absence of a fault nor do they identify the recency of activity. The types of equipment and techniques used should be described and supporting data presented (California Board of Registration for Geologists and Geophysicists, 1993).
     - a. High resolution seismic reflection (Stephenson and others, 1995; McCalpin, 1996b).
     - b. Ground penetrating radar (Cai and others, 1996).
     - c. Other methods include: seismic refraction, magnetic profiling, electrical resistivity, and gravity (McCalpin, 1996b).
  6. Age-dating techniques are essential for determining the ages of geologic units, soils, and surfaces that bracket the time(s) of faulting (Pierce, 1986; Birkeland and other, 1991; Rutter and Catto, 1995; McCalpin, 1996a).
     - a. Radiometric dating (especially 14C).
     - b. Soil-profile development.

c. Rock and mineral weathering.

d. Landform development.

e. Stratigraphic correlation of rocks/minerals/fossils.

f. Other methods — artifacts, historical records, tephrochronology, fault scarp modeling, thermoluminescence, lichenometery, paleomagnetism, dendrochronology, etc.

7. Other methods should be included when special conditions permit or requirements for critical structures demand a more intensive investigation.

a. Aerial reconnaissance overflights.

b. Geodetic and strain measurements.

c. Microseismicity monitoring.

E. Conclusions.

1. Location and existence (or absence) of hazardous faults on or adjacent to the site; ages of past rupture events.

2. Type of faults and nature of anticipated offset, including sense and magnitude of displacement, if possible.

3. Distribution of primary and secondary faulting (fault zone width) and fault-related deformation.

4. Probability of or relative potential for future surface displacement. The likelihood of future ground rupture seldom can be stated mathematically, but may be stated in semi-quantitative terms such as low, moderate, or high, or in terms of slip rates determined for specific fault segments.

5. Degree of confidence in and limitations of data and conclusions.

F. Recommendations.

1. Setback distances of proposed structures from hazardous faults. The setback distance generally will depend on the quality of data and type and complexity of fault(s) encountered at the site. In order to establish an appropriate setback distance from a fault located by indirect or interpretative methods (e.g., borings or cone penetrometer testing), the area between data points also should be considered underlain by a fault unless additional data are used to more precisely locate the fault. State and local regulations may dictate minimum distances (e.g., Section 3603 of California Code of Regulations in Appendix B in Hart and Bryant, 1997).

2. Additional measures (e.g., strengthened foundations, engineering design, flexible utility connections) to accommodate warping and distributive deformation associated with faulting (Lazarte and others, 1994).

3. Risk evaluation relative to the proposed development.

4. Limitations of the investigation; need for additional studies.

II. References.

A. Literature and records cited or reviewed; citations should be complete.

B. Aerial photographs or images interpreted — list type, data, scale, source, and index numbers.

C. Other sources of information, including well records, personal communications, and other data sources.

III. Illustrations — these are essential to the understanding of the report and to reduce the length of text.

A. Location map — identify site locality, significant faults, geographic features, regional geology, seismic epicenters, and other pertinent data; 1:24,000 scale is recommended. If the site investigation is done in compliance with the Alquist-Priolo Act, show site location on the appropriate Official Map of Earthquake Fault Zones.

B. Site development map — show site boundaries, existing and proposed structures, graded areas, streets, exploratory trenches, borings geophysical traverses, locations of faults, and other data; recommended scale is 1:2,400 (1 inch equals 200 feet), or larger.

C. Geologic map — show distribution of geologic units (if more than one), faults and other structures, geomorphic features, aerial photo graphic lineaments, and springs; on topographic map 1:24,000 scale or larger; can be combined with III(A) or III(B).

D. Geologic cross sections, if needed, to provide three-dimensional picture.

E. Logs of exploratory trenches and borings — show details of observed features and conditions; should not be generalized or diagrammatic. Trench logs should show topographic profile and geologic structure at a 1:1 horizontal to vertical scale; scale should be 1:60 (1 inch = 5 feet) or larger.

F. Geophysical data and geologic interpretations.

IV. Appendix: Supporting data not included above (e.g., water well data, photographs, aerial photographs).

V. Authentication: Investigating geologist's signature and registration number with expiration data.

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* DMG Note 41 — General guidelines for reviewing geologic reports, 1998.

* DMG Note 42 — Guidelines for geologic/seismic reports, 1986.

* DMG Note 44 — Recommended guidelines for preparing engineering geologic reports, 1986.

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Public and Support Services Group
Land Use Services Department
BUILDING AND SAFETY DIVISION

STANDARD PROCEDURE

NO. A-146
REV BY W. Reeder PAGE 1 OF 3
EFFECTIVE 11/8/84 REVISED 9/28/07

APPROVED, Barbara Johnston, Building Official

SUBJECT

FAULT-RUPTURE HAZARD INVESTIGATION AND REPORT STANDARDS

The Alquist-Priolo Earthquake Fault Zoning Act is intended to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to prohibit the location of developments and structures for human occupancy across the trace of active faults. The Act allows cities and counties to establish additional policies and criteria so long as they are not less restrictive. These include setting specific investigation and report standards.

Generally, fault rupture hazard investigations and associated reports must adhere to the guidelines outlined in California Geological Survey (CGS) Note 49 entitled "Guidelines for Evaluating the Hazard of Surface Fault Rupture", with Appendix C of CGS Special Publication 42 entitled "Fault-Rupture Hazard Zones in California" and with Chapter 82.15 of the County Development Code.

The policies and criteria outlined in this standard procedure are intended to clarify County requirements and augment the State guidelines.

1. Trenches and/or other exposures in Quaternary age alluvium must provide adequate subsurface coverage for that portion of the project proposed within the Alquist-Priolo Earthquake Fault Zone or, when approved by the County Geologist, for individual building envelopes within the Alquist-Priolo Earthquake Fault Zone.

2. In determining the amount of subsurface coverage provided by widely spaced trenches and/or other exposures in Holocene age alluvium, a 5 degree "factor of safety" that is based on the overall trend of the principal faulting will be considered appropriate. Subsurface data (trench coverage or fault location) should not be extrapolated more than 600 feet without additional surface or subsurface information. *En echelon* or other complex faulting may require closer spacing of trenches.

3. The County Geologist shall be notified at least two working days prior to the start of trenching and shall be provided a trench schedule and a site map showing the approximate location of the proposed trenches. In most cases, the County Geologist must inspect the trenches once they are completed, cleaned and logged. Failure to notify the County Geologist may result in the need to re-excavate trenches.

4. A grading permit is currently not required for the excavation and backfilling of fault trenches when conducted under the supervision of a California Professional Geologist. However, exemption from a grading permit does not grant authorization for any work that may be regulated by other agencies. It is the responsibility of the applicant to determine the need for any additional biological, air quality or water quality, studies, permits or monitoring that may be necessary to excavate trenches on a particular site.

5. Appropriate erosion and sediment control measures are expected during and/or following a site investigation when the excavation and backfilling could result in erosion or migration of sediments off site.

6. Trenches excavated in Holocene age alluvium must be a minimum depth of 10 feet. Deeper trenching may be appropriate depending upon the recency of the deposit. In pre-Holocene materials, trenches must be excavated to a reasonable depth to adequately expose faulting.

7. A trench log must be completed on each trench. The log must be a reasonable graphic representation of the subsurface conditions encountered within the trench, show the topographic profile and be at an undistorted scale no smaller than 1 inch equals 5 feet. Trench logs must show distances along the trench, depth and direction and/or identify which trench wall was logged. The strike and dip of faulting, fracturing, bedding and any other prominent features must be clearly shown.

8. The determined or estimated age of faulted and unfaulted materials exposed within the trenches must be discussed within the report.

9. In accordance with Section 82.15.040 of the County Development Code, a minimum 50 foot setback from active faulting is required for non-critical structures. Greater setbacks may be appropriate from poorly defined faulting or complex faulting such as low angle and thrust faulting. Lesser setbacks may be considered from well defined active faulting exposed in pre-Holocene age materials. The Development Code requires a minimum setback of 150 feet for critical facilities such as police and fire stations, schools, hospitals, nursing homes and emergency communication facilities.

10. If there is a potential for active faulting to occur within 50 feet beyond the end of a trench, a 50 foot setback from the end of the trench will be considered appropriate.

11. An active fault is a fault that has produced surface ground rupture during Holocene time (within approximately the last 11,000 years). A potentially active fault is a Quaternary age fault with unknown Holocene activity. For purposes of the Alquist-Priolo Earthquake Fault Zone Act, if it can be demonstrated that surface ground rupture has not occurred along a fault during all of the Holocene, the fault should be designated as "not active". However, determining fault activity is often difficult and may require multiple lines of evidence including soil profiling, geomorphology and age dating techniques. Building setbacks will be required from faults where Holocene activity remains unknown.

12. Principal faulting exposed within the trenches must be accurately located and staked in the field. Fault laths must be surveyed or tied to a recoverable monument. Trench locations must be tied to a recoverable point. Building setback lines must be tied to a surveyed point.

14. Fault location and building setbacks must be shown on a plat within the report and on the Composite Development Plan as well as any other required development or grading plans. The direction, length and setback distance of each segment of the recommended building setbacks must be specified on the plat within the report as well as discussed within the text.

15. Conclusions based solely on geophysical investigation methods are unacceptable. Geophysical methods alone never prove the absence of faulting nor do they determine the recency of activity.

16. Any portion of a site that lies within an Alquist-Priolo Earthquake Fault Zone which was not covered by trenching or other approved means during the fault rupture hazard investigation, must remain restricted. No human occupancy structures or fault sensitive development can occur within that portion of the site unless a subsequent investigation demonstrates it is free of active faulting.

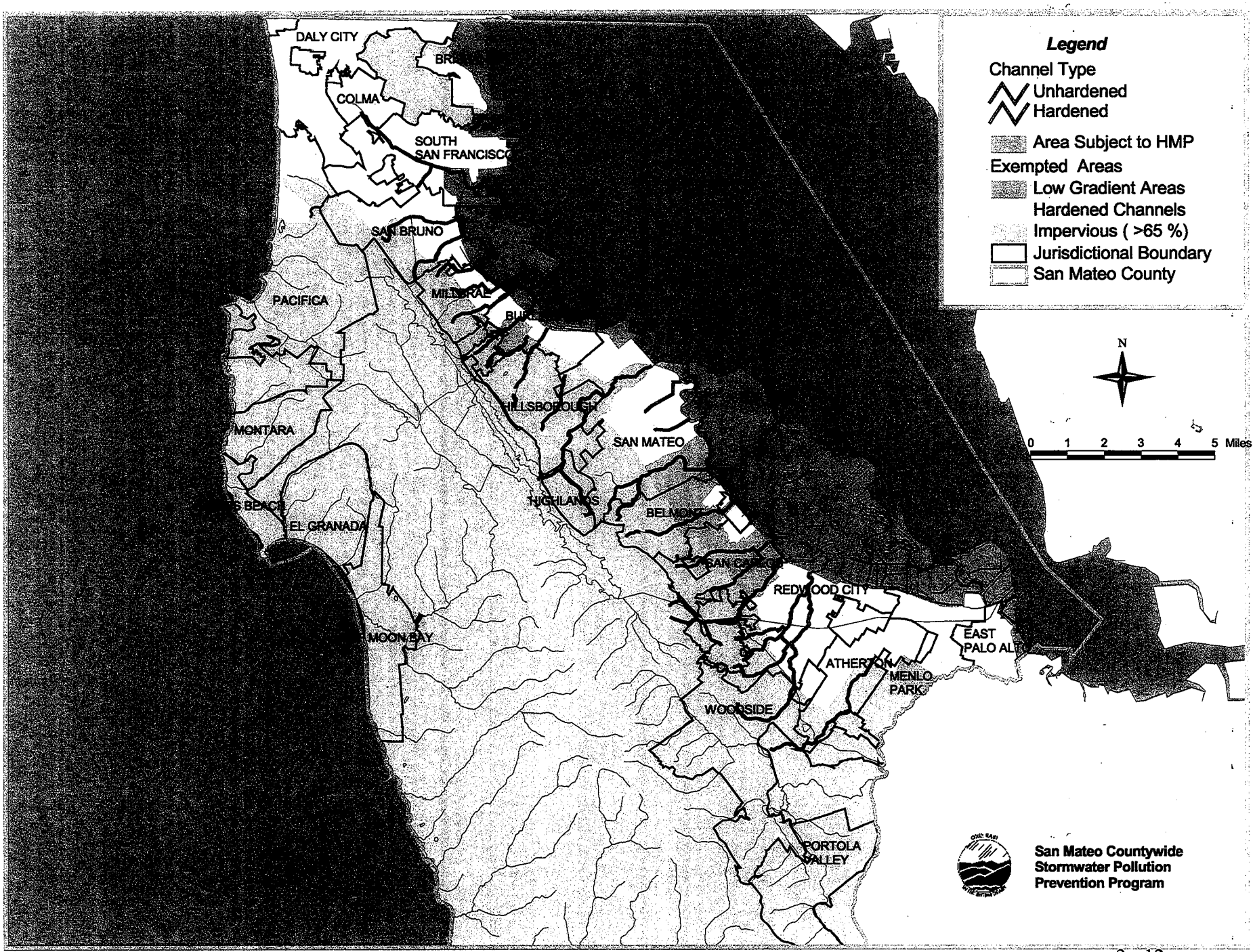


Figure 3-1. Watershed areas proposed as exempt from hydromodification requirements.

Chapter

7

Hydromodification Management Measures

In this Chapter

- *Explanation of hydromodification*
- *Description of hydromodification management controls*
- *Summary of requirements for reducing erosive flows from development projects*

7.1 What is Hydromodification?

Key Point

Changes in the timing and volume of runoff from a site are known as "hydrograph modification" or "hydromodification". When a site is developed, much of the rainwater can no longer infiltrate into the soils, so it flows offsite at ***faster rates and greater volumes***. As a result, erosive levels of flow occur more frequently and for longer periods of time in creeks and channels downstream of the project. Hydrograph modification is illustrated in Figure 7-1, which shows the stormwater peak discharges after rainstorms in an urban watershed (the red, or dark, line) and a less developed (the yellow, or light, line). The axes indicate the volume of water discharged, and the time over which it is discharged.

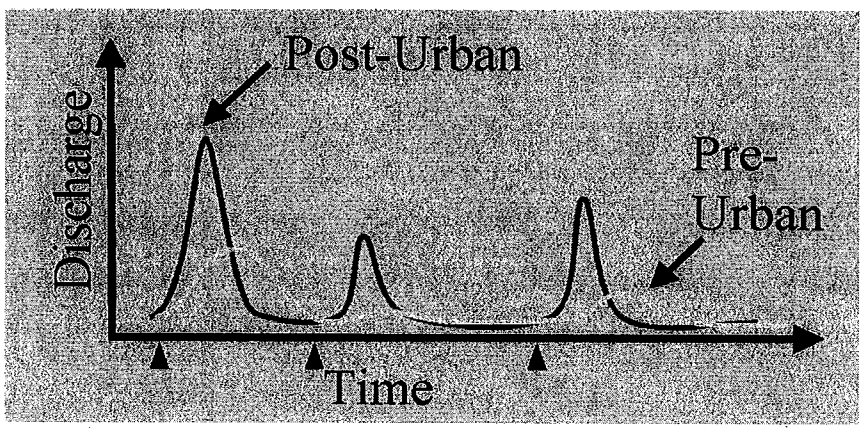


Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

In watersheds with large amounts of impervious surface, the larger volumes, faster rates and extended durations of discharge often cause natural creeks or earthen channels to erode, as the channel enlarges in response to the increased flows. ***Problems from this additional erosion*** often include property damage, degradation of stream habitat and loss of water quality, and have not been addressed by traditional detention designs. Figures 7-2 and 7-3 illustrate the effect of increasing urbanization on stormwater volumes.

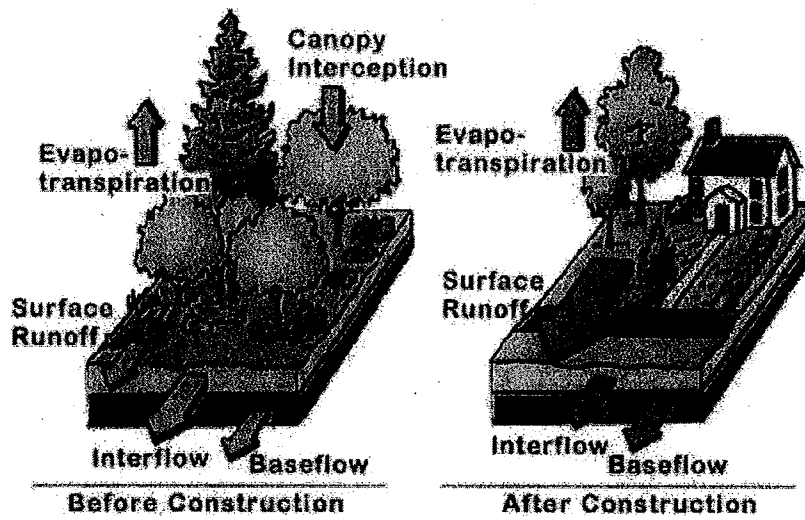


Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

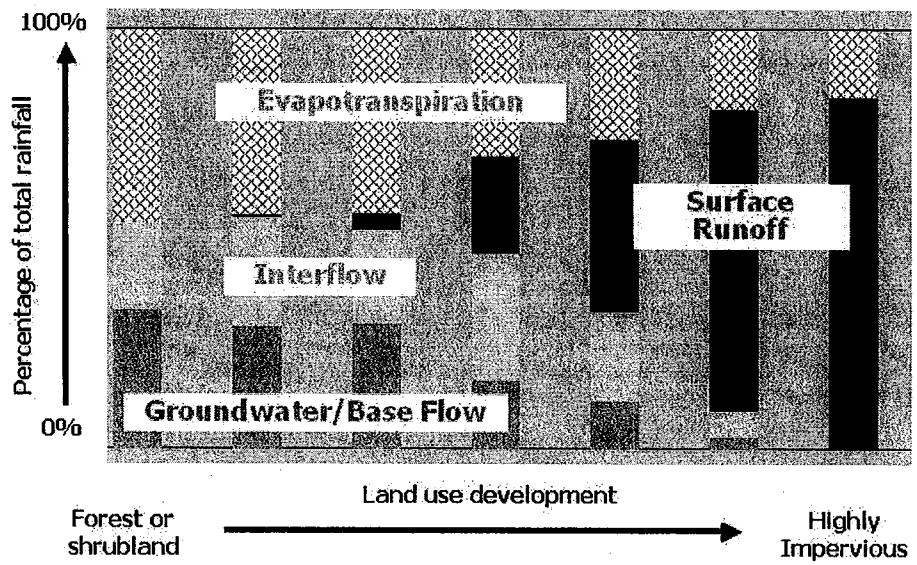


Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek Solutions.)

7.2 Hydromodification Management (HM) Controls

Hydromodification management (HM) measures can be grouped into three types:

- ***Integrated management practices***, or IMPs, which are small-scale, stormwater management techniques that are generally distributed throughout a project site. IMPs are designed to minimize directly-connected impervious areas, slow runoff, and maximize infiltration (where appropriate) as described in *Start at the Source* (BASMAA, 1999: www.cleanwaterprogram.org/uploads/SAS_Manual_index.pdf). IMPs may also include the use of bioretention areas, vegetated buffer strips, vegetated swales, roofs that detain water, and multi-functional landscape areas.

- ***Flow duration control measures*** are used to manage excess runoff from the site after IMPs are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes from stormwater collected in pipes and channels before the runoff is discharged to a natural channel that could suffer adverse effects. Examples include extended detention basins, wet ponds and constructed wetlands. Please note that there is a difference between the design approach for sizing measures to remove pollutants from stormwater and the approach for designing flow duration controls to prevent an increase in the potential for creek bank erosion. The treatment of stormwater pollutants targets capture of 80% of average runoff volume, which means that treatment measures will be bypassed every one to two years. Flow duration controls must be sized to control the statistical duration of a wide range of flow levels under simulated runoff conditions. Depending on pre-project and post project conditions, the required detention volume is ***likely to be greater*** than the capture volume required for treatment. Flow duration controls are typically used on-site, but larger facilities, such as detention basins, may be sized to control runoff from a regional drainage area.

> Flow duration control measures are sized to control the flow and duration of stormwater runoff according to a ***Flow Duration Control*** standard, which is often greater than size requirements for volume-based treatment.



- ***In-creek or restorative measures*** that modify susceptible watercourses to withstand projected increases in runoff flows and durations without increasing erosion or other impacts to beneficial uses. In-creek measures are more complicated to use than the IMPs and flow duration controls, and are best suited for creeks or channels that have ***already received impacts*** from previous development and have only localized channel instability. Examples include biostabilization techniques using roots of live vegetation roots to stabilize banks and localized structural measures such as rock weirs, boulder clusters or deflectors. These measures will not automatically provide HM protection for channel reaches farther downstream and may require longer planning timelines and cooperation among multiple jurisdictions compared to flow duration controls.

7.3 Hydromodification Management Plan (HMP) Requirements

The Water Board required the Countywide Program to prepare a hydrograph modification management plan, or ***"Hydromodification Management Plan" (HMP)*** in order to reduce erosive flows that result from increasing impervious surfaces in the watersheds of natural creeks. The Water Board is scheduled to adopt an amendment to the countywide municipal stormwater NPDES permit approving the HMP in March 2007. The HMP requirements will go into effect immediately, or as specified in the permit amendment.

HMP Management Objective

Key Point

The HMP's management objective is to control stormwater discharges from non-exempt development projects so that these discharges do ***not increase the erosion potential*** of the receiving creek over the pre-project (existing) condition. This will be accomplished by implementing four performance criteria:

- Projects shall ***provide hydromodification management (HM) controls*** as needed to maintain the pre-project creek erosion potential. These controls may include a combination of on-site or off-site (regional drainage area and/or in-creek) control measures. An erosion potential (Ep) of up to 1.0 shall be maintained for creek segments downstream of the discharge point. Ep can be expressed as the ratio of post-project to pre-project erosive "work" done on the creek.
- On-site stormwater controls that are designed to provide ***flow duration control*** to the pre-project condition shall meet the erosion potential management objective and comply with the HMP. Flow duration controls shall be designed so that the post-project stormwater discharge rates and durations match those of the pre-project condition, from 10 percent of the pre-project two-year peak flow up to the pre-project 10-year peak flow.

> Flow Duration Control looks at the full range of flows in a simulated long-term history, and is ***not directly comparable*** to approaches based on one or a few synthetic "design storms".

- ***Where on-site measures are impracticable*** for achieving flow duration control criteria, projects shall comply with the HMP requirements through the use of appropriate site design, source control and treatment control measures with flow control benefits to the maximum extent practicable. In addition, where available, off-site control measures must be used to meet the hydromodification management objective.
- Projects may use ***off-site control measures*** in lieu of or in combination with on-site controls, where an approved plan – including an appropriate funding mechanism – is in place and accounts for the creek changes expected to result from changes in project runoff conditions. The off-site control measures or combination of controls shall be designed to achieve the management objective of keeping the erosion potential (Ep) at 1.0 or less, from the point of discharge to the creek as far down stream as potential impacts will occur.

Map of Exempt Areas

The HMP includes a map showing areas that are exempt from the HMP requirements, due to their ***limited potential for hydromodification*** to occur. These areas were identified as exempt because they met at least one of following three criteria:

- Low-gradient bayside areas within or adjoining the tidal zone;
- Areas that are tributary to channel segments that have been hardened on all three sides and/or culverted continuously downstream to their outfall to low-gradient bayside areas or Pacific Ocean; and/or
- Highly developed areas with potential for infill projects.

The exempt areas tend to be ***heavily developed areas of the bayside***, while the more open and residential hillside, and coastside areas are subject to the HMP. Four municipalities – East Palo Alto, Foster City, Daly City, and Colma – are totally exempt, while all of the other municipalities have at least portions of their jurisdictions subject to the HMP.

Before they can be implemented, key provisions of the Program's HMP must be approved by the Water Board. Full implementation of the HMP will be required upon approval. Use this link, www.flowstobay.org/pdfs/New%20Development/HMP%20Report%20Final.pdf, to access the HMP on the Internet.

7.4 Determining Applicability



Unless it is listed as exempt in Table 7-1, your project will be required to comply with the HMP if it meets the following applicability criteria:

- The project creates one acre or more of new impervious surface.
- The project is not located in an exempt area, as shown on the HMP's map of exempt areas (included in Appendix J).

If your project will create one acre or more of impervious surface, the local municipality will use the map in Appendix J to determine whether it will need to comply with the HMP requirements. Specific types of projects are also exempt from the HMP requirements, as listed in Table 7-1. Please note that projects located in areas subject to the HMP should include appropriate integrated management practices (IMPs) for hydromodification management if they are likely to cause hydrograph changes, ***even if they do not meet the other applicability criteria.***

Table 7-1
Projects Exempt from HMP Requirements

1	The construction of a single-family residence that is not part of a larger plan of development (NOTE: the permit requires the project to use pollutant source control, site design, and landscaping to treat stormwater runoff from impervious surfaces.)
2	A redevelopment project that does not increase the amount of impervious surface and the time

Table 7-1 Projects Exempt from HMP Requirements	
	of concentration of stormwater runoff (NOTE: these projects should use appropriate integrated management practices (IMPs) to prevent the volume of runoff and time of concentration from increasing compared with the pre-project condition.)
3	A transit type of development within ¼ to ½ mile of a transit station and/or intermodal facility
4	A project within a "Redevelopment Project Area" that redevelops an existing brownfield site or creates housing units affordable to persons of low or moderate income.

7.5 How to Implement HMP Requirements

Projects subject to HMP requirements need to consider HM at every stage of project development, following the step-by-step instructions for C.3 submittals in Chapter 3. The most effective use of land and resources may require a combination of IMPs, flow duration control facilities and in-creek measures, which are described in Section 7.2. In general, the strategy for designing HM measures should:

- ***Start with site design*** to minimize the amount of runoff to be managed (see Chapter 4).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration is limited by site constraints such as slope stability concerns, low-permeability soils or groundwater protection constraints.
- Use ***flow duration controls*** to detain the remaining calculated runoff from the site enough to ***control its release*** in a way that meets the remaining runoff design requirements. This may be accomplished with a measure that also provides volume-based treatment, such as an extended detention basin. For some project locations, off-site options may be available to reduce or eliminate the need for onsite detention.

7.5.1 Flow Duration Control

Flow Duration Control (FDC) differs from traditional "design storm" approaches used to design detention facilities for flood control or water quality treatment. Instead of specifying static holding times for one or a few discrete events, the Flow Duration standard manages runoff discharge over the full range of runoff flow levels predicted through continuous hydrologic simulation modeling, based on a long-term precipitation record. Flow Duration Control requires that the increase in surface runoff resulting from new impervious surfaces be ***retained on-site with gradual discharge*** either to groundwater through infiltration, losses by evapotranspiration, and/or discharge to the downstream watercourse at a level below the critical flow that causes creek channel erosion. ***Critical flow,*** or Qc, is the lower threshold of in-stream flows that contribute to sediment erosion and sediment

Key Point

The duration of channel flows below the ***"critical flow"*** may be increased indefinitely without significant contribution to hydromodification impacts.

transport or effective work. The duration of channel flows below Qc may be increased indefinitely without significant contribution to hydromodification impacts.

7.5.2 Application of Flow Duration Control to Project Areas

The Flow Duration approach involves a continuous model that applies a time series of at least 20 years of rainfall records to a watershed area or project site to generate a simulated stormwater runoff record based on two sets of inputs, one representing future development and the other representing pre-project conditions. The 20-year precipitation record is the minimum length necessary to capture the range of runoff conditions that are cumulatively responsible for most of the erosion and sediment transport in the watershed, primarily flow levels that would recur at average intervals of 10 years or less in the pre-project condition. The design objective is to ***preserve the pre-project cumulative frequency*** distribution of flow durations and sizes under post-project flows. This is done with a combination of site design, infiltration and detention. Typically the post-project increase in surface runoff volume is routed through a ***flow duration control basin*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4).

The flow duration basin, tank or vault is designed conceptually to incorporate multiple pools that are filled with different frequencies and discharge at different rates. The low-flow pool is the bottom level designed to capture and retain small to moderate size storms, the initial portions of larger storms, and dry weather flows. These flows are discharged through the lowest orifice which allows continuous ***discharge below the critical flow rate*** for a project (Qcp). Successively higher-flow pools store and release higher but less frequent flows through other orifices or graded weir notches to approximate the pre-project runoff durations. In practice the multiple pools are usually integrated into a single detention basin, tank or vault that works as a unit with the specialized outlet structure. Matching the pre-project flow durations is achieved through fine-tuning of the number, heights and dimensions of orifices or weir notches, as well as depth and volume of the basin, tank or vault.

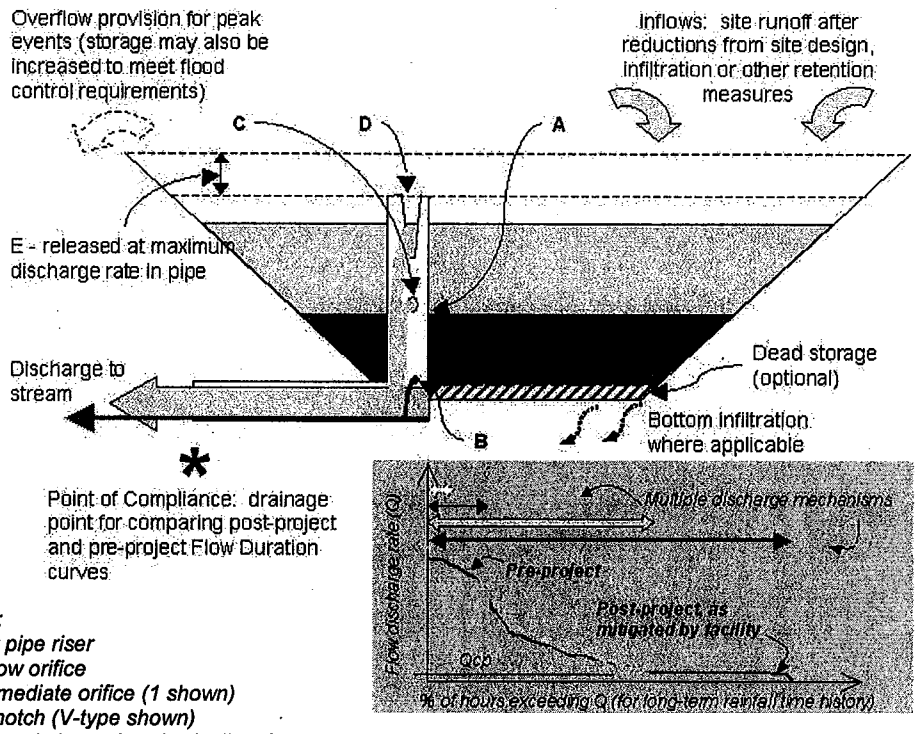
As shown in the example chart of Figure 7-4, the post-project flow duration curve (red, or dark line) is reduced by the facility to remain ***at or below the pre-project curve*** (yellow, or light line), except for flows less than Qcp. Minor exceedances are permissible at a limited number of higher flows since at other flow levels the post-project duration is actually less than the pre-project condition.

Flow Duration facilities are subject to ***Operations and Maintenance*** reporting and verification requirements similar to those for numerically sized treatment measures.

Try this!



If feasible, ***combining flow duration and water quality treatment*** into a single facility reduces the overall land requirements for stormwater management. Adequate maintenance of the low-flow orifice or notch is critical to proper performance. The outlet may be in a protective enclosure to reduce risk of clogging. Please note that Flow Duration facilities are subject to Operations and Maintenance verification requirements similar to those for numerically sized treatment measures.



Legend:
A-outlet pipe riser
B-low flow orifice
C- intermediate orifice (1 shown)
D-weir notch (V-type shown)
E-freeboard above riser (typically 1 foot)

Figure 7-4: Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume. (Source: ACCWP, 2006)

7.5.3 Bay Area Hydrology Model (BAHM)

To facilitate the simulation modeling aspect of FDC for project applicants and their engineers, the Countywide Program collaborated with the Santa Clara and Alameda counties' stormwater programs to develop a Bay Area Hydrology Model ***software package*** that is adapted from Version 3 of the Western Washington Hydrology Model (WWHM) developed by Clear Creek Solutions for the State of Washington Department of Ecology (WDOE). The WWHM was specifically developed to help engineers design facilities to meet a Flow Duration Control standard for development projects.

Key Point

The BAHM, which may be downloaded from the Program's website together with county-specific data, includes:

- Databases to automatically assign default ***rainfall conditions*** for a project location selected within the County boundary.
- A user interface for developing a ***schematic drainage model*** of the project site, with forms for entering areas of land use or impervious surface for multiple sub-basins.

- Continuous simulation modeling of ***pre-project and post-project runoff*** from the site using actual long-term rainfall records appropriately scaled for the project location.
- A design module for sizing a ***FDC detention facility*** and designing the discharge structure to meet the Flow Duration standard for matching post-project and pre-project duration-frequency curves. Pre-project and post-project runoff are compared at a "point of compliance" selected by the designer, usually near the point where runoff leaves the project area.
- Options to check facility sizing for ***volume-based treatment***, and incorporate runoff reductions attributable to some common hydrologic source control measures.
- Standardized output ***report files*** that can be saved in Word format, and include all information about data inputs, model runs, facility design, and summary of the hydrological statistics showing the compliance of post-project flow duration curves with the Flow Duration standard. Project input and output data can also be saved in Excel and other formats for other uses.

7.6 Area-Specific HM Provisions



Individual municipalities may have special policies or ordinances for creek protection applicable in all or part of their jurisdictions. ***Contact the municipal staff from your jurisdiction*** to identify any special local provisions that may encourage or affect specific forms of HM implementation. Examples of area-specific HM provisions can include:

- Watershed-based land-use planning measures, such as creek buffers, which may be incorporated in local General Plans, zoning codes or watercourse ordinances.
- Special permitting provisions for project design and review of projects on streamside properties.
- Specific plans for regional HM measures or in-stream restoration projects.
- Any Equivalent Limitation Protocols that may be proposed, in accordance with Provision C.3.f.vii of the municipal stormwater permit, as alternatives to the default HM requirements in specific jurisdictions or watersheds.

> Individual municipalities may have special policies or ordinances for ***creek protection*** applicable in all or part of their jurisdictions.

Pacific Institute: Sea-Level Rise - Mozilla Firefox

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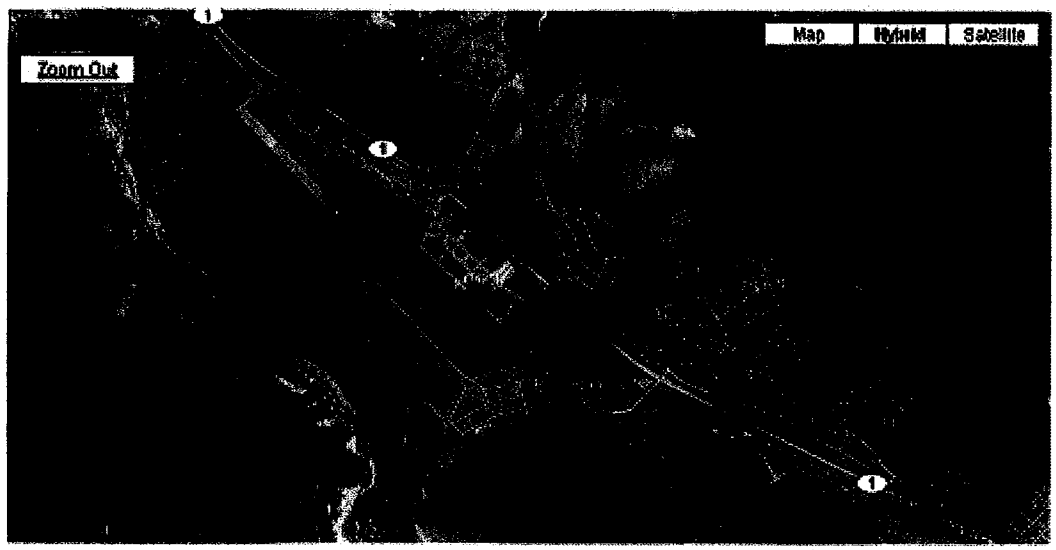
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Impacts of Sea Level Rise on the California Coast

Pacific Institute

Areas and infrastructure vulnerable to flooding and erosion

Please see full report for assumptions, methods, and conclusions.



Hazard Zones

- ☑ Area at risk from a 100-year coastal flood event
  - Current area at risk
  - Area at risk with a 1.4 meter sea-level rise
- ☐ Erosion
  - Area at risk from erosion in 2100 with a 1.4 meter sea-level rise
- ☐ Wetland Frontier
  - Areas where wetlands may migrate by 2100 if unimpeded

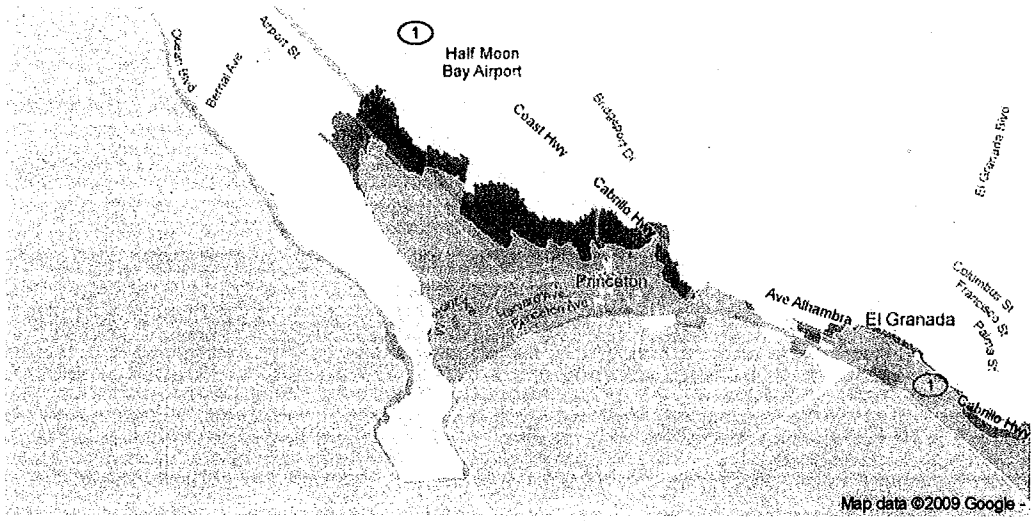
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Impacts of Sea Level Rise on the California Coast

Areas and infastructure vulnerable to flooding and erosion
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Pacific Institute

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Data Layer Opacity

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Infrastructure at Risk

Click map icon for details

- ☐ CA Coastal Zone
- ☐ Health-care facilities
- ☐ Schools
- ☐ Police stations
- ☐ Fire stations
- ☐ Wastewater treatment plants
- ☐ EPA-regulated sites

Disclaimer

This information is being made available for informational purposes only. Users of this information agree by their use to hold blameless the State of California, and its respective officers, employees, agents, contractors, and subcontractors for any liability associated with its use in any form. This work shall not be used to assess actual coastal hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

State of California
Department of Fish and Game

Flex your POWER

Memorandum

Date: October 15, 2009

To: Mr. Charles Fielder, District 1 Director
CA Department of Transportation – District 1
Post Office Box 3700
Eureka, CA 95502-3700

From: for Kenneth L. Moore
GARY B. STACEY, Regional Manager
Northern Region, Department of Fish and Game
601 Locust Street
Redding, CA 96001

Subject: **Eureka – Arcata Corridor Improvement Project – Draft EIR/EIS SCH # 2001092035 –Impacts Related to Sea Level Rise and Climate Change**

On July 3, 2009, the California Department of Fish and Game (DFG) received a request from your agency for comments and concurrence on the preliminary Least Environmentally Damaging Practicable Alternative (LEDPA) determination for the proposed Route 101 Eureka-Arcata Corridor Improvement Project (project). On July 21, 2009, DFG received a draft prospectus for a Humboldt Bay Transportation Mitigation Bank, which includes a conceptual wetland mitigation plan for this project.

As a trustee for the State's fish and wildlife resources, DFG has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants and the habitat necessary to sustain their populations. As a responsible agency, DFG administers the California Endangered Species Act (CESA) and other provisions of the Fish and Game Code that afford protection to the State's fish and wildlife public trust resources. While DFG is not a signatory agency to the National Environmental Policy Act and Clean Water Act Section 404 process, the refinement of the scope of the project to LEDPA Alternative 3(a), is an appropriate opportunity for DFG to provide additional comments and recommendations regarding impacts on Humboldt Bay habitats and species under the most recent sea level rise (SLR) scenarios. DFG is currently reviewing the wetland bank prospectus and comments on it will be included in a separate memorandum.

DFG has written two previous memoranda on this project, including one on the Draft Environmental Impact Report/Statement (DEIR/S). DFG Staff Environmental Scientists Craig Martz and Gordon Leppig have also attended a number of meetings with Department of Transportation (Caltrans) and wildlife agency staff to review potential environmental impacts and mitigation measures for this project.

DFG offers these comments pursuant to the California Environmental Quality Act (CEQA) in our role as a responsible and trustee agency for California's fish and wildlife.

Project Scope

According to the LEDPA determination, major project features may include: closing all Route 101 median openings; extending acceleration and deceleration lanes at existing intersections; constructing a Route 101/Indianola Cutoff interchange; realigning and signalizing Airport Road at Route 101; constructing an additional lane from the existing Cole Avenue acceleration lane to the Mid City Motor World entrance; replacing the bridge rails on the northbound Jacoby Creek and Gannon Slough Bridges; and replacing the southbound Jacoby Creek Bridge. The total estimated project cost ranges from $39 million to $62 million.

The project includes a section of highway approximately 10 kilometers (six miles) long. National Oceanic and Atmospheric Administration tide station elevation data indicates land within or adjacent to a majority of the project site's length is below year 2000 mean higher high water (MHHW) tidal elevation and a projected 1.4-meter sea level rise places nearly the entire project area below Humboldt Bay's MHHW. The MHHW is a 19-year average of the higher of the two daily high tides.

Nearly all of the project area is former tidal saltmarsh or intertidal mudflat. Open water in the form of sloughs, streams, and tidal drainage canals, or coastal wetlands, including subtidal mudflat, saltmarsh, brackish marsh, and freshwater palustrine wetlands occur directly adjacent to the majority of the project's length. The Humboldt Bay National Wildlife Refuge borders the project site to the north and east for approximately four kilometers (2.5 miles) and the DFG Fay Slough Wildlife Area borders the project site to the south-southeast for approximately two kilometers (1.25 miles).

Project Setting and Biological Significance of Humboldt Bay

Humboldt Bay is California's second largest estuary and provides regionally significant fish and wildlife habitat. Humboldt Bay provides refuge and nursery habitat for more than 120 fish species, many with important commercial and recreational fisheries value. Humboldt Bay is also a biodiversity hotspot in that its wetlands and dunes are habitat for at least 20 State-and federally-listed or otherwise sensitive species. Humboldt Bay is also California's largest producer of oysters and a vital nursery for juvenile Dungeness crab (*Cancer magister*).

Jacoby Creek is habitat for the State and federal "threatened" coho salmon (*Oncorhynchus kisutch*), as well as coastal cutthroat trout (*Oncorhynchus clarki clarki*), a California species of special concern; steelhead trout (*Oncorhynchus mykiss*) a federal "threatened" species; and tidewater goby (*Eucyclogobius newberryi*) a federal "endangered" species and California species of special concern. Longfin smelt (*Spirinchus thaleichthys*), a State "threatened" species, is documented in Humboldt Bay and its major tributaries. Areas within the project site, including Jacoby Creek, appear to provide habitat for this species.

The coho salmon population in Jacoby Creek has been designated by DFG as a key population to maintain or improve as part of the *Recovery Strategy of California Coho Salmon* (DFG 2004). Coho salmon have undergone at least a 70% decline in abundance since the 1960s, and is currently at 6 to 15% of its abundance during the 1940s (DFG 2004).

Humboldt Bay contains more than half of all the native eelgrass (*Zostera marina*) in California. Native eelgrass beds are highly productive nurseries and refuge areas that are widely recognized for their critically important ecological function in Pacific Northwest estuaries (Phillips 1984). The Pacific Flyway population of black brant (*Branta bernicla*) is dependent upon the eelgrass in Humboldt Bay because it has the greatest amount of eelgrass between the black brant wintering areas in Baja California and Willapa Bay in Washington. Native eelgrass may not be cut or disturbed (Title 14, California Code of Regulations §30.10) and is considered Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act.

More than two hundred species of birds have been recorded in the north Humboldt Bay area, including a wide variety of wetland, riparian and migratory species. The coastal wetlands around Humboldt Bay are essential habitat for shorebirds and more than one hundred thousand shorebirds winter in or migrate through Humboldt Bay annually (Galbraith et al., 2002; WHSRN 2009). Humboldt Bay, combined with the Eel River delta, is recognized as a site of national and international importance for shorebirds by the Western Hemisphere Shorebird Reserve Network (WHSRN 2009) and is used by greater than 10% of Pacific Flyway shorebirds.

Climate Change-Induced Sea Level Rise (SLR)

Information presented below is guided by the analysis and conclusions of the Intergovernmental Panel on Climate Change (IPCC 2001), U.S. Global Change Research Program (USGCRP 2009), and reports produced by the California Energy Commission for the California Climate Change Center (CEC 2005, 2009a, 2009b, 2009c). The research funded and produced by the California Energy Commission is the leading authoritative body of work on direct and indirect climate change effects on the

State's resources, infrastructure and economy. SLR is of significant concern to the State's leadership and in November 2008 the Governor signed Executive Order S-13-08 to create the first state-wide SLR assessment report to advise how California should plan for future SLR, as well as initiating the State's first climate change adaptation planning effort.

During the last 100 years, globally-averaged sea level has risen approximately 10 to 20 centimeters (approximately 4 to 8 inches), or about 1.0 to 2.0 millimeters/year (IPCC 2001). Tidal gauge data for California and the west coast of the United States have shown a similar trend in SLR during this period (CEC 2005). Current scenarios for the California coast project an increase in sea level from 1.0 to 1.4 meters (approximately 3.2 to 4.6 feet) by the year 2100 (CEC 2009a). Current SLR scenarios are roughly linear throughout their projected horizon, thus approximately half of the anticipated 2100 sea level rise is likely to occur by year 2050 (CEC 2009a).

Global warming is expected to result in an acceleration of current rates of SLR, resulting in inundation of many low-lying coastal areas (IPCC 2001; CEC 2005, 2009a; Nicholls and Tol 2006; USGCRP 2009). Throughout the current century, coastal areas worldwide are expected to experience higher rates of coastal erosion, flooding, inundation, and storm surges as a result of SLR (EPA 1988; IPCC 2001; CEC 2005, 2009a; USGCRP 2009). There is strong scientific consensus that coastal marine ecosystems, along with the goods and services they provide, are threatened by climate change-induced SLR (IPCC 2001; Scavia et al., 2002; Harley et al., 2006; Nicholls and Tol 2006; CEC 2009a; USGCRP 2009). By the 2080s, sea level rise could cause the loss of up to 22% of the world's coastal wetlands, according to a global analysis done by Nicholls et al., (1999).

The most recent and authoritative synthesis of future climate change and SLR scenarios and anticipated consequences for California come from the California Climate Change Center (CEC 2005, 2009a, 2009b, 2009c); some of their key findings include:

- During the last 100 years, sea level has risen nearly eight inches along the California coast, and general circulation model scenarios suggest very substantial increases in sea level as a significant impact of climate change over the coming century.

- Under medium to medium-high greenhouse-gas emissions scenarios, mean sea level along the California coast is projected to rise from 1.0 to 1.4 meters (approximately 3.2 to 4.6 feet) by the year 2100.

- National studies on the economic cost of sea-level rise suggest that while adapting to climate change will be expensive, so are the costs of doing nothing, as substantial investments are already at risk and vulnerable.

- Sea level rise must be integrated into the design of all coastal structures.

- Current efforts to build, maintain, or modify structures in coastal areas at risk of sea-level rise must be based on current estimates of a projected 1.4-meter sea level rise by the year 2100.

This project includes the replacement of the southbound Route 101 Bridge over Jacoby Creek and construction of a Route 101/Indianola Cutoff interchange. Caltrans currently designs bridges and overpasses with a 75-year design life (AASHTO 2007). Given a 75-year design life for these structures, if construction of this project is not scheduled to be completed until 2015, then the project life-span squarely overlaps with current SLR projections for this century.

Climate change, and consequent SLR, is principally driven by greenhouse gas (GHG) emissions (IPCC 2001). Given current and on-going state, national, and international efforts, GHG emissions during coming decades could be substantially reduced and climate change scenarios modified accordingly. However, even if GHG emissions are stabilized, the rate of SLR will likely continue to increase beyond 2100 because of the time it takes for oceans and ice sheets to approach equilibrium with the atmosphere (Scavia et al., 2002; CEC 2009a).

Changes in the rate of SLR at a given site will vary from global averages based upon local and regional variability in tectonic uplift, land subsidence, post-glacial isostatic rebound, compaction of sedimentary soils, and oil, natural gas, and water withdrawal (EPA 1988; Galbraith et al., 2002; Scavia et al., 2002).

Increased sea levels, especially in combination with storm-driven surges, extreme waves, intense low-pressure autumn or winter storms, high tides, and El Niño conditions, are predicted to result in extensive flooding in coastal regions of California and the Pacific Northwest and significant damage to coastal infrastructure (CEC 2005; USGCRP 2009). Kelvin waves, for instance, are generated in the tropical western Pacific during El Niño events and can intensify the impact of Northcoast winter storms. These waves move northward up the California coast bringing an influx of warm water and raising sea level by 15-25 cm (6-10 inches) as they pass (CEC 2005). The wave climate at Humboldt Bay is currently described as "extreme" in comparison to most inlets in the United States, and the Bay's orientation combines with prevailing winds to produce significant wind-generated waves within the Bay (Costa and Glatzel 2002; Claasen 2003).

In an analysis of 140 years of tidal data from central California, Bromirski et al., (2003) found that since about 1950, California has experienced a significant increasing trend in extreme winter storms resulting in extreme high sea level residuals. Intense storm events cause the greatest coastal erosion and have the greatest impact on coastal

development (Bromirski et al., 2003). In the past two decades, California has experienced significant increases in annual maximum wave heights and in the number of waves classified as extreme as a result of more intense El Niño events (Seymour 2003). The lower sloughs of the largest bay tributaries presently experience seasonal fluctuations in tidal height of up to 3 meters (Wallace and Allen 2009).

Despite considerable uncertainty in State-wide climate model predictions (CEC 2009b), regional climate studies project an increase in the frequency and intensity of high precipitation and high runoff storm events in Northern California and the northern Coast Range in the next 50 years (Kim et al., 2002; Snyder et al., 2002; Bell et al., 2004; Kim 2005; CEC 2009c). By projecting changes in streamflow output for eighteen stream gauging stations statewide, California Energy Commission scenarios show all California rivers studied will have an increase in average flow during January to April by the end of the century (years 2070–2099) compared to historical periods (CEC 2009c). Projections under certain high greenhouse gas emission scenarios predict spikes in February river flows of 60% above historic levels, and increases in December river flows of 20% to almost 40% in other scenarios (CEC 2009c).

Climate models predict the number of occasions when high sea levels and high river flows coincide will increase markedly in this century (CEC 2009b). According to CEC (2009b), "The combined impacts of sea level rise (and high sea-level stands) with concurrent flood flows have the potential to imperil many smaller coastal and estuarine settings and communities along the California coast."

According to CEC (2009a), to guard against flooding from a 1.4-meter sea level rise, Humboldt County will need an estimated 58 kilometers (36 miles) of new levees and 10.6 kilometers (6.6 miles) of new seawalls, with an estimated capital cost of $460 million (in year 2000 dollars). State wide, the estimated capital cost to guard against flooding from a 1.4-meter sea level rise will be $14 billion (in year 2000 dollars) (CEC 2009a).

According to the National Research Council (1987) and Nicholls and Tol (2006), the main environmental effects of SLR on coastal communities include:

- Inundation and flooding including storm damage from sea surges and backwater effects from rivers and steams,
- Wetland loss and change,
- Beach and shoreline erosion,
- Saltwater intrusion to surface waters and groundwater, and
- Rising water tables and impeded drainage.

According to the National Research Council (1987), there are two major options for addressing flooding and erosion caused by SLR:

- stabilize the shoreline either through beach nourishment or by new or augmented coastal armoring, or

- retreat from the shoreline, maintaining a more-or-less equal elevation above local sea level.

Potential Indirect Project Impacts and Ecosystem Interactions

Given the State-wide efforts to incorporate climate change into all levels of State Government planning activities, and Caltrans' specific role in the statewide adaptation planning effort, DFG is concerned this project's DEIR/S, Draft Biological Assessment, and LEDPA determination include no mention of SLR, despite the project's large size, significant cost, and close proximity to current sea level.

While the project description includes no SLR adaptation strategy, it is reasonable to assume that future abandonment of this section of highway is not being considered. Therefore, new or augmented armoring can be anticipated during the life of the project. According to the Humboldt Bay Management Plan Final EIR (HBHRCD 2006), "While the appropriate solutions to the quandaries posed by sea level rise are currently not known, these solutions almost certainly will involve placing fill into the bay's waters and/or into other wetlands behind the levees."

According to the preliminary recommendations in the 2009 California Climate Adaptation Strategy Discussion Draft (California Natural Resources Agency 2009):

> "State agencies should generally not plan, develop, or build any new significant structure in a place where that structure will require significant protection from sea-level rise, storm surges, or coastal erosion during the expected life of the structure. However, vulnerable shoreline areas containing existing and proposed development that have regionally significant economic, cultural, or social value may have to be protected, and in-fill development in these areas should be accommodated."

The Eureka-Arcata 101 Corridor is currently prone to overtopped levees, coastal erosion and flooding. The railroad levee, which follows the project site to the west, occurs between Humboldt Bay and the highway and has been out of use and unmaintained for more than a decade. This levee is currently ineffective in protecting the proposed project alignment from erosion, storm surges, and flood inundation. A storm on New Year's Eve 2005/2006 caused Humboldt Bay's surface elevation to overtop the railroad levee and partially

inundate the southbound lanes of Highway 101. Erosion of the ballast material from beneath the rails locally has reduced the effective levee height by as much as a foot in some locations, potentially increasing the risk of future flooding on the project site because of increased tidal elevations (HBHRCD 2006).

Based upon the above climate change and SLR data and the project's size, location, design life, and reasonable foreseeable adaptation strategy, there is a fair argument this project could have the following significant impacts on the Humboldt Bay ecosystem:

Direct Loss and Impacts to Wetlands

Much of the project site is directly adjacent to wetlands. Given the project site's current and accelerating risk of erosion and flooding, it is reasonably foreseeable that construction or reconstruction of armoring such as seawalls, levees, or rock slope protection is likely to result in wetland loss. As a result of SLR-related armoring, this project's wetland impacts are likely greater than those disclosed or evaluated by the project's current environmental documents. DFG believes further losses of Humboldt Bay saltmarsh should be considered cumulatively significant given diking and filling have already reduced bay saltmarsh habitat by 85 to 90% since 1897 (Barnhart et al.,1992).

The final EIS/EIR must evaluate the impacts to wetlands from the anticipated armoring and wetland filling needed to protect the project from SLR-related flooding and damage during its design life.

Indirect Habitat Loss by Prevention of Landward Migration

Coastal wetlands and subtidal habitats can adjust to changes in sea level when they are capable of remaining at the same elevation relative to the tidal range (EPA 1988; NOAA 2000). This can occur if sediment buildup (accretion) equals the rate of relative SLR or if the wetland is able to migrate landward (NOAA 2000; Morris et al., 2002; Scavia et al., 2002; CEC 2009a). If wetlands are unable to keep pace with relative SLR, or if their migration is blocked by coastal development or shoreline protection structures, then it will become immersed and eventually lost as rising seas submerge it (Titus 1991; NOAA 2000; Galbraith et al., 2002; CEC 2009a). The greatest loss and ecological impacts to intertidal habitats from future SLR is likely to occur at sites where the tidal zone is not allowed to migrate inland either by topography or by coastal protections such as seawalls, roads, and other infrastructure (Galbraith et al., 2002).

Humboldt County ranks third among California counties for total area of existing coastal wetlands, and second among California counties for both percentage and total area of coastal wetlands that can viably migrate upslope as a result of rising sea level (CEC 2009a). Of the approximately 52 square kilometers (20 square miles) of potential

coastal wetland migration area in Humboldt County, 39% is viable wetland habitat post-SLR (undeveloped), and an additional 54% is viable but with some economic loss to property owners (CEC 2009a). At least 7.8 square kilometers (three square miles) of potential wetland and intertidal mudflat migration area lies landward (east-southeast) of the project site.

Galbraith et al., (2002) conducted an analysis of the loss of intertidal shorebird habitat in Humboldt Bay based upon lower SLR estimates found in EPA (1995). Their model predictions assume that no new coastal protection structures will be installed. They project that by 2100, Humboldt Bay will lose approximately 29% of its intertidal habitat. This scale of habitat loss is highly likely to impair Humboldt Bay's ability to continue to support its current number of shorebirds (Galbraith et al., 2002). Under current SLR scenarios, this project has the potential to block the landward migration of saltmarsh and subtidal mudflats, and must be addressed in the final EIR.

Alterations to Humboldt Bay's Hydrology and Physical Processes

Construction of coastal armoring such as seawalls modifies waves that interact with them causing wave refraction, reflection, and changes in energy patterns (Sylvester and Hsu 1993). This in turn can alter numerous physical processes in the Humboldt Bay, including: circulation patterns; sediment transport and rates and patterns of deposition/accretion; current patterns and velocity; tidal exchange, mixing, and timing; and ultimately, Humboldt Bay's bathymetry (depth and topography) and shoreline erosion patterns and intensity (Sylvester and Hsu 1993; Claasen 2003).

These alterations to Humboldt Bay's physical processes are likely to affect wetland and intertidal habitats and their vital fisheries and wildlife values. Changes in marine and estuarine physical processes can affect, for instance, Humboldt Bay's ecological keystone eelgrass beds (*Zostera marina*). Eelgrass is sensitive to alterations in estuarine processes such as water depth, turbidity, substrate size and sorting, and current velocities (Phillips 1984).

The project's potential impacts on Humboldt Bay's sediment transport and deposition patterns, and erosion patterns and rates, combined with impediments to habitat migration are also likely to impact habitat for saltmarsh plants such as Humboldt Bay owl's clover (*Castilleja ambigua* var. *humboldtiensis*) and Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris*), both of which are present on the project site. Humboldt Bay owl's clover and Point Reyes bird's beak are listed by the California Native Plant Society (CNPS) as 1B species and have a State rank of S2.2. DFG believes these species meet the criteria of rare as provided by CEQA Guidelines Section 15380. Adverse impacts to these species could potentially constitute a significant effect on the environment.

Given the importance of the fish and wildlife habitat within and adjacent to the project site and the potentially significant SLR-related adaptation (armoring) impacts on Humboldt Bay's physical processes, DFG recommends the final EIR include these impacts in its environmental analysis.

Flooding

The DEIR/S states "Most of the existing Route 101 roadway and bridges within the project limits are either adjacent to, or within the 100-year floodplain. Any improvements to this facility to avoid floodplain encroachment would not be feasible."

The DEIR/S (pages 164-165) states: 1) the proposed drainage improvements for this project will result in no decrease in capacity, 2) the proposed work would not have a substantial effect on base flood elevations, and 3) there would be no increase in flooding risks because of this project.

However, the environmental analysis for this project does not utilize the most current (CEC 2009a; 2009b) climate change and SLR projections to determine the project's hydrologic impacts on the flooding regime and drainage capacity of adjacent wetlands and streams. Periodic flooding is an essential characteristic of wetlands (Titus 1991). In all floodplains, hydrology is a major driving ecological force and changes in the amplitude, duration, shape, frequency, and timing of flood events can have significant consequences for wetland habitat quality and biodiversity (Junk and Wantzen 2006).

As stated in DFG's September 28, 2007 memorandum, the Jacoby Creek Route 101 bridges and the railroad crossing immediately downstream currently constrict flood flows on Jacoby Creek, resulting in channel aggradation and backwater flooding upstream. The project design remains unclear as to whether the new southbound Jacoby Creek bridge design will result in increased channel capacity. The DEIR/S does not indicate the return frequency of the discharge the new Jacoby Creek structure will be designed to pass.

A recommended management action for North Coast estuaries is to assure adequate tidal circulation in estuarine restoration or enhancement projects through levee removal or setback, tidegate removal, and tidal circulation improvement (Waterboards 2009). An inadequate tidal prism has been identified as a principal limiting factor in a number of Humboldt Bay saltmarsh restoration projects. Without utilizing the most current 2100 SLR hydrologic projections, Caltrans cannot adequately evaluate what effect this project will have on adjacent floodplain hydrology and biodiversity, including the tidal circulation of existing, on-going, and future wetland, estuarine and riparian restoration projects.

The Recovery Strategy for California Coho Salmon (DFG 2004) includes the following specific watershed recommendations to promote coho salmon recovery in the Humboldt Bay Hydrologic Unit:

- work with agencies and landowners to re-establish estuarine function,
- maintain and restore a functioning flood plain and natural channel processes where practicable, and
- maintain functional riparian habitat.

The *Humboldt Bay Watershed Salmon and Steelhead Conservation Plan* (RCAA 2005) identifies a lack of estuary habitat as a limiting factor for steelhead trout in Jacoby Creek. Specific habitat goals for Jacoby Creek include the restoration of floodplain and estuarine processes that benefit salmonids (RCAA 2005).

We reiterate here the concerns expressed in DFG's 2007 memorandum, that to benefit future riparian, floodplain, and wetland functions adjacent to the project site, the Jacoby Creek bridge and all of the project's other stream crossings and drainage facilities should provide adequate channel or flow capacity based upon calculations using current SLR and climate change projections. By using the most current SLR and climate change projections, the project will have the highest likelihood of protecting and maintaining adjacent wetland and riparian habitats and preventing project structures from impeding flow and becoming bottlenecks during high flow or high tide events.

Without incorporating SLR into the hydrologic analysis of this project, it is difficult to assess with a high degree of confidence the project's impacts on the numerous State- and federal-listed fish species documented as occurring in the project area.

Humboldt Bay Sea Level Rise Adaptation Strategy

The integration of SLR into the design of coastal structures and local coastal plan and general plan updates is currently recommended by the State (CEC 2009a; California Natural Resources Agency 2009). However, effective adaptation to climate change and sea level rise requires a coordinated regional or community-level planning approach (see for example van Aalst et al., 2008). This is especially important when the area at risk is covered by multiple plans implemented by numerous local, State, and federal agencies. Therefore, DFG recommends Caltrans participate in a Humboldt Bay SLR adaptation planning process with agencies such as the Humboldt Bay Harbor, Recreation, and Conservation District; the Cities of Arcata and Eureka; the County of Humboldt; the North Coast Regional Water Quality Control Board; DFG; the National Marine Fisheries Service; and the U.S. Fish and Wildlife Service, among others. While the process to develop an adaptation strategy is not currently underway, DFG encourages its establishment, looks forward to participating, and anticipates it will soon begin.

Conclusions

Based upon the most current, reasonably foreseeable and State-adopted SLR scenarios, DFG makes a fair argument supported by substantial evidence that this project is likely to have significant environmental impacts that are not analyzed or addressed in its current CEQA documents. Furthermore, this project does not appear to comply with State recommendations that SLR be integrated into the design of all coastal structures (CECa 2009).

The ecological impacts of SLR and its engineering implications for coastal ecosystems and structures have been well known for over 20 years (EPA 1988; National Research Council 1987). Likewise, local agencies in California and elsewhere have incorporated SLR into coastal development for more than 20 years. By 1987, California's Bay Area Conservation and Development Commission was requiring an additional one foot of elevation on any newly reclaimed land in San Francisco Bay, based on a scenario of a one-foot rise in fifty years (EPA 1995). Reclamation in Hong Kong also includes a safety margin for accelerated sea level rise, as do the design of new seawalls in eastern Britain and the Netherlands (EPA 1995).

DFG recommends this project's Final EIR evaluate how this project will adapt to SLR. While adaptation options are reasonably foreseeable, they need not be undertaken in the current project. However, given that potentially significant indirect environmental impacts from such adaptations are reasonably foreseeable, they should be evaluated during the current environmental review for this project.

According to CEQA Section 15378(a), the definition of a project includes, "...a reasonably foreseeable indirect physical change in the environment." DFG believes this project's impacts on coastal wetlands and marine, brackish, and freshwater species in Humboldt Bay, when analyzed using current SLR and climate change scenarios are both reasonably foreseeable and significant.

Specific Recommendations

1) The project's bridges, culverts and other drainage facilities should be evaluated and designed to provide adequate channel or flow capacity based upon calculations using current year 2100, 1.4-meter SLR and climate change hydrology projections.

2) The final EIR should describe and evaluate the following potential direct and indirect SLR-related impacts:

    a) How and where will the project be protected from SLR-induced flooding, inundation, and erosion, and what impacts or loss will this protection have on intertidal, wetland, riparian, and other sensitive habitats and the species that depend on them?

b) Under a 1.4-meter year 2100 SLR scenario, what is the project's potential to block the landward migration of saltmarsh and intertidal habitat?

c) How will the project's new and augmented armoring such as seawalls and rock-slope protection affect the Humboldt Bay's hydrology and physical processes?

d) The hydrology and floodplain evaluation (Section 3.2.1) should be revised to evaluate the project's floodplain impacts in relation to year 2100, 1.4-meter SLR and climate change hydrology projections.

Thank you for the opportunity to provide comments on this project. For questions or additional information, contact Staff Environmental Scientist Gordon Leppig at 441-2062 or via e-mail at gleppig@dfg.ca.gov.

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FIRST AMENDMENT TO AGREEMENT BETWEEN THE COUNTY OF SAN MATEO AND CHRISTOPHER A. JOSEPH & ASSOCIATES

THIS FIRST AMENDMENT TO THE AGREEMENT, entered into this _____ day of _____, 20_____, by and between the COUNTY OF SAN MATEO, hereinafter called "County," and Christopher A. Joseph & Associates, hereinafter called "Contractor";

W I T N E S S E T H:

WHEREAS, pursuant to Government Code, Section 31000, County may contract with independent contractors for the furnishing of such services to or for County or any Department thereof; and

WHEREAS, on December 5, 2006, the parties entered into an Agreement for environmental consulting services for the preparation of Draft and Final Environmental Impact Reports (EIR) for the Big Wave project; and

WHEREAS, the parties wish to amend the Agreement to add additional funding in the amount of $137,700 and extend the term to June 30, 2010,

NOW, THEREFORE, IT IS HEREBY AGREED BY THE PARTIES HERETO AS FOLLOWS:

1. Paragraph 3, Payments, is amended in its entirety to read as follows:

   In consideration of the services provided by Contractor in accordance with all terms, conditions and specifications set forth herein and in Exhibit "A," County shall make payment to Contractor based on the rates and in the manner specified in Exhibits "B," "C," "D" and "E." The County reserves the right to withhold payment if the County determines that the quantity or quality of the work performed is unacceptable. In no event shall the County's total fiscal obligation under this Agreement exceed Three Hundred Forty-Two Thousand One Hundred Two Dollars ($342,102).

2. Paragraph 4, Term and Termination, is amended in its entirety to read as follows:

   Subject to compliance with all terms and conditions, the term of this Agreement shall be from December 5, 2006 through June 30, 2010.

   This Agreement may be terminated by Contractor, the Director of Community Development or his/her designee at any time without a requirement of good cause upon thirty (30) days' written notice to the other party.

   In the event of termination, all finished or unfinished documents, data, studies, maps, photographs, reports, and materials (hereafter referred to as materials) prepared by

Contractor under this Agreement shall become the property of the County and shall be promptly delivered to the County. Upon termination, the Contractor may make and retain a copy of such materials. Subject to availability of funding, Contractor shall be entitled to receive payment for work/services provided prior to termination of the Agreement. Such payment shall be that portion of the full payment which is determined by comparing the work/services completed to the work/services required by the Agreement.

3. Exhibit E, Additional Scope of Work with Cost Amendment and Schedule, attached hereto, is added to the Agreement and incorporated herein by reference.

4. All other terms and conditions of the Agreement dated December 5, 2006 between the County and Contractor shall remain in full force and effect.

IN WITNESS WHEREOF, the parties hereto, by their duly authorized representatives, have affixed their hands.

COUNTY OF SAN MATEO

By:_____
President,
Board of Supervisors, San Mateo County

Date:_____

ATTEST:

By:_____
Clerk of Said Board

Christopher A. Joseph & Associates

Jennie Anderson
Contractor's Signature

Date: 3·19·09

EXHIBIT E

ADDITIONAL SCOPE OF WORK

Big Wave Wellness Center and Office Park Environmental Impact Report (EIR) Scope and Budget

ESTIMATED ADDITIONAL TIME AND EXPENSES (*CAJA AMENDMENT 1*)

The following includes the scope of work tasks and associated expenses for the remaining EIR process. This information follows those EIR Tasks outlined in the executed original contract scope of work with supplements included as necessary to reflect the revised Project Description, associated technical data, and time lapsed since the execution of the original contract.

Task 1. Project Management

This budget amendment includes 38 additional hours for project management by Geoff Reilly (Principal/Project Manager) and Jennie Anderson (Project Manager). This includes additional time for: project scheduling; budgeting/invoicing; management & coordination of CAJA staff; oversight of production and circulation of EIR and notices; review of EIR sections for quality assurance; oversight of document format and word processing; and coordination with County staff and preparation of status updates.

Task 2. Finalize Project Description

Based on a review of the Draft Facilities Plan, CAJA submitted a Draft Project Description to the County for review on January 28, 2009. This Draft version included various comments and data gaps for response from the County/Applicant. Per email correspondence from the County/Applicant on February 27, 2009 the Applicant will be providing additional data to CAJA for Project Description finalization during the scheduled March 4, 2009 meeting. This scope of work task includes time for CAJA to finalize the Project Description for use in the update of the EIR.

Deliverables: One electronic copy of the Final Project Description for County verification.

Task 3. Prepare and Update Administrative Draft EIR (ADEIR)

Prepare and Update General Sections/Section I of the ADEIR – Cover, Title Page, Table of Contents, Introduction

CAJA will update the abovementioned sections of the ADEIR to reflect the Final Project Description and tasks completed since 2007 hold date.

Prepare and Update Section II of ADEIR – Summary

CAJA will prepare and update the following subtopics to be included in the Summary Section of the ADEIR: Introduction; Summary of the Proposed Project; Topics of Known Concern; Summary of Alternatives to the Proposed Project; Areas of Controversy; and Summary of Environmental Impacts and Mitigation Measures (including a summarized Table).

Prepare and Update Section III of ADEIR – Project Description

See Task 2 outlined above regarding CAJA's finalization of project description. Additionally, CAJA will update Related Projects Table; amendment assumes County will assist in providing the most recent related project County list.

Prepare and Update Section IV of ADEIR - Environmental Impact Analysis

For each Impact Analysis section in Section IV, CAJA will prepare and update: the introduction and methodology subsections, the environmental setting, the regulatory framework, the impact analysis, the cumulative impacts analysis based on the related projects list to be provided by the County, and mitigation measures (as appropriate). The section scopes will follow the CEQA Guidelines and will factor applicable environmental-related comments (as appropriate) received during the NOP and scoping meeting period, as well as from the County on the project referral. Additionally, this amendment includes funding and time for the preparation of associated graphics and technical appendices updates. In addition to completing the abovementioned tasks, other specific tasks related to each respective section are provided below for each of the following section titles.

Section IV.A (Aesthetics)

- CAJA will review all revised technical documents and materials associated with the revised proposed project for completeness, methodology, findings, adequacy, and relevance with regard to potential aesthetic impacts.
    - CAJA will peer review and provide feedback on the updated simulations provided in the Draft Facilities Plan once the final Project Description is determined and (if necessary) during the preparation of the EIR, specifically, the Aesthetics section analysis. Based on a preliminary review by our Graphics Department, the provided simulations appear adequate. Any applicable CAD files, etc. would be required to facilitate edits as necessary. Additional figures will be updated and provided as necessary for this visual analysis.
- As part of the Environmental Setting update, based on past site visits and using information in the County's General Plan, Facilities Plan, and other recent County CEQA documents, CAJA will confirm the regional and local context relative to aesthetics and the existing physical characteristics of the project site, focusing on visual features such as topography, vegetation, existing uses, and the site's relationship to nearby uses. In addition, CAJA will describe views from and of the project site, focusing on character-defining features and the project site's relationship to the entire field of view.
- CAJA will define scenic vistas and scenic resources in the project area. Generally describe any scenic vistas available from nearby public vantage points and the location of any scenic resources in relation to the project site (e.g., scenic roadways). Note whether the project site is visible and/or how much of the project

site is visible within these views. Describe how these views and/or resources might change due to the project, using the Applicant-provided visual simulations as a guide.

- Describe the overall visual character of the project site and areas surrounding the site. Describe how the revised project would alter the existing visual character of the site and surrounding area, focusing on how the project would change the character-defining features described previously. This discussion will be based on revised project plan elevations and descriptions of building materials and design as provided by the Applicant. Based on this discussion, determine whether the project would adversely change the existing character of the site and/or the surrounding area, and the potential to result in a significant impact under CEQA.
- Describe the types and relative amounts of light and glare that would be associated with the revised project and describe how these sources might affect the surrounding area. Based on this discussion, determine whether the project would result in significant light and/or glare impacts.
- Recommend updated mitigation measures as necessary.

Section IV.B (Agriculture Resources)

- CAJA will update and reconfirm the agriculture impact analysis via the CEQA process in order to determine if the revised project would result in significant impacts to agriculture resources. Should the analysis determine that impacts would be significant, mitigation measures would beprepared. As the site is not under contract with the County under the provisions of a Williamson Act contract, CAJA will evaluate the project's impacts to agriculture resources based on the Land Evaluation and Site Assessment (LESA) analysis in order to determine if the project would convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use.

Section IV.C (Air Quality)

- CAJA will utilize as much existing data as possible provided by the Applicant in the Facilities Plan.
- Describe baseline air quality information, including the pollutants of concern in the Bay Area, the agencies responsible for improving air quality in the Bay Area, and the existing air quality conditions in the county and local vicinity. Existing regional emissions will be identified using information obtained from the California Air Resources Board. Existing localized emissions of carbon monoxide will be calculated using data from the revised project traffic report, as described in Section IV (Transportation/Traffic). Any emissions that may be associated with the existing conditions at the project site will also be discussed.
- Identify the thresholds of significance recommended by the Bay Area Air Quality Management District (BAAQMD) as presented in the BAAQMD CEQA Guidelines and used by the County to evaluate air quality impacts under CEQA.
- Construction-related activities are generally short-term in duration, and the BAAQMD does not recommend any thresholds of significance for their associated emissions. Instead, the BAAQMD bases the determination of significance on a consideration of the control measures to be implemented. Therefore, the

EIR will discuss the potential impacts that would occur during construction and recommend the appropriate measures to reduce these impacts to less-than-significant levels.

- Calculate operational mobile and area source emissions for reactive organic gases, nitrogen oxides, and particulates using the URBEMIS model recommended for use by the BAAQMD. Calculations will be based on the trip generation factors provided in the revised project traffic study. The predicted emissions will be compared to the thresholds of significance recommended by the BAAQMD.

- Calculate future localized carbon monoxide concentrations at intersections in the project vicinity that would be most affected by project-generated traffic. These emissions will be calculated using data from the revised project traffic report. The resulting emissions will be compared to state and national ambient air quality standards. These methods are based on the Caline4 Line Source Dispersion Model.

- Discuss the consistency of the project with the current Clean Air Plan for the Bay Area.

- Generally characterize the types of emissions, including toxic air contaminant (TAC) emissions, associated with the wastewater treatment plant, etc. Qualitatively discuss potential health risks associated with siting new residences in proximity to these stationary sources.

- Discuss the potential for the project to result in a cumulatively considerable net increase in emissions. The BAAQMD recommends that projects that generate project-specific emissions that exceed their recommended thresholds of significance also be considered to cause a significant cumulative air quality impact.

- Identify mitigation measures as necessary to reduce or avoid any potential project-specific or cumulative impacts to air quality, and quantify their effectiveness based on methodologies available from BAAQMD and other sources.

- CAJA will prepare a Greenhouse Gas (GHG) Emission Analysis to assess the project's expected contributions to global warming via the emission of GHGs. At this time there are currently no thresholds or official guidance adopted by the Air Districts or other agencies in California to assess the significance of potential GHG emissions. However, Senate Bill 97 (SB 97), which was enacted in 2007, requires the State Office of Planning and Research (OPR) to develop CEQA guidelines for the effects and mitigation of GHG emissions. These guidelines and regulations are expected to be certified and adopted by the State Resources Agency before January 1, 2010. In the interim, OPR recently provided a new technical advisory containing informal guidance for public agencies as they address the issue of climate change in their CEQA documents.

  The OPR technical advisory recommends each public agency that is a lead agency for complying with CEQA develop its own approach to performing a climate change analysis for projects that generate GHG emissions. A consistent approach should be applied for the analysis of such projects, and the analysis must be based on best available information. For such projects, three types of analyses are used to determine whether the project could be in conflict with the State, regional, and local measures for reducing greenhouse gas emissions. The analyses will include the following:

  - Quantify the potential GHG emissions associated with the implementation of the project.

- Assess the significance of the impact on climate change using applicable guidance documents and State, regional, and local GHG reduction goals.
- Assess whether elements of the project and associated mitigation measures contribute to the efficiency of the project and sufficiently reduce GHG emissions.

Section IV.D (Biological Resources)

- Per previous memo discussions, CAJA has agreed that the Biological Resources data provided by WSP appears adequate and appropriate and has therefore agreed to use it as part of our updated ADEIR Biological Resources impact analysis. Under this scope, CAJA Biologists will continue to work with WSP, the County, and Applicant for any additional data necessary to complete our analysis. The Biological Resources section will be updated based on the above and the revised Project Description. Additional mitigation measures, etc. will be suggested as appropriate.

Section IV.E (Cultural Resources)

- CAJA has incorporated the *Cultural Resources Survey for the Big Wave Project, prepared by Tom Origer and Associates, February 28, 2007* into the Cultural Resources section of the ADEIR. Per the report, a 100-foot buffer zone was recommended to help protect resources from the original project development footprint; however, CAJA does not know how far into the site the resources extended. Under this scope, CAJA will reconfirm the extent with our cultural subconsultant.

Section IV.F (Geology & Soils)

- Treadwell & Rollo conducted one peer review based on the original Project Description (*Third Party Geotechnical Peer Review, prepared by Treadwell & Rollo, April 3, 2007*). Based on the supplemental information provided in the Facilities Plan (*BAGG's Response to Treadwell & Rollo Third Party Geotechnical Review, 2008*), Treadwell & Rollo will need to review and provide updated comments as appropriate. Per Treadwell & Rollo their remaining contract budget ($1,248.63) will be adequate to complete their updated review.
- The Geology & Soils section of the ADEIR will be updated from the available and pending project's Geotechnical Report database including revising any impact analyses and mitigation measures based on the revised Project Description as necessary.

Section IV.G (Hazards & Hazardous Materials)

- CAJA utilized the site Phase I report prepared by Treadwell & Rollo (*Phase I Environmental Site Assessment for the Big Wave Site (Phase I ESA), prepared by Treadwell & Rollo, March 26, 2007*) in order to prepare the Draft Environmental Setting of the Hazards & Hazardous Materials section of the ADEIR. Based on the revised Project Description, the impacts and mitigation measures will need to be updated accordingly. No additional Phase I data revisions are anticipated at this time, as historical/existing conditions information still remains applicable. Per the Applicant, a Phase II will also be prepared as part of the mitigation to be outlined in the EIR impact analysis. However, we do have concerns related to the new proposed operational uses (e.g., microwave towers, etc.) and potential associated hazards. *Although,*

not included in this amendment, if deemed necessary during future research efforts, we may need the assistance of a subconsultant (i.e., Paul Spillane of Acumen (Industrial Hygienist), as appropriate – Treadwell & Rollo is not experienced in this analysis)) to determine the associated environmental impacts during the ADEIR analysis. If this is found to be necessary, a small supplemental budget may be warranted and will be negotiated and approved by the County/Applicant prior to initiation.

Section IV.H (Hydrology & Water Quality)

- The hydrology & water quality information provided in the Facilities Plan will be incorporated into the Hydrology & Water Quality section analysis as appropriate. Per the original contract included for the EIR analysis, no peer review was provided; instead, Schaaf & Wheeler prepared the preliminary version of the EIR Hydrology & Water Quality section of the ADEIR based on the original Project Description (*Hydrology and Water Quality Review for Big Wave, prepared by Schaaf & Wheeler, May 2007*). Further, as stated previously, Schaaf & Wheeler prepared an additional hydrology study related to the wetlands issues in late 2007 (*Review of Wetland Hydrology Indicators for Big Wave Jurisdictional Delineation Including Site Visit Commentary prepared by Schaaf & Wheeler on September 17, 2007*). In order to reflect the revised Project Description, additional time and budget has been included herein for Schaaf & Wheeler to update the section accordingly utilizing the revised Site Plans and additional information provided in the Facilities Plan.

<u>Schaaf & Wheeler Scope/Cost</u>

- Review the new Project Description and Facilities Plan.
- Revise hydrologic calculations to reflect new Project Description.
- Analyze the water quality impacts of the newly proposed water recycling facility and increased groundwater infiltration.
- Update the Regulatory Setting section of the EIR document to reflect current regulations.
- Incorporate the more recent wetlands delineation work by CAJA, WSP. Prepare a revised section for Hydrology and Water Quality. Text and figures will be provided to CAJA in Microsoft Word and pdf formats, or as otherwise mutually arranged.
- A two hour meeting or site visit requested by the County is included as part of this amendment.
- Approximately 12 hours are included to assist CAJA in the response to comments efforts during the DEIR phase.
- Based on Schaaf & Wheeler's current fee schedule, the not-to-exceed fee for the above work is $10,300. Approximately $2,300 remains in their original budget, so the required contract amendment for this additional work is $8,000, which is provided for herein.

Section IV.I (Land Use & Planning)

- Update existing land uses and features of the project site. Also, under this scope, confirm existing land uses in the vicinity, based on aerial photographs and an additional windshield survey (if necessary).

- Confirm exhibits showing existing General Plan Land Use Map designations and Zoning Map districts for the site and vicinity.

- Evaluate and update the revised proposed project's consistency with relevant plans, policies, and regulations. In accordance with CEQA Guidelines Section 15125(b), the analysis will include applicable general plans and regional plans. Plans and policies that will be evaluated include (among others):

  - San Mateo County General Plan
  - Mid-Coast LCP
  - Montara/Moss Beach/El Granada Community Plan
  - LAFCO (regarding water service from CCWD)
  - Half Moon Bay Comprehensive Airport Land Use Plan
  - Existing County ordinances and regulations

- The General Plan consistency analysis will be updated based on the revised project and presented in a tabular format. County staff will be consulted to determine other relevant plans, if any. Where appropriate, the evaluation will cross-reference other section updates, such as Biological Resources or Transportation/Traffic.

- Updates to discuss potential impacts relating to policy inconsistency and land use compatibility from revised project. This discussion will cross-reference the analyses of other impacts in the EIR (as necessary).

Section IV.J (Noise)

- The information provided in the Facilities Plan will be confirmed and/or supplemented as part of the Noise ADEIR analysis. Per the original contract, CAJA will conduct a noise analysis (utilizing the steps outlined below), which will occur once the final revised traffic data and Project Description is confirmed.

- Define and describe the fundamentals of sound and environmental noise, and groundborne vibration.

- Discuss relevant noise policies, regulations and standards, including the relevant State noise guidelines and noise/land use compatibility standards used by San Mateo County.

- Confirm noise-sensitive land uses or activities in the vicinity of the project site or along roads providing access to the site.

- Briefly confirm and describe existing major noise sources in the project vicinity. Conduct up to four short-term noise measurements on the project site, along roadways most affected by increases in project traffic and airport associated noise events.

- Calculate existing noise levels for the roadway segments in the project vicinity that would be affected by project-generated traffic. These noise levels will be calculated using the Federal Highway Administration's (FHWA) Noise Prediction Model and data from the project traffic report.

- Discuss existing groundborne vibrations levels at the project site and local vicinity.
- Confirm significance thresholds based on these standards and consultation with San Mateo County.
- Describe characteristics of the revised proposed project that are relevant to the analysis of noise, based on the revised project site plan, the conceptual grading plan, and trip generation estimates from the revised project traffic study.
- Discuss construction noise impacts, based on revised proposed construction activities and scheduling information. Noise impacts from construction will be evaluated based on the duration, nature, phasing, and level of various construction activities.
- Describe typical noise generated by various elements of the revised project, including project-generated motor vehicle traffic.
- Calculate the expected increases in noise levels at noise sensitive locations along roadways most affected by project traffic using the FHWA Noise Prediction Model and data from the revised project traffic report.
- Discuss the potential for noise from the revised project or related activities to adversely affect sensitive land uses or activities, or to conflict with established noise compatibility guidelines.
- Discuss the potential for noise from the Half Moon Bay Airport to affect project site residents.
- Evaluate the compatibility of the proposed land uses with the existing and future noise environment at the site.
- Identify mitigation measures as necessary to avoid or reduce significant noise impacts, and evaluate their effectiveness based on published technical documents.

Section IV.K (Population & Housing)

- CAJA will initiate the peer review by Bay Area Economics once the Project Description has been finalized. As outlined in the original contract, Bay Area Economics will conduct a third party peer review of the Applicant's economic analysis, which will address the assumptions, methodology and overall conclusions regarding the overall demand for the project and the job match with employed residents on the coast area. Bay Area Economics will prepare an administrative draft memo outlining their peer review. Bay Area Economics will also review the memo with CAJA and County staff. Based on oral and written comments, Bay Area Economics will revise the administrative memo and produce a final memo. As stated above, the peer review of the Economic Analysis was included in the original contract and to date budget remains to complete this task. This peer review will be submitted to the County as an independent report, and will not be appended to the EIR.
- Prepare and update existing population and housing estimates, as well as policies and forecasts pertaining to population and housing growth in the County of San Mateo. The population and housing data and forecasts will be updated from the County's Housing Element, the California Department of Finance, the Association of Bay Area Governments (ABAG) and the U.S. Census Bureau, as needed.

- Based on population per household ratios provided by the County, CAJA will calculate the number of residents that would be accommodated by the revised proposed project.

- Evaluate the consistency of the project-generated population with County and regional growth forecasts and policies. Calculate the project's contribution as a percentage of the County's overall growth allocation by ABAG, the California Department of Finance, and other sources.

- Identify mitigation measures to reduce or avoid significant impacts for each of the sub-issues analyzed in the Population/Housing section, if any significant impacts are identified.

Section IV.L (Public Services)

- Confirm and update existing conditions in the County and project area, as appropriate. This will be done by contacting the current contacts at the Fire Department, Police Department, Parks and Recreation Department, and School District responsible for serving the project site by telephone or letter to obtain updated information on existing conditions, assess the potential impacts of the revised proposed project and cumulative development, and provide input on appropriate mitigation measures (as necessary).

- Based on updated population per household ratios provided by the County and/or the service providers (such as the Department of Finance), recalculate the number of residents that would be accommodated by the revised proposed project.

- Discuss the School District's eligibility to levy alternate developer fees.

- Based on County park standards, calculate the park acreage or in-lieu fee that would be required with buildout of the revised proposed project. Determine whether existing and planned parks in the County would be adequate to cover the revised proposed project and County-wide demand (as necessary). Consult with the County regarding cumulative projects in the area and their proposed parklands.

- Discuss potential impacts of revised project buildout in terms of demand for public services, ability to provide services, and the possible need for construction of additional facilities.

- Document project characteristics that would "pre-mitigate" potential impacts of the revised project.

- Update and list mitigation measures recommended by the service providers.

- Discuss the potential for the revised project in conjunction with related projects to result in cumulative impacts to public services.

Section IV.M (Transportation/Traffic)

- Per the Applicant and the January 1, 2009 Facilities Plan, the preferred Office Park option would include the 225,000 s.f. commercial/office space use. For $32,000 (in the requested amendment [included in this *CAJA Amendment 1*]), Hexagon Transportation Consultants, Inc. assisted the Applicant in the development of an Office Park option revised traffic analysis (which included the revised project and the 225,000 s.f. alternative). No updated peer review is required. $22,905 from the current budget has been used to pay for this work. The revised budget includes $9,095 for the balance of this work.

- The updated traffic report (*Revised Traffic Report for the Big Wave Office Park and Wellness Center, prepared by Hexagon Transportation Consultants, Inc., June 25, 2008*) will be incorporated by CAJA into the Transportation/Traffic ADEIR section analysis to reflect the revised proposed project. CAJA will work with Hexagon for any applicable updates and/or clarifications utilizing the requested remaining $9,095.

Section IV.N (Utilities & Service Systems)

- The information provided in the Facilities Plan will be incorporated into the ADEIR Utilities & Service Systems subsections (i.e., Water, Wastewater, Service Systems; as appropriate) and will be supplemented by our CAJA team as necessary. CAJA has reviewed the Solid Waste discussion in the Facilities Plan and this seems appropriate. In previous memos, CAJA encouraged the Applicant to narrow down various Utilities options to one option (e.g., various options proposed for water supply, wastewater treatment and energy). Otherwise, the project may appear to be more programmatic (i.e., necessitating the preparation of a Program EIR), potentially resulting in more environmental review at a later time when more specifics are provided or available. However, per direction from the Applicant, we will analyze each "option" in detail in the EIR analysis, pending that detailed data is available for each Water/Wastewater/Energy "option".

- The Utilities & Service Systems section of the ADEIR will be updated from the available and pending project's Utilities Report database including revising any impact analyses and mitigation measures based on the revised Project Description as necessary. Although not included in the original scope, based on the scope of the revised project, CAJA will include an Energy subsection analysis in the Utilities & Service Systems section to reflect all of the proposed Energy systems.

- For proposed municipal service options, CAJA will conduct the following tasks:

  - Confirm and update existing conditions in the County and project area, as appropriate. This will be done by contacting the currently proposed municipal contacts by telephone or letter to obtain updated information on existing conditions, assess the potential impacts of the revised proposed project and cumulative development, and provide input on appropriate mitigation measures (as necessary).

  - Based on readily available solid waste, water and sewage generation factors, calculate the revised project's estimated solid waste and sewage generation, as well as water demand.

  - Discuss LAFCO annexation requirements of the project site into the CCWD.

  - Discuss potential impacts of revised project buildout in terms of demand for municipal services, ability to provide services, and the possible need for construction of additional facilities.

  - Document project characteristics that would "pre-mitigate" potential impacts of the revised project.

  - Update and list mitigation measures recommended by the service providers.

  - Discuss the potential for the revised project in conjunction with related projects to result in cumulative impacts to public services.

- Additional CAJA subconsultants are necessary in order to assess and conduct peer reviews of the potential environmental impacts associated with the proposed wastewater (i.e., on-site MBR plant, drip irrigation of recycled wastewater) and water (on-site wells and groundwater/aquifer impacts, water treatment) systems.

This was not included in the original scope (Note: Per the original project RFP, the original scope was based on municipal hook-ups only) and hence requires a supplemental budget and scope, which is provided for herein. This review will be provided by Questa Engineering Corporation (water supply and wastewater). The additional scope and cost for Questa Engineering Corporation is included below.

Questa Engineering Corporation Scope/Cost

Water Supply

- Available background reports, maps and data relative to water availability in the project area will be compiled and reviewed.
- The water supply setting for the project will be described based upon the information developed in the background review. The Applicant's plan for supplying water to the project will be described and reviewed. This will include the sources of supply, treatment requirements (if any), storage and distribution system, and ownership and management of the system.
- The Applicant's estimated water demand for the proposed project will be reviewed for independent confirmation. It is anticipated that estimates will be broken down by the different elements of the project site and will include annual and seasonal demand, daily average and peak water supply requirements. The water needs will consider residential water demands (interior and exterior), other common area uses, fire flow, and storage requirements.
- The availability of a sufficient, dependable supply of water to serve the project will be evaluated and presented. Various possible sources of water to service the development have been identified including on-site well water, recycled water, and imported potable water. This analysis will also address the water quality and treatment requirements.
- Mitigations will be identified for water supply impacts determined to be significant or potentially significant. Mitigations may include such measures as limitations on the scale of development and corresponding water demand, incorporation of specific water conservation measures, and additional water storage.

Wastewater Treatment and Disposal

- Compile and review all available background information pertaining to wastewater treatment and disposal-reclamation plans for the project. This will include peer review of technical report(s) and supporting information supplied by the Applicant, as well as relevant publications related to soils, water resources, hydrogeology and water quality and information regarding the El Granada Wastewater District Facilities. A reconnaissance-level site visit will be performed to observe relevant landscape features and existing infrastructure. Contacts will be made with County and Regional Water Board staff, El Granada Wastewater District personnel, project consultants (as appropriate), and other knowledgeable individuals.
- Review and describe federal, state and local regulatory requirements applicable to the construction and operation of the proposed wastewater system, including, but not limited to, the Water Quality Control Plan for the San Francisco Bay Region (Basin Plan), Title 22 Water Recycling Criteria, County policies and standards.

- The proposed wastewater treatment plans will be reviewed for technical adequacy including compliance with accepted engineering standards, limitations of the project site, and applicable regulatory requirements. This will include review and independent confirmation and/or revisions of the sewage flow estimates for the project based on information provided by the Applicant. It will also include review of: (a) plans for wastewater collection; (b) proposed location and type of treatment system; (c) any plans for wastewater storage; (d) locations, methods and capacity for wastewater disposal and reclamation; (e) plans for system management; and (f) any identified water quality issues, including impacts to surface water and groundwater resources.

- Using information compiled from the background and regulatory review, prepare the environmental setting section for the EIR.

- Based on the results of the project analysis task, identify and describe any potentially significant impacts of the proposed wastewater treatment and disposal-reclamation plans for the project for inclusion in the EIR. Impacts discussion may include construction-related issues, operational impacts related to the collection, treatment and disposal-reclamation facilities; and potential short-term or long-term water quality and public health issues

- Identify and describe feasible mitigation measures to address any significant or potentially significant impacts related to the development and operation of wastewater collection, treatment and disposal-reclamation facilities for the project.

Associated Tasks to Complete Above

- (Task 1) Site Visits, Data Collection and Analysis. Questa will collect and review existing information related to the wastewater and water supply aspects of the project. Interviews, file research, peer review of consultant-provided reports, and site reconnaissance by experienced environmental personnel will be conducted. Contacts will be made with appropriate agencies to evaluate pertinent requirements and background information.

- (Task 2) Water Supply Analysis. Questa will identify and evaluate the potentially significant and significant water supply impacts associated with development of the proposed project. The analysis will include evaluation of the proposed methods of water supply for the project including on-site well water, recycled water and water imported from the Coastside County Water District (CCWD).

- (Task 3) Wastewater Disposal Analysis. Questa will identify and evaluate the potentially significant and significant wastewater treatment impacts associated with development of the proposed project. Methods for wastewater treatment and disposal that will be evaluated include on-site treatment and recycling, on-site disposal by spray irrigation and other methods, and off-site disposal to the El Granada Wastewater District.

- (Task 4) Formulate Mitigation Measures. Questa will develop reasonable and appropriate additional mitigation measures to offset the identified impacts. The mitigation measures may include development restrictions in sensitive or constraining project areas, on- and off-site infrastructure improvements, structural and non-structural best management practices, remedial action, and design recommendations related to the development of the project site. Additionally, Questa may develop monitoring and reporting strategies for mitigation measures.

- (Task 5) Review Project Alternatives. Questa will review alternatives to the proposed project. This will include the no project alternative, the proposed project, and one other alternative to be presented as part of the EIR. Questa will evaluate the Wastewater Treatment and Water Supply impacts associated with the project alternatives.

- (Task 6) Prepare Administrative DEIR. Questa will prepare the Water Supply and Wastewater sections of the EIR in an acceptable format.

- (Task 7) Response to Comments and Preparation of DEIR. Questa will respond to comments made to the ADEIR and finalize the DEIR sections.

- (Task 8) Response to Comments and Preparation of FEIR. Questa will assist in the final response to comments and preparation of the FEIR sections. We have included a limited budget for response to comments. If extensive comments are received requiring significant review and response time, additional budget may be required for this task.

- (Task 9) Public Hearings and Meetings. Questa will attend public hearings and meetings on a time-and-expenses basis. Questa has not included a budget for hearings/meetings. Any attendance at hearings or meeting would be in addition to the costs outlined in this amendment.

- The cost for the work effort described above in Tasks 1 to 8 is $18,600.

Prepare and Update Section V of ADEIR - General Impact Categories

The General Impact Categories section of the ADEIR will summarize the following: significant unavoidable impacts that were identified in the updated Environmental Impact Analysis (if any are identified); growth-inducing impacts of the revised proposed project; and the significant irreversible environmental changes associated with the revised project. Additionally, this section will include a discussion of the Impacts Found to be Less Than Significant. This section will include a discussion of the issues and sub-issues that were focused out for further analysis in the Initial Study. However, as the Initial Study format does not include detailed data on why these issues were scoped out, these issues will be confirmed for accuracy and will be documented in the above subsection analysis.

Prepare and Update Section VI of ADEIR - Summary of Cumulative Impacts

The cumulative impacts and mitigation (if appropriate) in each respective Environmental Impact Analysis section will be updated based on the revised Project Description, section analyses, and the updated related projects list provided by the County.

Prepare and Update Section VII of ADEIR - Alternatives to the Proposed Project

This section of the ADEIR will identify and evaluate a reasonable range of alternatives to the revised proposed project that are crafted to avoid or significantly lessen the significant environmental impacts of the project while still meeting most of the revised project objectives. One of the alternatives that will be analyzed in the EIR will be the No Project Alternative (assuming continuation of the existing conditions, no development of the site), as required by CEQA. As the project site does not permit residential uses, the EIR will address implementation of the proposed project at an alternative site(s). Other alternatives could include a Reduced Density Alternatives or

Modified Site Plan Alternative. The selection of other project alternatives will be made in consultation with County staff after all of the significant impacts of the revised proposed project have been identified. For the purposes of this amendment, CAJA will analyze up to four alternatives, including the No Project Alternative.

Prepare and Update Section VIII of ADEIR - Preparers of the EIR and Persons Consulted

This section will be updated to identify the lead agency staff, project Applicant and subconsultant staff, EIR consultant and subconsultant staff, and all agency personnel consulted during the preparation of the EIR.

Prepare and Update Section IX of ADEIR - Bibliography

The Bibliography section will be updated to list all sources of revised information used during the preparation of the EIR.

Deliverables: Five (5) bound hard copies and one electronic PDF copy of the ADEIR. CAJA will submit copies of the ADEIR to the County staff for distribution and one round of review.

Task 4. Preparation of the DEIR

CAJA will address all of the County's comments on the updated ADEIR. This amendment assumes one-round of review by the County and all comments made on the updated ADEIR will be submitted to CAJA in one consolidated set. *(Note: Any changes to the project description made during this review could require changes to the analysis in the ADEIR and could require additional amendments.)* After the review of the document, CAJA staff will address all comments and will prepare and submit one electronic PDF version of the Screencheck DEIR (SDEIR) to the County to confirm that all requested changes have been incorporated into the document. This SDEIR will be submitted to the County for approval as a DEIR. Once the County approves the SDEIR, CAJA will produce 50 copies of the DEIR and Technical Appendices for use and distribution by the County during the prescribed 45-day public review period. Additionally, CAJA will also prepare 15 electronic PDF copies of the DEIR and Technical Appendices and 15 hard copies of the Summary section for County submittal to the State Clearinghouse. CAJA will also prepare the Notice of Completion (NOC) for the State Clearinghouse per the CEQA requirements. This amendment assumes that the County will distribute the DEIR and NOC.

Additionally, it is assumed in this amendment that CAJA will produce a Notice of Availability (NOA) for the DEIR utilizing all three NOA noticing options as outlined in Section 15087(a)(1),(2),(3) of the CEQA Guidelines (although only one is required to fulfill the 45-day public review period, it is recommended by CAJA to utilize all three noticing methods during the public review period due to the controversial nature of the project). This includes: 1) publication of the NOA in a local newspaper, 2) posting the NOA on- and off-site, and 3) direct mailing of the NOA to contiguous property owners. Further, the NOA shall be sent to applicable state and local agencies; individuals that commented on during the NOP or scoping meeting process and that have requested to be notified throughout the EIR process; as well as the applicable County Clerk to post during the 45-day review period. This amendment assumes that the County will also distribute the NOA.

Deliverables: One (1) electronic PDF copy of the SDEIR; 50 bound copies of the DEIR and Technical Appendices, one electronic PDF format on a CD, 15 copies for the State Clearinghouse and one copy of the NOC for distribution by the County. The DEIR will be in 8.5-inch x 11-inch, black

and white format; color where applicable. Additionally, a electronic (PDF) copy of the NOA for distribution by County.

Task 5. Preparation of FEIR and Mitigation Monitoring Program (MMP)

The number of comments received at the end of the 45-day review period and the level of effort involved with preparing responses varies widely between projects. Following closure of the 45-day DEIR public comment period, CAJA staff will prepare responses to all written and oral comments received on the DEIR and will make any changes to the DEIR resulting from responses to comments. The FEIR will ultimately include the following chapters: Introduction, Response to Comments, Corrections and Additions to the DEIR, Mitigation Monitoring Program (MMP). CAJA will prepare the AFEIR and submit 5 copies to the County for one round of review. After the review of the document, CAJA staff will address all comments and will prepare and submit one electronic PDF version of the SFEIR to the County to confirm that all requested changes have been incorporated into the document. Once the SFEIR is approved for release as the FEIR, CAJA will produce 50 copies (as well as 15 copies for State Clearinghouse, if necessary) of the FEIR for County circulation to all appropriate commenting agencies and individuals ten days prior to consideration of certification of the EIR. This amendment assumes that the County will distribute the FEIR.

Although not required under CEQA, CAJA can prepare and provide the County with a NOA for the FEIR. This task is not included within our amendment; however (if requested, due to the controversial nature of the project), CAJA can be available to assist the County with this task utilizing a time and materials rate based on our current fee schedule. CAJA preparation of the NOA would follow those steps outlined under Task 4.

In accordance with CEQA Guidelines Section 15075, CAJA will prepare the Notification of Determination (NOD) for use by the County to file with the applicable County Clerk and State Clearinghouse (if necessary) within five days of certifying the EIR and approving the project. This amendment assumes that the County will file the FEIR.

Deliverables: Five (5) hard copies and one electronic (PDF) copy of the AFEIR; one electronic (PDF) of the SFEIR; 50 hard copies and one electronic (PDF) of the FEIR (as well as 15 copies for the State Clearinghouse, if necessary) for distribution by the County; and one electronic (PDF) copy of the NOD for filing by the County.

Task 6. Hearings and Meetings

While a public hearing on the DEIR during the 45-day review period is not required by CEQA (Section 15087(i), CEQA Guidelines), this amendment includes attendance by the appropriate CAJA staff member(s), but not its subconsultants, at one public hearing either on the DEIR during the 45-day review period or on the FEIR certification/final decision on the project. If the County chooses to hold a public hearing during the 45-day DEIR review period, County staff will schedule the meeting and arrange for the meeting space. CAJA highly recommends that if many people are expected to attend the public hearing and comment, a court reporter should be present to record all comments. CAJA staff will assist the County in preparing necessary materials for the hearing, such as: a) a handout depicting and briefly describing the project and summarizing impacts and mitigation measures, and b) other large-scale graphics. CAJA staff will arrange for a court reporter to attend the meeting to

record all oral comments, but the cost of a court reporter is not included in this amendment. After the close of the public comment period for the DEIR, CAJA staff will review all comments, identify which comments require special attention, and discuss response approach with County staff and CAJA team members. CAJA will prepare a topic-by-topic matrix summarizing all written and oral comments submitted during the hearing.

This amendment also includes the attendance of Ms. Anderson and Mr. Reilly at two Planning Commission hearings and one Board of Supervisors hearing. CAJA staff will be available to give a presentation related to the CEQA process, analysis, and conclusions. Additionally, time for 8 team meetings/conference calls has been included in this amendment. *Additional County-requested hearings and meetings attendance will be billed on a time-and-materials basis based on our agreed fee schedule.*

Deliverables: One (1) memo summarizing all substantive points made by the public hearing commenters.

Task 7. Findings of Fact and Statement of Overriding Considerations

Prior to consideration of the proposed project and subsequent to certification of the FEIR, CAJA staff will prepare the Statement of Facts and Findings (the Findings) for any significant environmental effects identified in the EIR. The Findings will individually identify the significant environmental effects of the proposed project and provide a reasoned discussion of the appropriate findings.

Also included in this amendment, prior to consideration of the proposed project and subsequent to certification of the FEIR, CAJA will prepare the Statement of Overriding Considerations in accordance with the specifications of Section 15093 of CEQA (if applicable). The Statement of Overriding Considerations will describe why the benefits of the project outweigh its significant and unavoidable effects.

Deliverables: Five (5) copies of each will be provided, as well as one electronic PDF copy.

Schedule and Cost

CAJA proposes the following draft schedule to prepare the EIR (see attached Table 1). This schedule is dependent on approval of the finalized Project Description and availability of Applicant-prepared data. Therefore, the proposed schedule dates would be updated accordingly based on actual completion dates. Overall, as shown in the attached Cost Amendment (Table 2), the total cost for the *Cost Amendment 1* scope of work is $137,700. CAJA's associated billing rate is included below:

Billing Rates

CAJA Fee Schedule
(*Effective January 1, 2009*)

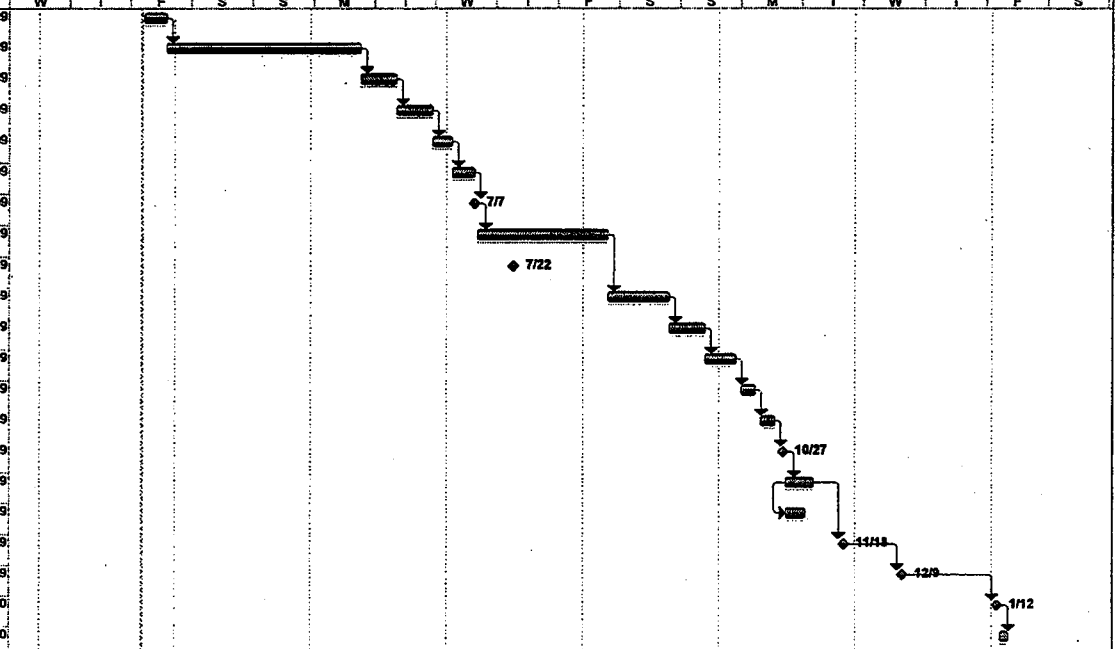
• Principal	$160.00/hour
• Project Manager	$135.00/hour
• Environmental Specialist (e.g., Biologist, Noise, Air Quality)	$135.00/hour
• Environmental Planner	$120.00/hour
• Associate Environmental Planner	$110.00/hour

• Assistant Environmental Planner	$95.00/hour
• Research Assistant	$55.00/hour
• Graphics Director	$60.00/hour

Attachments: Table 1 (Revised Draft Schedule)
Table 2 (Cost Amendment)

Big Wave Wellness Center and Office Park EIR -- Revised Draft Schedule

ID	Task Name	Duration	Start	Finish
1	Finalize Project Description for County Verification [1]	6 days	Wed 3/11/09	Wed 3/18/09
2	Prepare ADEIR for County Review	50 days	Thu 3/19/09	Wed 5/27/09
3	County Review of ADEIR [2]	9 days	Thu 5/28/09	Tue 6/9/09
4	Prepare SDEIR for County Review	9 days	Wed 6/10/09	Mon 6/22/09
5	County Review of SDEIR [2]	5 days	Tue 6/23/09	Mon 6/29/09
6	Prepare DEIR and Notices (NOA/NOC)	5 days	Tue 6/30/09	Tue 7/7/09
7	County to Circulate DEIR, NOC, and NOA	0 days	Tue 7/7/09	Tue 7/7/09
8	Circulate & Publish DEIR & Notices for 45-day Public Review	45 days	Thu 7/9/09	Mon 8/24/09
9	Attend Public Hearing at DEIR (at County discretion) [3]	0 days	Wed 7/22/09	Wed 7/22/09
10	Prepare Responses to Comments, AFEIR/MMP for County Review [4]	15 days	Tue 8/25/09	Tue 9/15/09
11	County Review of AFEIR/MMP [2]	9 days	Wed 9/16/09	Mon 9/28/09
12	Prepare SFEIR/MMP for County Review	9 days	Tue 9/29/09	Fri 10/9/09
13	County Review of SFEIR/MMP [2]	5 days	Mon 10/12/09	Fri 10/16/09
14	Prepare FEIR/MMP	5 days	Mon 10/19/09	Fri 10/23/09
15	County to Circulate FEIR/MMP	0 days	Tue 10/27/09	Tue 10/27/09
16	Circulate & Publish FEIR/MMP for Commenting Agencies (& Public)	10 days	Wed 10/28/09	Fri 11/6/09
17	Prepare Findings of Fact and SOC	7 days	Wed 10/28/09	Tue 11/3/09
18	EIR Meeting/Hearing (PC) [2]	0 days	Wed 11/18/09	Wed 11/18/09
19	EIR Meeting/Hearing (PC) [2]	0 days	Wed 12/9/09	Wed 12/9/09
20	EIR Meeting/Hearing (Board) [2]	0 days	Tue 1/12/10	Tue 1/12/10
21	Preparation of the NOD, Filing NOD with Clerk [2]	3 days	Wed 1/13/10	Fri 1/15/10



Note: Schedule is dependant on availability of all Project Facilities/technical reports from the Applicant, as well as the complexity of the multiple Utilities analyses. Schedule may need to be adjusted.

1 **Finalize Project Description for County Verification [1]**
[1] Assumes a finalization and approval date of March 18, 2009. This date is subject to change pending actual approval by the County. Schedule will be updated accordingly, if necessary.

3 **County Review of ADEIR [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

5 **County Review of SDEIR [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

9 **Attend Public Hearing at DEIR (at County discretion) [3]**
[3] Date is subject to change depending on availability of Planning Commission during this time. Overall, Public Hearing would be scheduled to take place during the 45-day review period.

10 **Prepare Responses to Comments, AFEIR/MMP for County Review [4]**
[4] May need to be revised depending on actual level of comments received, which is outside the control of CAJA and the County.

11 **County Review of AFEIR/MMP [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

13 **County Review of SFEIR/MMP [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

18 **EIR Meeting/Hearing (PC) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

19 **EIR Meeting/Hearing (PC) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

20 **EIR Meeting/Hearing (Board) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

21 **Preparation of the NOD, Filing NOD with Clerk [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

Note: Schedule is dependant on availability of all Project Facilities/technical reports from the Applicant, as well as the complexity of the multiple Utilities analyses. Schedule may need to be adjusted.

Table 2
Big Wave EIR, Cost Amendment #1

LABOR COSTS					
Task 1. Project Management					
Budgeting and Scheduling	Geoff Reilly	2	$160.00	Principal	$320.00
	Jennie Anderson	5	$135.00	Project Manager	$675.00
Coordination with County, Applicant & Subconsultants	Geoff Reilly	3	$160.00	Principal	$480.00
	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Document Review/Quality Assurance	Geoff Reilly	6	$160.00	Principal	$960.00
	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Administrative	Megan Steer	4	$55.00	Research Asst.	$220.00
	Jennie Anderson	2	$135.00	Project Manager	$270.0
Task 1 Subtotal		***38***			***$5,085.0***
Task 2. Finalize Project Description	Jennie Anderson	***6***	$135.00	Project Manager	***$810.00***
Task 3. Preparation of Administrative Draft EIR (ADEIR)					
Cover, Title Page, TOC	Megan Steer	1	$55.00	Research Asst.	$55.00
Introduction	Megan Marruffo	1	$95.00	Asst. Env. Planner	$95.00
Summary	Jennie Anderson	1	$135.00	Project Manager	$135.00
	Patricia Preston	6	$120.00	Env. Planner	$720.00
Project Description	Jennie Anderson	1	$135.00	Project Manager	$135.00
Regulatory Setting	Jasmine Patel	2	$110.00	Assoc. Env. Planner	$220.00
Aesthetics	Patricia Preston	30	$120.00	Env. Planner	$3,600.00
Agriculture Resources	Jasmine Patel	16	$110.00	Assoc. Env. Planner	$1,760.00
Air Quality (w/ GHG)	Dan Hooper	36	$135.00	Air Specialist	$4,600.00
Biological Resources	Amy Parravano	48	$135.00	Principal Biologist	$6,480.00
	Patricia Preston	4	$120.00	Env. Planner	$480.00
Cultural Resources	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00
Geology & Soils	Jennie Anderson	2	$135.00	Project Manager	$270.0
	Patricia Preston	16	$120.00	Env. Planner	$1,920.0
Hazards & Hazardous Materials	Jasmine Patel	16	$110.00	Assoc. Env. Planner	$1,760.00
Hydrology & Water Quality	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Land Use & Planning	Patricia Preston	12	$120.00	Env. Planner	$1,440.00
Noise	Scott Wirtz	30	$135.00	Noise Specialist	$4,050.00
Population & Housing	Jasmine Patel	22	$120.00	Assoc. Env. Planner	$2,640.00
Public Services	Jessica Viramontes	16	$120.00	Env. Planner	$1,920.00
Transportation/Traffic	Jessica Viramontes	16	$120.00	Env. Planner	$1,920.00
Utilities & Service Systems	Jennie Anderson	6	$135.00	Project Manager	$810.00
	Jessica Viramontes	32	$120.00	Env. Planner	$3,840.00
General Impact Categories	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00
Summary of Cumulative Impacts	Jasmine Patel	8	$110.00	Assoc. Env. Planner	$880.00

Table 2
Big Wave EIR, Cost Amendment #1

Alternatives to the Proposed Project	Geoff Reilly	4	$160.00	Principal	$640.00
	Jennie Anderson	24	$135.00	Project Manager	$3,240.00
Preparers of the EIR & Persons Consulted	Megan Steer	1	$55.00	Research Asst.	$55.00
Bibliography	Megan Steer	1	$55.00	Research Asst.	$55.00
Technical Appendices	Megan Steer	2	$55.00	Research Asst.	$110.00
Project Referral Comments	Megan Steer	3	$55.00	Research Asst.	$165.00
Task 3 Subtotal		***381***			***$46,595.00***
Task 4. Preparation of the Draft EIR (DEIR) *					
Screencheck Draft EIR (SDEIR)	Geoff Reilly	2	$160.00	Principal	$320.00
	Jennie Anderson	10	$135.00	Project Manager	$1,350.00
	Patricia Preston	14	$120.00	Env. Planner	$1,680.00
DEIR	Jennie Anderson	2	$135.00	Project Manager	$270.00
	Jasmine Patel	8	$110.00	Assoc. Env. Planner	$880.00
Task 4 Subtotal		***36***			***$4,500.00***
Task 5. Preparation of Final EIR (FEIR) and Mitigation Monitoring Program (MMP) [1]*					
Appendices & Delineation of Comments on DEIR	Geoff Reilly	1	$160.00	Principal	$160.00
	Jennie Anderson	10	$135.00	Project Manager	$1,350.00
	Jasmine Patel	20	$110.00	Assoc. Env. Planner	$2,200.00
Response to Comments	Geoff Reilly	3	$160.00	Principal	$480.00
	Jennie Anderson	20	$135.00	Project Manager	$2,700.00
	Patricia Preston	36	$120.00	Env. Planner	$4,320.00
	Jasmine Patel	38	$110.00	Assoc. Env. Planner	$4,180.00
Administrative Final EIR (AFEIR)	Jennie Anderson	4	$135.00	Project Manager	$540.00
	Patricia Preston	10	$120.00	Env. Planner	$1,200.00
Screencheck Final EIR (SFEIR)	Geoff Reilly	1	$160.00	Principal	$160.00
	Jennie Anderson	6	$135.00	Project Manager	$810.00
FEIR	Jennie Anderson	2	$135.00	Project Manager	$270.00
	Megan Marruffo	4	$95.00	Asst. Env. Planner	$380.00
MMP	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Task 5 Subtotal		***163***			***$19,830.00***
Task 6. Hearings & Meetings					
(4) Hearings	Geoff Reilly	12	$160.00	Principal	$1,920.00
	Jennie Anderson	12	$135.00	Project Manager	$1,620.00
(8) Meetings/Conference Calls	Geoff Reilly	12	$160.00	Principal	$1,920.00
	Jennie Anderson	12	$135.00	Project Manager	$1,620.00
Preparation of Materials	Jessica Viramontes	2	$120.00	Env. Planner	$240.00
	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00

Table 2
Big Wave EIR, Cost Amendment #1

Task 6 Subtotal		***58***			***$8,080.00***
Task 7. Findings of Facts and Statement of Overriding Considerations	Jennie Anderson	7	$135.00	Project Manager	$945.00
	Megan Marruffo	2	$95.00	Asst. Env. Planner	$190.00
Task 7 Subtotal		***9***			***$1,135.00***
Graphics					
EIR Graphics/Simulation Peer Review	Scott Johnson	***40***	$60.00	Graphics Director	***$2,400.00***
Production of Notices *					
Notice of Availability (NOA) - DEIR	Patricia Preston	1	$120.00	Env. Planner	$120.00
Notice of Completion (NOC)	Patricia Preston	1	$120.00	Env. Planner	$120.00
Notice of Determination (NOD)	Jennie Anderson	1	$135.00	Project Manager	$135.0
Subtotal		***3***			***$375.00***
Word Processing & EIR Production	Megan Marruffo	6	$95.00	Asst. Env. Planner	$570.00
	Megan Steer	5	$55.00	Research Asst.	$275.00
Subtotal		***11***			***$845.00***
	TOTAL CAJA LABOR COSTS				**$89,655.00**
SUBCONSULTANT COSTS					
Labor/Expenses to Complete Remaining Work					
Hydrology and Water Quality (Shaaf & Wheeler)		*Fixed Fee*			$8,000.00
Transporation/Traffic (Hexagon)		*Fixed Fee*			$9,095.00
Utilities & Service Systems - Water/Wastewater (Questa)		*Fixed Fee*			$18,600.00
	TOTAL SUBCONSULTANT COSTS				**$35,695.00**
DIRECT EXPENSES					
Printing and Reproduction					
Notices (NOA, NOC, NOD)					$100.00
ADEIR w/Appendices (5)					$1,000.00
DEIR w/Appendices (50)					$6,500.00
AFEIR w/Appendices (5)					$750.00
FEIR w/Appendices (50)					$3,000.00
Graphics/Map Reproductions					$150.00
Circulate Notices, EIRs to County					$200.00
Other Mailing/Publication Expenses (e.g., FedEx, supplies)					$150.00
Travel Expenses/Misc. Materials					$500.00
	TOTAL EXPENSES				**$12,350.00**
	GRAND TOTAL				**$137,700.00**

* This amendment assumes that the County will distribute the DEIR, FEIR and all Notices (NOA, NOC, NOD).

Table 2

Big Wave EIR, Cost Amendment #1

[1] This amendment assumes an average number of comments on the DEIR. Additional hours may be necessary depending on the number of comments received and the complexity of responses. Additional requested and approved hours will be billed at a Time & Materials rate utilizing CAJA's agreed fee schedule.

Global and regional climate changes due to black carbon

Black carbon in soot is the dominant absorber of visible solar radiation in the atmosphere. Anthropogenic sources of black carbon, although distributed globally, are most concentrated in the tropics where solar irradiance is highest. Black carbon is often transported over long distances, mixing with other aerosols along the way. The aerosol mix can form transcontinental plumes of atmospheric brown clouds, with vertical extents of 3 to 5 km. Because of the combination of high absorption, a regional distribution roughly aligned with solar irradiance, and the capacity to form widespread atmospheric brown clouds in a mixture with other aerosols, emissions of black carbon are the second strongest contribution to current global warming, after carbon dioxide emissions. In the Himalayan region, solar heating from black carbon at high elevations may be just as important as carbon dioxide in the melting of snowpacks and glaciers. The interception of solar radiation by atmospheric brown clouds leads to dimming at the Earth's surface with important implications for the hydrological cycle, and the deposition of black carbon darkens snow and ice surfaces, which can contribute to melting, in particular of Arctic sea ice.

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Black carbon (BC) is an important part of the combustion product commonly referred to as soot[1]. BC in indoor environments is largely due to cooking with biofuels such as wood, dung and crop residue. Outdoors, it is due to fossil fuel combustion (diesel and coal), open biomass burning (associated with deforestation and crop residue burning), and cooking with biofuels[1]. Soot aerosols absorb and scatter solar radiation. BC refers to the absorbing components of soot, often defined using elemental carbon and some condensed organics[2]. Recent findings suggest other secondary organics also contribute to strong absorption in the ultraviolet region of the spectrum, components that were presumably ignored in the original definition of BC[3]. Dust, which also absorbs solar radiation, is not included in the definition of BC. Globally, the annual emissions of BC are (for the year 1996) ~8 Tg yr^{-1} (ref. 4), with about 20% from biofuels, 40% from fossil fuels and 40% from open biomass burning. The uncertainty in the published estimates for BC emissions is a factor of two to five on regional scales and at least ±50% on global scales.

High BC emissions (Fig. 1) occur in both the northern and the Southern Hemisphere, resulting largely from fossil fuel combustion and open burning, respectively. Atmospheric brown clouds (ABCs) are composed of numerous submicrometre aerosols, including BC, but also sulphates, nitrates, fly ash and others. ABCs have been extensively documented by surface observatories, field observations and satellite data[5–15]. Single-particle mass spectrometer data reveal that BC is internally mixed with other aerosol species such as sulphates, nitrates, organics, dust and sea salt[16]. BC is removed from the atmosphere by rain and snowfall[2]. Wet removal as well as direct deposition to the surface limits the atmospheric lifetime of BC to about one (±1) week[17].

REGIONAL HOTSPOTS

Until about the 1950s, North America and Western Europe were the major sources of soot emissions, but now developing nations in the tropics and East Asia are the major source regions[18,19] (Fig. 1). Historical BC emissions are available for fossil fuel combustion and biofuel cooking[18,19]. Past emissions of BC from biomass burning are very uncertain[19], although, published reports of extensive brown clouds and their possible effects on the atmosphere date back to at least the 1880s[20].

Integration of field observations[7,14] and new satellite aerosol sensors[15] have revealed the global distribution of ABCs and their radiative forcing[21–23]. Their concentrations peak close to major source regions and give rise to regional hotspots of BC-induced atmospheric solar heating (Fig. 1b). Such hotspots have recently been identified[24] as the Indo-Gangetic plains in South Asia; eastern China; most of Southeast Asia including Indonesia; regions of Africa between sub-Sahara and South Africa; Mexico and Central America; and most of Brazil and Peru in South America. Populations of about 3 billion are living under the influence of these regional ABC hotspots.

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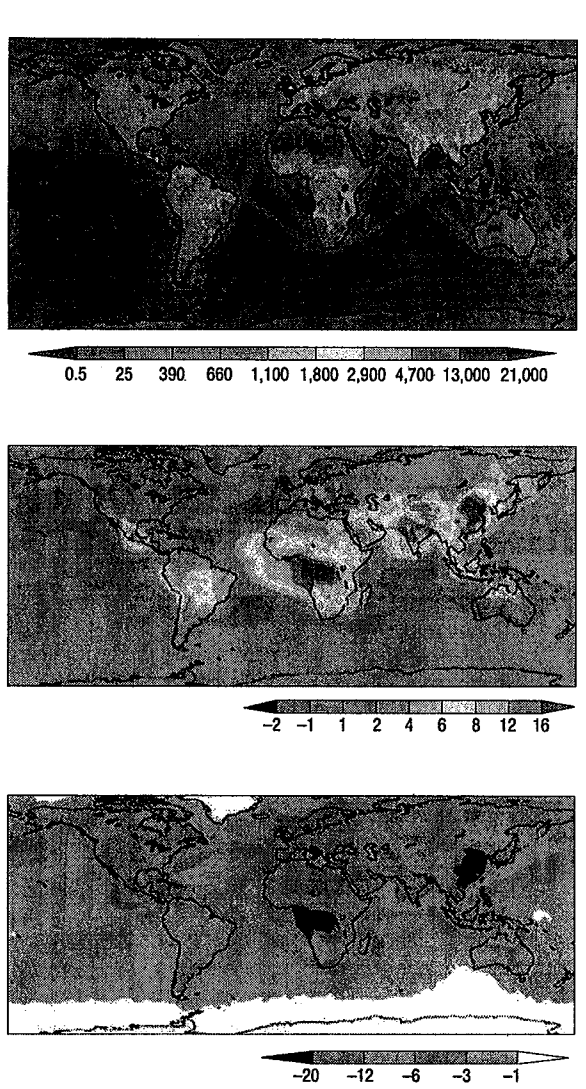


Figure 1 Global distribution of BC sources and radiative forcing. **a**, BC emission strength in tons per year from a study by Bond *et al.*[4], including emissions from fuel combustion (fossil fuels and biofuels) and open biomass burning (forest fires, savanna burning and outdoor cooking) for the year 1996. The uncertainty in the regional emission is about ±100% or more. **b**, Atmospheric solar heating due to BC from the study by Chung *et al.*[23] for the 2001 to 2003 period. This study integrates satellite aerosol data, surface network of aerosol remote sensing instruments and field observations with an aerosol-transport-chemical model and a radiative transfer model to obtain the forcing. Uncertainty in the forcing is ±30%. **c**, As in **b**, but for surface dimming due to ABCs. This shows the reduction in absorbed solar radiation at the surface by all anthropogenic aerosols (BC and non-BC) in ABCs.

RADIATIVE FORCING OF THE CLIMATE SYSTEM

Solar absorption by BC increases inversely with wavelengths from near-infrared (1 μm) to ultraviolet wavelengths with a power law of one to three depending on the source[3,25], thus giving the brownish colour to the sky. Unlike the greenhouse effect of CO_2, which leads to a positive radiative forcing of the atmosphere and at the surface[26] with moderate latitudinal gradients[27,28], black carbon has opposing effects of adding energy to the atmosphere and reducing it at the surface. Furthermore the forcing has significant latitudinal gradients. It alters the radiative forcing through a complex web of processes[7].

The first concerns the increase in top-of-the atmosphere (TOA) radiative forcing. This occurs via several pathways: (1) by absorbing the solar radiation reflected by the surface–atmosphere–cloud system, BC reduces the albedo of the planet; (2) soot deposited over snow and sea ice can decrease the surface albedo[29–32]; (3) soot inside cloud drops and ice crystals can decrease the albedo of clouds by enhancing absorption by droplets and ice crystals[31–34]. All three of these processes contribute to a positive TOA forcing. On the other hand, non-BC aerosols such as sulphates, nitrates and organics in ABCs reflect more solar radiation, increasing the albedo of the planet and resulting in a negative TOA forcing. In addition non-BC aerosols also nucleate cloud drops and thus increase the albedo of clouds. This effect is referred to as an indirect effect or 'cloud-albedo effect'[35–37].

Figure 2 compares the BC forcing (Fig. 2c) with forcing due to all greenhouse gases (GHGs; Fig. 2a), forcing due to CO_2 alone (Fig. 2b) and forcing of all aerosols other than BC (Fig. 2d). The BC forcing includes only the direct forcing from pathway 1 because pathways 2 and 3 are more uncertain and, furthermore, contribute only about 0.1 W m^{-2} to the global forcing[33]. At the TOA, the ABC (that is, BC + non-BC) forcing of −1.4 W m^{-2} (sum of TOA values in Figs 2c,d), which includes a −1 W m^{-2} indirect forcing, may have masked as much as 50% (±25%) of the global forcing due to GHGs. The estimated aerosol forcing of −1.4 W m^{-2} due to ABCs is within 15% of the aerosol forcing derived in the recent IPCC report[37] and is also consistent with other studies[35,36].

The BC forcing of 0.9 W m^{-2} (with a range of 0.4 to 1.2 W m^{-2}) (Fig. 2c) is as much as 55% of the CO_2 forcing and is larger than the forcing due to the other GHGs such as CH_4, CFCs, N_2O or tropospheric ozone[37]. Similar conclusions regarding the large magnitude of the BC forcing have been inferred by others[38–41] and their estimates range from 0.4 W m^{-2} to 1.2 W m^{-2}. The estimate shown in Fig. 2c is obtained from the observationally constrained study of Chung *et al.*[23]. Values generated by many general circulation climate models (GCMs) are mostly in the lower range of 0.2 W m^{-2} to 0.4 W m^{-2} (refs 37,42,43). There are several reasons for the lower estimates. Many ignore the internally mixed state of BC with other aerosols. Such mixing enhances forcing by a factor of two (ref. 39). Field observations have consistently shown that BC is well mixed with sulphates, organics and others[16,44]. Another factor contributing to lower BC forcing in GCMs is that observed BC concentrations peak at about 2 km above the surface[7,14,44] whereas, in most models they are concentrated close to the surface[45]. BC at elevated levels enhances solar absorption significantly because it can absorb the solar radiation reflected by the highly reflective low clouds[38,40,46]. Furthermore, GCMs with lower positive forcing, in general, ignore biomass burning, which is about 40% of the total BC emission. Column integrated aerosol absorption has been retrieved from a worldwide surface network of solar spectral radiometers, referred to as AERONET[47]. The retrieved aerosol absorption[11,48] is a factor of two or more larger than the GCM simulated values[41,49]. The exceptions to the low forcing bias of GCMs are the models that constrain aerosol solar absorption with AERONET values[50] and models that account for the mixing state of BC with other aerosols and include BC from biomass burning[39,40]. The BC forcings estimated by these models are in the range of 0.6 to 0.8 W m^{-2} (refs 39,40) and 0.8 to 1.2 W m^{-2} (refs 41,50).

The second process concerns atmospheric solar heating. In addition to absorbing reflected solar radiation, BC absorbs direct solar radiation and together the two processes contribute to a

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significant enhancement of lower atmosphere (from the surface to about 3 km altitude) solar heating, by as much as 50% in the hotspots (that is, regions with 15 W m^{-2} forcing) (see Fig. 1b). Direct measurement of this solar heating has evaded us until now as it requires multiple aircraft flying over the same domain at different altitudes to measure flux divergences (that is, heating rates) for an extensive period of time. These challenges were recently overcome by deploying three lightweight unmanned aerial vehicles (UAVs) with well-calibrated and miniaturized instruments to simultaneously measure aerosols, BC and spectral as well as broadband radiation fluxes[14,51,52]. The UAV study[14] demonstrated that ABCs with a visible absorption optical depth as low as 0.02 are sufficient to enhance solar heating of the lower atmosphere by 50%. Global average BC solar heating of the atmosphere, as per the present estimate, is 2.6 W m^{-2} (Fig. 2c), which is comparable to the TOA GHG forcing (Fig. 2a).

The third process is the surface dimming. The BC absorption of direct solar radiation reduces the solar radiation reaching the surface and leads to dimming (Fig. 2c). The BC dimming is further enhanced by the direct and indirect effects of non-BC aerosols (Fig. 2d). The total dimming effect is −4.4 W m^{-2} (sum of Fig. 2c,d) — about −3.4 W m^{-2} from the direct effect of ABCs and the remaining −1 W m^{-2} from the indirect effect[35–37]. The dimming can be as large as 5 to 10% over the regional hotspots (Fig. 1). It is important to note that the surface dimming and absorption of direct solar radiation do not contribute much to TOA forcing as it is simply a redistribution of the direct solar radiation between the surface and the atmosphere. However, globally, this redistribution can weaken the radiative–convective coupling of the atmosphere and decrease global mean evaporation and rainfall[26].

Is the planet dimmer now than it was during the early twentieth century? Solar radiometers around the world are indicating that surface solar radiation in the extra tropics was lower by as much as 5% to 10% during the mid-twentieth century[53,54], whereas in the tropics such dimming trends have been reported to extend into the twenty-first century. But many of these radiometers are close to urban areas and it is unclear if the published trends are representative of true regional to global averages[55]. The Indian Ocean Experiment[7] used a variety of chemical, physical and optical measurements to convincingly demonstrate that ABCs can lead to dimming as large as 5–10% (Fig. 1c) over widespread regions in the North Indian Ocean and South Asia. In order to get a handle on the global average dimming, Chung *et al.*[23] integrated field observations with satellite data and aerosol transport models to retrieve an observationally constrained estimate. As seen from Fig. 1c, over large regions the reduction of solar absorption at the surface exceeds 10 W m^{-2} (>5%), which is consistent with the dimming reported from surface observations. The global annual average dimming (for 2001–2003), however, is −4.4 W m^{-2}, as opposed to the −10 W m^{-2} estimated by surface radiometers. Thus, great care should be exercised to extrapolate surface measurements over land areas to global averages. The global dimming of −4.4 W m^{-2} has been compared to the GHGs forcing of 3 W m^{-2} from 1850 to present[54]. Such comparisons, without a proper context could be misleading because, as shown in Fig. 2, for BC, the surface forcing is negative whereas the TOA forcing is positive (Fig. 2c).

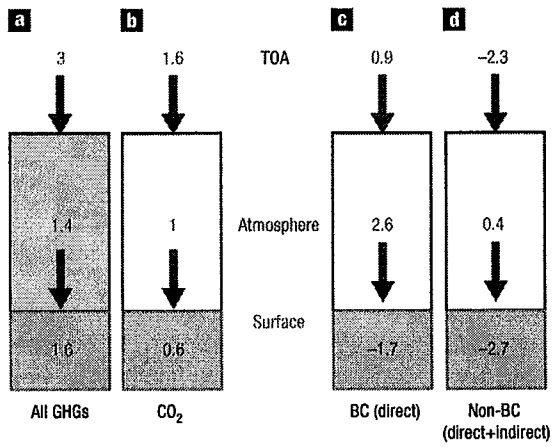


Figure 2 Comparison of the global mean radiative forcing due to greenhouse gases (GHGs) with that of ABCs. **a**,**b**, Forcing for all GHGs (CO_2, CH_4, N_2O, halons and ozone) (**a**), and for CO_2 (**b**). The number at the top of the atmosphere box (blue box) is the top-of-the atmosphere (TOA) forcing; the number within the atmosphere box is the atmospheric forcing; and the number within the brown box is the forcing at the surface. The TOA forcing is the sum of the forcing of the atmosphere and the surface. The forcing values represent the change in radiative forcing due to increase in gases for the year 2005, which is the same as the forcing from pre-industrial to present. The TOA numbers are taken from ref. 68 and the atmospheric and surface forcings are derived from an atmospheric radiative transfer model. The numbers at the surface and the atmosphere are slightly adjusted to agree with the TOA IPCC forcing. The uncertainty in the forcing values is ±20%. **c**, BC forcing obtained by running the Chung *et al.* analysis[23] with and without BC. The forcing values are valid for the 2001–2003 period and have an uncertainty of ±50%. **d**, Non-BC forcing. This includes the direct and the indirect forcing. The direct forcing is obtained by subtracting the total anthropogenic forcing in Chung *et al.* from the BC forcing shown in **b**. The indirect forcing (of about 1 W m^{-2} at the TOA and at the surface) is an average of values derived from recent studies[35–37].

GLOBAL CLIMATE EFFECTS

The TOA BC forcing implies that BC has a surface warming effect of about 0.5 to 1 °C, where we have assumed a climate sensitivity of 2 to 4 °C for a doubling of CO_2. Conversely, ABCs have a cooling effect of about −0.75 to −2.5 °C (ref. 35). Because BC forcing results in a vertical redistribution of the solar forcing, a simple scaling of the forcing with the CO_2 doubling climate sensitivity parameter may not be appropriate[40,56,57]. For example, GCMs suggest that the reduction of sea ice and snow albedo by BC is three times as effective as CO_2 forcing for global average surface warming[57].

BC and non-BC aerosols perturb the hydrological cycle significantly. The surface and atmospheric warming due to GHGs would lead to an increase in atmospheric humidity (owing to an increase in saturation vapour pressure) and rainfall (owing to an increase in the radiative heating at the surface)[26,58]. With respect to ABCs, the overall negative forcing at the TOA, as well as the surface dimming, should lead to a decrease in evaporation and rainfall[7,37]. It is difficult to predict the net effect of GHGs and ABCs on global rainfall, given the large positive forcing at the TOA and the larger negative forcing at the surface. We can not resort to observed rainfall trends to infer the net anthropogenic effect on global rainfall as long-term rainfall measurements are only available for land regions.

REGIONAL CLIMATE EFFECTS

We have just begun to comprehend the chain of response and feedbacks on the regional climate due to BC[9,12,14,23,59–65]. In regions where radiative–convective coupling of the surface and the atmosphere is strong (for example, equatorial oceans and tropical

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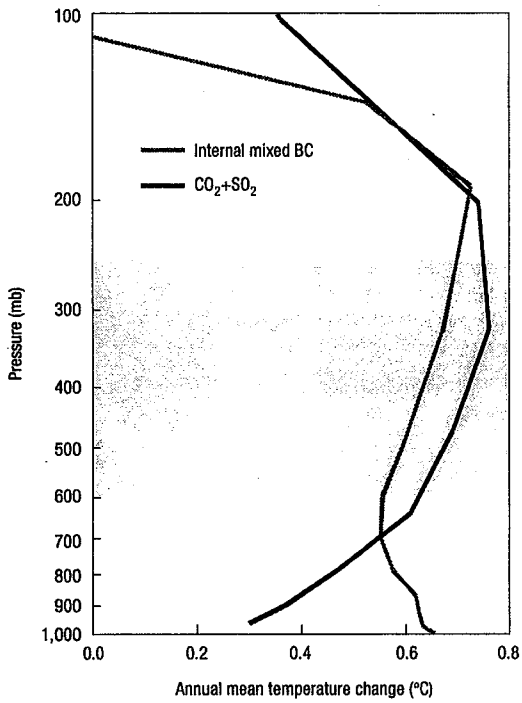


Figure 3 Simulated atmospheric temperature change due to GHGs and BC for the South Asian region. The values are annual mean temperature changes over the South Asian region, averaged from 20° N to 40° N and from 70° E to 100° E. The blue line is the change due to the increase in all GHGs and sulphate aerosols as simulated by ref. 60. The red line is the estimated temperature change due to BC taken from the global circulation model study of Chung and Seinfeld[67].

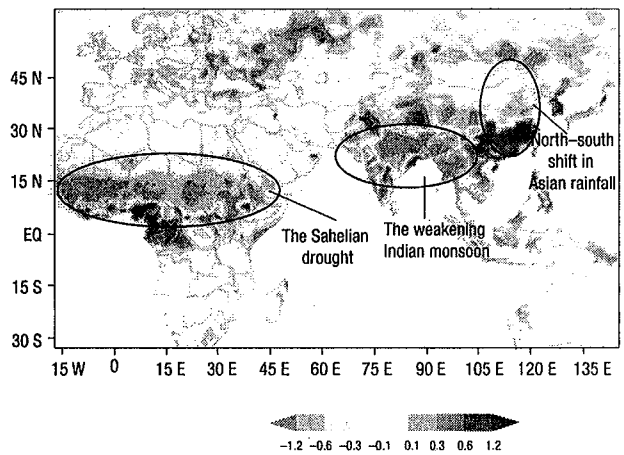


Figure 4 Precipitation trend from 1950–2002. The plot is adopted from ref. 65. (units: change in mm per day from 1950 to 2002). The red and dark blue shaded regions are statistically significant.

land during wet seasons), the surface–atmosphere response will be determined by the TOA forcing, and as a result BC by itself will lead to a warming of both the surface (in spite of the surface dimming) and the atmosphere (in spite of the atmospheric solar heating), whereas ABCs will lead to a cooling of both the surface and the atmosphere. In regions where such coupling is weak (for example, dry seasons in the tropics), the surface dimming due to ABCs can lead to surface cooling and thus can mask the greenhouse warming[66], whereas the atmospheric solar heating by BCs can lead to a warming of the atmosphere and intensify the greenhouse warming of the troposphere. GCMs that include just the BC forcing[14,64,67] show that BC leads to a warming from the surface to about 12 km altitude, by as much 0.6 °C over most of the Northern Hemisphere including the Arctic region (for example, see Fig. 11 in Chung and Seinfeld[40], and ref. 64). The magnitude of the BC atmospheric warming is comparable to the simulated warming due to GHGs forcing[68]. Regionally, the combined effect of ABCs is to cause a surface cooling[65] over South Asia while warming the atmosphere by as much as 0.6 °C during winter and spring[14,60]. Such differential warming of the atmosphere with respect to the surface over the South Asian region has also been observed with microwave satellite sensor observations of the trends from 1979 to 2003[14,60].

BC atmospheric heating may be an important contributing factor to the retreat of Himalayan glaciers. Analysis of temperature trends on the Tibetan side of the Himalayas reveals warming in excess of 1 °C since the 1950s. This large warming trend at the elevated levels is proposed as the causal factor for the retreat of glaciers through melting[69,70]. GCM simulations suggest that advection of the warmer air heated by BC from South and East Asia over the Himalayas contributes to a warming of about 0.6 °C (annual mean) in the lower and mid troposphere (see Fig. 3) of the Himalayan region[14,64]. This is as large as the warming trend due to the GHGs (Fig. 3), leading to the inference[14] that BC forcing is as important as GHGs in the observed retreat of over two thirds of the Himalayan glaciers[71].

BC contributes to melting of snow through another process. When soot is deposited over snow and sea ice, it darkens the snow and significantly enhances solar absorption by snow and ice[30,32]. Recent studies suggest that this is one of the important contributors to the retreat of the Arctic sea ice (see summary of earlier studies in ref. 57). Simulations by Flanner *et al.*[57] showed that the deposition of BC from sources in North America and Europe over the Arctic sea ice may have resulted in an Arctic surface warming trend of as much as 0.5 to 1 °C (ref. 72). In addition, the study estimated that BC-induced reduction of snow albedo is a major forcing term (about 20 W m^{-2}) in the Tibetan side of the Himalayas. Ice-core records of BC deposition over Greenland from the early nineteenth century onwards have now provided a historical record for examining the role of BC forcing in the retreat of sea ice[73].

Atmospheric heating and dimming by BC and non-BC aerosols can perturb the monsoon significantly. Precipitation trends over many regions of the tropics during the last 50 years have been negative, particularly over Africa, South Asia and northern China (Fig. 4)[68]. These drying patterns can not be explained solely by global warming[74,75]. Natural variability and anthropogenic aerosol forcing are emerging as major players in the observed trends[60,74–76]. The impacts of ABCs and BC on the South Asian monsoon have received attention recently[40,59,60,62,63,65,67,74]. Precipitation over land is driven by evaporation from the land surface and long-range transport of moisture from the surrounding Indian Ocean. These model studies reveal that ABCs have three distinct effects on the long-range transport of moisture and its convergence over South Asia:

(i) A decrease in the evaporation of the Indian Ocean owing to dimming. Emissions of BC and other aerosol precursors from South Asia have increased significantly since 1950s[18,19]. This has resulted in a dimming trend of about 7% as detected by surface radiometers in India[60]. Similar dimming has also occurred

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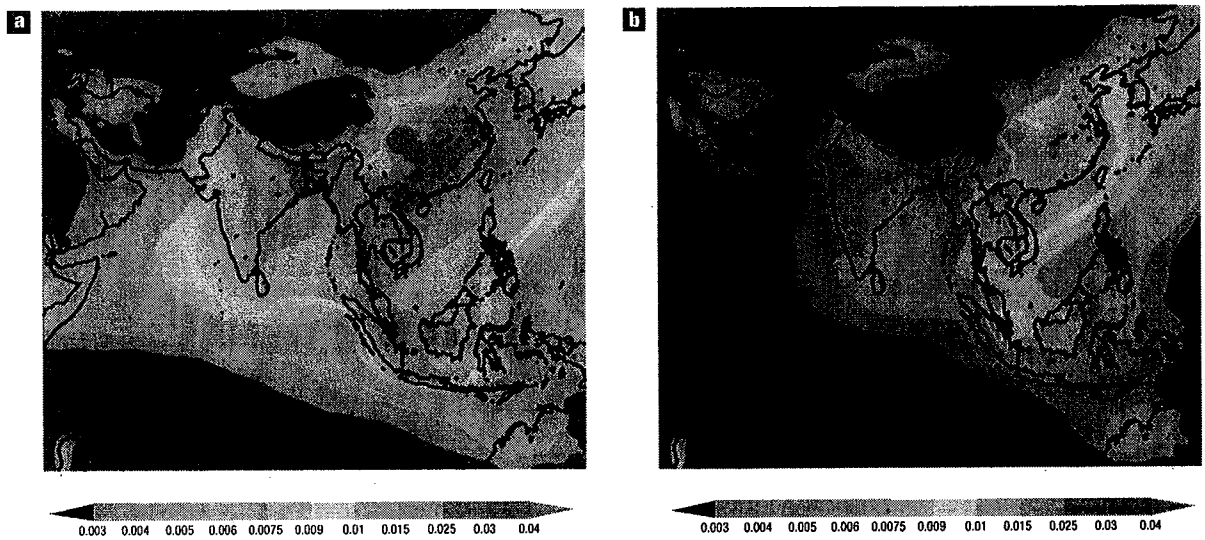


Figure 5 The effect of biofuel cooking on Asian BC loading. **a**, The simulated annual mean optical depth of BC aerosols for 2004–2005 using the regional aerosol/chemical/transport model described in ref. 96. The values include BC emissions from biofuel cooking (indoor cooking with wood/dung/crop residues), fossil fuels and biomass burning. **b**, As for **a**, but without biofuel cooking.

over the Indian Ocean[7] (See Fig. 1c). As about 75% or more of the surface radiative heating is balanced by evaporation[26], the dimming trend leads to a decrease in evaporation from the North Indian Ocean[60], so less moisture is fed to the monsoonal inflow into South Asia.

(ii) A decrease in meridional sea surface temperature (SST) gradient. Because ABCs are concentrated over the North Indian Ocean (Fig 1), the dimming is suppressing the greenhouse warming over the North Indian Ocean while the GHGs warming is proceeding unabated over the southern Indian Ocean. As a result, the summertime north-to-south SST gradient (with warmer waters over the North Indian Ocean) has decreased since the 1950s, as has been seen from observations[60,74]. The weakening of the SST gradient weakens the monsoonal circulation, as shown by numerous studies[60,74,75], and in turn weakens the monsoonal rainfall during summertime. It is important to note that, although the ABC dimming peaks in winter and spring, the SST response is delayed until summer owing to the slower response time of the ocean[60,64,74].

(iii) An increase in atmospheric meridional heating gradient. The stronger BC solar heating of the atmosphere over South Asia (Fig. 1b) strengthens the monsoonal outflow with stronger rising motions over the subcontinent, accompanied by a stronger moisture flux into South Asia[60,63,64,74]. This effect, which increases rainfall, peaks during spring when the BC heating is at its peak value.

The atmospheric heating shown in Fig. 1b is solely due to BC, whereas the dimming is due to both the BCs and non-BC aerosols in ABCs (Figs 1c and 2d). The larger dimming over the land regions compared with the adjacent oceans also suggest that the dimming decreases the land–sea contrast in surface temperature — a major monsoon forcing term. In order to account for the delayed oceanic response to the dimming, fully coupled ocean–atmosphere models are required. To date, three such studies have been published[60,62,64] and all of them estimate an increase in pre-monsoon rainfall during spring followed by a decrease in summer monsoon rainfall, in agreement with observed trends (Fig. 4; ref. 60). The link between dimming, the north–south SST gradient and a decrease in land rainfall has also been invoked to explain the Sahel drought[75] of the 1970s and 1980s.

CLIMATE SYSTEM RESPONSE AND FEEDBACKS

The immediate response of the atmosphere to ABCs is to increase or decrease cloud cover. The non-BC aerosols, by nucleating more cloud drops, decrease the effective radius of the cloud drop. This can suppress formation of larger drizzle drops, extend the lifetime of clouds, and thus increase cloud cover[37]. On the other hand, BC solar heating can decrease the relative humidity of the cloud layer, leading to evaporation of cloud drops and thus decreasing low cloud fraction and albedo. This semi-direct effect can enhance the positive climate forcing by BC[37]. A relative comparison of the increase in cloud cover by non-BC aerosols and the decrease due to BC was undertaken[77] empirically with a surface network of sun photometers[47]. This study suggested that the non-BC effects dominate overall, except for in heavily polluted regions with absorption optical depths exceeding 0.05 (for example, the Amazon during the burning season; Africa during Savanna burning season; and urban regions in South and East Asia). An alternative scenario is that BC solar heating induces convection and consequently leads to cloud formation[78]. The global magnitude of the semi-direct effect is highly uncertain.

Spring season dust storms from Asia and Africa transport large quantities of dust across the Pacific Ocean[79,80] and the Atlantic Ocean[81]. The dust is transported either as individual layers or mixed with industrial soot. Such dust–soot mixtures increase the atmospheric solar heating and surface dimming significantly[79,80] and can also serve as nuclei for ice clouds and feedback on precipitation[82]. For the first time, such dust–soot mixtures were tracked in an aircraft all the way across the Pacific Ocean from near the surface to about 14 km altitude[83].

An increase in drought intensity due to global warming can intensify occurrence of forest fires, as has been documented for California[84]. Increase in forest fires, such as the boreal forest fires of 1996, can increase soot deposition in sea ice and enhance its melting[57]. Surface cooling occurring simultaneously with lower atmosphere warming (due to BC and dust) can stabilize the

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boundary layer during the dry season and increase the lifetimes of aerosols in ABCs and increase persistence of soot-filled fog. Soot can also influence precipitation formation mechanisms[85,86].

Two extreme scenarios have been proposed for such feedbacks. For South Asia, GCM simulations suggest that a two- to threefold increase in soot loading (from present day levels) is sufficient to substantially weaken the monsoon circulation, decrease rainfall by more than 25% and increase drought frequency significantly[59]. As wash out by rain is a major sink for BC, large decreases in rainfall can have a positive feedback on BC concentrations. The other scenario is the so-called nuclear winter scenario[87–89], in which large-scale increase in BC from fires resulting from a global-scale nuclear war can nearly shut down sunlight at the ground (total dimming), which can collapse the troposphere and decrease rainfall drastically.

REDUCING FUTURE BLACK CARBON EMISSIONS

Given that BC has a significant contribution to global radiative forcing, and a much shorter lifetime compared with CO_2 (which has a lifetime of 100 years or more), a major focus on decreasing BC emissions offers an opportunity to mitigate the effects of global warming trends in the short term (see, for example, refs 90–92). Reductions in BC are also warranted from considerations of regional climate change and human health[93,94].

It is clear from Fig. 2 that air pollution mitigation steps can have significant impacts on future climate changes. The logical deduction from Fig. 2a,c,d is that the elimination of present day ABCs through emission reduction strategies would intensify surface warming by about 0.4 to 2.4 °C (see also, ref. 35). If only the non-BC aerosols were controlled, it could potentially add 2.3 W m^{-2} to the TOA forcing and push the system closer to the 3 °C cumulative warming (since 1850s), which is a likely threshold for unprecedented climate change[95]. If on the other hand, the immediate target for control shifts entirely to BC (owing to its health impacts) without a reduction in non-BC aerosols, the elimination of the positive forcing by BC will decrease both the global warming and the retreat of sea ice and glaciers. It is important to emphasize that BC reduction can only help delay and not prevent unprecedented climate changes due to CO_2 emissions.

ASIAN EMISSIONS AND FUTURE TRENDS

Given the fact that technology exists for large reductions of soot emissions, we explore the impact of a major focus on soot reductions. We focus on Asia, where emissions from China and India alone account for ~25 to 35% of global BC emissions and the regional climate responses to BC are (expected to be) large. In addition, with the economies of China and India expanding with double digit growth rates, Asia can become a much larger source of ABCs, depending on the energy path taken to sustain this growth rate. In fact new estimates indicate that BC emissions for China in 2006 have doubled since 2000, whereas SO_2 emissions have grown during this period by more than 50% (D. G. Streets, manuscript in preparation, data available at http://www.cgrer.uiowa.edu/EMISSION_DATA_new/summary_of_changes.html). East Asia and South Asia also represent a different mix of emissions, and therefore can illustrate potentials for various control options that are also representative of global choices. The majority of soot emission in South Asia is due to biofuel cooking, whereas in East Asia, coal combustion for residential and industrial uses plays a larger role. The large BC emissions are reflected in the geographical extent of the large absorbing component of aerosol optical depth, simulated with a regional aerosol-chemistry transport model[96] (see areas with BC optical depth > 0.01 in Fig. 5a).

What are the opportunities to reduce the positive forcing by BC? Providing alternative energy-efficient and smoke-free cookers and introducing transferring technology for reducing soot emissions from coal combustion in small industries could have major impacts on the radiative forcing due to soot[97]. Figure 4b shows the impact of replacing biofuel cooking with BC-free cookers (solar and bio and natural gas) in South and East Asia. The impacts are dramatic: over South Asia, a 70 to 80% reduction in BC heating; and in East Asia, a 20 to 40% reduction. The impact on human health will potentially be even more dramatic as over 400,000 annual fatalities among women and children are attributed to smoke inhalation during indoor cooking[93,94]. However, changes in BC alone do not tell the entire story as the climate response also depends on how the BC to non-BC aerosol fraction responds to future emissions. As BC is co-emitted with non-BC aerosols, it is necessary to evaluate how various mitigation strategies impact this fraction. With an emphasis on the opportunities discussed here, this ratio would probably decrease in the future, more quickly in East Asia, amplifying the effectiveness of BC reductions[98].

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C. NATURAL RESOURCE MANAGEMENT PROGRAM

The primary goal of the Master Plan is to preserve the natural resources of the Reserve, and to enhance them through careful management. Policies and activities that would accomplish this goal are described below.

Policy 1. **Natural resources within the Fitzgerald Marine Reserve will be protected and restored through development and implementation of resource management policies and programs.**

Policy 2. **Visitor management policies and programs will focus on education, one of the priority missions of the Reserve.**



Policy 3. **The Moss Beach Reef and Frenchman's Reef will be continuously monitored over a minimum period of 10 years to develop baseline information on the ecological system, to determine the rate and degree of recovery, and to determine the effectiveness of Master Plan policies limiting visitor use.**

Biological monitoring has been conducted by Reserve staff and volunteers between 1973 and the present, and the Reserve now participates in a joint research program with San Francisco State University. However, additional monitoring and scientific investigations are needed to establish baseline information from which to develop effective monitoring programs and long term management strategies. This Plan proposes that a program for monitoring be developed jointly by the County of San Mateo and the State of California Department of Fish and Game, with participation

by the Monterey Bay National Marine Sanctuary, that will meet the purposes stated in Policy 3, above. This information will be used to meet scientific and research objectives as well as to evaluate the effectiveness of management programs in achieving reef recovery and conservation goals. A monitoring report will be provided every two years to evaluate effectiveness of reef recovery measures and visitor management programs.

Policy 4. **Portions of the Moss Beach Reef may be closed to visitors as warranted by environmental conditions, research objectives, and monitoring activities.**

In order to conduct monitoring activities and scientific investigations of the Moss Beach Reef, portions of the reef may require closure to all visitors from time to time. Configuration of such closures, and the appropriate techniques for closure, would be determined by the Reserve Manager, as part of the adaptive management program for the Reserve.



Policy 5. **The Feasibility of Restoring Tidal Action to the Freshwater Marsh across West Point Avenue to the northeast of the existing saltwater marsh will be determined.**

Expansion of the saltwater marsh would be accomplished by creating channels for tidal flows through the area that was filled to create West Point Drive, and with dredging of fills placed in this area. Hydrologic and biological studies should be undertaken to determine whether restoration of a saltwater marsh is feasible, and the

relative environmental impacts and benefits of replacing the freshwater (seasonal) marsh that exists in this area now with tidal saltwater marsh.

Policy 6. **Water quality improvements in San Vicente Creek and Pillar Point Marsh will be undertaken.**



The program shall include drainage improvements, removal of fill in the San Vicente Creek drainage, implementation of Best Management Practices (BMPs), and enforcement of non-point source water quality regulations. The County will coordinate with surrounding landowners to implement BMPs to improve upstream water quality. Specifically, the County will coordinate with the Half Moon Bay Airport to develop detention basins and vegetation buffers within the Airport's drainage system to minimize impacts to the water quality of the Pillar Point Marsh, and will work with local landowners, the surrounding communities of Princeton, Half Moon Bay and Moss Beach, and the local resource agencies, such as the Farm Bureau, San Mateo County Resource Conservation Service and the Regional Water Quality Control Board to develop best management practices to improve water quality in the San Vicente, Denniston Creek and other drainages upstream from the Reserve.

Policy 7. **Special status wildlife and plant species shall be protected within the Reserve, and habitat management plans shall be developed to protect and restore all identified special status species.**

During implementation of the Master Plan, all areas where work is to be conducted shall be surveyed for special status wildlife and plant species prior to commencement of work. Habitat management programs shall be undertaken when special status species are identified, and impacts to such species shall be avoided or mitigated, as required by State and federal law.

Improvements to the San Vicente Creek and Pillar Point Marsh shall include creation and protection of habitat for the red-legged frog, a federally listed threatened species. A habitat management plan for the red-legged frog shall be implemented within the San Vicente Creek corridor and Pillar Point Marsh.

Policy 8. **A vegetation management program will be developed to restore and protect native plant communities.**



Specific objectives of this program will be to maintain the grove of Monterey cypress trees and to restore native vegetation to the San Vicente Creek channel, to upland areas and the Pillar Point Marsh. Non-native vegetation will be removed from the San Vicente Creek channel and the Pillar Point Marsh, and in the upland areas. The Monterey cypress grove will be thinned to improve the health of the forest and understory plants, and to remove eucalyptus trees, hazardous limbs and trees, and young cypress trees invading adjacent native habitat.

Policy 9. **Maintain the historic character and health of the plant community at the Smith-Dolger historic site.**



The landscape surrounding the historic Smith-Dolger home contributes to the historic character of the site. Some of the plants, such as the palm trees, are not native, but are typical of early California residential settlements of this period. This landscape should be protected and maintained. Invasive non-native plants that are not part of the historic landscape should be removed from around the home and archaeological site; other non-natives should be maintained as needed to protect the historic character of the site.

Policy 10. **Acquire land in the vicinity of Pillar Point Marsh and lands adjacent to the Reserve, as it becomes available, to add to the ecological system of the**

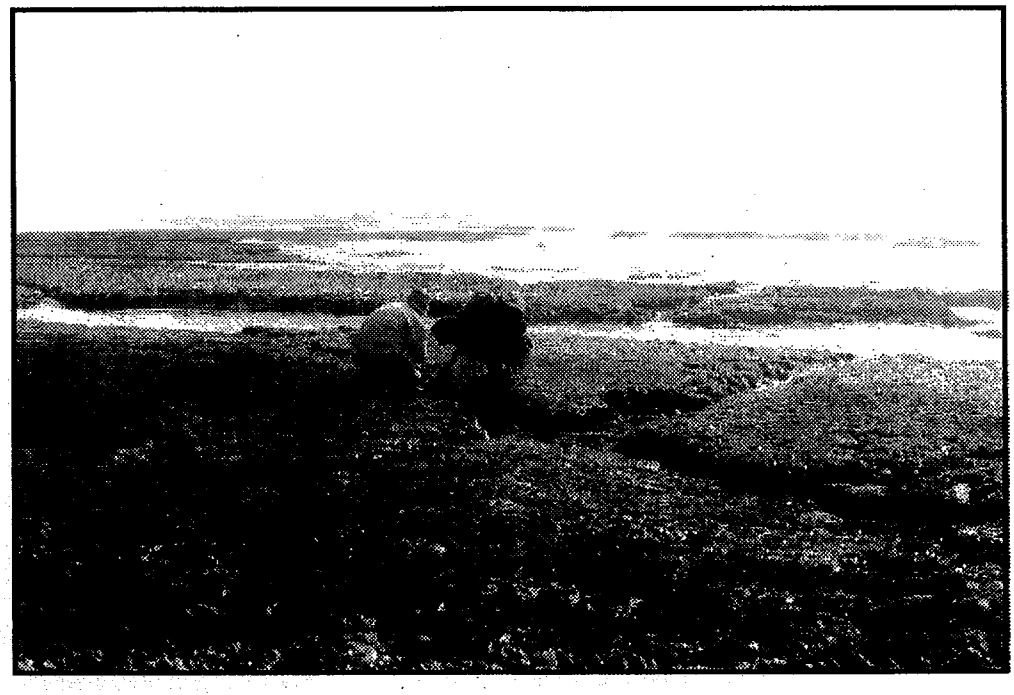
Reserve. Establish a working committee of the County Park and Recreation Commission and Board of Supervisors to coordinate and facilitate acquisitions.



The Pillar Point Marsh land is now separated from the main body of the Reserve. The County should acquire land as it becon..es available in order to connect Pillar Point Marsh with the Reserve, to expand the ecological system of the Reserve, to provide opportunities for future educational activities, and to avoid potential land use impacts that could result from management practices on adjacent lands in different ownership. Acquisition efforts should focus on land between the Reserve and Airport Street to the east, land between Pillar Point Marsh and the Reserve, and lands inland of Pillar Point, including the Pillar Point Air Force Station, should it become available at any time in the future.

Policy 11. **Introduction and possession of domestic and feral animals, including dogs, cats, ducks and any exotic, non-naturalized species are prohibited in the Reserve.**

Due to the potential for impacts to biological resources from predation or disease, dogs and other non-native species are not allowed within the Reserve. This policy will be implemented and enforced to prevent interference with and mortality of native species. Dogs will be allowed only on leash on the California Coastal Trail. Actions to reduce or remove existing populations of domestic and feral animals will be implemented by Reserve staff. This policy is consistent with County Code Section 3.68.080(i).



Policy 12. **Recreational hunting, gathering and collecting are prohibited within the Reserve because of the potential risks to public safety and biological resources.**

California Department of Fish and Game regulations for Marine Life Refuges limit taking and possession of species (see Part One, Section 8.a.1 of this report). However, gathering of species has been a common recreational activity within the Reef and has been responsible for impacts on the biodiversity of the Reef. Hunting has occurred in the bluff area of the Reserve, although infrequently. Subsistence gathering has also occurred on the Reef. These illegal activities have been discouraged through education and outreach by Reserve staff and volunteers; however, many of the Reef resources have been depleted through these activities. As a result, efforts are underway to establish the Reserve as a Marine Life Reserve (for additional discussion, see Part One. Chapter A.5 of this report). The Reserve Manager will be responsible for enforcement of this policy as part of the adaptive management program. This requirement is consistent with County Code Section 3.68.080(d), (g), (h) and (n).

FIRST AMENDMENT TO AGREEMENT BETWEEN THE COUNTY OF SAN MATEO AND CHRISTOPHER A. JOSEPH & ASSOCIATES

THIS FIRST AMENDMENT TO THE AGREEMENT, entered into this _____ day of _____, 20_____, by and between the COUNTY OF SAN MATEO, hereinafter called "County," and Christopher A. Joseph & Associates, hereinafter called "Contractor";

W I T N E S S E T H:

WHEREAS, pursuant to Government Code, Section 31000, County may contract with independent contractors for the furnishing of such services to or for County or any Department thereof; and

WHEREAS, on December 5, 2006, the parties entered into an Agreement for environmental consulting services for the preparation of Draft and Final Environmental Impact Reports (EIR) for the Big Wave project; and

WHEREAS, the parties wish to amend the Agreement to add additional funding in the amount of $137,700 and extend the term to June 30, 2010,

NOW, THEREFORE, IT IS HEREBY AGREED BY THE PARTIES HERETO AS FOLLOWS:

1. Paragraph 3, Payments, is amended in its entirety to read as follows:

   In consideration of the services provided by Contractor in accordance with all terms, conditions and specifications set forth herein and in Exhibit "A," County shall make payment to Contractor based on the rates and in the manner specified in Exhibits "B," "C," "D" and "E." The County reserves the right to withhold payment if the County determines that the quantity or quality of the work performed is unacceptable. In no event shall the County's total fiscal obligation under this Agreement exceed Three Hundred Forty-Two Thousand One Hundred Two Dollars ($342,102).

2. Paragraph 4, Term and Termination, is amended in its entirety to read as follows:

   Subject to compliance with all terms and conditions, the term of this Agreement shall be from December 5, 2006 through June 30, 2010.

   This Agreement may be terminated by Contractor, the Director of Community Development or his/her designee at any time without a requirement of good cause upon thirty (30) days' written notice to the other party.

   In the event of termination, all finished or unfinished documents, data, studies, maps, photographs, reports, and materials (hereafter referred to as materials) prepared by

Contractor under this Agreement shall become the property of the County and shall be promptly delivered to the County. Upon termination, the Contractor may make and retain a copy of such materials. Subject to availability of funding, Contractor shall be entitled to receive payment for work/services provided prior to termination of the Agreement. Such payment shall be that portion of the full payment which is determined by comparing the work/services completed to the work/services required by the Agreement.

3. Exhibit E, Additional Scope of Work with Cost Amendment and Schedule, attached hereto, is added to the Agreement and incorporated herein by reference.

4. All other terms and conditions of the Agreement dated December 5, 2006 between the County and Contractor shall remain in full force and effect.

IN WITNESS WHEREOF, the parties hereto, by their duly authorized representatives, have affixed their hands.

COUNTY OF SAN MATEO

By:_____
President,
Board of Supervisors, San Mateo County

Date:_____

ATTEST:

By:_____
Clerk of Said Board

Christopher A. Joseph & Associates

Jennie Anderson
Contractor's Signature

Date: 3.19.09

EXHIBIT E

ADDITIONAL SCOPE OF WORK

Big Wave Wellness Center and Office Park Environmental Impact Report (EIR) Scope and Budget

ESTIMATED ADDITIONAL TIME AND EXPENSES (*CAJA AMENDMENT 1*)

The following includes the scope of work tasks and associated expenses for the remaining EIR process. This information follows those EIR Tasks outlined in the executed original contract scope of work with supplements included as necessary to reflect the revised Project Description, associated technical data, and time lapsed since the execution of the original contract.

Task 1. Project Management

This budget amendment includes 38 additional hours for project management by Geoff Reilly (Principal/Project Manager) and Jennie Anderson (Project Manager). This includes additional time for: project scheduling; budgeting/invoicing; management & coordination of CAJA staff; oversight of production and circulation of EIR and notices; review of EIR sections for quality assurance; oversight of document format and word processing; and coordination with County staff and preparation of status updates.

Task 2. Finalize Project Description

Based on a review of the Draft Facilities Plan, CAJA submitted a Draft Project Description to the County for review on January 28, 2009. This Draft version included various comments and data gaps for response from the County/Applicant. Per email correspondence from the County/Applicant on February 27, 2009 the Applicant will be providing additional data to CAJA for Project Description finalization during the scheduled March 4, 2009 meeting. This scope of work task includes time for CAJA to finalize the Project Description for use in the update of the EIR.

Deliverables: One electronic copy of the Final Project Description for County verification.

Task 3. Prepare and Update Administrative Draft EIR (ADEIR)

Prepare and Update General Sections/Section I of the ADEIR – Cover, Title Page, Table of Contents, Introduction

CAJA will update the abovementioned sections of the ADEIR to reflect the Final Project Description and tasks completed since 2007 hold date.

Prepare and Update Section II of ADEIR – Summary

CAJA will prepare and update the following subtopics to be included in the Summary Section of the ADEIR: Introduction; Summary of the Proposed Project; Topics of Known Concern; Summary of Alternatives to the Proposed Project; Areas of Controversy; and Summary of Environmental Impacts and Mitigation Measures (including a summarized Table).

Prepare and Update Section III of ADEIR – Project Description

See Task 2 outlined above regarding CAJA's finalization of project description. Additionally, CAJA will update Related Projects Table; amendment assumes County will assist in providing the most recent related project County list.

Prepare and Update Section IV of ADEIR - Environmental Impact Analysis

For each Impact Analysis section in Section IV, CAJA will prepare and update: the introduction and methodology subsections, the environmental setting, the regulatory framework, the impact analysis, the cumulative impacts analysis based on the related projects list to be provided by the County, and mitigation measures (as appropriate). The section scopes will follow the CEQA Guidelines and will factor applicable environmental-related comments (as appropriate) received during the NOP and scoping meeting period, as well as from the County on the project referral. Additionally, this amendment includes funding and time for the preparation of associated graphics and technical appendices updates. In addition to completing the abovementioned tasks, other specific tasks related to each respective section are provided below for each of the following section titles.

Section IV.A (Aesthetics)

- CAJA will review all revised technical documents and materials associated with the revised proposed project for completeness, methodology, findings, adequacy, and relevance with regard to potential aesthetic impacts.
    - CAJA will peer review and provide feedback on the updated simulations provided in the Draft Facilities Plan once the final Project Description is determined and (if necessary) during the preparation of the EIR, specifically, the Aesthetics section analysis. Based on a preliminary review by our Graphics Department, the provided simulations appear adequate. Any applicable CAD files, etc. would be required to facilitate edits as necessary. Additional figures will be updated and provided as necessary for this visual analysis.
- As part of the Environmental Setting update, based on past site visits and using information in the County's General Plan, Facilities Plan, and other recent County CEQA documents, CAJA will confirm the regional and local context relative to aesthetics and the existing physical characteristics of the project site, focusing on visual features such as topography, vegetation, existing uses, and the site's relationship to nearby uses. In addition, CAJA will describe views from and of the project site, focusing on character-defining features and the project site's relationship to the entire field of view.
- CAJA will define scenic vistas and scenic resources in the project area. Generally describe any scenic vistas available from nearby public vantage points and the location of any scenic resources in relation to the project site (e.g., scenic roadways). Note whether the project site is visible and/or how much of the project

site is visible within these views. Describe how these views and/or resources might change due to the project, using the Applicant-provided visual simulations as a guide.

- Describe the overall visual character of the project site and areas surrounding the site. Describe how the revised project would alter the existing visual character of the site and surrounding area, focusing on how the project would change the character-defining features described previously. This discussion will be based on revised project plan elevations and descriptions of building materials and design as provided by the Applicant. Based on this discussion, determine whether the project would adversely change the existing character of the site and/or the surrounding area, and the potential to result in a significant impact under CEQA.

- Describe the types and relative amounts of light and glare that would be associated with the revised project and describe how these sources might affect the surrounding area. Based on this discussion, determine whether the project would result in significant light and/or glare impacts.

- Recommend updated mitigation measures as necessary.

Section IV.B (Agriculture Resources)

- CAJA will update and reconfirm the agriculture impact analysis via the CEQA process in order to determine if the revised project would result in significant impacts to agriculture resources. Should the analysis determine that impacts would be significant, mitigation measures would beprepared. As the site is not under contract with the County under the provisions of a Williamson Act contract, CAJA will evaluate the project's impacts to agriculture resources based on the Land Evaluation and Site Assessment (LESA) analysis in order to determine if the project would convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use.

Section IV.C (Air Quality)

- CAJA will utilize as much existing data as possible provided by the Applicant in the Facilities Plan.

- Describe baseline air quality information, including the pollutants of concern in the Bay Area, the agencies responsible for improving air quality in the Bay Area, and the existing air quality conditions in the county and local vicinity. Existing regional emissions will be identified using information obtained from the California Air Resources Board. Existing localized emissions of carbon monoxide will be calculated using data from the revised project traffic report, as described in Section IV (Transportation/Traffic). Any emissions that may be associated with the existing conditions at the project site will also be discussed.

- Identify the thresholds of significance recommended by the Bay Area Air Quality Management District (BAAQMD) as presented in the BAAQMD CEQA Guidelines and used by the County to evaluate air quality impacts under CEQA.

- Construction-related activities are generally short-term in duration, and the BAAQMD does not recommend any thresholds of significance for their associated emissions. Instead, the BAAQMD bases the determination of significance on a consideration of the control measures to be implemented. Therefore, the

EIR will discuss the potential impacts that would occur during construction and recommend the appropriate measures to reduce these impacts to less-than-significant levels.

- Calculate operational mobile and area source emissions for reactive organic gases, nitrogen oxides, and particulates using the URBEMIS model recommended for use by the BAAQMD. Calculations will be based on the trip generation factors provided in the revised project traffic study. The predicted emissions will be compared to the thresholds of significance recommended by the BAAQMD.

- Calculate future localized carbon monoxide concentrations at intersections in the project vicinity that would be most affected by project-generated traffic. These emissions will be calculated using data from the revised project traffic report. The resulting emissions will be compared to state and national ambient air quality standards. These methods are based on the Caline4 Line Source Dispersion Model.

- Discuss the consistency of the project with the current Clean Air Plan for the Bay Area.

- Generally characterize the types of emissions, including toxic air contaminant (TAC) emissions, associated with the wastewater treatment plant, etc. Qualitatively discuss potential health risks associated with siting new residences in proximity to these stationary sources.

- Discuss the potential for the project to result in a cumulatively considerable net increase in emissions. The BAAQMD recommends that projects that generate project-specific emissions that exceed their recommended thresholds of significance also be considered to cause a significant cumulative air quality impact.

- Identify mitigation measures as necessary to reduce or avoid any potential project-specific or cumulative impacts to air quality, and quantify their effectiveness based on methodologies available from BAAQMD and other sources.

- CAJA will prepare a Greenhouse Gas (GHG) Emission Analysis to assess the project's expected contributions to global warming via the emission of GHGs. At this time there are currently no thresholds or official guidance adopted by the Air Districts or other agencies in California to assess the significance of potential GHG emissions. However, Senate Bill 97 (SB 97), which was enacted in 2007, requires the State Office of Planning and Research (OPR) to develop CEQA guidelines for the effects and mitigation of GHG emissions. These guidelines and regulations are expected to be certified and adopted by the State Resources Agency before January 1, 2010. In the interim, OPR recently provided a new technical advisory containing informal guidance for public agencies as they address the issue of climate change in their CEQA documents.

  The OPR technical advisory recommends each public agency that is a lead agency for complying with CEQA develop its own approach to performing a climate change analysis for projects that generate GHG emissions. A consistent approach should be applied for the analysis of such projects, and the analysis must be based on best available information. For such projects, three types of analyses are used to determine whether the project could be in conflict with the State, regional, and local measures for reducing greenhouse gas emissions. The analyses will include the following:

  - Quantify the potential GHG emissions associated with the implementation of the project.

- Assess the significance of the impact on climate change using applicable guidance documents and State, regional, and local GHG reduction goals.
- Assess whether elements of the project and associated mitigation measures contribute to the efficiency of the project and sufficiently reduce GHG emissions.

Section IV.D (Biological Resources)

- Per previous memo discussions, CAJA has agreed that the Biological Resources data provided by WSP appears adequate and appropriate and has therefore agreed to use it as part of our updated ADEIR Biological Resources impact analysis. Under this scope, CAJA Biologists will continue to work with WSP, the County, and Applicant for any additional data necessary to complete our analysis. The Biological Resources section will be updated based on the above and the revised Project Description. Additional mitigation measures, etc. will be suggested as appropriate.

Section IV.E (Cultural Resources)

- CAJA has incorporated the *Cultural Resources Survey for the Big Wave Project, prepared by Tom Origer and Associates, February 28, 2007* into the Cultural Resources section of the ADEIR. Per the report, a 100-foot buffer zone was recommended to help protect resources from the original project development footprint; however, CAJA does not know how far into the site the resources extended. Under this scope, CAJA will reconfirm the extent with our cultural subconsultant.

Section IV.F (Geology & Soils)

- Treadwell & Rollo conducted one peer review based on the original Project Description (*Third Party Geotechnical Peer Review, prepared by Treadwell & Rollo, April 3, 2007*). Based on the supplemental information provided in the Facilities Plan (*BAGG's Response to Treadwell & Rollo Third Party Geotechnical Review, 2008*), Treadwell & Rollo will need to review and provide updated comments as appropriate. Per Treadwell & Rollo their remaining contract budget ($1,248.63) will be adequate to complete their updated review.
- The Geology & Soils section of the ADEIR will be updated from the available and pending project's Geotechnical Report database including revising any impact analyses and mitigation measures based on the revised Project Description as necessary.

Section IV.G (Hazards & Hazardous Materials)

- CAJA utilized the site Phase I report prepared by Treadwell & Rollo (*Phase I Environmental Site Assessment for the Big Wave Site (Phase I ESA), prepared by Treadwell & Rollo, March 26, 2007*) in order to prepare the Draft Environmental Setting of the Hazards & Hazardous Materials section of the ADEIR. Based on the revised Project Description, the impacts and mitigation measures will need to be updated accordingly. No additional Phase I data revisions are anticipated at this time, as historical/existing conditions information still remains applicable. Per the Applicant, a Phase II will also be prepared as part of the mitigation to be outlined in the EIR impact analysis. However, we do have concerns related to the new proposed operational uses (e.g., microwave towers, etc.) and potential associated hazards. *Although,*

not included in this amendment, if deemed necessary during future research efforts, we may need the assistance of a subconsultant (i.e., Paul Spillane of Acumen (Industrial Hygienist), as appropriate – Treadwell & Rollo is not experienced in this analysis)) to determine the associated environmental impacts during the ADEIR analysis. If this is found to be necessary, a small supplemental budget may be warranted and will be negotiated and approved by the County/Applicant prior to initiation.

Section IV.H (Hydrology & Water Quality)

- The hydrology & water quality information provided in the Facilities Plan will be incorporated into the Hydrology & Water Quality section analysis as appropriate. Per the original contract included for the EIR analysis, no peer review was provided; instead, Schaaf & Wheeler prepared the preliminary version of the EIR Hydrology & Water Quality section of the ADEIR based on the original Project Description (*Hydrology and Water Quality Review for Big Wave, prepared by Schaaf & Wheeler, May 2007*). Further, as stated previously, Schaaf & Wheeler prepared an additional hydrology study related to the wetlands issues in late 2007 (*Review of Wetland Hydrology Indicators for Big Wave Jurisdictional Delineation Including Site Visit Commentary prepared by Schaaf & Wheeler on September 17, 2007*). In order to reflect the revised Project Description, additional time and budget has been included herein for Schaaf & Wheeler to update the section accordingly utilizing the revised Site Plans and additional information provided in the Facilities Plan.

Schaaf & Wheeler Scope/Cost

- Review the new Project Description and Facilities Plan.
- Revise hydrologic calculations to reflect new Project Description.
- Analyze the water quality impacts of the newly proposed water recycling facility and increased groundwater infiltration.
- Update the Regulatory Setting section of the EIR document to reflect current regulations.
- Incorporate the more recent wetlands delineation work by CAJA, WSP. Prepare a revised section for Hydrology and Water Quality. Text and figures will be provided to CAJA in Microsoft Word and pdf formats, or as otherwise mutually arranged.
- A two hour meeting or site visit requested by the County is included as part of this amendment.
- Approximately 12 hours are included to assist CAJA in the response to comments efforts during the DEIR phase.
- Based on Schaaf & Wheeler's current fee schedule, the not-to-exceed fee for the above work is $10,300. Approximately $2,300 remains in their original budget, so the required contract amendment for this additional work is $8,000, which is provided for herein.

Section IV.I (Land Use & Planning)

- Update existing land uses and features of the project site. Also, under this scope, confirm existing land uses in the vicinity, based on aerial photographs and an additional windshield survey (if necessary).

- Confirm exhibits showing existing General Plan Land Use Map designations and Zoning Map districts for the site and vicinity.

- Evaluate and update the revised proposed project's consistency with relevant plans, policies, and regulations. In accordance with CEQA Guidelines Section 15125(b), the analysis will include applicable general plans and regional plans. Plans and policies that will be evaluated include (among others):

  - San Mateo County General Plan
  - Mid-Coast LCP
  - Montara/Moss Beach/El Granada Community Plan
  - LAFCO (regarding water service from CCWD)
  - Half Moon Bay Comprehensive Airport Land Use Plan
  - Existing County ordinances and regulations

- The General Plan consistency analysis will be updated based on the revised project and presented in a tabular format. County staff will be consulted to determine other relevant plans, if any. Where appropriate, the evaluation will cross-reference other section updates, such as Biological Resources or Transportation/Traffic.

- Updates to discuss potential impacts relating to policy inconsistency and land use compatibility from revised project. This discussion will cross-reference the analyses of other impacts in the EIR (as necessary).

Section IV.J (Noise)

- The information provided in the Facilities Plan will be confirmed and/or supplemented as part of the Noise ADEIR analysis. Per the original contract, CAJA will conduct a noise analysis (utilizing the steps outlined below), which will occur once the final revised traffic data and Project Description is confirmed.

- Define and describe the fundamentals of sound and environmental noise, and groundborne vibration.

- Discuss relevant noise policies, regulations and standards, including the relevant State noise guidelines and noise/land use compatibility standards used by San Mateo County.

- Confirm noise-sensitive land uses or activities in the vicinity of the project site or along roads providing access to the site.

- Briefly confirm and describe existing major noise sources in the project vicinity. Conduct up to four short-term noise measurements on the project site, along roadways most affected by increases in project traffic and airport associated noise events.

- Calculate existing noise levels for the roadway segments in the project vicinity that would be affected by project-generated traffic. These noise levels will be calculated using the Federal Highway Administration's (FHWA) Noise Prediction Model and data from the project traffic report.

- Discuss existing groundborne vibrations levels at the project site and local vicinity.
- Confirm significance thresholds based on these standards and consultation with San Mateo County.
- Describe characteristics of the revised proposed project that are relevant to the analysis of noise, based on the revised project site plan, the conceptual grading plan, and trip generation estimates from the revised project traffic study.
- Discuss construction noise impacts, based on revised proposed construction activities and scheduling information. Noise impacts from construction will be evaluated based on the duration, nature, phasing, and level of various construction activities.
- Describe typical noise generated by various elements of the revised project, including project-generated motor vehicle traffic.
- Calculate the expected increases in noise levels at noise sensitive locations along roadways most affected by project traffic using the FHWA Noise Prediction Model and data from the revised project traffic report.
- Discuss the potential for noise from the revised project or related activities to adversely affect sensitive land uses or activities, or to conflict with established noise compatibility guidelines.
- Discuss the potential for noise from the Half Moon Bay Airport to affect project site residents.
- Evaluate the compatibility of the proposed land uses with the existing and future noise environment at the site.
- Identify mitigation measures as necessary to avoid or reduce significant noise impacts, and evaluate their effectiveness based on published technical documents.

Section IV.K (Population & Housing)

- CAJA will initiate the peer review by Bay Area Economics once the Project Description has been finalized. As outlined in the original contract, Bay Area Economics will conduct a third party peer review of the Applicant's economic analysis, which will address the assumptions, methodology and overall conclusions regarding the overall demand for the project and the job match with employed residents on the coast area. Bay Area Economics will prepare an administrative draft memo outlining their peer review. Bay Area Economics will also review the memo with CAJA and County staff. Based on oral and written comments, Bay Area Economics will revise the administrative memo and produce a final memo. As stated above, the peer review of the Economic Analysis was included in the original contract and to date budget remains to complete this task. This peer review will be submitted to the County as an independent report, and will not be appended to the EIR.
- Prepare and update existing population and housing estimates, as well as policies and forecasts pertaining to population and housing growth in the County of San Mateo. The population and housing data and forecasts will be updated from the County's Housing Element, the California Department of Finance, the Association of Bay Area Governments (ABAG) and the U.S. Census Bureau, as needed.

- Based on population per household ratios provided by the County, CAJA will calculate the number of residents that would be accommodated by the revised proposed project.

- Evaluate the consistency of the project-generated population with County and regional growth forecasts and policies. Calculate the project's contribution as a percentage of the County's overall growth allocation by ABAG, the California Department of Finance, and other sources.

- Identify mitigation measures to reduce or avoid significant impacts for each of the sub-issues analyzed in the Population/Housing section, if any significant impacts are identified.

Section IV.L (Public Services)

- Confirm and update existing conditions in the County and project area, as appropriate. This will be done by contacting the current contacts at the Fire Department, Police Department, Parks and Recreation Department, and School District responsible for serving the project site by telephone or letter to obtain updated information on existing conditions, assess the potential impacts of the revised proposed project and cumulative development, and provide input on appropriate mitigation measures (as necessary).

- Based on updated population per household ratios provided by the County and/or the service providers (such as the Department of Finance), recalculate the number of residents that would be accommodated by the revised proposed project.

- Discuss the School District's eligibility to levy alternate developer fees.

- Based on County park standards, calculate the park acreage or in-lieu fee that would be required with buildout of the revised proposed project. Determine whether existing and planned parks in the County would be adequate to cover the revised proposed project and County-wide demand (as necessary). Consult with the County regarding cumulative projects in the area and their proposed parklands.

- Discuss potential impacts of revised project buildout in terms of demand for public services, ability to provide services, and the possible need for construction of additional facilities.

- Document project characteristics that would "pre-mitigate" potential impacts of the revised project.

- Update and list mitigation measures recommended by the service providers.

- Discuss the potential for the revised project in conjunction with related projects to result in cumulative impacts to public services.

Section IV.M (Transportation/Traffic)

- Per the Applicant and the January 1, 2009 Facilities Plan, the preferred Office Park option would include the 225,000 s.f. commercial/office space use. For $32,000 (in the requested amendment [included in this *CAJA Amendment 1*]), Hexagon Transportation Consultants, Inc. assisted the Applicant in the development of an Office Park option revised traffic analysis (which included the revised project and the 225,000 s.f. alternative). No updated peer review is required. $22,905 from the current budget has been used to pay for this work. The revised budget includes $9,095 for the balance of this work.

- The updated traffic report (*Revised Traffic Report for the Big Wave Office Park and Wellness Center, prepared by Hexagon Transportation Consultants, Inc., June 25, 2008*) will be incorporated by CAJA into the Transportation/Traffic ADEIR section analysis to reflect the revised proposed project. CAJA will work with Hexagon for any applicable updates and/or clarifications utilizing the requested remaining $9,095.

Section IV.N (Utilities & Service Systems)

- The information provided in the Facilities Plan will be incorporated into the ADEIR Utilities & Service Systems subsections (i.e., Water, Wastewater, Service Systems; as appropriate) and will be supplemented by our CAJA team as necessary. CAJA has reviewed the Solid Waste discussion in the Facilities Plan and this seems appropriate. In previous memos, CAJA encouraged the Applicant to narrow down various Utilities options to one option (e.g., various options proposed for water supply, wastewater treatment and energy). Otherwise, the project may appear to be more programmatic (i.e., necessitating the preparation of a Program EIR), potentially resulting in more environmental review at a later time when more specifics are provided or available. However, per direction from the Applicant, we will analyze each "option" in detail in the EIR analysis, pending that detailed data is available for each Water/Wastewater/Energy "option".

- The Utilities & Service Systems section of the ADEIR will be updated from the available and pending project's Utilities Report database including revising any impact analyses and mitigation measures based on the revised Project Description as necessary. Although not included in the original scope, based on the scope of the revised project, CAJA will include an Energy subsection analysis in the Utilities & Service Systems section to reflect all of the proposed Energy systems.

- For proposed municipal service options, CAJA will conduct the following tasks:

  - Confirm and update existing conditions in the County and project area, as appropriate. This will be done by contacting the currently proposed municipal contacts by telephone or letter to obtain updated information on existing conditions, assess the potential impacts of the revised proposed project and cumulative development, and provide input on appropriate mitigation measures (as necessary).

  - Based on readily available solid waste, water and sewage generation factors, calculate the revised project's estimated solid waste and sewage generation, as well as water demand.

  - Discuss LAFCO annexation requirements of the project site into the CCWD.

  - Discuss potential impacts of revised project buildout in terms of demand for municipal services, ability to provide services, and the possible need for construction of additional facilities.

  - Document project characteristics that would "pre-mitigate" potential impacts of the revised project.

  - Update and list mitigation measures recommended by the service providers.

  - Discuss the potential for the revised project in conjunction with related projects to result in cumulative impacts to public services.

- Additional CAJA subconsultants are necessary in order to assess and conduct peer reviews of the potential environmental impacts associated with the proposed wastewater (i.e., on-site MBR plant, drip irrigation of recycled wastewater) and water (on-site wells and groundwater/aquifer impacts, water treatment) systems.

This was not included in the original scope (Note: Per the original project RFP, the original scope was based on municipal hook-ups only) and hence requires a supplemental budget and scope, which is provided for herein. This review will be provided by Questa Engineering Corporation (water supply and wastewater). The additional scope and cost for Questa Engineering Corporation is included below.

Questa Engineering Corporation Scope/Cost

Water Supply

- Available background reports, maps and data relative to water availability in the project area will be compiled and reviewed.

- The water supply setting for the project will be described based upon the information developed in the background review. The Applicant's plan for supplying water to the project will be described and reviewed. This will include the sources of supply, treatment requirements (if any), storage and distribution system, and ownership and management of the system.

- The Applicant's estimated water demand for the proposed project will be reviewed for independent confirmation. It is anticipated that estimates will be broken down by the different elements of the project site and will include annual and seasonal demand, daily average and peak water supply requirements. The water needs will consider residential water demands (interior and exterior), other common area uses, fire flow, and storage requirements.

- The availability of a sufficient, dependable supply of water to serve the project will be evaluated and presented. Various possible sources of water to service the development have been identified including on-site well water, recycled water, and imported potable water. This analysis will also address the water quality and treatment requirements.

- Mitigations will be identified for water supply impacts determined to be significant or potentially significant. Mitigations may include such measures as limitations on the scale of development and corresponding water demand, incorporation of specific water conservation measures, and additional water storage.

Wastewater Treatment and Disposal

- Compile and review all available background information pertaining to wastewater treatment and disposal-reclamation plans for the project. This will include peer review of technical report(s) and supporting information supplied by the Applicant, as well as relevant publications related to soils, water resources, hydrogeology and water quality and information regarding the El Granada Wastewater District Facilities. A reconnaissance-level site visit will be performed to observe relevant landscape features and existing infrastructure. Contacts will be made with County and Regional Water Board staff, El Granada Wastewater District personnel, project consultants (as appropriate), and other knowledgeable individuals.

- Review and describe federal, state and local regulatory requirements applicable to the construction and operation of the proposed wastewater system, including, but not limited to, the Water Quality Control Plan for the San Francisco Bay Region (Basin Plan), Title 22 Water Recycling Criteria, County policies and standards.

- The proposed wastewater treatment plans will be reviewed for technical adequacy including compliance with accepted engineering standards, limitations of the project site, and applicable regulatory requirements. This will include review and independent confirmation and/or revisions of the sewage flow estimates for the project based on information provided by the Applicant. It will also include review of: (a) plans for wastewater collection; (b) proposed location and type of treatment system; (c) any plans for wastewater storage; (d) locations, methods and capacity for wastewater disposal and reclamation; (e) plans for system management; and (f) any identified water quality issues, including impacts to surface water and groundwater resources.

- Using information compiled from the background and regulatory review, prepare the environmental setting section for the EIR.

- Based on the results of the project analysis task, identify and describe any potentially significant impacts of the proposed wastewater treatment and disposal-reclamation plans for the project for inclusion in the EIR. Impacts discussion may include construction-related issues, operational impacts related to the collection, treatment and disposal-reclamation facilities; and potential short-term or long-term water quality and public health issues

- Identify and describe feasible mitigation measures to address any significant or potentially significant impacts related to the development and operation of wastewater collection, treatment and disposal-reclamation facilities for the project.

Associated Tasks to Complete Above

- (Task 1) Site Visits, Data Collection and Analysis. Questa will collect and review existing information related to the wastewater and water supply aspects of the project. Interviews, file research, peer review of consultant-provided reports, and site reconnaissance by experienced environmental personnel will be conducted. Contacts will be made with appropriate agencies to evaluate pertinent requirements and background information.

- (Task 2) Water Supply Analysis. Questa will identify and evaluate the potentially significant and significant water supply impacts associated with development of the proposed project. The analysis will include evaluation of the proposed methods of water supply for the project including on-site well water, recycled water and water imported from the Coastside County Water District (CCWD).

- (Task 3) Wastewater Disposal Analysis. Questa will identify and evaluate the potentially significant and significant wastewater treatment impacts associated with development of the proposed project. Methods for wastewater treatment and disposal that will be evaluated include on-site treatment and recycling, on-site disposal by spray irrigation and other methods, and off-site disposal to the El Granada Wastewater District.

- (Task 4) Formulate Mitigation Measures. Questa will develop reasonable and appropriate additional mitigation measures to offset the identified impacts. The mitigation measures may include development restrictions in sensitive or constraining project areas, on- and off-site infrastructure improvements, structural and non-structural best management practices, remedial action, and design recommendations related to the development of the project site. Additionally, Questa may develop monitoring and reporting strategies for mitigation measures.

- (Task 5) Review Project Alternatives. Questa will review alternatives to the proposed project. This will include the no project alternative, the proposed project, and one other alternative to be presented as part of the EIR. Questa will evaluate the Wastewater Treatment and Water Supply impacts associated with the project alternatives.

- (Task 6) Prepare Administrative DEIR. Questa will prepare the Water Supply and Wastewater sections of the EIR in an acceptable format.

- (Task 7) Response to Comments and Preparation of DEIR. Questa will respond to comments made to the ADEIR and finalize the DEIR sections.

- (Task 8) Response to Comments and Preparation of FEIR. Questa will assist in the final response to comments and preparation of the FEIR sections. We have included a limited budget for response to comments. If extensive comments are received requiring significant review and response time, additional budget may be required for this task.

- (Task 9) Public Hearings and Meetings. Questa will attend public hearings and meetings on a time-and-expenses basis. Questa has not included a budget for hearings/meetings. Any attendance at hearings or meeting would be in addition to the costs outlined in this amendment.

- The cost for the work effort described above in Tasks 1 to 8 is $18,600.

Prepare and Update Section V of ADEIR - General Impact Categories

The General Impact Categories section of the ADEIR will summarize the following: significant unavoidable impacts that were identified in the updated Environmental Impact Analysis (if any are identified); growth-inducing impacts of the revised proposed project; and the significant irreversible environmental changes associated with the revised project. Additionally, this section will include a discussion of the Impacts Found to be Less Than Significant. This section will include a discussion of the issues and sub-issues that were focused out for further analysis in the Initial Study. However, as the Initial Study format does not include detailed data on why these issues were scoped out, these issues will be confirmed for accuracy and will be documented in the above subsection analysis.

Prepare and Update Section VI of ADEIR - Summary of Cumulative Impacts

The cumulative impacts and mitigation (if appropriate) in each respective Environmental Impact Analysis section will be updated based on the revised Project Description, section analyses, and the updated related projects list provided by the County.

Prepare and Update Section VII of ADEIR - Alternatives to the Proposed Project

This section of the ADEIR will identify and evaluate a reasonable range of alternatives to the revised proposed project that are crafted to avoid or significantly lessen the significant environmental impacts of the project while still meeting most of the revised project objectives. One of the alternatives that will be analyzed in the EIR will be the No Project Alternative (assuming continuation of the existing conditions, no development of the site), as required by CEQA. As the project site does not permit residential uses, the EIR will address implementation of the proposed project at an alternative site(s). Other alternatives could include a Reduced Density Alternatives or

Modified Site Plan Alternative. The selection of other project alternatives will be made in consultation with County staff after all of the significant impacts of the revised proposed project have been identified. For the purposes of this amendment, CAJA will analyze up to four alternatives, including the No Project Alternative.

Prepare and Update Section VIII of ADEIR - Preparers of the EIR and Persons Consulted

This section will be updated to identify the lead agency staff, project Applicant and subconsultant staff, EIR consultant and subconsultant staff, and all agency personnel consulted during the preparation of the EIR.

Prepare and Update Section IX of ADEIR - Bibliography

The Bibliography section will be updated to list all sources of revised information used during the preparation of the EIR.

Deliverables: Five (5) bound hard copies and one electronic PDF copy of the ADEIR. CAJA will submit copies of the ADEIR to the County staff for distribution and one round of review.

Task 4. Preparation of the DEIR

CAJA will address all of the County's comments on the updated ADEIR. This amendment assumes one-round of review by the County and all comments made on the updated ADEIR will be submitted to CAJA in one consolidated set. *(Note: Any changes to the project description made during this review could require changes to the analysis in the ADEIR and could require additional amendments.)* After the review of the document, CAJA staff will address all comments and will prepare and submit one electronic PDF version of the Screencheck DEIR (SDEIR) to the County to confirm that all requested changes have been incorporated into the document. This SDEIR will be submitted to the County for approval as a DEIR. Once the County approves the SDEIR, CAJA will produce 50 copies of the DEIR and Technical Appendices for use and distribution by the County during the prescribed 45-day public review period. Additionally, CAJA will also prepare 15 electronic PDF copies of the DEIR and Technical Appendices and 15 hard copies of the Summary section for County submittal to the State Clearinghouse. CAJA will also prepare the Notice of Completion (NOC) for the State Clearinghouse per the CEQA requirements. This amendment assumes that the County will distribute the DEIR and NOC.

Additionally, it is assumed in this amendment that CAJA will produce a Notice of Availability (NOA) for the DEIR utilizing all three NOA noticing options as outlined in Section 15087(a)(1),(2),(3) of the CEQA Guidelines (although only one is required to fulfill the 45-day public review period, it is recommended by CAJA to utilize all three noticing methods during the public review period due to the controversial nature of the project). This includes: 1) publication of the NOA in a local newspaper, 2) posting the NOA on- and off-site, and 3) direct mailing of the NOA to contiguous property owners. Further, the NOA shall be sent to applicable state and local agencies; individuals that commented on during the NOP or scoping meeting process and that have requested to be notified throughout the EIR process; as well as the applicable County Clerk to post during the 45-day review period. This amendment assumes that the County will also distribute the NOA.

Deliverables: One (1) electronic PDF copy of the SDEIR; 50 bound copies of the DEIR and Technical Appendices, one electronic PDF format on a CD, 15 copies for the State Clearinghouse and one copy of the NOC for distribution by the County. The DEIR will be in 8.5-inch x 11-inch, black

and white format; color where applicable. Additionally, a electronic (PDF) copy of the NOA for distribution by County.

Task 5. Preparation of FEIR and Mitigation Monitoring Program (MMP)

The number of comments received at the end of the 45-day review period and the level of effort involved with preparing responses varies widely between projects. Following closure of the 45-day DEIR public comment period, CAJA staff will prepare responses to all written and oral comments received on the DEIR and will make any changes to the DEIR resulting from responses to comments. The FEIR will ultimately include the following chapters: Introduction, Response to Comments, Corrections and Additions to the DEIR, Mitigation Monitoring Program (MMP). CAJA will prepare the AFEIR and submit 5 copies to the County for one round of review. After the review of the document, CAJA staff will address all comments and will prepare and submit one electronic PDF version of the SFEIR to the County to confirm that all requested changes have been incorporated into the document. Once the SFEIR is approved for release as the FEIR, CAJA will produce 50 copies (as well as 15 copies for State Clearinghouse, if necessary) of the FEIR for County circulation to all appropriate commenting agencies and individuals ten days prior to consideration of certification of the EIR. This amendment assumes that the County will distribute the FEIR.

Although not required under CEQA, CAJA can prepare and provide the County with a NOA for the FEIR. This task is not included within our amendment; however (if requested, due to the controversial nature of the project), CAJA can be available to assist the County with this task utilizing a time and materials rate based on our current fee schedule. CAJA preparation of the NOA would follow those steps outlined under Task 4.

In accordance with CEQA Guidelines Section 15075, CAJA will prepare the Notification of Determination (NOD) for use by the County to file with the applicable County Clerk and State Clearinghouse (if necessary) within five days of certifying the EIR and approving the project. This amendment assumes that the County will file the FEIR.

Deliverables: Five (5) hard copies and one electronic (PDF) copy of the AFEIR; one electronic (PDF) of the SFEIR; 50 hard copies and one electronic (PDF) of the FEIR (as well as 15 copies for the State Clearinghouse, if necessary) for distribution by the County; and one electronic (PDF) copy of the NOD for filing by the County.

Task 6. Hearings and Meetings

While a public hearing on the DEIR during the 45-day review period is not required by CEQA (Section 15087(i), CEQA Guidelines), this amendment includes attendance by the appropriate CAJA staff member(s), but not its subconsultants, at one public hearing either on the DEIR during the 45-day review period or on the FEIR certification/final decision on the project. If the County chooses to hold a public hearing during the 45-day DEIR review period, County staff will schedule the meeting and arrange for the meeting space. CAJA highly recommends that if many people are expected to attend the public hearing and comment, a court reporter should be present to record all comments. CAJA staff will assist the County in preparing necessary materials for the hearing, such as: a) a handout depicting and briefly describing the project and summarizing impacts and mitigation measures, and b) other large-scale graphics. CAJA staff will arrange for a court reporter to attend the meeting to

record all oral comments, but the cost of a court reporter is not included in this amendment. After the close of the public comment period for the DEIR, CAJA staff will review all comments, identify which comments require special attention, and discuss response approach with County staff and CAJA team members. CAJA will prepare a topic-by-topic matrix summarizing all written and oral comments submitted during the hearing.

This amendment also includes the attendance of Ms. Anderson and Mr. Reilly at two Planning Commission hearings and one Board of Supervisors hearing. CAJA staff will be available to give a presentation related to the CEQA process, analysis, and conclusions. Additionally, time for 8 team meetings/conference calls has been included in this amendment. *Additional County-requested hearings and meetings attendance will be billed on a time-and-materials basis based on our agreed fee schedule.*

Deliverables: One (1) memo summarizing all substantive points made by the public hearing commenters.

Task 7. Findings of Fact and Statement of Overriding Considerations

Prior to consideration of the proposed project and subsequent to certification of the FEIR, CAJA staff will prepare the Statement of Facts and Findings (the Findings) for any significant environmental effects identified in the EIR. The Findings will individually identify the significant environmental effects of the proposed project and provide a reasoned discussion of the appropriate findings.

Also included in this amendment, prior to consideration of the proposed project and subsequent to certification of the FEIR, CAJA will prepare the Statement of Overriding Considerations in accordance with the specifications of Section 15093 of CEQA (if applicable). The Statement of Overriding Considerations will describe why the benefits of the project outweigh its significant and unavoidable effects.

Deliverables: Five (5) copies of each will be provided, as well as one electronic PDF copy.

Schedule and Cost

CAJA proposes the following draft schedule to prepare the EIR (see attached Table 1). This schedule is dependent on approval of the finalized Project Description and availability of Applicant-prepared data. Therefore, the proposed schedule dates would be updated accordingly based on actual completion dates. Overall, as shown in the attached Cost Amendment (Table 2), the total cost for the *Cost Amendment 1* scope of work is $137,700. CAJA's associated billing rate is included below:

Billing Rates

CAJA Fee Schedule
(*Effective January 1, 2009*)

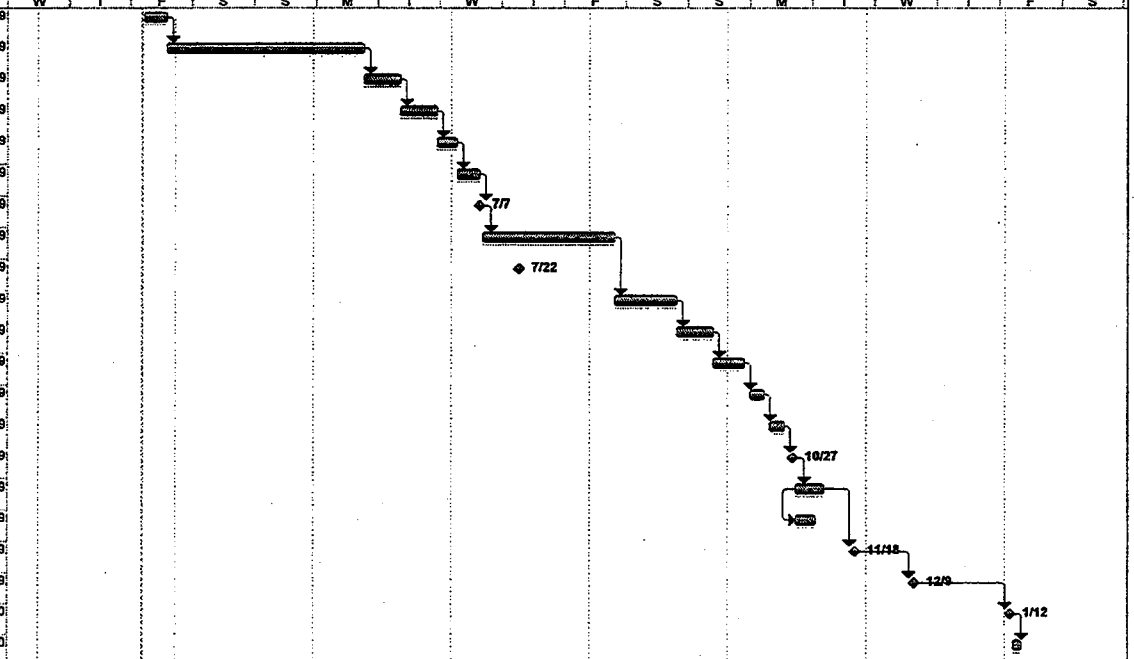
• Principal	$160.00/hour
• Project Manager	$135.00/hour
• Environmental Specialist (e.g., Biologist, Noise, Air Quality)	$135.00/hour
• Environmental Planner	$120.00/hour
• Associate Environmental Planner	$110.00/hour

- Assistant Environmental Planner $95.00/hour
- Research Assistant $55.00/hour
- Graphics Director $60.00/hour

Attachments: Table 1 (Revised Draft Schedule)
Table 2 (Cost Amendment)

Big Wave Wellness Center and Office Park EIR -- Revised Draft Schedule

ID	Task Name	Duration	Start	Finish
1	Finalize Project Description for County Verification [1]	6 days	Wed 3/11/09	Wed 3/18/09
2	Prepare ADEIR for County Review	50 days	Thu 3/19/09	Wed 5/27/09
3	County Review of ADEIR [2]	9 days	Thu 5/28/09	Tue 6/9/09
4	Prepare SDEIR for County Review	9 days	Wed 6/10/09	Mon 6/22/09
5	County Review of SDEIR [2]	5 days	Tue 6/23/09	Mon 6/29/09
6	Prepare DEIR and Notices (NOA/NOC)	5 days	Tue 6/30/09	Tue 7/7/09
7	County to Circulate DEIR, NOC, and NOA	0 days	Tue 7/7/09	Tue 7/7/09
8	Circulate & Publish DEIR & Notices for 45-day Public Review	45 days	Thu 7/9/09	Mon 8/24/09
9	Attend Public Hearing at DEIR (at County discretion) [3]	0 days	Wed 7/22/09	Wed 7/22/09
10	Prepare Responses to Comments, AFEIR/MMP for County Review [4]	15 days	Tue 8/25/09	Tue 9/15/09
11	County Review of AFEIR/MMP [2]	9 days	Wed 9/16/09	Mon 9/28/09
12	Prepare SFEIR/MMP for County Review	9 days	Tue 9/29/09	Fri 10/9/09
13	County Review of SFEIR/MMP [2]	5 days	Mon 10/12/09	Fri 10/16/09
14	Prepare FEIR/MMP	5 days	Mon 10/19/09	Fri 10/23/09
15	County to Circulate FEIR/MMP	0 days	Tue 10/27/09	Tue 10/27/09
16	Circulate & Publish FEIR/MMP for Commenting Agencies (& Public)	10 days	Wed 10/28/09	Fri 11/6/09
17	Prepare Findings of Fact and SOC	7 days	Wed 10/28/09	Tue 11/3/09
18	EIR Meeting/Hearing (PC) [2]	0 days	Wed 11/18/09	Wed 11/18/09
19	EIR Meeting/Hearing (PC) [2]	0 days	Wed 12/9/09	Wed 12/9/09
20	EIR Meeting/Hearing (Board) [2]	0 days	Tue 1/12/10	Tue 1/12/10
21	Preparation of the NOD, Filing NOD with Clerk [2]	3 days	Wed 1/13/10	Fri 1/15/10



Note: Schedule is dependant on availability of all Project Facilities/technical reports from the Applicant, as well as the complexity of the multiple Utilities analyses. Schedule may need to be adjusted.

1 **Finalize Project Description for County Verification [1]**
[1] Assumes a finalization and approval date of March 18, 2009. This date is subject to change pending actual approval by the County. Schedule will be updated accordingly, if necessary.

3 **County Review of ADEIR [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

5 **County Review of SDEIR [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

9 **Attend Public Hearing at DEIR (at County discretion) [3]**
[3] Date is subject to change depending on availability of Planning Commission during this time. Overall, Public Hearing would be scheduled to take place during the 45-day review period.

10 **Prepare Responses to Comments, AFEIR/MMP for County Review [4]**
[4] May need to be revised depending on actual level of comments received, which is outside the control of CAJA and the County.

11 **County Review of AFEIR/MMP [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

13 **County Review of SFEIR/MMP [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

18 **EIR Meeting/Hearing (PC) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

19 **EIR Meeting/Hearing (PC) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

20 **EIR Meeting/Hearing (Board) [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

21 **Preparation of the NOD, Filing NOD with Clerk [2]**
[2] Duration and completion of County document review is outside the control of CAJA.

Note: Schedule is dependant on availability of all Project Facilities/technical reports from the Applicant, as well as the complexity of the multiple Utilities analyses. Schedule may need to be adjusted.

Table 2

Big Wave EIR, Cost Amendment #1

[1] This amendment assumes an average number of comments on the DEIR. Additional hours may be necessary depending on the number of comments received and the complexity of responses. Additional requested and approved hours will be billed at a Time & Materials rate utilizing CAJA's agreed fee schedule.

Table 2
Big Wave EIR, Cost Amendment #1

LABOR COSTS					
Task 1. Project Management					
Budgeting and Scheduling	Geoff Reilly	2	$160.00	Principal	$320.00
	Jennie Anderson	5	$135.00	Project Manager	$675.00
Coordination with County, Applicant & Subconsultants	Geoff Reilly	3	$160.00	Principal	$480.00
	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Document Review/Quality Assurance	Geoff Reilly	6	$160.00	Principal	$960.00
	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Administrative	Megan Steer	4	$55.00	Research Asst.	$220.00
	Jennie Anderson	2	$135.00	Project Manager	$270.00
Task 1 Subtotal		***38***			***$5,085.00***
Task 2. Finalize Project Description	Jennie Anderson	***6***	$135.00	Project Manager	***$810.00***
Task 3. Preparation of Administrative Draft EIR (ADEIR)					
Cover, Title Page, TOC	Megan Steer	1	$55.00	Research Asst.	$55.00
Introduction	Megan Marruffo	1	$95.00	Asst. Env. Planner	$95.00
Summary	Jennie Anderson	1	$135.00	Project Manager	$135.00
	Patricia Preston	6	$120.00	Env. Planner	$720.00
Project Description	Jennie Anderson	1	$135.00	Project Manager	$135.00
Regulatory Setting	Jasmine Patel	2	$110.00	Assoc. Env. Planner	$220.00
Aesthetics	Patricia Preston	30	$120.00	Env. Planner	$3,600.00
Agriculture Resources	Jasmine Patel	16	$110.00	Assoc. Env. Planner	$1,760.00
Air Quality (w/ GHG)	Dan Hooper	36	$135.00	Air Specialist	$4,600.00
Biological Resources	Amy Parravano	48	$135.00	Principal Biologist	$6,480.00
	Patricia Preston	4	$120.00	Env. Planner	$480.00
Cultural Resources	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00
Geology & Soils	Jennie Anderson	2	$135.00	Project Manager	$270.00
	Patricia Preston	16	$120.00	Env. Planner	$1,920.00
Hazards & Hazardous Materials	Jasmine Patel	16	$110.00	Assoc. Env. Planner	$1,760.00
Hydrology & Water Quality	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Land Use & Planning	Patricia Preston	12	$120.00	Env. Planner	$1,440.00
Noise	Scott Wirtz	30	$135.00	Noise Specialist	$4,050.00
Population & Housing	Jasmine Patel	22	$120.00	Assoc. Env. Planner	$2,640.00
Public Services	Jessica Viramontes	16	$120.00	Env. Planner	$1,920.00
Transportation/Traffic	Jessica Viramontes	16	$120.00	Env. Planner	$1,920.00
Utilities & Service Systems	Jennie Anderson	6	$135.00	Project Manager	$810.00
	Jessica Viramontes	32	$120.00	Env. Planner	$3,840.00
General Impact Categories	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00
Summary of Cumulative Impacts	Jasmine Patel	8	$110.00	Assoc. Env. Planner	$880.00

Table 2
Big Wave EIR, Cost Amendment #1

Alternatives to the Proposed Project	Geoff Reilly	4	$160.00	Principal	$640.00
	Jennie Anderson	24	$135.00	Project Manager	$3,240.00
Preparers of the EIR & Persons Consulted	Megan Steer	1	$55.00	Research Asst.	$55.00
Bibliography	Megan Steer	1	$55.00	Research Asst.	$55.00
Technical Appendices	Megan Steer	2	$55.00	Research Asst.	$110.00
Project Referral Comments	Megan Steer	3	$55.00	Research Asst.	$165.00
Task 3 Subtotal		***381***			***$46,595.00***
Task 4. Preparation of the Draft EIR (DEIR) *					
Screencheck Draft EIR (SDEIR)	Geoff Reilly	2	$160.00	Principal	$320.00
	Jennie Anderson	10	$135.00	Project Manager	$1,350.00
	Patricia Preston	14	$120.00	Env. Planner	$1,680.00
DEIR	Jennie Anderson	2	$135.00	Project Manager	$270.00
	Jasmine Patel	8	$110.00	Assoc. Env. Planner	$880.00
Task 4 Subtotal		***36***			***$4,500.00***
Task 5. Preparation of Final EIR (FEIR) and Mitigation Monitoring Program (MMP) [1]*					
Appendices & Delineation of Comments on DEIR	Geoff Reilly	1	$160.00	Principal	$160.00
	Jennie Anderson	10	$135.00	Project Manager	$1,350.00
	Jasmine Patel	20	$110.00	Assoc. Env. Planner	$2,200.00
Response to Comments	Geoff Reilly	3	$160.00	Principal	$480.00
	Jennie Anderson	20	$135.00	Project Manager	$2,700.00
	Patricia Preston	36	$120.00	Env. Planner	$4,320.00
	Jasmine Patel	38	$110.00	Assoc. Env. Planner	$4,180.00
Administrative Final EIR (AFEIR)	Jennie Anderson	4	$135.00	Project Manager	$540.00
	Patricia Preston	10	$120.00	Env. Planner	$1,200.00
Screencheck Final EIR (SFEIR)	Geoff Reilly	1	$160.00	Principal	$160.00
	Jennie Anderson	6	$135.00	Project Manager	$810.00
FEIR	Jennie Anderson	2	$135.00	Project Manager	$270.00
	Megan Marruffo	4	$95.00	Asst. Env. Planner	$380.00
MMP	Jennie Anderson	8	$135.00	Project Manager	$1,080.00
Task 5 Subtotal		***163***			***$19,830.00***
Task 6. Hearings & Meetings					
(4) Hearings	Geoff Reilly	12	$160.00	Principal	$1,920.00
	Jennie Anderson	12	$135.00	Project Manager	$1,620.00
(8) Meetings/Conference Calls	Geoff Reilly	12	$160.00	Principal	$1,920.00
	Jennie Anderson	12	$135.00	Project Manager	$1,620.00
Preparation of Materials	Jessica Viramontes	2	$120.00	Env. Planner	$240.00
	Megan Marruffo	8	$95.00	Asst. Env. Planner	$760.00

Table 2
Big Wave EIR, Cost Amendment #1

Task 6 Subtotal		***58***			***$8,080.00***
Task 7. Findings of Facts and Statement of Overriding Considerations	Jennie Anderson	7	$135.00	Project Manager	$945.00
	Megan Marruffo	2	$95.00	Asst. Env. Planner	$190.00
Task 7 Subtotal		***9***			***$1,135.00***
Graphics					
EIR Graphics/Simulation Peer Review	Scott Johnson	***40***	$60.00	Graphics Director	***$2,400.00***
Production of Notices *					
Notice of Availability (NOA) - DEIR	Patricia Preston	1	$120.00	Env. Planner	$120.00
Notice of Completion (NOC)	Patricia Preston	1	$120.00	Env. Planner	$120.00
Notice of Determination (NOD)	Jennie Anderson	1	$135.00	Project Manager	$135.0
Subtotal		***3***			***$375.00***
Word Processing & EIR Production	Megan Marruffo	6	$95.00	Asst. Env. Planner	$570.00
	Megan Steer	5	$55.00	Research Asst.	$275.00
Subtotal		***11***			***$845.00***
	TOTAL CAJA LABOR COSTS				**$89,655.00**
SUBCONSULTANT COSTS					
Labor/Expenses to Complete Remaining Work					
Hydrology and Water Quality (Shaaf & Wheeler)		*Fixed Fee*			$8,000.00
Transporation/Traffic (Hexagon)		*Fixed Fee*			$9,095.00
Utilities & Service Systems - Water/Wastewater (Questa)		*Fixed Fee*			$18,600.00
TOTAL SUBCONSULTANT COSTS					**$35,695.00**
DIRECT EXPENSES					
Printing and Reproduction					
Notices (NOA, NOC, NOD)					$100.00
ADEIR w/Appendices (5)					$1,000.00
DEIR w/Appendices (50)					$6,500.0
AFEIR w/Appendices (5)					$750.00
FEIR w/Appendices (50)					$3,000.00
Graphics/Map Reproductions					$150.00
Circulate Notices, EIRs to County					$200.00
Other Mailing/Publication Expenses (e.g., FedEx, supplies)					$150.00
Travel Expenses/Misc. Materials					$500.00
TOTAL EXPENSES					**$12,350.00**
GRAND TOTAL					**$137,700.00**

* This amendment assumes that the County will distribute the DEIR, FEIR and all Notices (NOA, NOC, NOD).

Hawaii Water Environment Association

Water Reuse Clean Water Act Sanitary Sewer OverflowsHonouliuli WRF

Education - Sanitary Sewer Overflows (SSOs)

Overflows and spills from sewer lines onto our roadways and into our streams and oceans spoil our beautiful Hawaiian environment and can endanger public health. Read more on how **you** can help prevent overflows and spills from occurring.

PREVENTING SEWAGE OVERFLOWS AND SPILLS - Page 1

Table of Contents

Click here to download this entire paper in Adobe PDF Format (890 kb)
Click here to download the Official PSA brochure in Adobe PDF Format (763 kb)

1. Learn about the sanitary sewer system and what you can do to help prevent sewage spills
2. More information on sewer spills
3. Ten terms to help you better understand your sewer system
4. What is the difference between "sanitary sewers" and "storm drains"?
5. Why are sewage spills a public health, environmental and economic problem?
6. What are the main causes of sewage spills?
7. Keeping fats, oils and grease out of the sewer system
8. How should we properly dispose of grease and oils?
9. Keeping rubbish out of the sewer system
10. Keeping rainwater and other excess water out of the sewer system
11. What is infiltration and inflow?
12. Why are infiltration and inflow big problems?
13. Who is responsible for the infiltration and inflow problem?
14. What can you do to prevent and reduce infiltration and inflow?
15. What should you do if you see a sewage spill?
16. Where can I obtain more information?

Preventing Sewage Spills

Overflows and spills from sewer lines onto our roadways and into our streams and oceans spoil our beautiful Hawaiian environment and can endanger public health. Sewage spills are costly to clean up (increasing your sewer bills) and can even hurt our tourist industry by causing beach closures. In a typical year, there are over 400 spills statewide involving more than two million gallons of raw sewage!

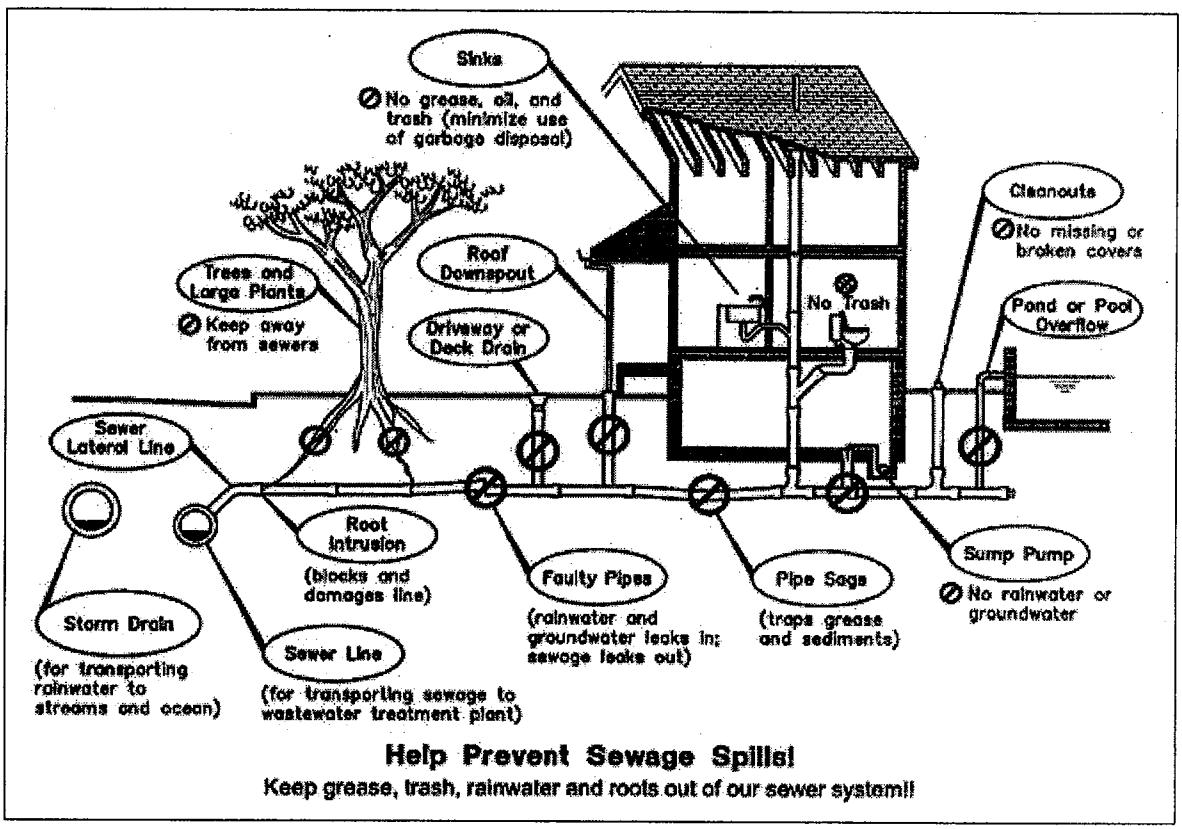


Learn about the sanitary sewer system and what you can do to help prevent SEWAGE SPILLS!

A Quick Overview

Preventing sewage spills is quite simple. Spills are simply caused by clogged pipes and/or too much flow. All everyone needs to do is keep unwanted things out of our sewer pipes such as grease, trash, rainwater and tree roots.

Illustrated below are some of the causes of sewage spills and how you can help prevent these spills (click here to download a higher resolution image shown below):



More Information on Sewage Spills

Now that you have a feel for the basic ways to prevent sewage spills, take some time to learn about the fascinating details of sewage spills and your underground sewer system. By reading through the information presented below, you can learn:

- Important sewer system terms.
- The difference between "sanitary sewers" and storm drains.
- Why sewage spills are a BIG problem.
- Typical causes of sewage spills.
- How to keep grease and oils out of the sewer system.
- How to keep rubbish out of the sewer system.

- What infiltration and inflow are and why it is important to keep rainwater and other excess water out of the sewer system.
- What you should do if you see a sewage spill.
- Where more information on your sewer system can be obtained.

Ten Terms to Help You Better Understand Your Sewer System

1. **"SEWAGE"** or **"WASTEWATER."** This is the "used" water that contains human wastes from toilets and water from other sources such as sinks, showers, washing machines, etc. In addition to being odorous, sewage can contain large amounts of germs that cause disease. The term "wastewater" is often used in place of "sewage" to make things sound more pleasant when discussing this unpleasant subject.

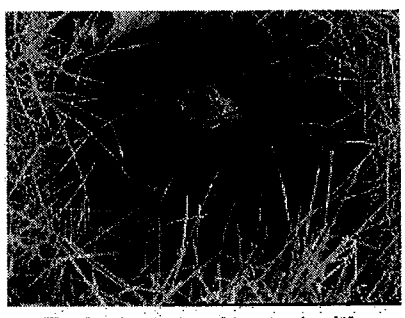
2. **"SANITARY SEWER SYSTEM,"** also known as **"WASTEWATER COLLECTION SYSTEM,"** or **"SEWERS."** These are pipes through which sewage is carried from homes and businesses to a treatment plant. The sanitary sewer system includes the main sewer lines in the streets and the branch lines to individual sewer customers called "sewer laterals."

   Sewer systems are generally designed to flow by gravity through sloped pipes until it reaches either the treatment plant or a sewage pumping station (which pumps the sewage up to another higher sewer or a treatment plant).

   Although sewage is very unsanitary, the term "sanitary sewer" is used because the sewer pipes are separate from the pipes used for storm water drainage. This helps protect public health and the environment. In some older cities, sewage and rainwater flow through the same pipes. This can cause major environmental and public health problems because untreated or partially treated-sewage is discharged into streams, rivers and other water bodies during heavy rain.

3. **"SEWER LATERAL."** This is the sewer pipe that connects a building's plumbing system to the main sewer line in the street. Maintenance of sewer lateral pipes located within private property is generally the responsibility of the property owner. Sewer laterals are also called "service laterals," "house laterals," or simply "laterals."

4. **"SEWER CLEANOUT."** This is a pipe rising from the sewer lateral to the ground surface with a removable cap or plug. It is used to access the sewer lateral to free blockages. A sewer cleanout is usually located just inside the property line. There may be additional sewer cleanouts at various other locations in your property.

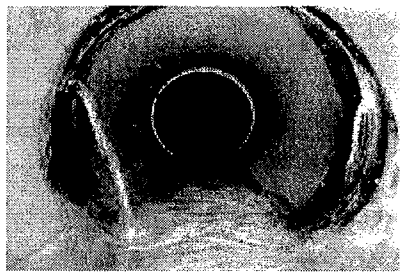


Typical sewer cleanout with properly installed plug.

5. **"WASTEWATER TREATMENT PLANT"** or **"WASTEWATER RECLAMATION FACILITY"**. These are facilities where organic matter, bacteria, viruses and solids are removed from sewage through physical, biological and chemical processes. The treated wastewater (called effluent) may be disposed of by discharging it to water bodies (mainly the ocean in Hawaii), injecting it into the ground, or

reusing it for irrigation or other beneficial non-potable (non-drinking) uses.

6. **"INFILTRATION."** This refers to groundwater (water found below the ground surface) that enters sewer pipes through cracks, pipe joints, and other system leaks. Because sewers in coastal areas are typically buried deep, they are often located below the water table. Since most sewer lines do not flow full (under pressure), groundwater "infiltrating" into the sewer line is actually more of a problem than sewage leaking out of the line. Storm events can raise groundwater levels and increase infiltration of groundwater into sewer pipes. The highest infiltration flows are observed during or right after heavy rain. Too much infiltration will overload the sewers and cause spills!

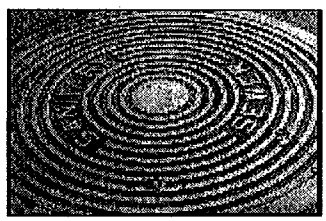


Water infiltrating into a sewer line.

7. **"INFLOW."** This is rainwater that enters the sewer system from sources such as yard and patio drains, roof gutter downspouts, uncapped cleanouts, pond or pool overflow drains, footing drains, cross-connections with storm drains, and even holes in manhole covers. Inflow is greatest during heavy rainfall and like infiltration, can cause excessive flows and sewage spills.

8. **"PATHOGENS."** These are harmful germs in raw sewage that cause diseases such as cholera, dysentery, hepatitis and gastroenteritis.

9. **"MANHOLES."** Sewer manholes are underground structures used to provide access to underground sewer lines and are usually found in a street, parking area or sidewalk. Access is required to periodically inspect and clean the lines. Sewer manholes typically have heavy round covers with the words "Sanitary Sewer" on the cover.



10. **"SANITARY SEWER OVERFLOW."** Sewage spills are technically called "sanitary sewer overflows" since it involves the overflow of sewage from the sanitary sewer system. The word "sanitary" is used only because the overflow is from the sanitary sewer system, and not because the raw sewage is sanitary! (See definition of sanitary sewer above). For simplicity, we will use the term "sewage spill" or "sewage overflow."



Sewage overflows often occur from sewer manholes in the streets. Sewage can also backup into homes through your toilets, showers and floor drains. Sewage spills are caused by sewage filling the sewer pipes behind the clog to the point where it spills out of an opening in the system (generally the lowest manhole, shower drain or other plumbing fixture).

Go to SSO Page 2 >>

Last Updated:December 13, 2007

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EPA United States Environmental Protection Agency
Office of Water

OFFICE OF WASTEWATER MANAGEMENT

Sanitary Sewer Overflows

Sanitary Sewer Overflows
What are they and how can we reduce them?

EPA 832-K-96-001 - Summer 1996

What are Sanitary Sewer Overflows?

A sanitary sewer overflow can spill raw sewage into basements or out of manholes and onto city streets, playgrounds and into streams, before it can reach a treatment facility.

Why are SSOs a problem?

EPA has found that Sanitary Sewer Overflows (SSOs) caused by poor sewer collection system management pose a substantial health and environmental challenge in some parts of our nation. The response to this challenge varies considerably from state to state. Many municipalities have asked fo national consistency in the way permits are considered for wastewater discharges, including SSOs, and in enforcement of the law prohibiting unpermitted discharges.

In response, EPA has convened representatives of states, municipalities, health agencies, and environmental advocacy groups to advise the Agency on how to best meet this challenge. This *Federal Advisory Subcommittee* examines the need for national consistency in permitting and enforcement, effective sewer operation and maintenance principles, public notification for SSOs wit potential health or environmental dangers, and other public policy issues.

EPA carefully considers the Subcommittee recommendations for regulatory and nonregulatory actions to reduce SSOs nationally.

Why Do Sewers Overflow

SSOs occasionally occur in almost every sewer system even though systems are intended to collect and contain all the sewage that flows into them. When SSOs happen frequently, however, it means something is wrong with the system.

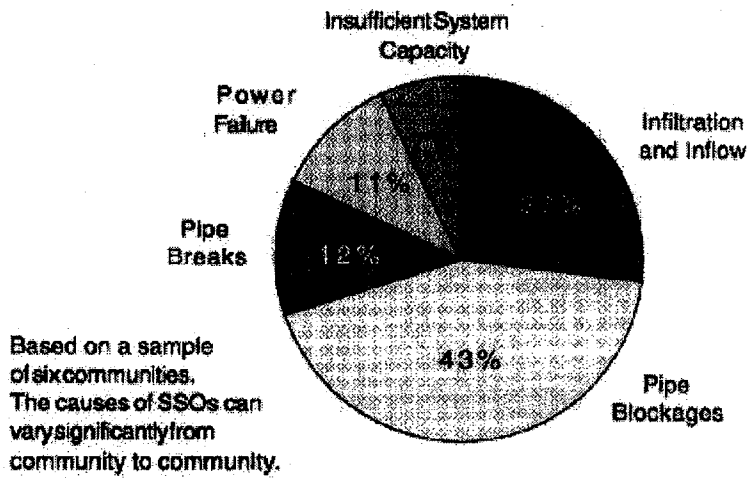
Problems that can cause chronic SSOs include:

- Too much rainfall or snowmelt **infiltrating** through the ground into leaky sanitary sewers,

which are not intended to hold rainfall or to drain property. Excess water can also **inflow** through roof drains connected to sewers and broken or badly connected sewer service lines

- Sewers and pumps too small to carry sewage from newly-developed subdivisions or commercial areas
- Blocked, broken or cracked pipes and other equipment or power failures that keep the system from doing its job. Tree roots can grow into the sewer. Sections of pipe can settle or shift so that pipe joints no longer match. Sediment and other material can build up and cause pipes to break or collapse. This can also happen to sewer service connections to houses and other buildings. Some cities estimate that as much as 60 percent of the water over-filling their sewer systems comes from service lines. The chat below shows major types of problems that cause SSOs most frequently.
- A deteriorating sewer system. When sewers are not properly installed or maintained, widespread problems that can be expensive to fix develop over time. Some municipalities have found severe problems, necessitating billion-dollar correction programs. Often, communities have had to curtail new development until problems are corrected or system capacity is increased.

Estimated Occurence of Sanitary Sewer Overflows by Cause



What Health Risks Do SSOs Present

Because SSOs contain raw sewage they can carry bacteria, viruses, protozoa (parasitic organisms), helminths (intestinal worms), and borroughs (inhaled molds and fungi). The diseases they may cause are shown in the table below and range in severity from mild gastroenteritis (causing stomach cramp and diarrhea) to life-threatening ailments such as cholera, dysentery, infections hepatitis, and severe gastroenteritis.

PATHOGENS IN RAW SEWAGE(6)

ORGANISMS	DISEASES AND SYMPTOMS
Bacteria	Chlorea, salmonellosis (food poisoning),

	typhoid fever, bacillary dysentery, gastroenteritis (including diarrhea and abdominal pain)
Viruses	Hepatitis, meningitis, pneumonia, fever, common colds, paralysis, encephalitis, gastroenteritis, diarrhea, respiratory infections
Protozoa	Gastroenteritis, acute enteritis, giardiasis (including diarrhea, abdominal cramps, and weight loss), dysentery, toxoplasmosis, crypotosporidiosis
Helminths	Digestive and nutritional disturbances, abdominal pain, vomiting, restlessness, coughing, chest pain, fever, abdominal pain, diarrhea, anemia, weight loss, fever, muscle aches, nervousness, insomnia, anorexia, hookworm disease, taeniasis
Bioaerosols	Allergic reactions (such as asthma), Legionnaire's disease

People can be exposed through:

- Sewage in drinking water sources.
- Direct contact in areas of high public access such as basements, lawns or streets, or to waters used for recreation. At least one study has estimated a direct relationship between gastrointestinal illness contracted while swimming and bacteria levels in the water(1).
- Shellfish harvested from areas contaminated by raw sewage. One study indicates that an average of nearly 700 cases of illness per year were reported in the 1980s from eating shellfish contaminated by sewage and other sources. The number of unreported cases is estimated to be 20 times that(2).

Some cases of disease contracted through inhalation and skin absorption have also been documented (3).

What Other Damage Can SSOs Do?

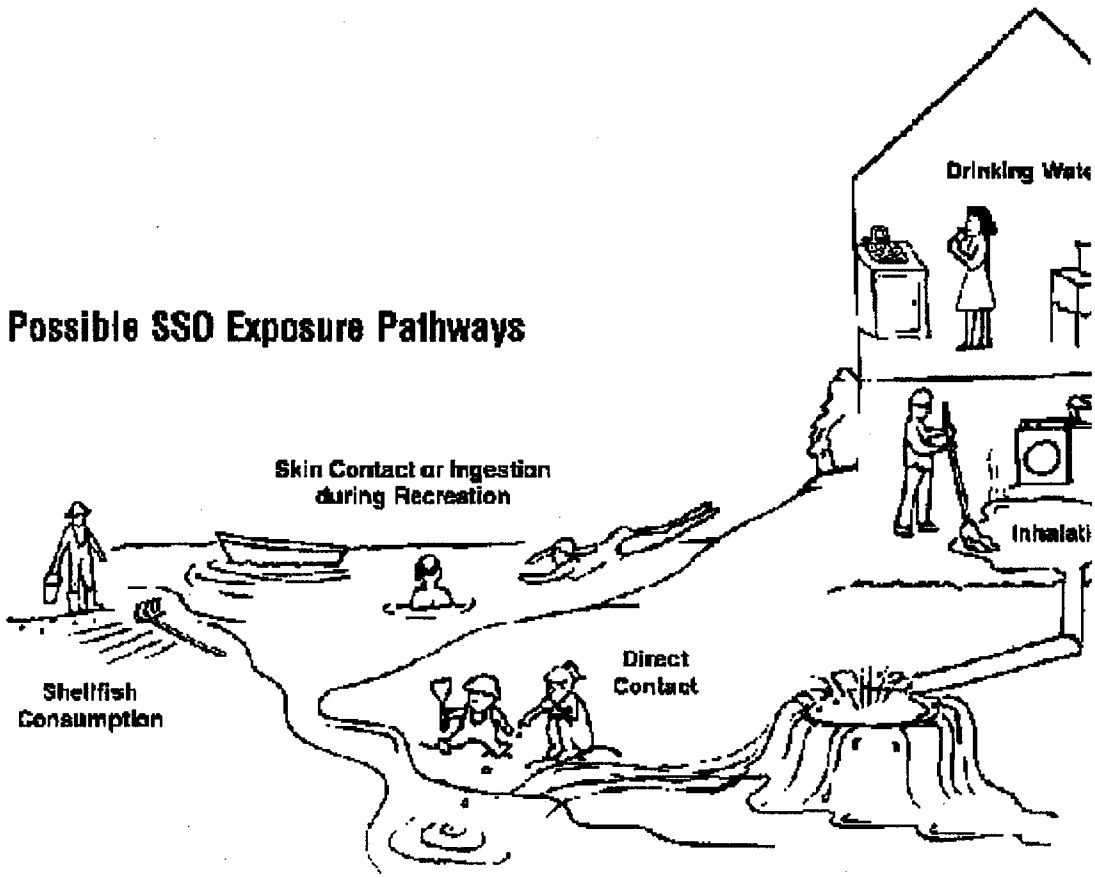
SSOs also damage property and the environment. When basements flood, the damaged area must be thoroughly cleaned and disinfected to reduce the risk of disease. Cleanup can be expensive for homeowners, and municipalities. Rugs, curtains, flooring, wallboard panels, and upholstered furniture usually must be replaced.

A key concern with SSOs which enter rivers, lakes, streams, or brackish waters is their effect on water quality. When bodies of water cannot be used for drinking water, fishing, or recreation, society experiences an economic loss. Tourism and water front home values may fall. Fishing and shellfish harvesting may be restricted or halted. SSOs can also close beaches. One 1994 study claims that SSOs closed beaches across the nation that year for more than 300 days(4).

How Big Is The Problem?

The total number of SSOs that occur nationwide each year is not known. In some areas, they might not be reported or are underreported to EPA and state environmental agencies. Two surveys, however, hep to define the size of the problem:

- In a 1994 survey of 79 members of the Association of Metropolitan Sewerage Agencies, 65 percent of the respondents reported wet weather SSOs(5). They reported that between 15 and 35 percent of their sewers were filled above capacity and/or overflowed during wet weather. However, municipal respondents with SSOs had only limited information about them. Only 6C percent had estimated the annual number. half of those had estimated the amount of sewerage discharged, and 17 percent had determined what pollutants were in their overflows.
- A 1981 survey conducted by the National Urban Institute indicated an average of 827 backups and 143 breaks per 1,000 miles of sewer pipe *(about 1,000 miles of sewer pipe are needed to serve 250,000 people.)* per year. Breaks occurred most often in the young, growing cities of th South and West. The report authors suggested that cities with the most collection system problems were doing the least to correct them---even cleaning pipes at a very low rate.



How Can SSOs Be Reduced Or Eliminated

Many avoidable SSOs are caused by inadequate or negligent operation or maintenance, inadequate system capacity, and improper system design and construction. These SSOs can be reduced or eliminated by:

- Sewer system cleaning and maintenance
- Reducing infiltration and inflow through system rehabilitation and repairing broken or leaking service lines.
- Enlarging or upgrading sewer, pump station, or sewage treatment plant capacity and/or reliability.
- Construction wet weather storage and treatment facilities to treat excess flows.

Communities also should address SSOs during sewer system master planning and facilities planning, or while extending the sewer system into previously unsewered areas.

A few SSOs may be unavoidable. Unavoidable SSOs include those occurring from unpreventable vandalism, some types of blockages, extreme rainstorms, and acts of nature such as earthquakes or floods.

What Costs Are Involved?

Sanitary sewer collection systems are a valuable part of the nation's infrastructure. EPA estimates

that our nation's sewers are worth a total of more than $1 trillion. The collection system of a single large municipality is an asset worth billions of dollars, and that of a smaller city could cost many millions to replace. Sewer rehabilitation to reduce or eliminate SSOs can be expensive, but the cost must be weighed against the value of the collection system asset and the added costs of this asset is allowed to further deteriorate. Ongoing maintenance and rehabilitation adds value to the original investment by maintaining the system's capacity and extending its life.

The costs of rehabilitation and other measures to correct SSOs can vary widely by community size and sewer system type. Those being equal, however, costs will be highest and ratepayers will pay more in communities that have not put together regular preventive maintenance or asset protection programs in place.

Assistance is available through the Clean Water Act State Revolving Fund for capital projects to control SSOs. State Revolving Funds in each state and Puerto can help arrange low-interest loans. For the name of your State Revolving Fund contact, please call the EPA Office of Water Resource Center, (202)260-7786.

Identifying SSO Problems and Finding Solutions

Cabool, Missouri(7)

In 1990 the sewer system for this city of 5,000 exceeded its capacity, causing overflows and backups at several locations. Breaks in drinking water mains lowered the water pressure, allowing contamination from nearby SSOs to enter the drinking water system.

Researchers linked these overflows with a pathogenic strain of *Escherichia coli* which killed 4 people, hospitalized 32 and caused diarrhea and other problems in 243 people.

Ocoee, Florida(8)

Sewage overflows from November 1988 to April 1989 periodically flooded a mobile home park during heavy rains and caused occasional outbreaks of disease.

Thirty nine cases of hepatitis A were identified among residents. In addition, four infected food handlers living in the park were linked to 100 cases of hepatitis A in Ft. Lauderdale where they worked. Hepatitis A is a chronic liver disease that can lead to permanent health injury and shorten life expectancy. Using a special health analysis scale, health damages were measured at up to 20 years' lost life expectancy. Diarrhea and other symptoms continued for 2 years.

Washington Suburban Sanitary Commission, Maryland(9)

From 1990 to 1994 the number of SSO-related basement backups ranged from 484 to 659 per year, for a total of 2,960. Basement cleanups cost an average of $700 each, including removal and disposa of sewage; removal and cleaning or disposal of carpet, wallpaper, wallboard, insulation, and other materials; disinfection; and drying.

Overflows at sewage pumping stations and treatment plants occurred from 11 to 50 times per year.

The costs of upgrades to reduce the level of overflows in the system (which serves 1.4 million people and handles 180 million gallons of wastewater a day) include:

- Upgrades at pumping stations and sewage treatment plants: $38 million
- Collection System improvements: $22 million
- Sewer reconstruction: $6 million (annual)
- Maintenance program: $10 million (annual)

These upgrades costs system users about $50 per household per year.

Lynn, Massachusetts(10)

SSOs caused street flooding, basement flooding, and sewer house connection backups in low locations. Some homeowners had to install pumps to reduce basement flooding.

Some of the SSO problems were attributed to badly cracked pipes, blocked, damaged manholes, leaky pipe joints, and large debris in some sewer sections.

The city has undertaken sewer separation and rehabilitation projects that have reduced the number and frequency of SSOs at a cost of $2.6 million. Additional work will further reduce overflows. Costs are estimated at about $10 per household per year.

Louisville/Jefferson County, KY(11)

From 1989 to 1994, 165 overflows were reported in 80 different locations, 70 percent caused by wet weather infiltration and inflow.

The county began corrective actions to reduce the number and frequency of SSOs through sewer rehabilitation and preventive maintenance. Further work was planned to remove private infiltration and inflow source connections such as sump pumps, foundation drains, and other connections. Future SSO reduction projects were investigated.

The long-term budget plan for corrective actions totaled $14.6 million. This program costs each household about $40 per year.

Office of Wastewater Management

For more information about EPA's work to help reduce sanitary sewer overflows please write to:

SSO Program Manager
U.S. EPA Office of Waste Water Management
401 M Street, SW (4201)
Washington, DC 20460

For publications about U.S. EPA Office of Wastewater Management programs and policies, please consult these sources:

Office of Water Resources Center

RC- 4100 - 2615 OWM
401 M Street, SW
Washington, DC 20460
(202)260-7786
Fax: (202)260-0386
(U.S. EPA Office of Water publications including information about storm water and combined sewer overflows. Also available is a list of commonly-used technical references for managing sanitary sewer overflows.)

Center for Environmental Research Information (CERI)
26 West Martin Luther King
Cincinnati, OH 45268
(513)569-7566
(Technical information about all U.S. EPA regulatory programs.)

Education Resource Information Center
Clearinghouse for Science, Mathematics and Environmental Education (ERIC/CSMEE)
1929 Kenny Road
Columbus, OH 43210-1080
(800)276-0462 or (614)292-6717
Fax: (614)292-0263
(Comprehensive information about environmental education. Charge applies.)

U.S. Dept. of Commerce
National Technical Information (NTIS)
5285 Port Royal Road
Springfield,, VA 22161
(800)553-6847 (rush orders) or (703)487-4650
Fax: (703)321-8547
(Many U.S. government agency publications. Charge applies)

National Small Flows Clearinghouse
West Virginia University
P.O Box 6064
Morgantown, WV 26506-6064
(800)624-8301
Fax: (304)293-3161
(Small communities technical assistance and information. Charge applies.)

Also see the U.S. EPA Office of Water Internet Home Page at http://www.epa.gov/OW

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9) Washington Suburban Sanitary Commission, MD, 1995, *Separate Sanitary Sewer Overflows: Report to the U.S. Environmental Protection Agency.*

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11) Fort Worth, TX, 1995, *Sanitary Sewer Main 161 and 221 Drainage Areas Inflow/Infiltration Evaluation Study.*

APPENDIX E

ATTACHMENTS TO COMMENT LETTER 209 FROM WITTWER & PARKIN, LLP.,
JONATHAN WITTER, DATED DECEMBER 23, 2009

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

RESOLUTION NO. 78-14

POLICY ON DISCRETE SEWERAGE FACILITIES

I. Whereas, on June 16, 1966, the Board adopted a policy statement, Resolution No. 768, with respect to sewerage in urbanizing areas of the region, and;

II. Whereas, the policy has been followed by the Board and its staff in judging the acceptability of the use of septic tanks or small community systems since 1966, and;

III. Whereas, this Regional Board finds:

A. The application of Resolution No. 768 has been difficult due to its indirect nature (it requests City and County government to act rather than stating the Regional Board will act).

B. There is a need for restatement of the Regional Board's policy to clearly set forth the actions which the Regional Board will take with respect to proposals for new discrete sewerage systems, as well as what it will request of local governments.

IV. Whereas, this Regional Board has prepared a negative delcaration in accordance with the California Environmental Quality Act (Public Resources Code, Section 21000 et seq.) and the State guidelines, and the Board determines that there will be no substantial adverse change in the environment as a result of the project.

V. Whereas, on September 20, 1977, October 18, 1977, December 20, 1977, April 18, 1978, and July 18, 1978, this Board held public hearings and heard and considered all comments pertaining to this matter, and;

VI. Whereas, this Regional Board has determined that there are no state mandated local costs under Section 2231 of the Revenue and Taxation Code as a result of the foregoing regulation because such regulation is not an executive regulation by virtue of Section 2209 of the Revenue and Taxation Code, and;

VII. Therefore, Be It Resolved that this Regional Board adopts the policies set forth in the attached document entitled "Policy on Discrete Sewerage Facilities" and rescinds this Board's Resolution No. 768 to become effective upon approval by the State Water Resources Control Board.

I, Fred H. Dierker, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, San Francisco Bay Region, on July 18, 1978.

FRED H. DIERKER
Executive Officer

POLICY ON DISCRETE SEWERAGE FACILITIES

BACKGROUND

As the population of the Bay Area increases, demand for residential development increases. In many cases, residential development is occurring in close proximity to existing urban areas and within the service areas of existing municipal sewerage agencies. In an increasing number of instances, however, development is being proposed in outlying areas which cannot easily be served by existing sewerage agencies. In these instances discrete sewerage systems are being proposed (i.e. separate from existing sewerage systems). In many cases the legal and financial arrangements for the planning, design, operation and maintenance of these discrete sewerage systems are uncertain at the time the residential development is proposed.

On June 16, 1966 this Regional Board adopted a policy statement (Resolution 768) with respect to sewerage in urbanizing areas of the region. Resolution 768 contains the following request of City and County governments.

"BE IT FURTHER RESOLVED, that it is the policy of this Regional Board:

A. That City and County government is requested to:

1. Prohibit the use of septic tanks and leaching systems for sewage disposal:

   a. For any subdivision of land which comes under the provisions of the Subdivision Map Act of California unless the subdivider clearly demonstrates to the satisfaction of the governing body having jurisdiction that the use of septic tanks will be in the best public interest and that the beneficial uses of water of the State will not be adversely affected; and

   b. For any other area where minimum lot sizes and dwelling densities, meeting the approval of the appropriate health officer, have not been established by ordinance.

2. Prevent the development of any subdivision, trailer park, or similar development that will use its own community system for the disposal of sewage unless:

   a. The subdivision, trailer park, or similar development is within a pre-existing governmental sewerage entity (city or district) that has authority to and has stated its intent to assume responsibility for the planning, construction, operation, and maintenance of the sewerage system; and

   b. The governmental sewerage entity (city or district) has developed a master plan for sewerage which includes the subdivision, trailer park, or similar development;"

Resolution 768 does not set forth a course of action for the Regional Board to follow when proposals are made for discrete systems. Since the adoption of Resolution 768 both State and Federal law have been amended to strengthen the regulatory authority of the Board.

The Regional Board has determined that there is a need for restatement of its policy to clearly set forth the actions which the Regional Board will take with respect to proposals for new discrete sewerage systems. Definitions of certain terms used in this document are included at the end of the document.

PRINCIPLES

This Regional Board is a State regulatory agency which has been given legislative authority and direction to protect the quality of the waters of the State. The Board's basic authority and responsibilities are set forth in the Porter-Cologne Water Quality Control Act. The Regional Board has no authority to regulate land use as a Responsible Agency under the California Environmental Quality Act (CEQA). This Regional Board has operated under the principle that regulation of land use is the responsibility of city and county governments. The policies which follow are based upon this principle.

This Regional Board will apply the following principles to all wastewater discharges:

1. The system must be designed, constructed, and installed so as to be capable of preventing pollution or contamination of the waters of the State or creating nuisance for the life of the development.

2. The system must be operated, maintained and monitored so as to continually prevent pollution or contamination of the waters of the State and the creation of a nuisance.

3. The responsibility for both of the above must be clearly and legally assumed by a public entity with the financial and legal capability to assure that the system provides protection to the quality of the waters of the State for the life of the development.

POLICY

The policy of this Regional Board with respect to the use of new discrete sewerage systems is set forth below. The policy recognizes that there are certain actions which are best undertaken by local governments to minimize the potential for water quality problems resulting from the use of new discrete sewerage systems.

POLICY 1

It is the Policy of this Regional Board that city and county governments are requested:

1. Prohibit the use of new discrete sewerage systems where existing community sewerage systems are reasonably available. The determination of whether or not existing systems are reasonably available will be the responsibility of the local agency or agencies having jurisdiction over the project.

2. Prohibit the use of individual septic tank disposal systems for any subdivision of land unless the governing body having jurisdiction determines that the use of septic tanks will be in the best public interest and that the existing quality of the waters of the State will be maintained consistent with the State Water Resources Control Board's Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality Waters in California."

3. Assure that individual disposal systems are maintained to the satisfaction of the responsible Health Officer. This could be accomplished through establishment of special maintenance districts, by the amendment of existing ordinances assuring adequate maintenance documented through periodic inspections, or other alternatives as deemed appropriate by the local Health Officer.

4. Consider the cumulative impacts of individual disposal system discharges as a part of the approval process for development.

POLICY 2

This Board will require a Report of Waste Discharge to be filed for all proposed waste discharges which involve the use of new community wastewater treatment an disposal systems. Before this Board will consider the Report of Waste Discharge to be complete, the following requirements must be met:

A. A public entity must assume legal authority and responsibility for the planning, design, financing, construction, operation, and maintenance of the proposed wastewater treatment and disposal system. The Report of Waste Discharge must be submitted by the public entity.

B. The Report of Waste Discharge must include the following:

1. A final Environmental Impact Report or Negative Declaration covering the total project, unless categorically exempt, prepared and approved by the local lead agency pursuant to the California Environmental Quality Act of 1970 (as amended) and Chapter 3, Division 6, Title 14, of the California Administrative Code (as amended).

2. Include operation, maintenance, revenue and contingency plans for the wastewater treatment and disposal facility or a commitment by the public entity to prepare such plans and submit them to the Regional Board at least sixty (60) days prior to the initiation of discharge. In the absence of a satisfactory report, the discharge will be prohibited.

RATIONALE: The filing of a Report of Waste Discharge is required by Section 13260 of the California Water Code. The requirement for a public entity to assume authority for the proposed treatment and disposal system is based upon State-wide experience with small community wastewater systems. In general, it has been the experience of this Regional Board and other Regional Boards throughout the State, that public entities are more capable of providing adequate resources to assure the proper planning, design, construction, operation, and maintenance of wastewater systems. With the establishment of a public entity, legal procedures and remedies are greatly simplified in the event of violation of Board Requirements. The California Environmental Quality Act of 1970 requires

that a final Environmental Impact Report or Negative Declaration (unless categorically exempt) be considered by this Regional Board prior to the adoption of waste discharge requirements. The preparation of this document should be the responsibility of the local agency responsible for approval of the project.

Operation and maintenance and revenue plans have been required for all new facilities constructed through the grant program. The development of these plans helps to assure proper operation and maintenance of a facility once it is constructed and future replacement of that facility. The development of these plans for all new facilities will help assure proper operation and maintenance and will aid the public entity in determining the appropriate level of funding and staffing for the operation and maintenance of the facilities. Contingency plans have been required from all dischargers pursuant to the Board's Resolution No. 74-10.

POLICY 3

This Regional Board will pursue the following course of action with respect to the use of individual wastewater treatment and disposal systems.

A. It will require assessments of the cumulative impact of discharges from individual wastewater treatment and disposal systems on water quality and public health where the density of systems is such that adverse impacts may occur. The Board will identify each area where such assessments are necessary and will adopt individual time schedules for the appropriate public entity to develop the required report. The Executive Officer is directed to work with local planning and health departments to:

   1. Identify areas within each County where the ultimate density of individual wastewater treatment and disposal systems is such that adverse impacts on water quality or public health might occur.

   2. Define the scope and time schedule for each cumulative impact assessment.

   3. Estimate assessment costs and identify potential sources of funding.

B. It will periodically review its waivers of the reporting of waste discharge pursuant to Section 13269 of the California Water Code to determine if they should be continued. The criteria by which the Board will determine whether or not to continue the waivers will be the adequacy of local ordinances for the control of individual wastewater treatment and disposal systems and the actions of local agencies in implementing those ordinances.

This Board believes that adequate surveillance and maintenance of individual wastewater treatment and disposal systems is imperative. In the review of its waivers, the Board will look for provisions for adequate maintenance such as periodic inspections or establishment of maintenance districts and will also evaluate the response of local agencies to Policy 1 and Policy 3A.

This Board will adopt guidelines by which it will judge the adequacy of local ordinances for the control of the individual wastewater treatment and disposal systems.

C. It will require a Report of Waste Discharge to be filed for all individual wastewater treatment and disposal systems which discharge to the surface of the land or to surface waters of the State.

RATIONALE: Individual treatment and disposal systems are an acceptable means of wastewater disposal in rural area. Septic tanks and leachfields have been the predominant types of individual systems. It has been the experience of this Board that water quality and public health problems can result when such systems are used inappropriately. Failure of septic tank systems may occur due to their design or the physical characteristics of the disposal site or failure may occur due to inadequate or improper construction, maintenance or operation of the system. Adequate local ordinances for the control of individual systems should help prevent the first cause of failure. In the absence of a governmental public entity that has assumed this responsibility, only proper maintenance and operation by the homeowner can prevent the second cause noted above. Homeowner maintenance and operation is generally inadequate. Periodic inspections by local agencies or the establishment of maintenance districts should assure proper operation and maintenance.

The use of proper design codes and good operation and maintenance practices will minimize the failure of individual systems. However even a properly functioning system will contribute nitrate nitrogen and TDS to groundwaters. High nitrate or TDS concentrations will impair the beneficial uses of groundwater.

The impacts of the discharge from individual system on groundwaters must be analyzed on a case-by-case basis for each groundwater basin. It is obviously not necessary to study all groundwater basins. Those basins should be studied where the density of individual systems may result in elevated nitrate or TDS concentrations. The studies will assure the use of individual systems will not impair beneficial uses of the groundwaters and will be consistent with the State Water Resources Control Board's Nondegradation Policy (Resolution No. 68-16).

POLICY 4

This Regional Board will prohibit the discharge of wastes which threaten to cause water pollution, water quality degradation, or the creation of health hazards or nuisance conditions or which do not comply with the provisions set forth in Policy 2 above.

RATIONALE: Section 13243 of the California Water Code states that a Regional Board, in a water quality control plan or waste discharge requirements, may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.

POLICY 5

It is the position of this Board that the Alameda Creek Water shed above Niles must receive special consideration with respect to the use of new discrete sewerage systems. It is the intent of this Board to discourage new discrete discharges within the Alameda Creek Watershed which will not be part of the LAVWMA export project until a water quality management plan for the Alameda Creek Watershed above Niles has been completed and approved by this Regional Board.

RATIONALE: The Alameda Creek Water shed above Niles has been an area of critical Regional Board Concern for over two decades. To date, the Board's efforts have focused on the three major dischargers in the Livermore-Amador Valley, however, the Board has on several occasions expressed concern over the lack of water quality management planning for the entire watershed.

The Niles Cone groundwater system and Livermore-Amador Valley groundwater basin are two of the most important groundwater systems in the Region. Both are used as sources of domestic water supply and they serve a combined population of approximately 250,000.

There is a long history of actions taken by the Regional Board to protect the Niles Cone and Livermore-Amador Valley groundwaters. In the past three years the Board has taken several actions in the attempt to get local agencies to develop an overall water quality management plan for the entire Alameda Creek Watershed above Niles.

Existing wastewater disposal practices are creating water quality problems in both the Niles Cone and Livermore-Amador Valley groundwaters. The Regional Board has prohibited wastewater discharge to the surface waters of the watershed. Implementation of this prohibition through the LAVWMA export project and application of the prohibition to any new discharges proposed for the watershed will protect the Niles Cone groundwaters from discharges in the Livermore-Amador Valley. Recent studies indicate that degradation of the Livermore-Amador Valley groundwaters will continue even with the export of all wastewaters. New discharges could accelerate that degradation.

The Alameda County Flood Control and Water Conservation District - Zone 7 has recoznized this problem through adoption of an Interim Policy (Resolution 823) which prohibits any new reuse of treated wastewater within the Livermore-Amador Valley and express its intent to evaluate the long-term effects of existing reuse on the groundwater resources.

A water quality management plan is necessary to determine if new discharges should be allowed in the watershed and to provide appropriate management practices to protect the quality of the groundwaters.

DEFINITIONS

Terms used in this policy are defined as follows:

COMMUNITY SYSTEMS - collection sewers plus treatment facilities serving multiple discharges under separate ownership, such as package plants or common septic tanks plus disposal facilities such as evaporation ponds or leachfields.

INDIVIDUAL SYSTEMS - systems for an individual home such as septic tank and leachfield systems.

MAINTENANCE DISTRICT - an entity established to own, monitor, inspect, and maintain individual treatment and disposal systems. Pursuant to SB430 on-site wastewater disposal zones may be formed which have broader powers than those described above.

PUBLIC ENTITY - A local agency, as defined in the State of California Government Code Section 53090 et seq., which is empowered to plan, design, finance, construct, operate, maintain, and to abandon, if necessary, any sewerage system or the expansion of any sewerage system and sewage treatment facilities serving a land development. In addition, the entity shall be empowered to provide permits and to have supervision over the location, design, construction, operation, maintenance, and abandonment of individual sewage disposal systems within a land development, and shall be empowered to design, finance, construct, operate, and maintain any facilities necessary for the disposal of wastes pumped from individual sewage disposal systems and to conduct any monitoring or surveillance programs required for water quality control purposes.

WATERS OF THE STATE - as defined in Section 13050 of the California Water Code, means any water, surface or underground, including saline waters, within the boundaries of the State.

WATER QUALITY MANAGEMENT PLAN - a plan which integrates the following elements into a management tool in a manner compatiable with maintaining the quality of the waters of the State consistent with the water Quality Control Plan for the San Francisco Bay Basin.

(1) Water supply (surface & groundwater);
(2) Surface water quality;
(3) Groundwater quality;
(4) Water-related recreation & wildlife preservation;
(5) Water reclamation, reuse, and conservation; and
(6) Wastewater collection, treatment and disposal.

LOCAL LEAD AGENCY - as defined in Section 21062 and 21067 of CEQA means any public agency other than a State agency, Board, or Commission which has the principal responsibility for carrying out or approving a project which may have a significant effect upon the environment.

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION 9

NPDES COMPLIANCE EVALUATION REPORT

SEWER AUTHORITY MID-COASTSIDE
HALF MOON BAY
GRANADA SANITARY DISTRICT
MONTARA WATER AND SANITARY DISTRICT

NPDES Permit No.:	CA0038598 (Regional Board Order No. 00-016)
Dates of Inspection:	Site visits: November 3 - 5, 2004; January 13, 2005 Information Updated Through: February 2006
Inspection Participants:	Jack Foley, Sewer Authority Mid-Coastside Tony Pullin, Sewer Authority Mid-Coastside George Irving, Montara Water and Sanitary District Mike Donovan, Nute Engineering (consultant to MWSD) Paul Nagengast, City of Half Moon Bay Ed Marlow, Somas Engineering (consultant to Half Moon Bay) Chuck Duffy, Granada Sanitary District Brenda Donald, Sewer Authority Mid-Coastside Pat McGowen, Sewer Authority Mid-Coastside Norm Simons, Special Investigator for NOAA Greg Walker, California Regional Water Quality Control Board Ken Greenberg, USEPA Region 9 Dianne Stewart, SAIC Bill Hahn, SAIC
Report Date:	August 18, 2006

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NPDES COMPLIANCE EVALUATION REPORT
Sewer Authority Mid-Coastside

1 INTRODUCTION

Under contract with the U.S. Environmental Protection Agency (EPA), Science Applications International Corporation (SAIC) conducts NPDES compliance evaluations. On November 3 - 5, 2004, EPA Region 9 and SAIC conducted a compliance evaluation inspection of the collection system operated by the Sewer Authority Mid-Coastside (SAM) and SAM member agencies. SAM is a regional sewer authority that provides wastewater treatment for the City of Half Moon Bay, the Granada Sanitary District, and the Montara Water and Sanitary District; all located in San Mateo County, California. SAM owns and operates regional sewer interceptor pipes that collect wastewater from the member agencies and convey the wastewater to the SAM wastewater treatment plant in Half Moon Bay. Each member agency owns and operates its own local collection system which convey sewage either directly to the SAM treatment plant or to the SAM interceptor.

Inspection participants included: Jack Foley, Tony Pullin and Pat McGowen (SAM); George Irving, Montara San District and Mike Donovan of Nute Engineering (consultant to Montara); Paul Nagengast, City of Half Moon Bay and Ed Marlow of Somas Engineering (consultant to Half Moon Bay); Chuck Duffy of Dudek Engineering, General Manager for the El Granada Sanitary District; Norm Simons, Special Investigator for NOAA; Greg Walker, California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region; Ken Greenberg, USEPA Region 9; and Dianne Stewart and Bill Hahn (SAIC).

A meeting was held with all of the representatives except Chuck Duffy on the morning of November 3rd to discuss the overall system. In the afternoon the inspectors visited several of the SAM facilities. On the morning of November 4, the inspectors met with representatives of the Montara Water and Sanitary District and toured the Montara collection system. In the afternoon of November 4, the inspectors met with representatives of the City of Half Moon Bay and toured its collection system. On Friday, November 5th, the inspection team met with the El Granada Sanitary District, and conducted a closeout meeting at the SAM offices. On January 13, 2005, Ken Greenberg and Dianne Stewart met with SAM representatives, Brenda Donald, Jack Foley, Tony Pullin, and Pat McGowen, to discuss the source control program implemented by SAM. Between January 2005 and February 2006, SAM provided additional information related to the inspection by letter and e-mail in response to inquiries by EPA.

Attachment 1 to this report consists of photographs taken during the inspection. Attachment 2 is a list of sanitary sewer overflows reported during the period from 2000 through 2004. Attachment 3 is a list of pump stations and their characteristics.

2 APPLICABLE REGULATIONS

Under section 301(a) of the CWA, 33 U.S.C. § 1311(a), it is unlawful for any person to discharge any pollutant from a point source into "navigable waters" except in compliance with a permit issued under the CWA. Pollutants include sanitary sewage. 33 U.S.C. § 1362(6). A point source is any confined and discrete conveyance, including a pipe or other conduit. 33 U.S.C. § 1362(14). Navigable waters are defined as 'waters of the United States," which include all waters used in interstate commerce, including tidal waters and all their tributaries. 33 U.S.C. § 1362(7); 40 C.F.R. §122.3, 230.3(s).

Under section 402 of the CWA, the State of California, Regional Water Quality Control Board issued National Pollutant Discharge Elimination System permit number CA0038598 to SAM and its member agencies authorizing the discharge of treated wastewater from the SAM wastewater treatment plant to the Pacific Ocean. The SAM permit was last reissued on March 15, 2000. The permit states that the discharger (SAM) and its member agencies (City of Half Moon Bay, Montara Sanitary District and El Granada Sanitary District) shall comply with the requirements of the NPDES permit.

Several provisions of the NPDES permit apply to the collection systems owned by SAM and the member agencies. Some of the applicable provisions are listed below:

- Provision A.1. prohibits the discharge of wastewater from any location other than the authorized ocean outfall.
- Provision A.3. prohibits the discharge of water, materials or wastes to storm drains or waters of the State except as authorized by the permit.
- Provision E.6. Inflow/Infiltration Plan: requires development of an Inflow/Infiltration Reduction Plan by November 30, 2000 with annual reports due each year by November 30th.
- Provision E.9. Treatment Facilities Evaluation Program: requires a regular review and evaluation of the permittees' wastewater conveyance, treatment and disposal facilities with annual reports due to the Regional Board by April 15th each year.
- Self-Monitoring Program, Part A section F.2. requires immediate reports to the Regional Board of any violation of the waste discharge prohibitions.
- Self-Monitoring Program, Part B.1.E. requires monthly reports to the Regional Board of any "bypass or overflows from manholes, pump stations or collection system".
- Standard Provisions, Paragraph A.4. requires that "the discharger shall take all reasonable steps to minimize or prevent any discharge in violation of this order and permit which has a reasonable likelihood of adversely affecting public health or the environment..."
- Standard Provisions, Paragraph A.8. requires that "collection, treatment, storage and disposal systems shall be operated in a manner that precludes public contact with wastewater, except where excluding the public is inappropriate, warning signs shall be posted."

- Standard Provision section D.1 requires proper operation and maintenance of all facilities.

The Pacific Ocean offshore of SAM's service area has been designated as a marine sanctuary (Monterey Bay National Marine Sanctuary), and thus some provisions of the National Marine Sanctuaries Act apply to discharges from SAM and its member facilities. Section 15 CFR 922.132(a)(2)(i) prohibits:

> Discharge or depositing from within the boundary of the Sanctuary, any material or other matter except: (A) Fish, fish parts, chumming materials or bait used in or resulting from traditional fishing operations in the Sanctuary; (B) Biodegradable effluent incidental to vessel use and generated by marine sanitation devices approved in accordance with section 312 of the Federal Water Pollution Control Act, as amended, (FWPCA), 33 U.S.C. 1322 et seq.; (C) Water generated by routine vessel operations (e.g., cooling water, deck wash down and graywater as defined by section 312 of the FWPCA) excluding oily wastes from bilge pumping; (D) Engine exhaust; or (E) Dredged material deposited at disposal sites authorized by the U.S. Environmental Protection Agency (EPA) (in consultation with the U.S. Army Corps of Engineers (COE)) prior to the effective date of Sanctuary designation (January 1, 1993), provided that the activity is pursuant to, and complies with the terms and conditions of, a valid Federal permit or approval existing on January 1, 1993.

Provision E.13 of the NPDES permit requires SAM to concurrently notify the Monterey Bay National Marine Sanctuary offices in Monterey and San Francisco, in writing, about any violations of effluent limitations, receiving water limitations, or sludge management practices.

2.1 Enforcement Actions

On May 23, 2003, the US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), the agency charged with enforcing the National Marine Sanctuaries Act, issued a warning letter to SAM. The letter was in response to overflows of raw sewage into the marine sanctuary from the Montara Pump Station. These overflows occurred on or about May 5 - 7, 2000. The warning letter cited 15 CFR 922.132(a)(2)(i) as the regulation that was violated.

On March 21, 2001, the Regional Board issued Order No. 01-033 that contained a penalty amount of $21,000 for effluent violations during the period from January to June 2000. The violations consisted of exceedances of the permit's total chlorine residual and total coliform limitations.

3 BACKGROUND

Sewer Authority Mid-Coastside (SAM) was formed in 1976 by its three member agencies; the City of Half Moon Bay, the Granada Sanitary District, and the Montara Sanitary District (now the Montara Water and Sanitary District). SAM operates a secondary wastewater treatment facility and ocean outfall to treat and dispose the wastewater from about 22,000 people from its member agencies. It also owns about 8 miles of large diameter interceptor pipeline which includes 1.9 miles of gravity sewer and 5.8 miles of force mains. These pipes and the associated

pump stations are collectively referred to as the Intertie Pipeline System (IPS). The IPS parallels Highway 1 from Montara to the SAM treatment plant and collects sewage from the member agencies. SAM owns 3 pump stations which transport wastewater from the member agencies to the treatment facility. The treatment facility is located in the City of Half Moon Bay, and discharges into the Pacific Ocean through a submerged diffuser that extends about 1900 feet offshore. The wastewater is discharged directly into the Monterey Bay National Marine Sanctuary.

The Monterey Bay National Marine Sanctuary is a Federally protected marine area offshore of California's central coast. Stretching from Marin to Cambria, the MBNMS encompasses a shoreline length of 276 miles and 5,322 square miles of ocean. It is one of the world's most diverse marine ecosystems, home to numerous mammals, seabirds, fishes, invertebrates and plants.

The SAM service area is approximately 12 square miles, and is located on the western edge of San Mateo County. Approximately half of the service area is within the boundaries of the City of Half Moon Bay, with the remainder equally divided between Granada Sanitary District and Montara Water and Sanitary District. The service area is approximately 30 miles south of San Francisco, and 40 miles north of San Jose. The three member agencies retain ownership and responsibility for their individual collection systems. They have separate capital improvement programs, and each has a different consulting engineering firm for advice on capital improvement projects. Each of the member agencies contracts with SAM for collection system operation and maintenance with the level of service provided by SAM being determined by each member agency. Costs of operating and maintaining the SAM facilities are shared among the member agencies using a cost sharing formula established in the Joint Powers Agreement. In the FY2005-05 budget, 45% of SAM costs are provided by the City of Half Moon Bay, 31% by the Granada Sanitary District and 23% by the Montara Water and Sewer District.

The City of Half Moon Bay (HMB) collection system serves a population of around 10,000 with approximately 3,750 service connections. The HMB service area includes the City of Half Moon Bay except for the northern most portion of the City which is served by the Granada Sanitary District. The HMB collection system includes approximately 35 miles of gravity sewer pipes and an estimated 3 to 4 miles of force mains. Gravity sewer pipes are almost exclusively vitrified clay and force mains have historically be constructed with asbestos cement pipe. The City owns the portion of laterals between the property line and the main. The City owns 3 sewage pump stations in its collection system.

The Montara Sewer District was formed in the late 1950s to provide sewer service to the unincorporated communities of Montara and Moss Beach. On August 1, 2003 it acquired the community water system from a private operator, and changed its name to the Montara Water and Sanitary District (MWSD). MWSD sewage collection system serves a population of about 5,500 with approximately 1,500 to 1,600 connections. The MWSD collection system includes

approximately 23.6 miles of gravity sewers and approximately 3 miles of force mains. Most gravity pipe consists of vitrified clay (VCP). In 1998, MWSD established PVC pipe as the standard for installation of new sewer mains, but repairs of existing VCP mains can be performed using VCP. Asbestos cement pipe has been used for some force mains. In the MWSD service area, the homeowner owns all of the lateral up to the connection with the sewer main. The MWSD owns 13 sewage pump stations on its mainlines and 23 point-of use (POU) pump stations serving individual homes in the geologically active Seal Cove area. Both the mainline and POU pump stations are maintained by SAM under contract with MWSD.

The Granada Sanitary District (GSD) serves the central portion of the SAM service area, including El Granada, Princeton-by-the Sea and the northern portion of the City of Half Moon Bay. GSD services about 3,200 connections (2,957 equivalent dwelling units (EDUs)). The population served was not stated. The GSD collection system includes about 33 miles of gravity sewers, and under 200 feet of force mains. In the GSD, the homeowner owns the entire lateral from the house to the main, but GSD maintains the portion from the property line to the main. GSD owns one pump station, the San Pablo Lift Station.

Table 1 shows a summary of the pipe size distribution for each of the collection systems. Throughout the SAM service area, most of the gravity pipe is vitrified clay and most of the force mains are made of asbestos cement pipe. System-wide, approximately 65% of the gravity sewer lines are 6-inch diameter pipes which are generally more prone to blockage because of the small size. In the GSD system, 83% of the gravity pipeline is 6-inch diameter while 92% of the MWSD gravity pipes are 6-inch diameter.

Table 1: Pipeline Length (feet)

Pipe Diameter	GSD	HMB	MWSD	SAM	Total
6"	117,049	81,725	115,160		313,940
8"	36,002	84,377	3,790		124,177
10"	7,711	3,014	-		10,725
12"	9,177	4,795	5,600		19,584
15"	2,844	-	-		2,844
18"	1,150	11,305	-		12,455
21"	-	60	-		60
Gravity Total	173,933	185,276	124,550	10,032 (21 & 24-inch)	461,389

Table 1: Pipeline Length (feet)					
Pipe Diameter	GSD	HMB	MWSD	SAM	Total
Force Mains	166	Est. 17,400 - 23,200	17, 930	31,152 (8, 12 & 14-inch)	49,082
TOTAL	173,933 (~33 miles)	185,276 (~35 miles)	142,480 (~27 miles)	41,184 (~8 miles)	542,873 (~103 miles)

Numeric information on pipe age was provided by GSD and MWSD. In the GSD service area, approximately 72% of pipes were installed before 1965, according to a pipe database provided by the District. MWSD provided data indicating that about 85% of its 24 miles of sewer mains were constructed in the 1960s. Pipes were installed in the downtown area of HMB beginning in the 1930s, but no further specific information was provided by HMB on pipe age.

4 SANITARY SEWER OVERFLOW RESPONSE AND REPORTING

SAM performs sanitary sewer overflow (SSO) response, record keeping and reporting for all of the SAM member agencies.

4.1 SSO Reporting Requirements

Spill reporting requirements for SAM and its member agencies can be found in several places. First, the NPDES permit establishes spill reporting requirements. (Self-Monitoring Program, Part A, section F.2 requires immediate (24-hour) reports of violations of the WDR prohibitions (could include spills) to the Regional Board. Self-Monitoring Program, Part B.1.E. requires monthly reports of all spills to the Regional Board.) State regulations require reporting of certain spills to the Office of Emergency Services. In a May 1999 memo, the Regional Board clarified the various spill reporting requirements and explained spill response expectations. Finally, in November 2004, the Regional Board issued a Water Code 13267 letter requiring all collection systems, including SAM, to report spills through a web-based electronic reporting system. Since the NPDES permit has not been modified, both the permit and 13267 reporting requirements remain in affect.

In a memo dated May 3, 1999, the Regional Board provided recommended procedures for notification, reporting and cleanup response actions for sewage spills. The memo requires immediate verbal notification to the Regional Board and a written follow up report within 5 working days for all sewage spills exceeding 1,000 gallons. The Office of Emergency Service and the state Department of Fish and Game must be notified in the event of a fish kill. Spill response procedures from the May 1999 memo are described in section 4.2 below.

On November 15, 2004, the Regional Board issued a Water Code 13267 letter requiring all collection systems, including SAM, to report spills through a web-based electronic reporting system beginning December 1, 2004. The Board required 24-hour reporting of spills of 1,000 gallons or more and spills that cause a fish kill or imminently and substantially endanger human health. All other spills of 100 gallons or more are to be reported within 10 days and a tabulation of all spills of any volume must be submitted in annual reports.

In contrast to the 1999 and 2004 letters, SAM's NPDES permit requires reporting of all spills (regardless of volume) to the Regional Board on a monthly basis (Self-Monitoring Program, Part B.1.E.).

4.2 SAM's Spill Response and Reporting Procedures

SAM's spill response procedures are shaped in part by the guidelines delineated in the Regional Board's May 1999 memo. The Board's memo states that warning signs should be posted in the affected area; the signs should remain until County Health or the Regional Board staff authorize their removal or until receiving water sample results indicate that background levels (levels as determined by upstream samples) have been attained. The memo states that all sewage flows should be contained and diverted to the nearest sanitary sewer or removed by vactor. Sewage solids should be raked up and/or vactored and the area should be flushed with clean water. According to the memo, all flush water should be contained and removed and disinfectants should not be used. If the spill exceeds 10,000 gallons, the memo stipulates that sampling for fecal coliform, dissolved oxygen and ammonia should be conducted both upstream and downstream of the point where sewage entered the receiving water. During wet weather flushing and sampling may be omitted if impractical.

SAM staff are currently using a May 2000 spill response plan entitled *Sanitary Sewer Overflow Response Procedures*. The plan includes spill reporting procedures consistent with the permit and state regulation requirements for reporting 1,000 gallon spills and 100 gallon spills to waters to the Regional Board, OES and the San Mateo County Department of Health Services (County Health). In the event of a fish kill, the state Department of Fish and Game must be notified immediately. The plan includes emergency phone numbers, a spill reporting form, a copy of a warning sign, and includes three methods for estimating spill volume. The plan does not include monthly spill reporting required by the permit or the new spill reporting requirements established in the Board's November 2004 13267 letter.

The May 2000 plan describes procedures for relieving the spill, spill containment and recovery, cleanup and disinfection, sign posting and barricading. The plan states that SAM will post the contaminated water warning sign, block the contaminated areas with yellow caution taped barricades and check the signs daily to ensure that they are still in place. The plan calls for County Health to notify SAM when they have released any areas which were posted based on

their sampling and lab testing. The May 200 plan, however does not include procedures for cleaning spills from storm drains.

During the inspection, SAM provided a copy of a *Draft Sewer Overflow Response, Reporting, and Mitigation Plan*, dated September 2004. The September 2004 draft plan is much more comprehensive than the May 2000 version. The new draft plan includes a spill detection and notification flow chart, a chronological listing of field crew response activities and associated flow chart, a response procedures checklist, cleanup and mitigation methods, spill investigation, tracking and documentation procedures, spill volume estimation and spill reporting procedures. The September 2004 draft includes 24-hour reporting procedures consistent with the permit, state regulations and the November 2004 13267 letter. The plan also incorporates the new Regional Board electronic reporting protocol. The inspection revealed two deficiencies in the 2004 draft plan. The draft plan stipulates that spills less than 5 gallons that do not reach a waterbody need not be reported to any agency, but the 13267 letter requires annual reporting of all spills, regardless of volume. Secondly, the draft plan does not include procedures for monthly reporting of all spills as required by the NPDES permit.

The September 2004 draft plan calls for water quality sampling by SAM staff to determine the area impacted by a spill that entered a waterbody. The draft procedures call for sampling (ammonia monitoring) any time 100 gallons of sewage or more enters a creek, stream, lagoon, wetland or impoundment. The draft plan, however, does not call for sampling of spills to the ocean. In addition, the draft plan includes procedures for requesting support from County Health for all major spills that enter a waterbody, or spills of any size that enter the ocean or occur on or near a bathing beach or other area used for water contact activity.

In terms of public notification of spills, the September 2004 draft plan states that warning signs should be posted in the vicinity of an overflow when streams, creeks, rivers, impoundments, wetlands, and/or ocean beaches have been contaminated with sewage. The draft plan goes beyond the May 2000 plan in that it notes that major spills may warrant broader public notice, including notification of local media. In some cases, SAM might involve 'special interest organizations' (such as Surfrider) to assist in notifying segments of the public.

As of the date of the EPA inspection, the September 2004 draft plan had not been adopted as SAM's official procedures. SAM should modify the draft plan to ensure complete consistency with the reporting requirements in the NPDES permit and the Board's 13267 letter and then adopt the updated plan.

4.3 Spill Response and Record Keeping Practices

The inspection included a review of SAM's spill response practices to determine if they were consistent with SAM's response plans and regulatory requirements.

According to SAM staff, they usually learn about spills by calls from the public. An emergency telephone number is posted on the SAM website. During working hours, the phone is answered by SAM staff and during off-hours, calls go to a voice-mail box that will automatically dial the SAM staff person designated as the after-hours on-call responder. SAM staff receiving a call of sewer problems completes the first page of a two-page form titled "Collection Crew Callout/Nuisance Complaint." This form provides a record of the problem complaint and the dispatch of a crew to address the sewer problem.

The SAM spill responders' first effort is to stop the overflow by relieving the problem in the pipe. The crew also attempts to block the wastewater from entering storm drains or creeks. Once this has been done, the crew concentrates on cleanup. A vendor may be called in to provide a large vactor if needed to clean up any wastewater that has pooled. Cleanup consists of removal of debris, followed by flushing with clean water. Disinfectant is not used. The flush water is allowed to enter the storm drain, a practice that is not consistent with the 1999 Regional Board guidance. SAM does not use CCTV to aid in evaluating the cause or corrective action for spills, although the individual member agencies may do so.

The volume of the spill is estimated beginning with the time that the call is received, unless they have other information indicating an earlier start time, such as pooled wastewater, or the time that a pump station was offline. The volume of flush water is not included in this estimate, however. Crews receive training in spill volume estimation.

SAM staff stated that they collaborate with County Health in determining when to post a spill. Responsibility for actual placement and removal of the signs rests with SAM. They do not post for spills that occur at the Montara pump station because they believe there is no use of this area by the public. They also do not post if the area is already posted, for instance, where creeks are already posted due to stormwater runoff or animal contamination. In addition, if SAM cleans up a spill that doesn't enter a waterbody, they generally do not post the area. Tests of water quality by County Health determine when signs can be removed. SAM does not perform any tests. Posted beaches are identified on a website maintained by County Health.

SAM maintains records of all spills on the second page of the callout form in the section titled "Sanitary Sewer Overflow (SSO) Report Form." The response crew completes the SSO report form after returning to the SAM office. These SSO report forms include information on spill location; date, time and duration of the spill; response date and time; spill volume; receiving waters; spill cause; and spill response and cleanup method. The form also has a section to indicate if and when notifications are made to County Health, the Regional Board or OES. If the staff determines that a spill is 'reportable' (see below), they will also complete a standard spill report form on SAM's e-mail system. Spill data from the SSO report forms is periodically entered into SAM's SSO database.

SAM spill response crews do not record spill information while in the field responding to a spill. Many collection systems require spill response crews to complete a spill record form while at the scene of the spill. This allows for the recording of information at the scene where field observations can be made and while the incident is fresh in the minds of the response crew.

Since December 2004, SAM has been reporting spills to the Regional Board's SSO database in accordance with the Board's November 2004 13267 letter (24-hour reporting of 1,000 gallon spills and 10-day reporting of spills between 100 and 1,000 gallons). Prior to December 2004, SAM was reporting spills to the Regional Board in accordance with SAM's May 2000 SSO Response Procedures and the Board's 1999 guidance. At no time, during the period reviewed in the inspection, has SAM reported all spills (any volume) in its monthly reports to the Board as required by SAM's NPDES permit. SAM is required to conform with the spill reporting requirements established in both the 13267 letter and the NPDES permit.

5 SANITARY SEWER OVERFLOWS

During the inspection, Mr. Foley provided EPA with a list of sewer overflows from the SAM and member agency collection systems. The list includes 174 overflows that occurred from January 2000 through December 2004. In February 2006, SAM provided a list of 23 spills recorded during 2005. All of these spills are listed in Attachment 2.

For the 2000 - 2004 spill list provided to EPA, Mr. Foley explained that he made his best effort to include only the spills for which SAM or its member agencies are responsible. In other words, he excluded spills where there was clear indication that the spill was on private property and caused by a problem in the private property owner's lateral or plumbing. According to Mr. Foley, despite these efforts, because SAM spill responders did not always record the spill source mainline vs private), the spill lists provided to EPA may still include some private property spills. In addition, three spills, clearly recorded as private lateral spills, were intentionally left in the list provided to the EPA inspectors because they had been previously included in SAM's spill reports to the Regional Board or NOAA.[1] SAM's current spill response procedures call for recording who is responsible for the spill (public system or private property owner) and SAM staff are now keeping accurate records of responsible party.

Sections 5.1 through 5.5 below address spills between January 2000 and December 2004. Section 5.6 includes an analysis of spills between January 2005 and December 2005.

5.1 Spill Statistics, 2000 to 2004

The number of spills each year is summarized in Table 2. There was a general increase in the numbers of spills from 2000 through 2003. The total number of spills for each agency decreased

[1] The private lateral spills occurred on 1/31/2000, 2/28/2002, and 3/18/2002, all in GSD.

in 2004. Table 3 lists the source or device from which the spills occurred. The majority of the reported spills are overflows from manholes on the gravity sewer mains.

Table 2: Spills by Year

Year	GSD	HMB	MWSD	SAM	Grand Total
2000	9	8	13	2	32
2001	14	13	4	2	33
2002	12	17	11	0	40
2003	14	9	18	3	44
2004	8	7	8	2	25
TOTAL	57	54	54	9	174

Table 3: Spills by Device, January 1, 2000 to December 31, 2004

Device	GSD	HMB	MWSD	SAM	Grand Total
Force Main	1	1		1	3
Lateral	3				3
Gravity Main	35	41	37		113
Outfall		1			1
Pump Station	1	3	7	8	19
Unknown	10				10
Blank	7	8	10		25
Grand Total	57	54	54	9	174

Of the 174 spills, 52 (30%) were identified by SAM as having entered storm drains or waterbodies. Of these, 19 spills (36%) were equal to or greater than 1,000 gallons in volume. An additional 92 spills (53%) were indicated as going onto the ground, and for 30 spills (17%) no information on the destination of the spill was provided. Table 4 shows the number of spills less than or equal to 1,000 gallons, the number greater than 1,000 gallons, and the number of spills that entered storm drains or waterbodies for SAM and each member agency. SAM did not report the volume for 16 spills.

Table 4: Spill Statistics for Each Agency

	GSD	HMB	SAM	MWSD	Total
No. spills < or = 1,000 gal	49	38	0	44	131
No. spills > 1,000 gal	4	12	5	6	27
No. spills to storm drain or waterbody	10	23	9	10	52

SAM reported six spills that were at least 10,000 gallons in volume, and another two spills exceeded 9,000 gallons. Five of the spills of 10,000 gallons or more were associated with pump stations, and two of the five occurred as a result of lack of capacity at the Portola and Montara pump stations during the 12/27/2004 rain event. The other three spills associated with pump stations occurred due to equipment failures on 2/26/2002 and 2/15/2003 (Charthouse pump station) and 5/7/2000 (Montara pump station). The remaining spill of 10,000 gallons or more was due to a force main air release valve failure on 12/24/2003. The spills that exceeded 9,000 gallons were due to grease blockages at 445 Oak Avenue in Half Moon Bay on 4/14/2002 and 6/1/2003. All of these spills entered the ocean and/or creeks.

5.2 Spill Causes (2000 to 2004)

The causes of sewage spills reported by SAM are summarized in Table 5. The most common cause of sewage spills is mainline blockages, by roots, grease or debris, which are responsible for 74% of the spills where a cause is recorded. In the Granada and Montara systems, root blockages are the most common cause of overflows. Both Granada and Montara service areas are heavily wooded. Montara has one to two miles of sewer mains in easements. Adding to the risk of blockage spills, the Granada and Montara systems both have a high percentage of small (6 inch) diameter sewer pipes. In contrast, Half Moon Bay had only one spill reported as being caused solely by root blockage. In Half Moon Bay, grease blockages are the most common cause of spills. HMB staff explained that most grease blockage spills have been in residential areas near high density housing such as apartment buildings. The HMB service area is generally flat, which may contribute to the risk of grease accumulation. The nine spills from the SAM IPS were caused by equipment failure (pump station or force main) or insufficient capacity. These spills are more fully described below in the pump station and capacity sections of the report.

Table 5: Causes of Overflows, January 1, 2000 to December 31, 2004

Cause	GSD	HMB	MWSD	SAM	Grand Total
Unknown	16	19	14		49
Root Blockage	20	1	15		36
Grease Blockage	4	17	8		29
Debris Blockage	7	3	5		15
Equipment Failure	1	4	7	3	15
Multiple Causes*	2	6	4		12
Pipe Break	3	3			6
Capacity		1	1	6	8
Private Lateral Problem	3				3
Construction	1				1
Grand Total	57	54	54	9	174

* "Multiple causes" typically consists of a blockage caused by grease and roots.

5.3 Spills to Waters (2000 to 2004)

From 2000 to 2004, at least 14 spills entered the Monterey Bay National Marine Sanctuary. These are the spills that SAM identified as flowing directly to the Pacific Ocean. However, wastewater that enters storm drains and creeks in SAM's service area will reach the ocean. Therefore it is possible that any of the 52 spills to storm drains and waterbodies could have entered the Marine Sanctuary. Together, these spills to waters and storm drains amounted to a minimum of 417,800 gallons of wastewater (several spills had no volume estimate). Warning signs were posted for only 14 of the 52 spills to waters and storm drains. Warning signs were not posted for some of the spills that flowed directly to the ocean and for some large spills to creeks or storm drains that could have impacted beaches or ocean waters. The failure to post warning signs for spills to the ocean and significant spills to creeks and storm drains leading to beaches appears to conflict with the County Health Department policy to post warning signs anytime that waters are contaminated by known sewer spills.[2]

5.4 Repeat Spills (2000 to 2004)

SAM and the member agencies have experienced a number of repeat spills, i.e., spills that occur in the same location on different dates. For example, during the period from January 2000 through December 31, 2004, three spills occurred at 1 Terrace Avenue in Moss Beach (9/16/2000, 8/13/2002, 8/20/2002). One of these was identified as being caused by grease, while the causes of the other two were not identified. Each of these overflows was between 30 to 50 gallons. In Montara, there were two grease blockage spills at 1191 Cedar Street (4/8/2000 - 50 gallons; 8/13/2003 - 500 gallons). Roots caused repeat spills (3/25/2002 - 250 gallons; 3/1/2004 - 50 gallons) at 11th and Main Street within MWSD. Roots caused repeat spills (1/13/2001 - 800 gallons; 9/22/2003 - 15 gallons) at 466 El Granada Blvd within GSD. Spills occurred at the Charthouse pump station on 2/26/2002 and 2/15/2003, reportedly due to equipment failures. Six spills occurred due to lack of capacity or equipment failure at the Montara pump station (2/13/2000, 5/7/2000, 12/1/2001, 12/2/2001, 12/29/2003, 12/27/2004). This is only a partial list of repeat spills within the SAM service area.

Repeat spills at the same location can be an indicator of maintenance deficiencies including incomplete cleaning of the initial pipe blockage, failure to repair a defective pipe or pump equipment. The system also clearly has capacity shortfalls in certain well-known locations. SAM and its member agencies should take aggressive steps to eliminate repeat spills.

5.5 Comparisons of Spill Rates (2000 to 2004)

Table 6 provides a comparison of spill rates in the SAM service area. The spill rate is a normalized measure of spill frequency that allows for comparison of collection systems of

[2] http://www.co.sanmateo.ca.us/smc/department/home/0,,1954_191102_187763,00.html

different sizes. The spill rate also provides a good overall indicator of system performance as affected by system capacity, management, operations and maintenance practices. A well managed and maintained system with adequate capacity tends to have a lower spill rate than a poorly managed system or a system with inadequate capacity. Taken as a single system, the SAM service area has an average spill rate of 32 spills per 100 miles of collection system per year. Spill rates for the member agencies range from 30 to 40 spills per 100 miles of collection system per year. These spill rates were calculated excluding the three private lateral spills identified by SAM, and the 'outfall' spill (due to a relief valve failure on the outfall force main).

A benchmark study of more than 80 municipal sewage collection systems in southern California conducted by Ken Greenberg of EPA Region 9 show a median spill rate of 3 spills per 100 miles of collection system per year (SSOs/100 mi./yr.) and an average spill rate of 5 SSOs/100 mi./yr. Thus, the rates experienced by SAM and the member agencies are well above the southern California benchmark level.

TABLE 6: Comparison of Spill Rates (2000 to 2004)

System	Pipe Length (miles)	Number of SSOs	Spill Rate (SSO/100 miles/year)
GSD	33	54 (excludes 3 lateral spills)	32.7
HMB	38	53 (excludes 1 outfall spill)	27.9
MWSD	27	54	40
SAM	8	9	22.5
TOTAL System	106	170	32.1

Note: Pipe length includes gravity mains and force mains but excludes laterals. Number of spills includes all types of SSOs for which the system is responsible regardless of volume or destination.

5.6 Year 2005 Spills

In February 2006, SAM provided a list of spills in the SAM service area between January 1, 2005 and December 31, 2005. During this time period, there were a total of 23 spills, with 8 of these spills being in the GSD system, 5 in HMB and 10 in the MWSD. There were no spills in 2005 from the SAM IPS or pump stations. This data reveals a continuing downward trend in the annual number of spills. The previous three years had 40, 44 and 25 spills in 2002, 2003 and 2004 respectively. In 2005, there was a marked decrease in spill volume compared to previous years. SAM reported a total spill volume of 3,562 gallons in 2005 compared to about 108,000 gallons spilled in both 2003 and 2004. In 2005, only 4 spills were equal to or greater than 100

gallons and each of these was reported to the Regional Board's SSO database as required by the Board's 13267 letter.[3] The spill volumes were less in 2005 than previous years because there were no capacity or pump station related spills. The system successfully conveyed all wastewater without a capacity related spill during rainy weather in early 2005 and through some heavy storms in December 2005. Only two spills in 2005 reached surface waters and both of these were to the golf course lake in Ocean Colony in the HMB system.[4]

In other respects, spills in 2005 showed a similar pattern to previous years. Root blockages (10 spills) and grease blockages (5 spills) were the leading causes of spills. With 10 spills in 2005, MWSD had both the largest number of spills and, as in previous years, the highest spill rate (37 spills/100 miles of pipe/year) among the SAM member agencies.

6 PUMP STATIONS AND FORCE MAINS

SAM and HMB each own three pump stations, GSD owns one, and MWSD owns 13 mainline pump stations. In addition, MWSD owns 23 point-of-use pumps located at private residences. The largest pump stations are located along the Intertie Pipeline System (IPS) used to convey sewage from the Montara WSD and Granada SD to the sewage treatment plant. (See Attachment 4, map of IPS) MWSD's Chart House pump station and SAM's Montara pump stations collect most of the wastewater from Montara and direct it into the northern end of the IPS. MWSD's Vallemar Pump Station collects much of the Moss Beach wastewater and sends it into the IPS. Wastewater from the Princeton Harbor area is directed through SAM's Princeton Pump Station to the IPS. In El Granada, all of the IPS flow passes through the Portola Pump Station, the largest in the SAM service area, where it is pumped through the final force main section on the IPS and into the gravity flow section of the IPS leading to the treatment plant. Half Moon Bay wastewater is introduced into the final gravity section of the IPS just upstream of the sewage treatment plant.

SAM maintenance mechanics perform routine maintenance for all 20 pump stations in the service area. SAM also hires contractors to test generators annually under load and perform pump tests. All of the maintenance work performed on member agency pump stations is done by SAM on a contractual arrangement with the member agencies. Each agency is responsible for capital improvements on its own stations. A list of the stations and relevant information is provided as Attachment 3.

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[3] 900 gallon spill in MWSD on February 9, 2005; 1,000 gallon spill in MWSD on March 13, 2005; 100 gallon spill in GSD on May 18, 2005; and 750 gallon spill in HMB on September 29, 2005.

[4] A 750 gallon spill in HMB on September 29, 2005 to the golf course lake and an 80 gallon spill on December 24, 2005 in HMB to a storm drain leading to the golf course lake.

Many of the pump stations have experience sewage spills related to electrical and control system problems or insufficient pump or force main capacity. In some instances, pump station alarms failed to alert SAM to the spills. A summary of pump station spills is provided in Table 7.

Table 7: Spills at Pump Stations

Station	Owner	SSO Dates	Volume	Cause	Alarm Failure?
Airport Lift Station	MWSD	10/9/2004	400	suspect low voltage	Yes
Chart House Lift Station	MWSD	2/20/2002	100,000	motor starters tripped	Yes
		2/15/2003	10,000 to 15,000	control failure	Yes
Date Harte Lift Station	MWSD	12/27/2004	2,410	lack of capacity	NA
Montara Pump Station	SAM	2/13/2000	Unknown	lack of capacity	NA
		5/5/2000	116,000	pump run relay failure/alarm failure	Yes
		12/1/2001	Unknown	lack of capacity	NA
		12/2/2001	Unknown	lack of capacity	NA
		12/29/2003	63,000	lack of capacity	NA
		12/27/2004	83,970	lack of capacity	NA
Ocean Colony Lift Station	HMB	3/4/2001	3,700	pumps tripped	Yes
		12/14/2002	1,000 to 10,000	power failure/ generator failure	Unknown
		11/3/2004	9,773	UPS failed	Yes
Portola Pump Station	SAM	12/19/2002	5,000	controller failure	Unknown
		12/27/2004	19,020	lack of capacity	NA
Princeton Pump Station	SAM	2/27/2003	5,000	failed start/stop switch	Unknown
Seal Cove 3 Lift Station	MWSD	2/26/2000	3,000	level control failure	Unknown
		3/1/2000	300	level control failure	Unknown
Seal Cove 4 Lift Station	MWSD	12/16/2002	100	power failure/ controller failure	Unknown

Findings from the EPA inspection team visits to 10 pump stations are summarized below.

Montara PS, SAM (Photos 1 - 6) - The Montara Pump Station, owned by SAM, is located on the bluffs above the ocean in Montara. This station experienced six overflows during the period from January 2000 through December 2004. Spills on February 13, 2000; December 1 and 2, 2001; December 29, 2003 and December 27, 2004 were due to insufficient capacity during heavy rains. The May 5, 2000 spill of 116,000 gallons was caused by a pump run relay failure accompanied by a failure of the alarm dialer. All of these Montara PS spills flowed into the ocean. SAM has addressed the alarm failure problem by installing a redundant alarm and testing it weekly. A high level alarm is transmitted both by autodialer and by radio directly to the SCADA system.

In late 2002, SAM converted an old sewage treatment tank adjacent to the Montara PS to a 430,000 gallon off-line storage tank (Photo 1) for excess wet weather flow. This tank was in operation for most of the 2002/03 wet weather season and all of the 2003/04 season. The purpose of the tank is to provide off-line storage for peak wet weather flows that exceed the capacity of

the Portola Pump Station pumps or the intertie pipeline force main downstream of the Portola PS. During wet weather, the pumps at Montara PS are set on automatic controls such that as the wet well fills at the Portola PS rises the pumps at Montara will slow down, and as the Portola PS wet well level falls the Montara pumps will speed up. In this wet weather operating mode, as the pumping speed at Montara PS is reduced, incoming wastewater can exceed the capacity of the Montara PS wet well. At this point, rather than pumping the excess wastewater down the IPS to the over-capacity Portola PS, wastewater coming into the Montara PS is diverted to the off-line storage tank. When the Montara storage tank becomes full, an overflow will occur from a maintenance hole on the diversion pipe.

The spill on December 29, 2003 illustrates how overflows occur at the Montara PS in the wet weather operating mode. (Because the storage tank control system was new, on December 29, 2003 SAM operated the Montara/Portola pump speed interplay in a manual mode. The resulting operation, however, was similar to the automatic mode.) During a heavy rain storm on December 29, 2003, wastewater exceeded the capacity of the Portola PS. At this point, SAM operators reduced output of the Montara PS pumps. The Montara PS overflow storage tank filled and overflowed from the diversion pipe. The overflow ran across the ground, down a gully and into the ocean.

SAM representatives explained that the wet weather operating mode is established to preferentially overflow at the Montara PS rather than at or near the Portola PS in El Granada. This is how the system worked on December 29, 2003 when Montara PS overflowed but there was no spill from the Portola PS. But even with the Montara/Portola wet weather operating scheme in use, SAM was not able to prevent the Portola PS from being overwhelmed by the storm flows on December 27, 2004. In this event overflows occurred both from the Montara PS storage tank and from gravity pipes flowing into the Portola PS. A more complete description of the Portola PS overflows is provided below.

There were several wet weather capacity related spills at the Montara PS prior to completion of the offline storage tank including the spills on February 13, 2000 and December 1 and 2, 2001.

The inspection team observed that the Montara PS wet well appears to have a thick grease layer. MWSD and SAM representatives explained that wet wells are vactor cleaned as needed by a SAM contractor.

Princeton PS, SAM (Photos 7 - 11) - Between January 2000 and December 2004, there was one overflow from the Princeton PS, on February 27, 2003. Corrosion and short circuiting of a pump start/stop switch caused a 5,000 gallon spill that entered the harbor at West Point Avenue. The alarm system also failed and SAM estimates that the spill had gone on for 10 hours before it was discovered. The station has both an autodialer and radio alarms. SAM representatives were not able to explain why the alarm system failed. It is not clear if these alarms were installed, or fully operational, at the time of the spill.

A July 7, 2005 letter from SAM states that responding personnel restarted the pumps and that the failed start/stop switch was replaced. SAM's long-term plan is to continue annual electrical inspections, including start/stop switches.

The inspection team observed that the wet well appears to have a thick grease layer.

Portola PS, SAM (Photos 12 - 15) - Between January 2000 and December 2004 the Portola PS experienced two overflows. A spill of 5,000 gallons on December 19, 2002 was caused by problems in the computer program for the pump controller system. The station was operating on emergency generator power at the time of the controller failure. The staff manually placed the diversion tank at the Montara pump station online to address the problem while the controller was reprogrammed. On December 27, 2004 a rain event caused a spill estimated at 19,024 gallons. Despite use of the Montara PS off-line storage tank, incoming wastewater overwhelmed the capacity of the Portola PS. Incoming wastewater backed up from the Portola PS wet well into the gravity pipes feeding into the Portola PS causing overflows from the two lowest upstream manholes. One overflow was from the manhole at the RV park adjacent to the Surfers' Beach and the second overflow was from a manhole near the Miramar Beach Inn at Marada Road and Magellan. Both of these overflows flowed to the beach and into the ocean.

The Intertie Pipeline System Capacity Evaluation, Phase II, Final Report (dated September 18, 1998, Carollo Engineers) found that the Portola pump station is a bottleneck because the IPS downstream of this station has a rated capacity of only 4 MGD. The alternatives to correct this situation are to either install a storage tank at or near the station, or to enlarge the IPS downstream of the Portola station. The report also recommends reductions in rainfall dependent inflow and infiltration (RD I/I) in the member agency collection systems. SAM is considering improvements to eliminate the wet weather flow bottleneck at the Portola PS. The proposed improvements are addressed in the Capacity section below.

Chart House PS, MWSD (Photos 16 - 17) - Between January 2000 and December 2004, the Chart House PS had overflows on February 20, 2002 and February 15, 2003. Both of the Chart House PS spills flowed to a gully or creek tributary to the Pacific Ocean at Montara State Beach. The 2002 spill, with a reported volume of 100,000 gallons, was caused when "both motor starters tripped." According to SAM's pump station operation manual, alarms are transmitted to a service (Half Moon Bay Alarm) via auto-dialer. A mis-communication during the 2002 spill resulted in staff who responded to the alarm going to the wrong pump station; they found no spill and assumed it was a false alarm. The Chart House PS spill was not discovered until the next day during a routine maintenance visit to the station. The duration of this overflow was 15.75 hours. The 2003 spill, estimated at 10,000 to 15,000 gallons, occurred as a result of a controller failure and an alarm failure caused by a housing nick in a new PG&E supply cable. The spill flowed into a gully next to the station. SAM's written reports on the Chart House PS spills do not indicate how far these spills flowed or whether they actually entered the ocean. During the inspection, however, SAM staff said they didn't think either spill reached the ocean. Since the

2003 spill, the PG&E power supply cables have been replaced, and separate backup power to the alarm and controller has been installed.

The City plans to remove the dry pit pumps and install submersible pumps to reduce the possibility of flooding and eliminate the need for confined space entry to work on the electrical controls at this location.

Vallemar PS, MWSD (Photo 18) - This station receives flow from 7 smaller stations in the MWSD and pumps the wastewater into the inter-tie pipeline. Alarms for the Vallemar PS go to Half Moon Bay Alarm service by auto-dialer, and to the SCADA system. The SCADA system automatically calls the operator on call. According to SAM's pump station operation manual, as a safeguard in the event of pump station failure, overflows from Vallemar PS flow by gravity to the Niagara PS. SAM plans to install a third, smaller, pump at the Vallemar PS to handle dry weather flows and eliminate flow spikes to the wastewater treatment plant caused by the large pumps at Vallemar.

Seal Cove 4, MWSD (Photo 20) - Between January 2000 and December 2004, the Seal Cove 4 PS experienced one overflow, on December 16, 2002. The volume of this overflow was estimated to be about 100 gallons, and the cause was a failure of the pump controller following a power outage. The wastewater overflowed into a house.

Seal Cove 3, MWSD (Photo 22) - Between January 2000 and December 2004, the Seal Cove 3 PS experienced two overflows. On February 26, 2000, the air compressor for the wet well level control system failed resulting in a reported 3,000 gallon spill. The bubbler was replaced, but the new one failed and caused a 300 gallon spill on March 1, 2000. The bubbler compressor was replaced again and no further spills have occurred since. Both spills were reported to have flowed to the Pacific Ocean in the Fitzgerald Marine Reserve off Moss Beach.

A 7/7/05 letter from SAM states that "MWSD made $80,000 in control system upgrades at Seal Cove 4, including radio communications, variable frequency drives and control enclosures. Seal Cove #3 now communicates with Seal Cove #4. If Seal Cove #4 is not in a ready state, Seal Cove #3 will not pump to it."

Airport PS, MWSD (Photos 23 - 26) - The Airport PS experienced one overflow between January 2000 and December 2004. On October 9, 2004 the pump station failed resulting in a reported 400 gallon spill. SAM suspects that the failure was caused by low voltage from PG&E causing the pumps to trip off. Alarms from the Airport pump station go to the Half Moon Bay Alarm service by auto-dialer. The station did not send an alarm, however, because the autodialer's backup battery failed and the station does not have an uninterruptible power supply (UPS). Although the station has a standby generator onsite, it did not function because the breaker was tripped. After SAM learned of the problem, it took three hours to stop the overflow. When the Airport PS failed, the wet well filled, wastewater backed into the tributary sewer main

and overflowed at an upstream manhole located in the nearby mobile home park. The EPA inspection team visited the overflow site, and found that spills from the manholes in Photo 25 would flow to the concrete-lined ditch shown in Photo 26. A topographic map shows that this ditch leads towards a marsh and Pillar Point Harbor. The ditch was posted with a warning sign as a result of the 10/9/04 spill.

It is possible that the overflow could have been controlled more quickly rather than continuing for three hours after SAM learned of it. Use of a vacuum truck to capture the sewage prior to the overflow point in the mobile home park could have reduced the size of the spill.

According to SAM's pump station operation manual, this station has three hours of storage time during normal dry weather before an overflow would occur. However, it is necessary for operators to receive alarms from the station in order to respond quickly enough to prevent overflows. Therefore, it is recommended that a UPS be installed for the autodialer.

Ocean Colony PS, HMB (Photos 29 - 30) - The Ocean Colony pump station experienced three overflows between January 2000 and December 2004. On March 4, 2001, the pumps tripped off due to an electrical overload resulting in a 3,700 gallon spill to the ocean. The alarm company did not notify SAM.

A power outage on December 14, 2002 resulted in a spill from the Ocean Colony PS, with an estimated volume of 1,000 to 10,000 gallons, that flowed to the nearby golf course pond and on to the ocean. The onsite emergency generator failed to operate during the power outage.

The third spill occurred on November 3, 2004. SAM and HMB representatives suspect that the station failed when the Uninterruptible Power Supply failed. The pump station alarm system failed and the spill was discovered by chance by a system employee who happened to be visiting the nearby Ocean Colony facilities. The spill, with an estimated volume of 9,733 gallons, entered the golf course pond, which has an outlet to the ocean. Alarms from this station are supposed to go to Half Moon Bay Alarm by auto-dialer, and to SCADA by radio. The station was upgraded in late 2003 with installation of new variable frequency drives, an auto switch for the generator, level controls, and a UPS. The spill report for this event states that the UPS failed. There are plans to replace the station's force main.

San Pablo PS, GSD (Photos 33 - 37) - This station, located in the Miramar section of Half Moon Bay, is also equipped with alarms that go by auto-dialer to the Half Moon Bay Alarm service. The wet well was examined and found to be fairly clean. The station's two pumps are equipped with stirring devices so that less wet well cleaning is needed. GSD has plans to reroute the force main for this PS so it connects to the Intertie Pipeline downstream of the Portola PS thus allowing for abandonment of the precarious force main crossing of Media Creek near the beach.

General Comments on Pump Stations - SAM depends on automatic dialers to notify of alarms at most of the pump stations. Autodialers at all pump stations should have a true Uninterruptible Power Supply (UPS) rather than just a battery. Battery back-up units switch to the battery in the event that the power level drops below a usable level for the computer in both brownout and blackout situations. A true UPS is always delivering filtered power from a 'reservoir' of clean power, so there is no switching that occurs during low power or blackout conditions.

Intertie Pipeline Force Main, SAM - The IPS includes about 5.8 miles of force main (including force mains from the associated pump stations). The IPS came on-line in 1983. The IPS force main is made of tar coated steel pipe. It has not been inspected other than at the pipe ends that go into junction structures. When the junction structures were replaced about 2 - 3 years ago, the ends of the force main looked good. SAM has a capital project to conduct an intertie structural integrity analysis and propose an appropriate maintenance and improvement schedule. This project is ongoing.

On December 24, 2003, bolts holding an air relief valve in place on the IPS force main failed, and the valve fell down into the force main. This resulted in a spill of 10,000 gallons. SAM's system includes about 30 such valves.

The IPS is the only means of conveying wastewater to the SAM wastewater treatment plant. However, SAM's Draft *Sewer Overflow Response, Reporting and Mitigation Plan* (September 2004) includes no contingency provisions in the event of a failure along the IPS. This plan mentions monthly inspections of the force mains and intertie pipeline but does not provide details of how such inspections would be conducted.

Continuous operation of the IPS is crucial to the save conveyance of wastewater to the SAM WWTP. Unlike pump stations, there is no redundancy or failure alarms for the IPS. Because of the large size of the IPS pipeline and the fact that it carries all flow in the service area, failure of the IPS could result in a major spill that could be difficult to repair. SAM should complete condition inspections of the gravity and force main sections of the IPS and make necessary repairs or replacements. SAM should implement a regular program to maintain and replace air release valves on the force main sections of the IPS. SAM should develop an emergency contingency plan for responding to a failure of the IPS. As part of the contingency plan, SAM should consider whether to install parallel force mains that could serve as a backup in the event of a catastrophic failure of one of the force main sections. (Carollo Engineers considered options for construction of a parallel force main downstream of the Portola Pump Station to relieve the capacity bottleneck in this section of the IPS.)

7 COLLECTION SYSTEM MAINTENANCE

Each of the member agencies in the SAM system is responsible for cleaning and maintaining its own system. The agencies either contract with SAM for sewer cleaning or hire outside contractors. None of the member agencies has staff or equipment for conducting their own sewer cleaning. Each of the member agencies establish a sewer cleaning schedule for SAM which consists of routine (production) cleaning and/or hot spot cleaning based on the history of SSOs and previous cleaning needs. SAM also provides spill response and other problem call-outs on a contractual basis for the member agencies. Because there is only one SAM sewer cleaning crew, production cleaning can be interrupted by call-outs. SAM receives about 10 to 20 call-outs per month. SAM should evaluate whether its staffing level is sufficient to meet the production and call-out cleaning demands of the member agencies.

At the time of the inspection, SAM indicated that it does not provide emergency or spot repair services for the member agencies. Instead, this work is arranged by the member agencies with outside contractors. In correspondence dated February 10, 2006, however, Sam explained that "the member agencies have given SAM greater authority to implement repairs to greatly reduce response times."

Equipment owned by SAM includes a 700-gallon hydroflusher truck that includes a 100-gallon vactor; power snake for laterals; 500-gallon vactor trailer; 2-inch and 4-inch trash pumps; and 700 feet of discharge hose. At the time of the inspection, SAM did not have CCTV equipment for sewer pipe inspections, so all CCTV work was arranged by the individual member agencies with outside contractors. But, SAM obtained a new hydro flusher truck equipped with CCTV and DVD recording equipment. This new equipment should enable SAM to more quickly identify sewer pipe defects that may be leading to sewage spills. The CCTV equipment can also be used to conduct quality assurance (QA) checks on sewer cleaning operations. Other systems evaluated by EPA have found CCTV QA checks to be an effective means of improving the quality of pipeline cleaning.

Neither SAM or the member agencies use a computerized maintenance management system or GIS tools to manage the sewer cleaning, maintenance and repair functions. SAM representatives explained that the member agencies use SAM to varying degrees with the City of Half Moon Bay being the biggest user of SAM's cleaning services. Because cleaning schedules are dictated by member agencies, there is not a consistent approach across the service area and no system-wide prioritization of sewer cleaning needs. Each agency's sewer cleaning and maintenance practices are described below.

7.1 Montara Water and Sanitary District

Prior to 2002, MWSD contracted with SAM for annual cleaning of its entire system. The MWSD representative stated "SAM cleaning was always falling behind" on that schedule. At the time of the inspection, Montara was near completion of a three-year, system-wide cleaning

and CCTV program implemented by an outside contractor. Since the inspection, SAM reported that MWSD had renewed it's contract with SAM for "a one-year program to clean all sewer lines" (February 10, 2006 letter from SAM). It is not clear if this means that MWSD will have SAM clean the entire MWSD system on a annual basis.

Aside from the production cleaning described above, MWSD has identified 22 hot spots for cleaning by SAM with 20 of the hot spots on a semiannual schedule and 2 being cleaned every 4 months. From June 2004 through May 2005, SAM cleaned 1.9 miles of sewer pipe in the MWSD system (7% of its system, including repeat cleaning).[5] Despite having the highest spill rates in the SAM service area, MWSD representatives explained that they do not believe additional cleaning would be cost effective. MWSD has retained the services of a contractor to do chemical root treatment.

MWSD has not completed any spot or emergency sewer repairs in the lest few years. Instead, repair needs are placed in the Capital Improvement Program (CIP) which has a longer planning horizon than is typical for spot repairs.

In contrast to MWSD, other systems evaluated by EPA have successfully reduced spills with a combination of increased hot-spot cleaning and timely spot repairs of defective pipes.

7.2 Granada Sanitary District

The GSD contracts with SAM to clean its entire system on a three-year cycle, so one-third of the system is cleaned annually. The District also contracts with SAM for semiannual cleaning of 11 hot spots. From June 2004 through May 2005, SAM cleaned 10.7 miles of sewer pipe in the GSD system (32% of its system, including repeat cleaning).[6]

7.3 City of Half Moon Bay

The City of Half Moon Bay contracts with SAM for annual production cleaning of its entire system. In addition, the City contracts with SAM for cleaning 44 hot spots with 19 on a semiannual schedule and 25 being cleaned every 2 months. Several of the hot spots on the two-month cleaning schedule are known problem areas for grease accumulation. From June 2004 through May 2005, SAM cleaned 49 miles of sewer pipe in the HMB system (129% of its system, including repeat cleaning).[7]

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[5] July 7, 2005 letter from John Foley, SAM to Ken Greenberg, EPA.

[6] July 7, 2005 letter from John Foley, SAM to Ken Greenberg, EPA.

[7] July 7, 2005 letter from John Foley, SAM to Ken Greenberg, EPA.

8 GREASE CONTROL

Food related grease is a common cause of blockages in sewage collection systems. Grease is introduced to sewers from residents, restaurants and other food processing facilities. Grease can accumulate more rapidly on roots growing into sewer pipes or at other sewer pipe defects, such as pipe sags or offset joints. In the SAM service area, for spills where they were able to determine the cause of the spill, grease was identified by SAM as the primary cause of 24% of spills and a contributing cause in 34% of all spills.[8] Grease may also be a factor in some of the 49 spills whose cause was identified as unknown. Grease blockage spills are most common in the City of Half Moon Bay system where between 47% and 64% of the spills were caused by grease accumulation in the sewer mains.[9]

In 1994, SAM developed a sewer use ordinance (SUO) aimed at controlling grease discharges to the sewer system. Since then, each member agency has adopted the same ordinance. These SUOs require each restaurant (exceptions noted below) to have a grease control device, and prohibits the use of garbage grinders. The SUOs include provisions for inspections and enforcement actions.

SAM is responsible for implementing the source control program for all of the member agencies. The program is funded by user permit fees. SAM has issued permits to 52 restaurants and six food processors (including grocery stores). Each of these food service establishments (FSEs) is required to have grease control equipment such as a trap or interceptor. Three car washes also have grease control devices. Facilities that do little food preparation are not permitted. Examples include coffee or sandwich shops such as Starbucks or Subway. Restaurants in the Harbor area are also subject to SAM's program. Unrelated to food origin grease discharges, there are several other types of facilities permitted under the SAM source control program including automotive facilities (17), photo developers (4), dry cleaners (3), septic dump stations (2), agricultural (2), groundwater remediation (1), and a rental hall. A total of just over 100 sewer use permits have been issued.

Each of the 52 permitted restaurants have some type of grease control device. Ten facilities have large in-ground interceptors. The remainder have smaller control units, such as grease traps, that are typically located in the kitchen. SAM's policy has been to base grease trap or interceptor sizing on the Uniform Plumbing Code. Approval of the grease trap or interceptor design in new or remodeled restaurants is the responsibility of City or County building inspectors. SAM representatives informally coordinate with the building inspectors to keep track of new restaurant

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[8] 29 grease blockage spills out of 122 total spills with designated cause. Additional 12 spills with "multiple" causes, usually including grease.

[9] Half Moon Bay system had 17 spills designated as grease blockage and an additional 6 with "multiple causes" out of a total of 36 spills with designated causes.

plans. SAM representatives explained that the SUO oil and grease (O&G) limitation of 200 mg/L may also be used to aid in determining whether a grease trap is sized properly, although routine sampling is not done.

For restaurants and other food processors, the permit specifies how often the unit must be cleaned. The required cleaning frequency is determined by SAM based on factors such as the flow rate, seasonal business trends, experience, reports from the collection maintenance staff, and consultation with the grease hauler. SAM requires some small grease traps to be cleaned three times per week, whereas a large interceptor may only need to be cleaned twice per year. FSEs are required to keep a log identifying when its grease control unit was cleaned. Typically, restaurant staff clean out the small grease trap units located in kitchens, placing the waste in bins or barrels for later pickup by the grease hauler. The SUO contains no specific interceptor maintenance requirements, such as the 25% accumulation rule, but only specifies that the interceptor must be maintained in efficient operating condition by periodic removal of the accumulated grease (Article IV, Section 4.3(f)). The SUO does not require kitchen best management practices (BMPs).

SAM schedules inspections of permitted facilities based on the amount of daily water usage. Every facility is scheduled for inspection at least once per year. For every 1,000 gallons above the initial 1,000 gallons, another annual inspection is added to the schedule. The largest water user is scheduled for eight inspections per year.

A review of SAM's inspection records revealed that SAM is not conducting annual inspections of every permitted food service establishment (FSE). The percentage of FSEs receiving at least one annual inspection was 64% in 2002, 36% in 2003 and 64% in 2004.[10] SAM representatives explained that, in addition to on-site inspections, FSEs may also be evaluated by telephone interview or review of grease hauling manifests that are mailed to SAM. SAM does not have an inspection checklist form for use in the FSE inspections and does not produce written reports of their FSE inspections.

Collection system maintenance staff have referred facilities to the source control program on occasion. Mezza Luna Restaurant was given as an example. After it was determined that grease discharges from this restaurant were causing grease accumulation in the pipes, in April 2004 SAM issued an NOV to get this restaurant to install a larger grease trap. The trap was installed by July 2004. The Harbor District in general and the residential area around Oak and Pilarcitos Streets in Half Moon Bay were also identified as grease hot spots. Grease in sewer mains in the latter area is thought to be from residential sources, as there is high density housing in the area. Here, the grease accumulation problem is further exacerbated by accumulation in a siphon crossing of Pilarcitos Creek. SAM developed a door hanger with information in both English

[10] March 18, 2005 letter from John Foley, SAM to Ken Greenberg, EPA.

and Spanish and distributed it in an effort to address the problem. At the request of the City of Half Moon Bay, SAM also increased the sewer cleaning frequency in the area.

The EPA team accompanied SAM staff to inspect two facilities: 3 Amigos and Mezza Luna. The grease trap at 3 Amigos is located in the kitchen. Staff opened the trap for examination by the inspectors. There was only a light amount of grease on the surface. It is not known when the trap was last cleaned, but the light grease accumulation indicates that either the trap was not working effectively or that it had been cleaned very recently. During the inspection, the SAM inspector did not check whether a baffle was present in the grease trap. Baffles are essential to achieve grease removal and should always be checked during FSE grease control inspections.

Mezza Luna installed two new grease traps inside their kitchen in 2004 after enforcement action was taken by SAM. The new units are a unique design incorporating a valve to draw off the grease. Thus the units do not have to be opened as frequently for cleaning, although it is still necessary to open the unit periodically to remove solids from the bottom. Mezza Luna staff demonstrated the grease draw-off procedure. SAM staff explained that this treatment unit has been effective at reducing grease discharges to the sewer.

The EPA inspectors discussed a variety of fats, oils and grease (FOG) control measures employed by other Cities in California that SAM should consider for it's program. Some of the measures include:

- kitchen BMP requirements[11];
- 25% accumulation rule limiting the build-up of grease and solids in grease removal devices;
- standard inspection checklist forms; and
- FOG characterization studies.

A number of Cities in Orange County are conducting FOG characterization studies as part of their new FOG control programs. SAM has had a FOG program in place for several years and seems to have a good handle on the location of FOG hot spots. Nevertheless, some elements of the FOG characterization approach may be useful. The hallmark of the FOG characterization approach is to use CCTV inspection of sewer pipes to determine if the FOG problem is caused by FSE discharge, sewer pipe defects, incomplete sewer pipe cleaning or a combination of these factors. FOG problems should be addressed by a combination of source control, sewer cleaning and sewer pipe repair. After an initial FOG characterization, systems can continue to use CCTV to do spot quality checks on sewer cleaning and to check on grease accumulation in sewer mains impacted by suspect restaurants.

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[11] Typical BMP requirements include dry wiping kitchenware, disposal of grease and fryer oil in barrels, use of sink strainers, exhaust hood cleaning practices and worker training and awareness

9 SEWER ASSESSMENT, REHABILITATION AND REPLACEMENT PROGRAM

Each of the SAM member agencies is independently responsible for inspecting their sewer systems and conducting necessary pipe repairs or replacement. SAM has no role in pipe inspection or repairs within the member agency systems. Sewer inspection and rehabilitation/replacement practices of each member agency is described below.

9.1 Montara Water and Sanitary District

MWSD is in the fourth phase of a multi-year project to correct system deficiencies. In Phase 1 (1986-1988), Montara televised its entire system and assigned a numerical condition rating to each pipe. In Phase II (1987-1993), MWSD conducted major renovations and/or construction of pump stations and the collection system. In Phase III (1994-1996), second tier problems involving repairs to the pump stations and collection system were addressed. At the time of the inspection, MWSD was continuing Phase IV, a three-year program, started in 2002, to CCTV its entire collection system for the purpose of identifying and correcting I/I problems and overflows. Since the site visit, MWSD reported that the CCTV inspection work was completed in 2005.

During the inspection, MWSD provided a map of the district with color coded indicators of which sewer pipes have been rehabilitated or replaced over the last three decades (1980's, 1990's and 2000's). Measurement of the marked pipe segments indicates that MWSD has rehabilitated or replaced about 4.5 miles of pipe, or 17% of its system, since 1980.

MWSD does not believe pipe rehabilitation (such as slip lining or cured-in-place pipe) is an effective means of correcting pipe deficiencies. The service area is hilly, and the original clay pipes tend to break. Therefore, their rehabilitation and repair program is based largely on pipe replacement. The District will make spot repairs if it is an emergency, but normally they just add the problem area to the capital improvement project (CIP) contract. MWSD has two major contractors, and an emergency contingency fund of about $30,000 to $50,000 per year. By contrast, the City of Half Moon Bay repair and replacement program does about 70 percent repair or rehabilitation and 30 percent pipe replacement. While replacement will completely correct any pipe deficiencies, it represents the most expensive approach to doing so. A blend of repair and replacement projects may represent a more cost effective approach to sewer rehabilitation, thus allowing more deficiencies to be addressed in a shorter period of time for the same cost.

MWSD uses a combination of user fees and new connection charges to fund its capital improvement projects. The replacement budget set at 2.5% of asset value is supplemented with new connection charges resulting in a total CIP budget of from $444,000 to $489,000 per year (according to the July 2004 Five Year Capital Improvement Program). In the July 2004 Five Year Capital Improvement Program, MWSD is proposing to spend from $230,000 to $310,000 per year to replace sewer lines identified in Phase IV efforts. In addition, various pump station

upgrades are planned, with about $150,000 per year allocated for this. A total of $107,000 is proposed for I/I testing during the five year period.

As noted in Table 6, MWSD has the highest spill rate among the SAM agencies based on data from 2000 to 2004. Many of the spills are caused by root blockages, an indication of pipe defects such as cracked pipes or offset joints. MWSD is also known to have significant infiltration and inflow, another indication of sewer pipe defects. Despite the extensive pipe rehabilitation and replacement completed to date (4.5 miles since 1980) it may be necessary for MWSD to complete additional sewer pipe rehabilitation and replacement as an element of a strategy to deal with the spill and I&I problems. MWSD should use CCTV to examine sewer pipes at overflow sites to determine if pipe repair or rehabilitation is needed.

9.2 Granada Sanitary District

GSD performed smoke testing on their entire system in 1999. Inflow due to missing cleanout caps was the major finding and the caps were replaced. In 1998 and 1999, GSD conducted CCTV evaluations of approximately 25,000 feet of sewer pipe in its system. A larger CCTV effort was conducted in 2002, with an additional 82,000 feet televised. During the 2004-2005 rainy season GSD is performing flow monitoring. Based on the results of the flow metering additional targeted CCTV work may be done.

Since 1988, GSD has rehabilitated or replaced approximately 9.7 miles of sewer pipe, or 29% of the GSD system. Prior to 1988, there had been little pipe rehabilitation or replacement completed in the GSD system.

According to a 5-Year Capital Improvement Program for FY2001/2002 through FY2005/2006 (prepared by Kennedy/Jenks, March 2001), GSD planned to spend about $500,000 to $560,000 per year for sewer repair and replacement. This includes associated sewer televising and lateral replacement. GSD's FY2004-2005 budget shows $400,000 allocated for the Medio Creek Bridge Sewer Line Relocation Design and Construction. $65,000 is allocated for an I/I study, and $9,000 for lateral repairs. No other projects for replacement or rehabilitation of gravity sewer mains are included in this budget.

9.3 City of Half Moon Bay

In 1998, the City hired a consultant to develop a three-phase capital improvement program for the City's collection system. At the time of the inspection, the City had completed the first two phases and was implementing the third phase. In each of the first two phases, the City rehabilitated or replaced about 20,000 feet of sewer pipe to repair structural defects and reduce infiltration. Work in the first phase was based primarily on CCTV inspections conducted in the early 1990's. In 2002, the City again TV'd the entire system and the results of these inspections were used to target work for the second and third phases. Phase III work, with funding of

$700,000 per year, will include sewer pipe point repairs (expected to total less than 5,000 feet of pipe), upgrades to pump stations and force mains and any other sewer pipe rehabilitation needs that may be revealed by the new CCTV inspections.

So far, most of the pipe work done by the City has been replacement by pipe bursting, for about 30% of the work to date, with the remaining work being fold-in-form type pipe rehabilitation. According to the City's figures, by the end of the three phase project, the City should have rehabilitated or replaced as much as 45,000 linear feet of sewer pipe or about 22% of its system.

10 CAPACITY ASSURANCE

The SAM sewer system does not have sufficient capacity to convey peak flows during the winter rains. The capacity shortages are manifested most noticeably in the large volume overflows at the Montara Pump Station or from manholes upstream of the Portola Pump Station. Table 8 provides a summary of capacity related overflows in the SAM service area between January 2000 and December 2005. For the first time in five years, there were no capacity related spills in 2005.

TABLE 8: Capacity Related Overflows, January 2000 to December 2005

Date	Overflow Volume (gallons)	Location	Agency
12/13/00	unknown	Montara PS	SAM
12/1/01	unknown	Montara PS	SAM
12/2/01	unknown	Montara PS	SAM
12/19/02	5000	Portola PS	SAM
12/19/02	500	First/Grove St.	HMB
12/29/03	63,000	Montara PS	SAM
12/27/04	83,970	Montara PS	SAM
12/27/04	19,020	upstream of Portola PS	SAM
12/27/04	2,410	Date/Harte PS	MWSD

As noted above, SAM and the member agencies have identified only 8 spills since 2000 as being caused by inadequate capacity. Most of the other spills during this time period are attributed to blockages by roots, grease or debris. A review of the spill data, however, reveals that there are typically more blockage spills during the wet winter months than during the dry months. It may

be that I/I is influencing this pattern. If the sewer mains are flowing near full in the wet season they will more readily overflow (spill) if there is a blockage. If this is the case, it may be possible to reduce blockage related spills with a more aggressive cleaning effort in advance of the wet season.

Capacity assessment studies conducted by SAM indicate that the capacity problems stem primarily from excess infiltration and inflow (I/I) in the member agencies' sewer systems. This excess wet weather flow can cause spills within the member agencies systems (see HMB and MWSD spills in Table 8 above). The largest spills, however, have occurred when the excess wet weather flow hits bottlenecks in the SAM IPS at the Montara and Portola Pump Stations.

Infiltration is the introduction of groundwater to the sanitary sewer system through pipe defects such as cracks or offset joints. Infiltration typically increases in the rainy season as the ground becomes saturated. Inflow involves a more direct and rapid introduction of rain water to the sanitary sewers through illicit storm drain and roof drain connections or standing water flowing into pick holes in manhole covers. Capacity limitations caused by I/I can be managed either by reducing the I/I, conveying the excess flow through larger sewers and storage basins, or a combination of these two basic approaches. Eliminating inflow sources is normally the cheapest and quickest control measure. Infiltration control can be costly and is generally accomplished by repairing or replacing sewer mains and/or laterals. Expansion of sewage conveyance and storage capacity can also be expensive and is normally accomplished by eliminating bottlenecks with relief sewers (typically in the interceptors) or larger pump stations, or by constructing off-line storage for excess flow.

SAM hired Carollo Engineers to conduct a series of studies to evaluate wet weather flows in the IPS and offer recommendations for relieving the capacity restrictions in the IPS. In 1998, Carollo conducted a wet weather flow metering study that examined flow inputs to the IPS and capacity of the IPS pipe and pump stations. (*Wet Weather Flow Monitoring and Model Calibration*, by Carollo Engineers, 1998.) The 1998 report made general recommendations to install off-line flow storage on the IPS, expand the capacity of the IPS downstream of the Portola PS and conduct a comprehensive I/I evaluation and corrective measures in each of the member agency collection systems. In 2002, SAM installed a 430,000 gallon off-line storage tank at the Montara PS at the head of the IPS. MWSD made some modifications to the Vallemar and Niagra pump stations and reconfigured force mains to provide some additional capacity relief at these stations and in the IPS. In 2003 and 2004, Carollo examined the effectiveness of these measures and made recommendations for additional capacity relief at the Portola PS on the IPS. (*Wet Weather Flow Management Program Facility Plan Update*, Carollo Engineers, August 2004 and *Additional Analysis of Alternative 1A of the Wet Weather flow Management Program Facility Plan*, Carollo Engineers, October 2004.) The 2004 studies, did not identify I/I sources or make recommendations for corrective measures in the member agency systems.

SAM has elected to pursue Alternative 1A from Carollo's August 2004. In October 2004, Carollo suggested, and SAM selected, variation 1A-2 which uses a pipe rather than a basin for storage at the Portola PS. Alternative 1A (with variation 1A-2), has a total project cost of $3.2 million and includes construction of a 200,000 gallon off-line storage pipes upstream of the Portola Pump Station, replacement of pumps at the Portola PS and improvements to controls and equipment at the Portola PS. The off-line storage pipes are designed to temporarily hold wet weather flows that exceed the capacity of the bottleneck in the Portola PS and downstream IPS. After flows subside, the stored wastewater can be conveyed through the Portola PS and on to the WWTP. Carollo recommended implementing the project in two phases, starting with installation of the off-line storage at a cost of $1.3 million. SAM is now pursuing funding to implement Alternative 1A-2 but has not yet committed to a schedule for completing the project. The improvements are designed to accommodate excess wet weather flow from a 5-year, 6-hour storm (2 inches of rain in 6 hours).

Carollo also considered alternatives for conveying the larger 5-year, 24-hour storm event (4 inches of rain in 24 hours). For this size storm, Carollo devised alternative 2A (2.3 million gallons of storage at Portola) at a cost of $11 million and alternative 2B (400,000 gallon storage at the Portola PS, 470,000 gallon storage at the WWTP and a new 8,850 foot 14" parallel force main downstream of the Portola PS) at a cost of $10 million. Carollo also estimated that, in storms larger than the 5-year, 24-hour storms, excess wastewater would overflow in the member agency systems before reaching the IPS.

Pending completion of additional permanent overflow storage, in 2005, SAM installed 4 temporary storage tanks at the Montara PS and 2 temporary tanks at the Portola PS. Each of tank has a capacity of 21,000 gallons for a total capacity of 126,000 gallons. The tanks are set to capture excess wet weather flow in the IPS.

Carollo's flow monitoring studies looked at member agency inputs to the SAM IPS and concluded that each of the member systems was experiencing significant levels of I/I. Carollo's flow monitoring during two storms in February 1998 showed peaking factors ranging up to 6.0 in the MWSD system, 3.0 in the GSD system and 4.7 in the HMB system. (The peaking factor indicates the ratio of flow during a storm compared to normal dry-weather flow.) Using an alternative measure of I/I, gallons of flow per mile of sewer pipe, Carollo reached the same conclusion that each system had I/I, with MWSD and HMB having higher rates than GSD. Based on monitoring of storms in the 2003/04 rainy season, Carollo concluded that recent improvements in the member agency systems have yielded as much as 1 million gallons of I/I reduction during a 5-year, 6 hour storm, but that I/I remains high. Over the years, each of the member agencies has done some level of flow metering and I/I study within their systems. In fact, each of the member agencies was planning to conduct flow monitoring either in the 2004/05 or 2005/06 rainy seasons. These local studies could be used to pinpoint I/I sources and identify pipe repairs and other measures that could reduce I/I, the root cause of SAM's capacity problems. Brief descriptions of the I/I studies conducted by the member agencies is provided below.

MWSD staff explained that, in 1997, the District conducted smoke testing to look for inflow sources. MWSD did not find this study to be effective, but did not explain why. At the time of the site visit, MWSD had not done wet weather flow metering or modeling of its system. (Since then, MWSD reports that they have entered into an agreement to conduct wet weather flow monitoring, although we don't know the scope of this planned study.) During the inspection, MWSD staff explained that they have concluded that infiltration in the MWSD service area is not concentrated in any particular area but is widespread throughout the system. The District believes that storage and capacity increases on the SAM IPS are the key to preventing wet weather overflows. It is not clear that the District has conducted sufficient studies to support these conclusions or to determine if there are options for cost effective I/I control in its system. MWSD should conduct an I/I evaluation of it's system to determine if there are options for cost effective control of I/I.

GSD completed a smoke testing program in 1999 and eliminated some inflow sources, including replacement of cleanout caps. During the 2005/06 rainy season, GSD is conducting wet weather flow metering at 10 locations. The goal is to identify which sub-basins have the greatest I/I problems and determine if there are opportunities for cost effective I/I control. GSD is also implementing a project to reroute the Naples Beach Pump Station (also known as San Pablo PS) away from Medio Creek and directly into the SAM IPS downstream of the Portola PS. This will reduce the flow at the Portola PS bottleneck.

HMB did an I/I assessment program in the mid-1990's but did not take action to correct I/I following those studies. HMB was planning to conduct flow monitoring during the 2004-2005 rainy season and will also model the system. This work may also provide information on I/I reductions realized from the recent sewer pipe rehabilitation and replacement as well as information on the I/I contribution from private laterals.

The regional agreement between SAM and the member agencies creates some challenges for effectively managing I/I and wet weather capacity problems. Each member agency is responsible for managing and maintaining the sewer pipes within their jurisdictions. As noted above, the historic record shows that most of the wet weather capacity spills occur on the SAM IPS and not in the local member agency systems. SAM has not placed limitations on wet weather flow that the member agencies convey to the IPS. In addition, SAM is responsible (using revenues from the member agencies) for capacity capital improvements to the IPS. The MWSD has high levels of I/I and the misfortune to connect to the SAM IPS upstream of the bottlenecks at the Montara and Portola Pump Stations. On the other hand, HMB, which also has high levels of I/I, connects to the SAM IPS at a point where there is no capacity bottleneck. But neither system is required by SAM to reduce I/I and neither system has a financial incentive to reduce I/I. In fact, under the regional agreement, MWSD contributes only 20% of the revenue for capacity fixes to the SAM IPS. I am not saying that any of the member agencies are taking advantage of this arrangement and avoiding improvements to their systems. In fact, each member agency has spent considerable amounts of money on capital improvements to their systems and has rehabilitated or

replaced significant portions of their pipe networks. In addition, SAM meets regularly with the member agencies so they can plan and coordinate their shared and individual capacity management efforts. Yet, I/I remains and SAM is faced with making capacity fixes on the IPS.

I recommend that SAM and the member agencies continue to work together and look for ways to enhance the effectiveness of the regional capacity management efforts. From an engineering stand-point, the best technical approach is to conduct a regional I/I assessment and determine the most cost-effective mix of I/I controls, capacity expansion and excess flow storage. This is not being done in the SAM service area since each agency is on its own to study and plan I/I controls. But SAM has an opportunity to approximate a regional I/I approach by ensuring that each member agency conducts comprehensive I/I studies using similar methodology. With the data from comprehensive and uniform I/I studies, SAM and the member agencies could then see what is the most cost effective mix of controls in the regional service area. SAM could consider cost sharing options to create incentives for the member agencies to pursue cost effective I/I controls within their systems. (For example, base member fees on peak flows rather than average dry-weather flows.) SAM could consider establishing commitments for I/I reductions from the member agencies. This type of regional approach will take time and SAM should not delay planned improvements to the IPS pending completion of the member agency I/I studies.

11 BUDGETS

SAM's most recent annual budget document (*Comprehensive Budget Fiscal Year 2004-05* dated June 28, 2004) includes a two-year estimate of the Operating Budget (FY 04-05 and FY 05-06) and a five-year Capital Asset Management Plan (Capital Budget).

Each of the member agencies contributes funds to SAM. Each member agency relies on a variety of revenue sources to support its wastewater collection and treatment expenses including household user fees, commercial user fees, new connection fees, and property taxes. The state plans to claim a portion of the property tax that the districts would normally receive, due to the budget crisis. To offset the projected 40% loss in their property tax share, GSD increased annual household sewer service charges a few months ago from $273.50 to the current $314.

Table 9 summarizes the projected revenues and expenditures for the member agencies during FY 04-05. This table is constructed from numbers provided in the budgets provided by each member agency and from SAM's budget figures.

Table 9: Summary of Member Agency Budgets			
Item	HMB	GSD	MWSD
Revenue Sources	sewer service charge based on water usage; connection fees	flat rate sewer service charge ($314); property tax; connection fees	flat rate sewer service charge ($320 - $500); property tax; connection fees
Revenue	$2,484,000	$1,320,498	$1,640,160
Transfers to SAM for administration	$334,625	$195,474	$132,525
Transfers to SAM for WWTP operation	$705,454	$483,583	$324,879
Transfers to SAM for collection operation	$110,353	$121,077	$148,084
Transfers to SAM for Capital (mostly WWTP)	$382,444	$264,329	$181,959
Total Transfers to SAM	$1,532,875	$1,064,463	$787,447
Member agency collection system capital budget	$1,560,000	$830,329	$483,350

11.1 SAM's Operating Budget

SAM's Treatment Operating Budget is funded by contributions from the member agencies based on percentage of average flow (HMB - 46.6%; GSD - 31.9%; and MWSD - 21.5%) during the twelve-month period from June 2003 through May 2004. The total wastewater treatment operating budget for FY 04-05 is $1,512,731.

The Collection Operating Budget is paid by the member agencies based on average employee hours recorded for SAM work for each member agency during the previous year. The distribution in the FY 04-05 budget is HMB - 28.5%; GSD - 32.0%; and MWSD - 39.5%. MWSD has the highest percentage because of the number of pump stations maintained by SAM and the number of call-outs to address sewer problems and overflows. But, at the time of the inspection, MWSD had the lowest use of SAM staff for routine sewer pipe cleaning. Fixed costs for insurance and contract services are also added to each member's total contributions to SAM. The total Collection Operating budget for FY 04-05 is $380,563.

11.2 Capital Improvements

SAM's capital improvement budget for FY 04-05 totals $940,391. Over $600,000 is for Wet Weather Capital Improvements. These could include the recommended capacity improvements to the IPS and Portola Pump Station. Future capital budgets will include not only the remainder of the Wet Weather Capital Improvements but also wet weather flow monitoring, which will measure the impact of the previous year's capital improvement. SAM also has a capital contingency fund of $40,000 to address unanticipated equipment failures. SAM has also budgeted $55,000 to analyze the structural integrity of the inter-tie pipeline system.

MWSD plans to completely rehabilitate the Chart House PS and put in a third pump. There are also plans to improve the Niagara station and add a third, smaller, pump at Vallemar. Pipeline projects have been awarded and were scheduled to begin in November 2004. MWSD has assigned an asset value for its system of $10 million. The district puts aside two percent of this amount annually for capital replacements.

HMB capital projects include upgrades to the Pelican Point and Bell Moon stations. They plan to install a grinder in the Bell Moon PS. They are waiting for a coastal development permit to replace piping, improve pumps, and raise the Pelican Point station. Capital projects also include Phase III of the sanitary sewer study and sewer replacements.

GSD capital projects in FY 04-05 include $400,000 for design and construction of the project to reroute the Naples Beach PS force main away from the Medio Creek crossing. GSD also plans to spend $65,000 on an I/I study and $25,000 for the District's 5-year capital plan.

12 RECOMMENDATIONS

1. SAM should adopt the September 2004 *Draft Sewer Overflow Response, Reporting, and Mitigation Plan* after making some recommended modifications including:
   - Include cleanup and mitigation procedures for spills that occur inside buildings that are due to problems in the sewer mainline.
   - Add procedures for cleanup and mitigation of spills that enter storm drains.
   - Include procedures for preventing the flow of spill cleanup flush water to storm drains.

2. SAM should submit monthly reports of all spills to the Regional Board as required by its NPDES permit. Perhaps the Regional Board could make the NPDES spill reporting requirements consistent with the 13267 letter when it renews SAM's NPDES permit.

3. SAM should conform to the policy of the San Mateo County Health Department to post warning signs whenever a wastewater spill contaminates recreational waters, so that the public can avoid activities that could expose them to sewage pathogens. SAM should

also post warning signs if Montara pump station overflows enter the ocean. (Neither the May 2000 or the draft September 2004 overflow plans provide an exception for posting at this or any other spill location.)

4. Spill response crews should record spill information in the SSO report form before they leave the scene of a spill. This allows for better recording of field observations while the incident is fresh in the minds of the response crew

5. It is recommended that SAM make efforts to reduce the size of overflows by using a vacuum truck, temporary pump around, or other means to prevent sewage from overflowing the collection system into the environment.

6. The Intertie Pipeline, especially the force main sections, are a critical element of the SAM system. Failure of the pipeline could be difficult to repair and result in a large spill. SAM should take the following measures to safeguard against failure of the intertie pipeline:
   - Complete condition inspections of the gravity and force main sections of the IPS and make necessary repairs or replacements.
   - Implement a regular program to maintain and replace air release valves on the force main sections of the IPS.
   - Develop an emergency contingency plan for responding to a failure of the IPS. As part of the contingency plan, SAM should consider whether to install parallel force mains that could serve as a backup in the event of a catastrophic failure of one of the force main sections.

7. Autodialers at all pump stations should be equipped with true Uninterruptible Power Supplies (UPS) rather than just a battery.

8. At the time of the inspection, SAM was not able to fully explain the failure of alarm systems and backups that contributed to spills at the Princeton and Ocean Colony Pump Stations. SAM should determine the causes of these failures and take measures to prevent recurrence.

9. SAM should conduct annual inspections of each permitted FSE and complete reports on each inspection.

10. The EPA inspectors discussed a variety of FOG control measures employed by other Cities in California that SAM should consider for it's program. Some of the measures include:
    - kitchen BMP requirements;
    - 25% accumulation rule limiting the build-up of grease and solids in grease removal devices;

- standard inspection checklist forms; and
- FOG characterization studies.

11. The SAM system, including its member agencies, experiences a higher rate of spills than surveyed systems in southern California. Other systems have managed to reduce spills with well managed and expanded sewer cleaning programs. SAM recently obtained a new sewer cleaning truck equipped with CCTV. This should help its sewer cleaning efforts. SAM and the member agencies should consider the following:
    - Adopting regional criteria or standards for sewer cleaning by the member agencies. Taking a regional approach to identifying hot spots and recommending minimum cleaning frequencies by the member agencies.
    - Increase hot spot cleaning locations and frequency as needed to reduce spills.
    - Identify repeat spill locations and take aggressive steps (cleaning and/or pipe repair) to eliminate repeat spills.
    - SAM should evaluate whether its staffing level is sufficient to meet the production, hot spot and call-out cleaning demands of the member agencies.
    - Chemical root control where appropriate. Control of roots from private laterals as needed.
    - Conduct more aggressive hot spot cleaning in advance of the rainy season to reduce the number of rainy season blockage spills.
    - Use the CCTV equipment to make follow-up inspection of sewer pipes at spill sites and document any observed pipe defects.
    - Use the CCTV equipment to conduct a sewer cleaning QA/QC program. Such a program could involve random CCTV of pipe segments after cleaning to determine the effectiveness of the cleaning. Effective cleaning should remove all sediment and debris, and restore the pipe to its nominal diameter.
    - SAM should develop a computerized sewer cleaning Maintenance Management System to provide ready access to the maintenance history for any pipe segment and facilitate maintenance scheduling.

12. SAM should proceed expeditiously with planned capacity improvements to the IPS.

13. The SAM member agencies should complete comprehensive and uniform I/I studies and then work together with SAM to identify and implement cost effective I/I controls.

14. SAM and the member agencies should look for ways to improve the regional management of capacity control measures and create incentives for completion of the most cost effective capacity control improvements.

Attachment 1
Inspection Photographs



Photo 1: SAM - Montara PS wet weather storage tank



Photo 2: SAM - Montara PS pumps



Photo 3: SAM - Montara PS pumps

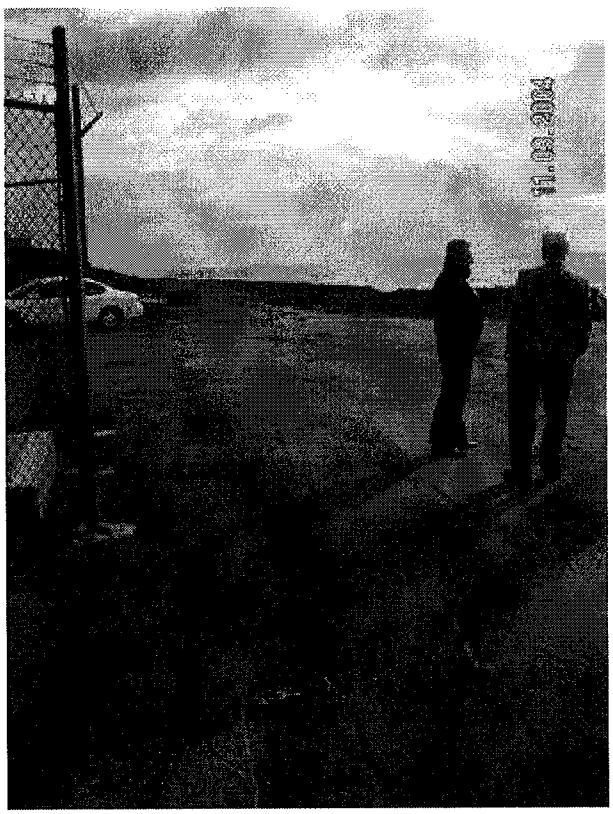


Photo 4: SAM - Montara PS manhole that overflows



Photo 5: SAM - Montara PS path of wastewater overflow to ocean

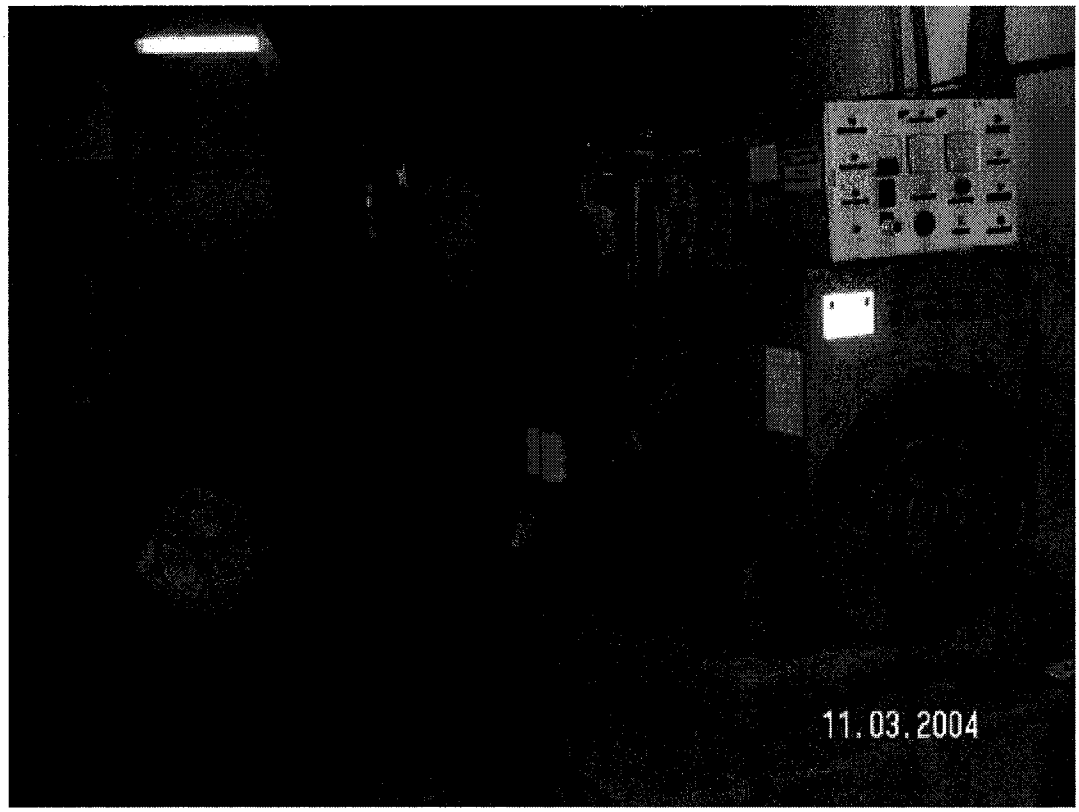


Photo 5: SAM - Montara PS generator

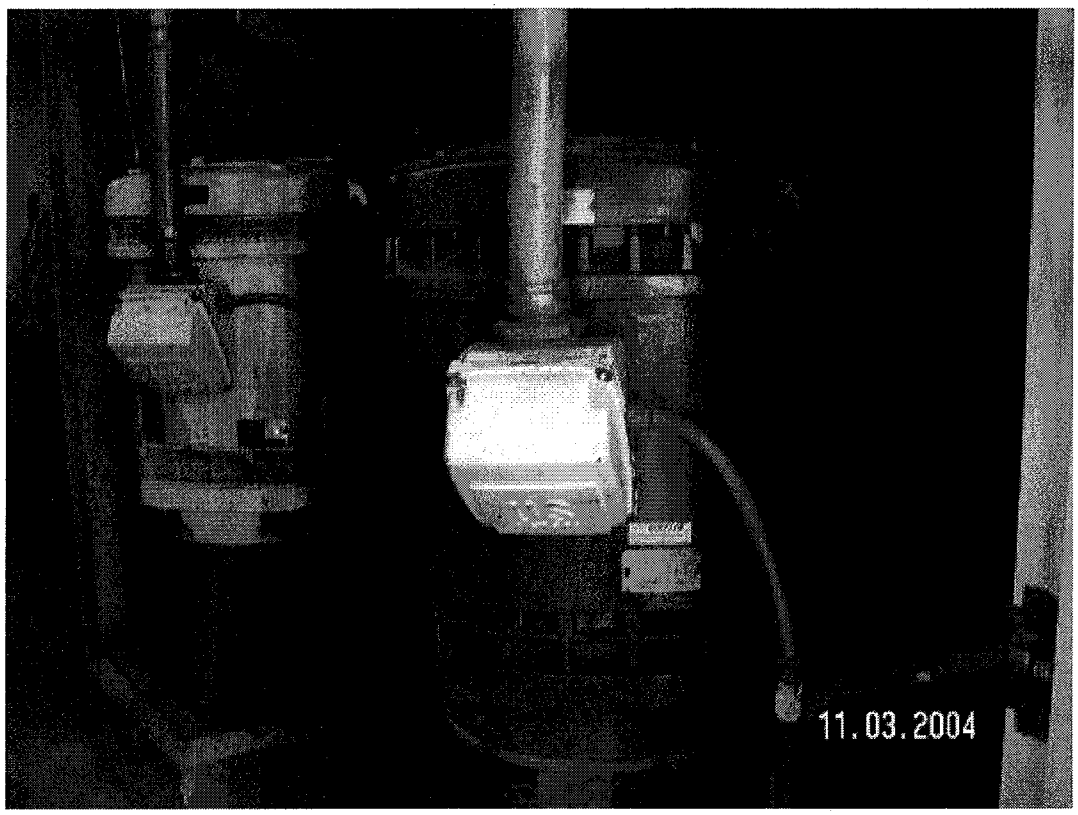


Photo 7: SAM - Princeton PS pumps



Photo 8: SAM - Princeton PS generator



Photo 9: SAM - Princeton PS



Photo 10: SAM - Princeton PS manhole that overflows to ocean



Photo 11: SAM - Princeton PS overflow point to ocean



Photo 12: SAM - Portola PS biofilter



Photo 13: SAM - Portola PS pumps

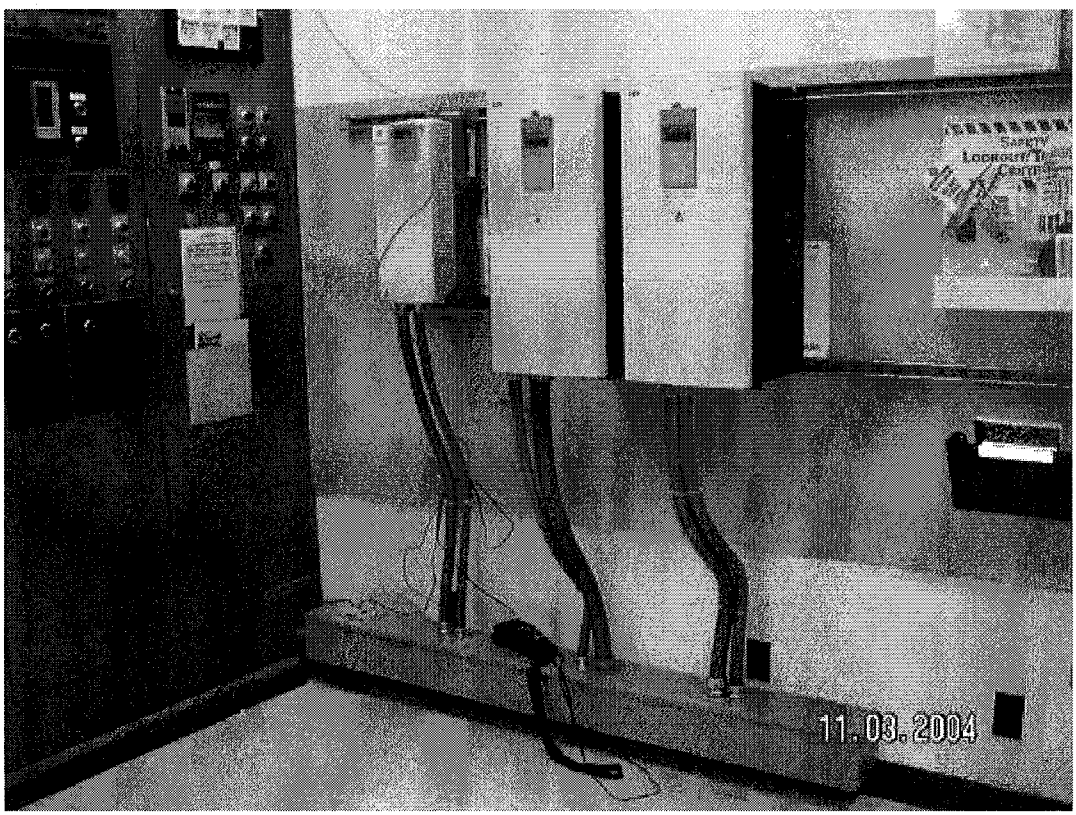


Photo 14: SAM - Portola PS alarm system

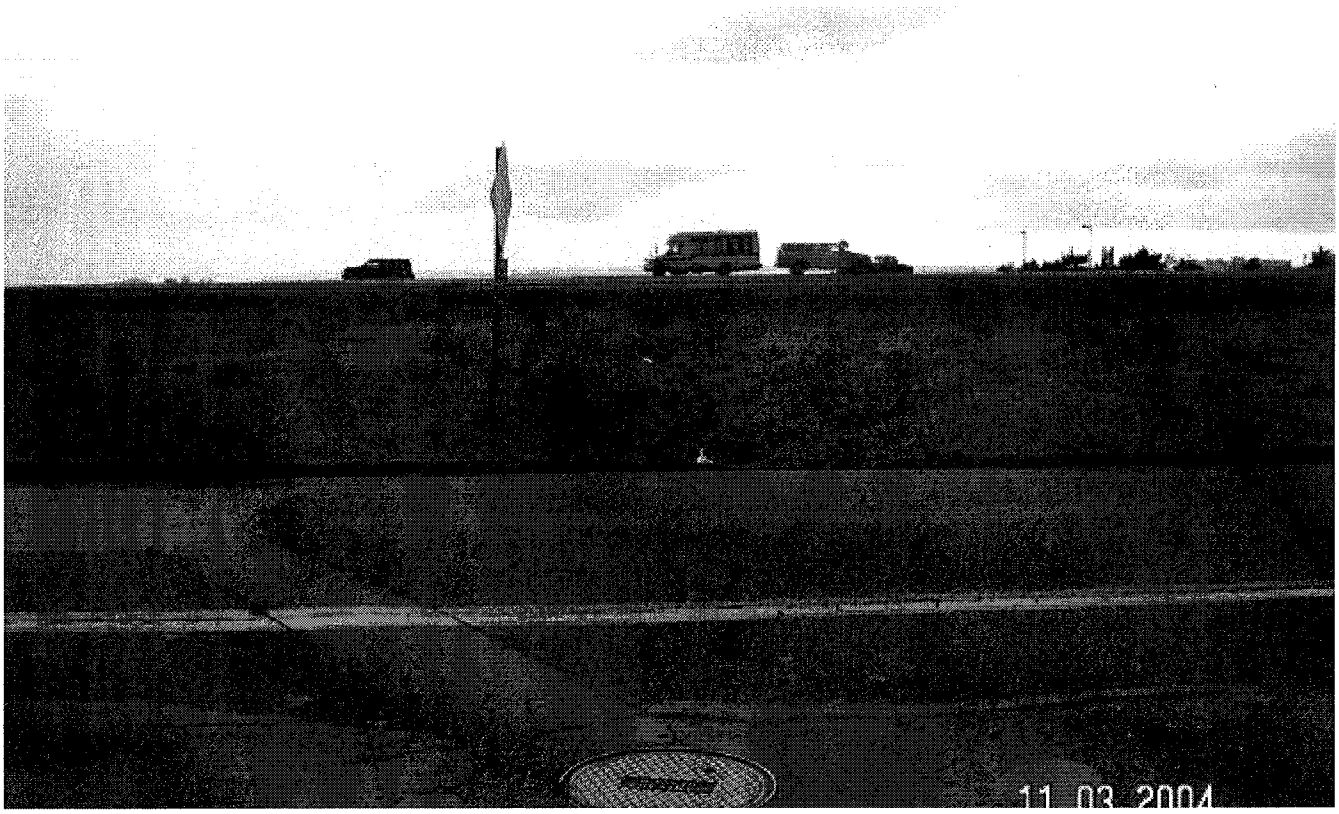


Photo 15: SAM - Portola PS overflows go to this channel

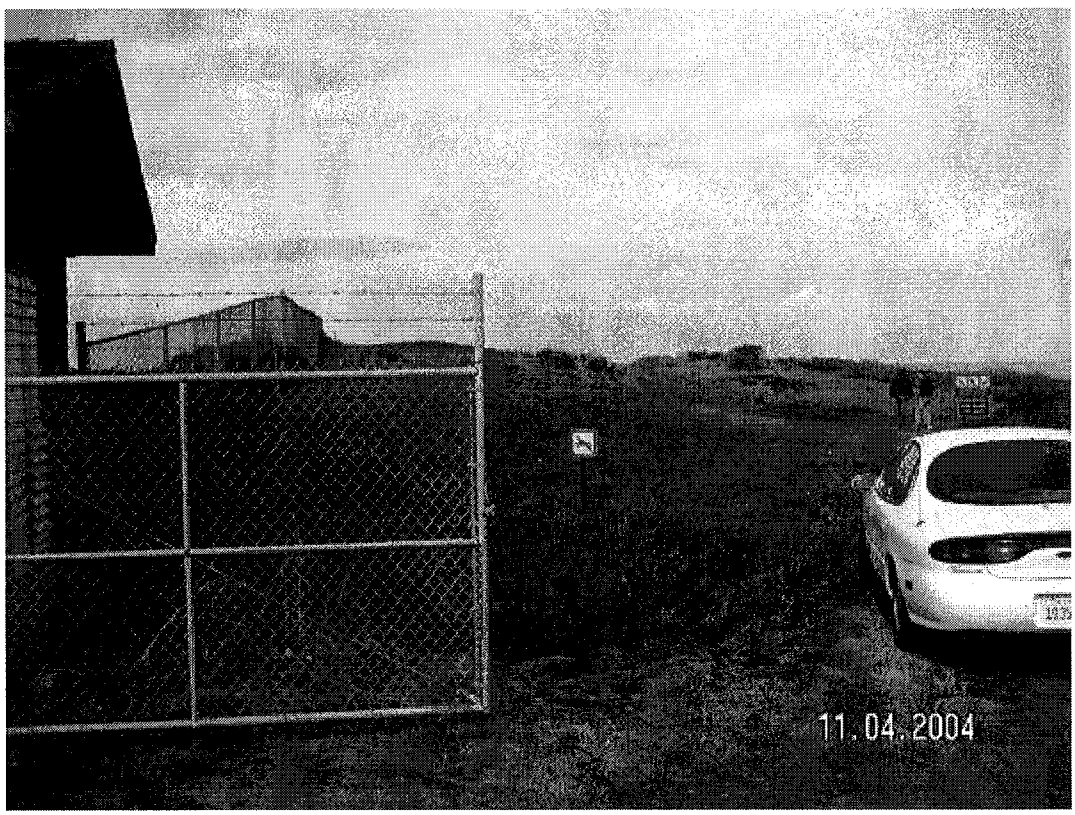


Photo 16: MSD - Charthouse PS overflow point to ocean



Photo 17: MSD - Charthouse PS storage tank

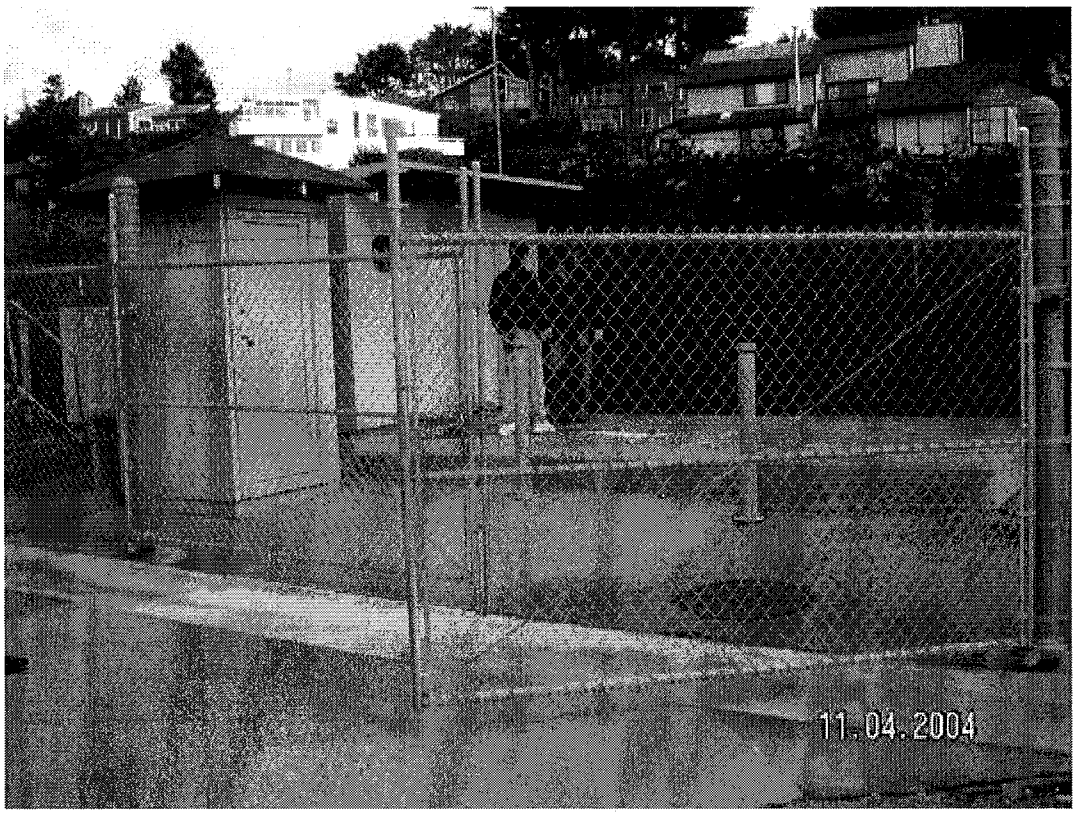


Photo 18: MSD - Vallemar PS

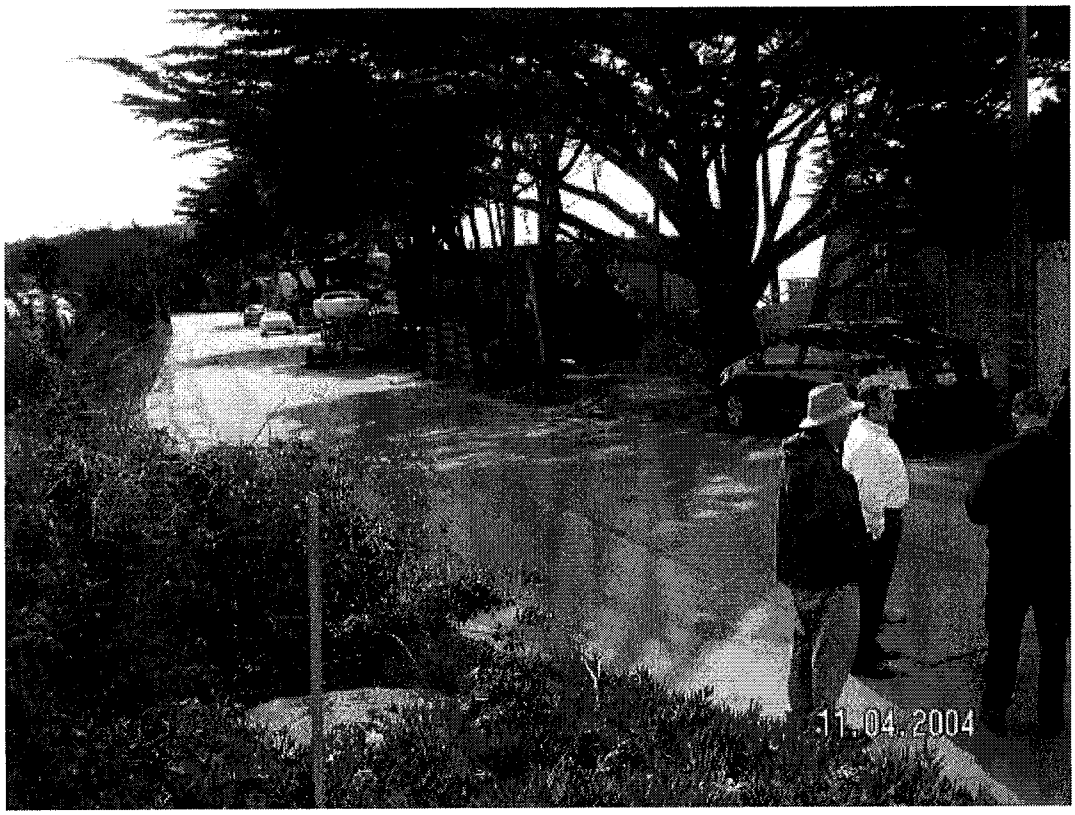


Photo 19: MSD - Vallemar FM air relief valve location

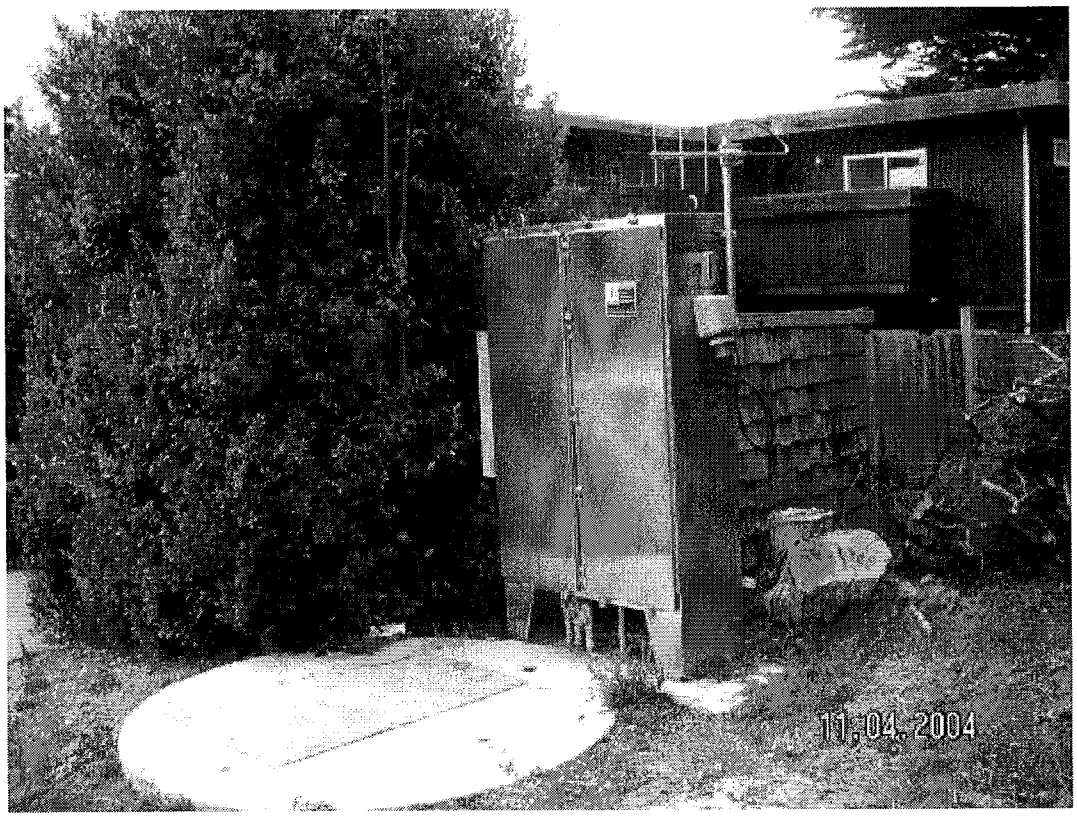


Photo 20: MSD - Seal Cove 4 PS



Photo 21: MSD - typical grinder PS



Photo 22: MSD - Seal Cove 3 PS

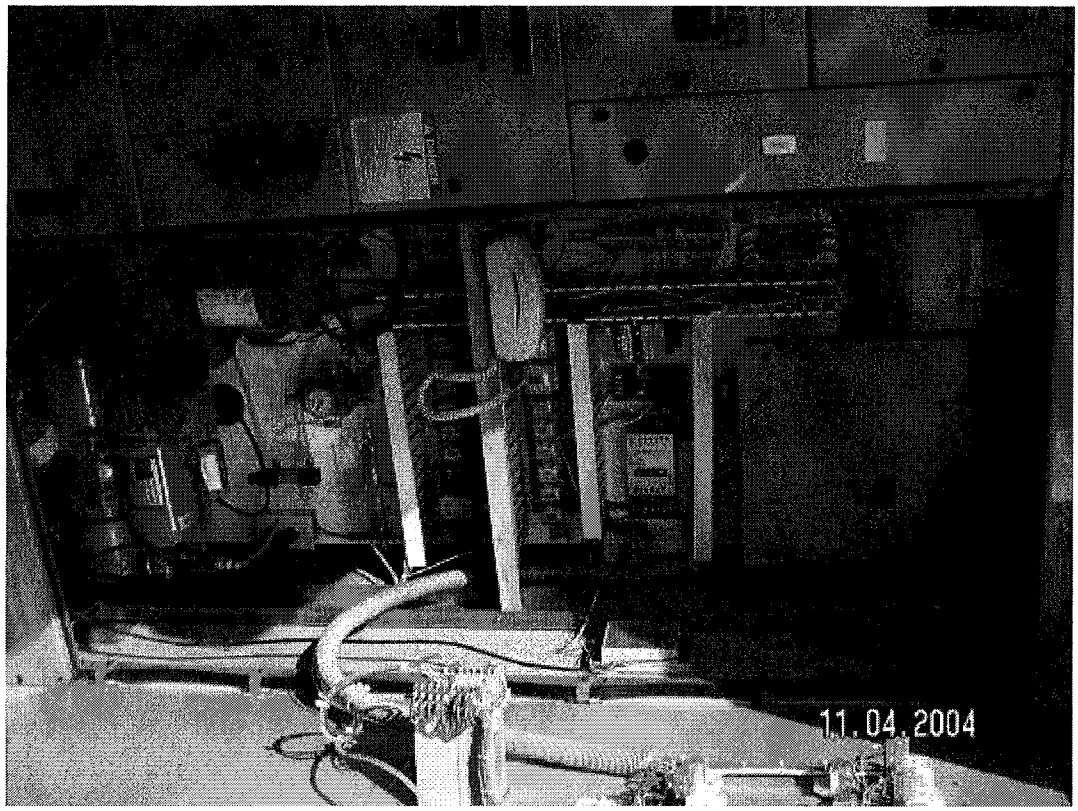


Photo 23: MSD - Airport PS panel

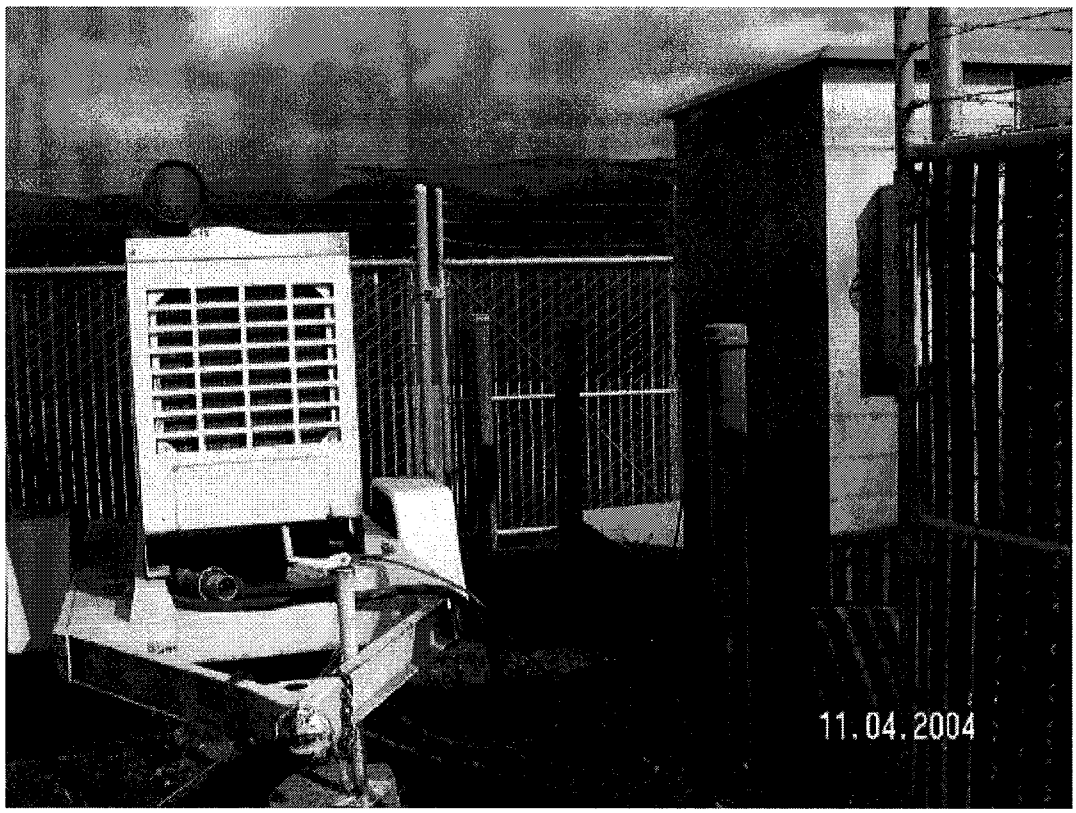


Photo 24: MSD - Airport PS generator

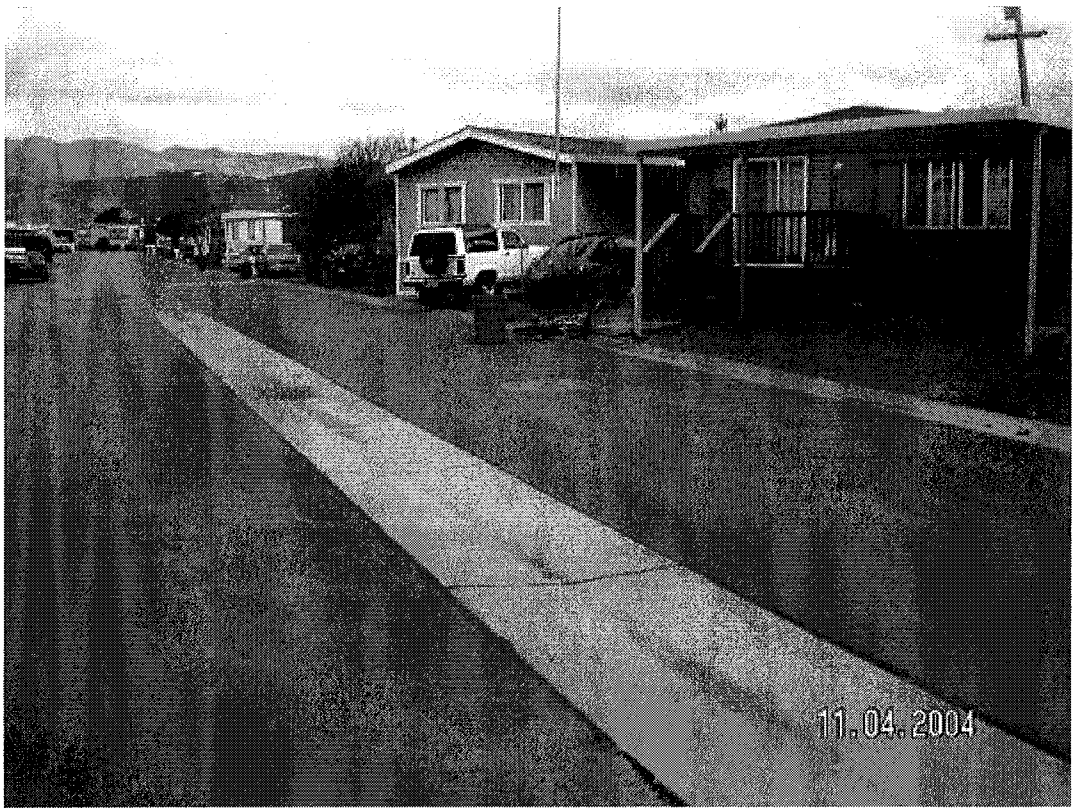


Photo 25: MSD - Airport PS overflow from this manhole



Photo 26: MSD - Airport PS overflow to ditch



Photo 27: Example of new type of ARV in use by SAM



Photo 28: HMB - Oak Street spill site adjacent to creek



Photo 29: HMB - Ocean Colony PS spill location

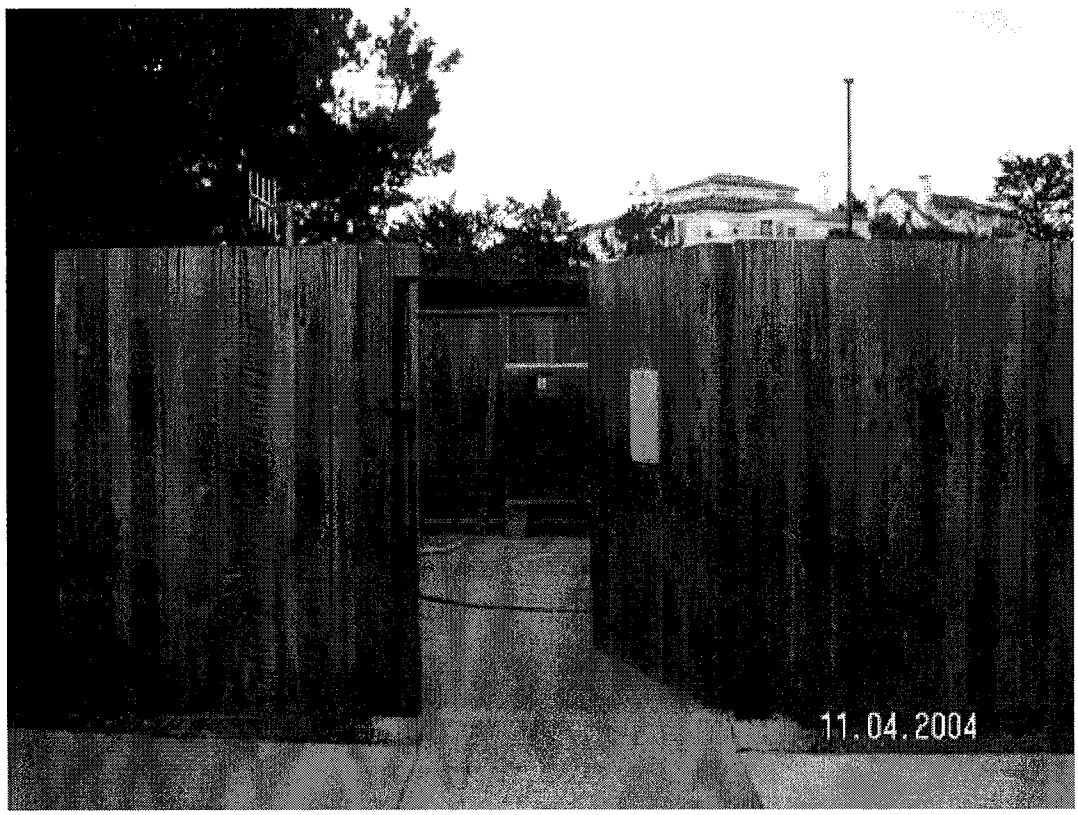


Photo 30: HMB - Ocean Colony PS

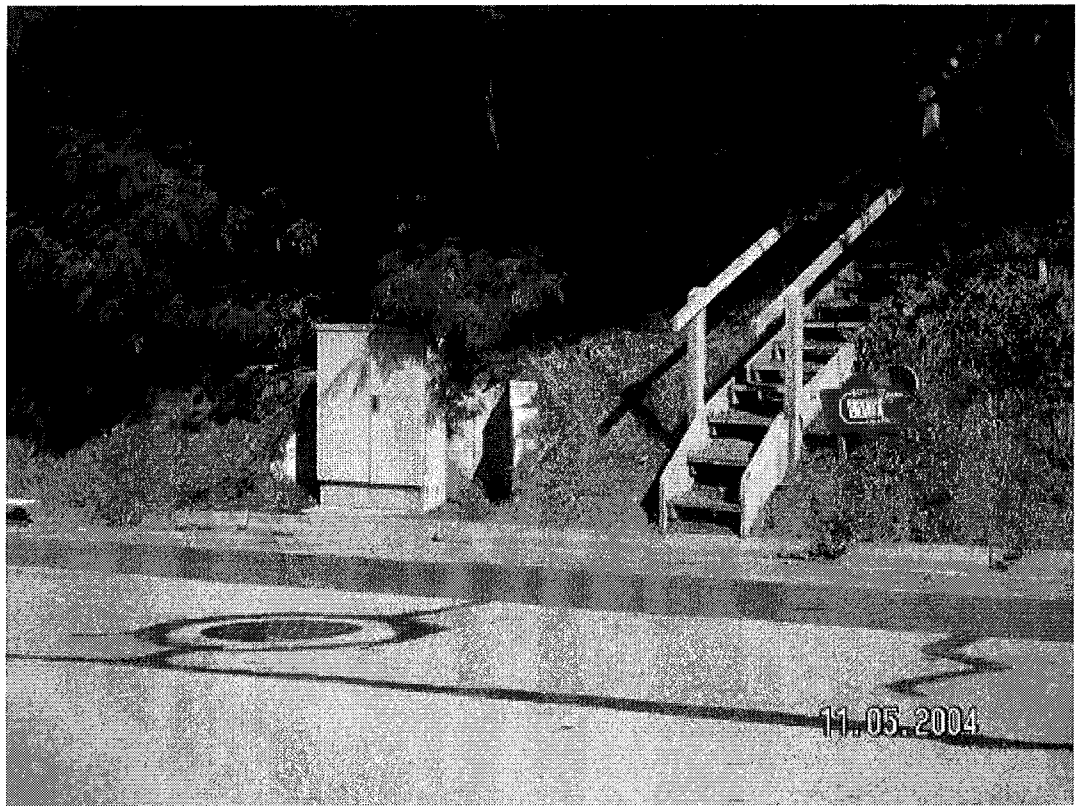


Photo 31: GSD - Isabella and Columbus spill area



Photo 32: GSD - Isabella and Columbus spill area

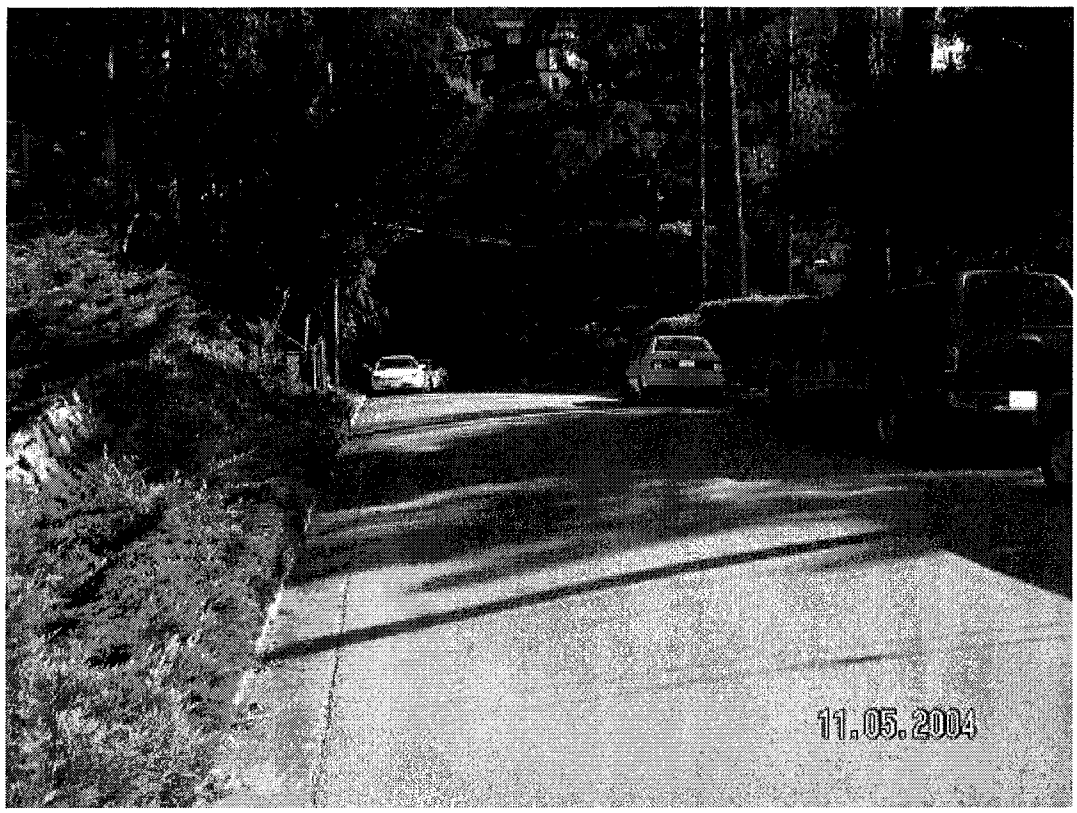


Photo 33: GSD - 546 Isabella area



Photo 33: GSD - San Pablo PS

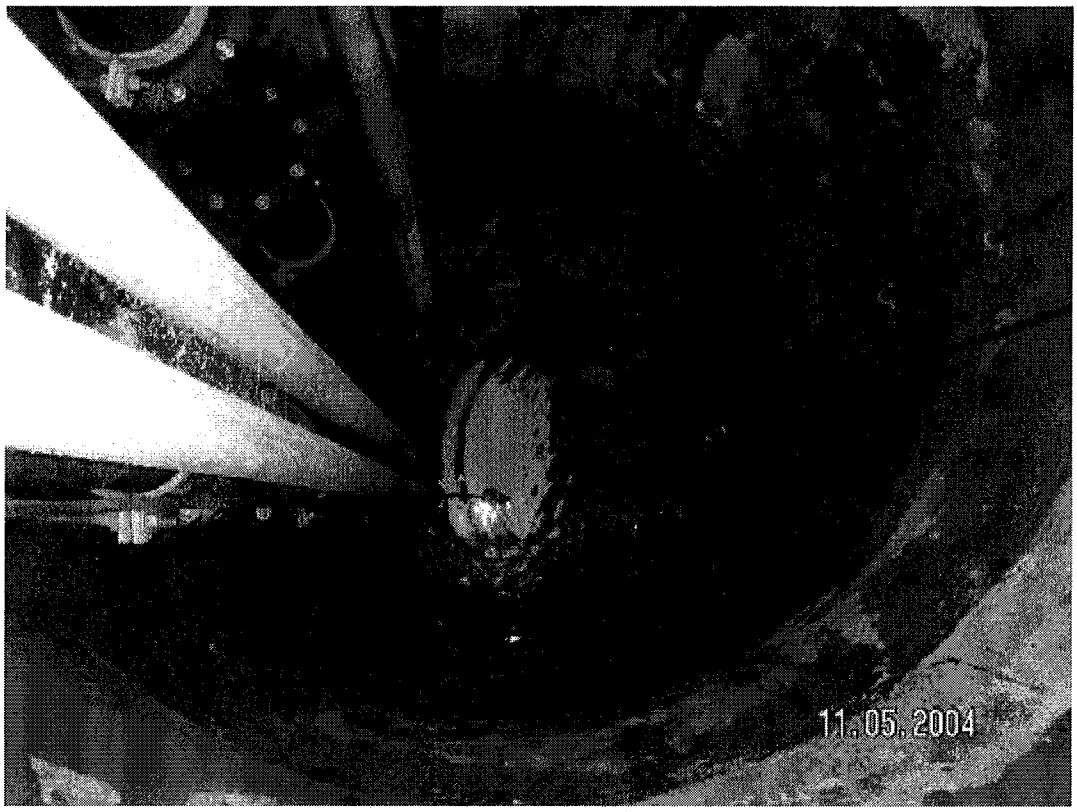


Photo 34: GSD - San Pablo PS wet well



Photo 35: GSD - San Pablo FM break area

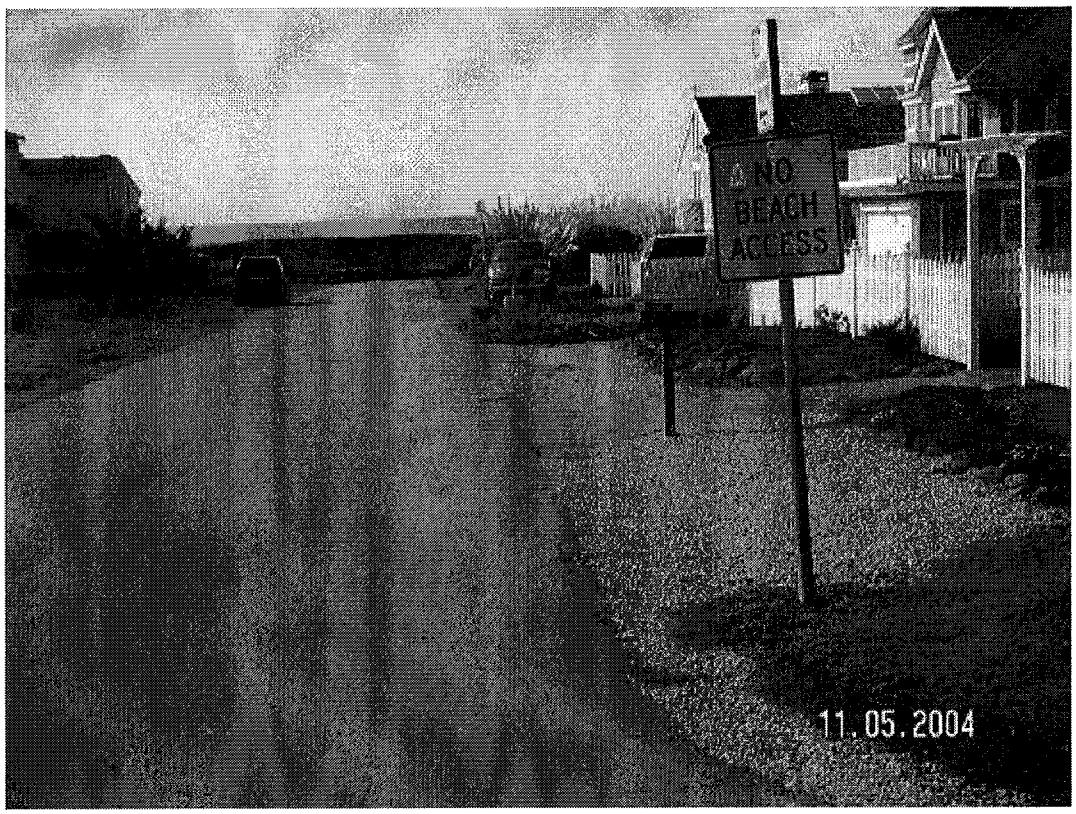


Photo 36: GSD - San Pablo FM overflow would move toward beach



Photo 37: GSD - San Pablo FM break area

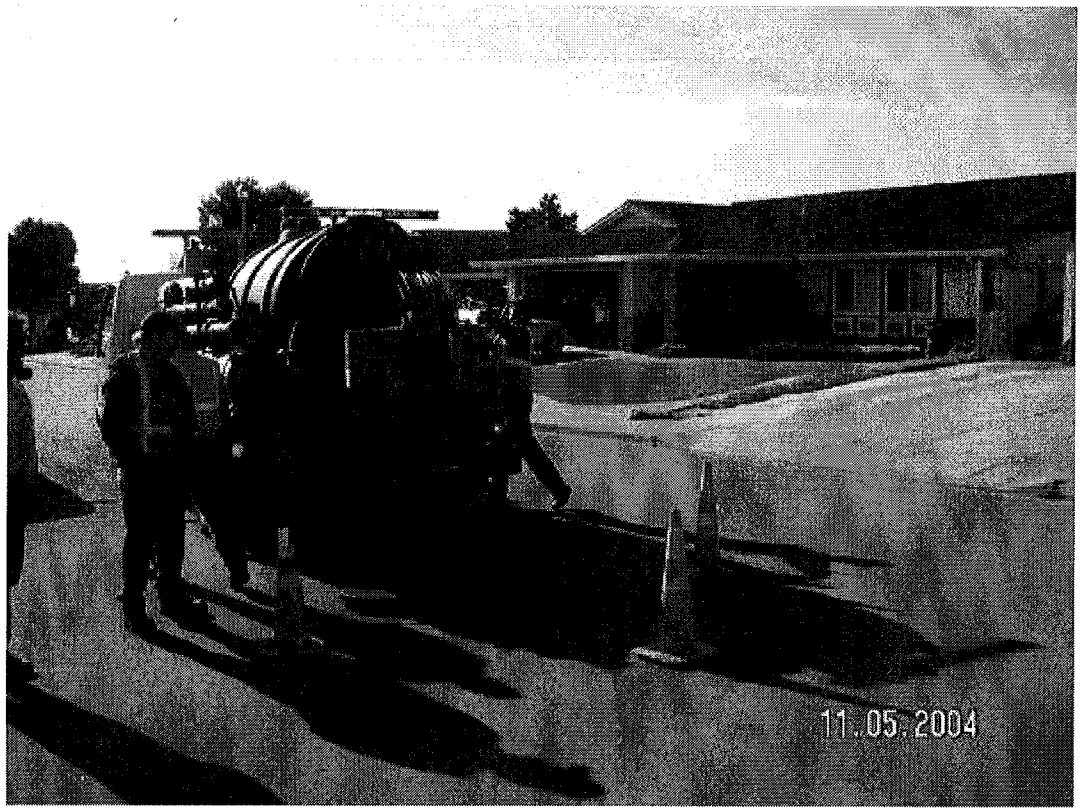


Photo 38: SAM - cleaning truck

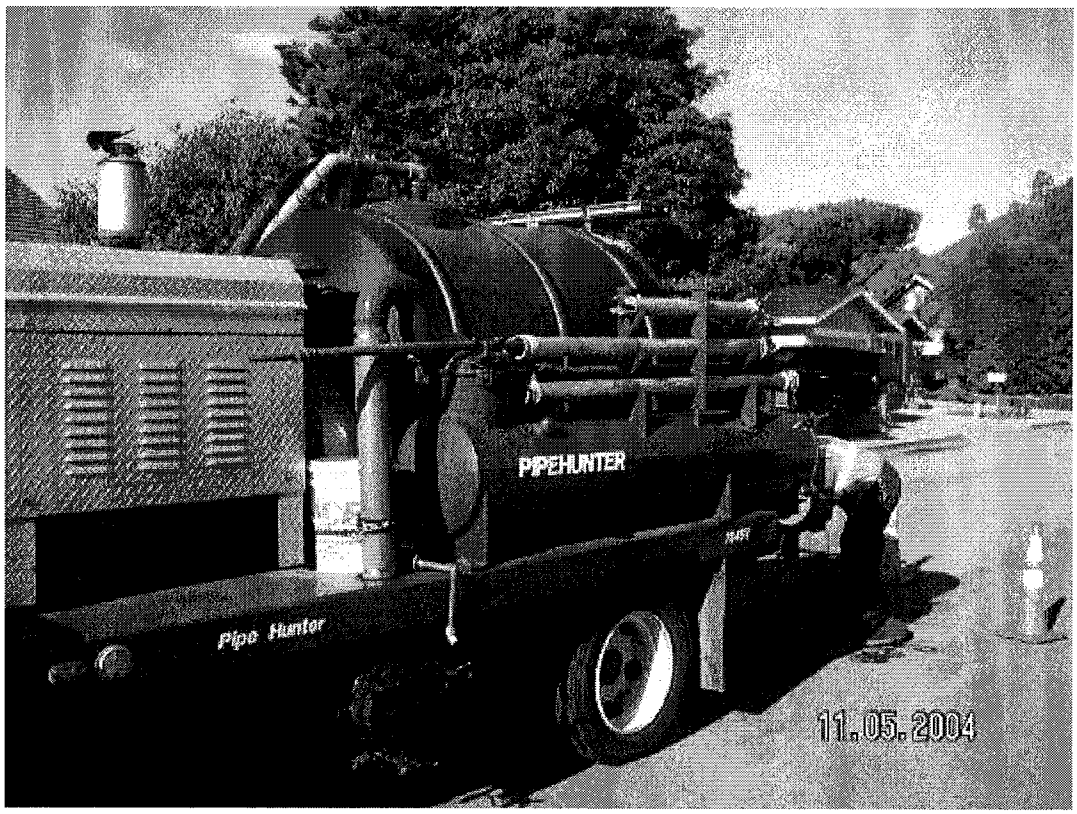


Photo 39: SAM - cleaning truck

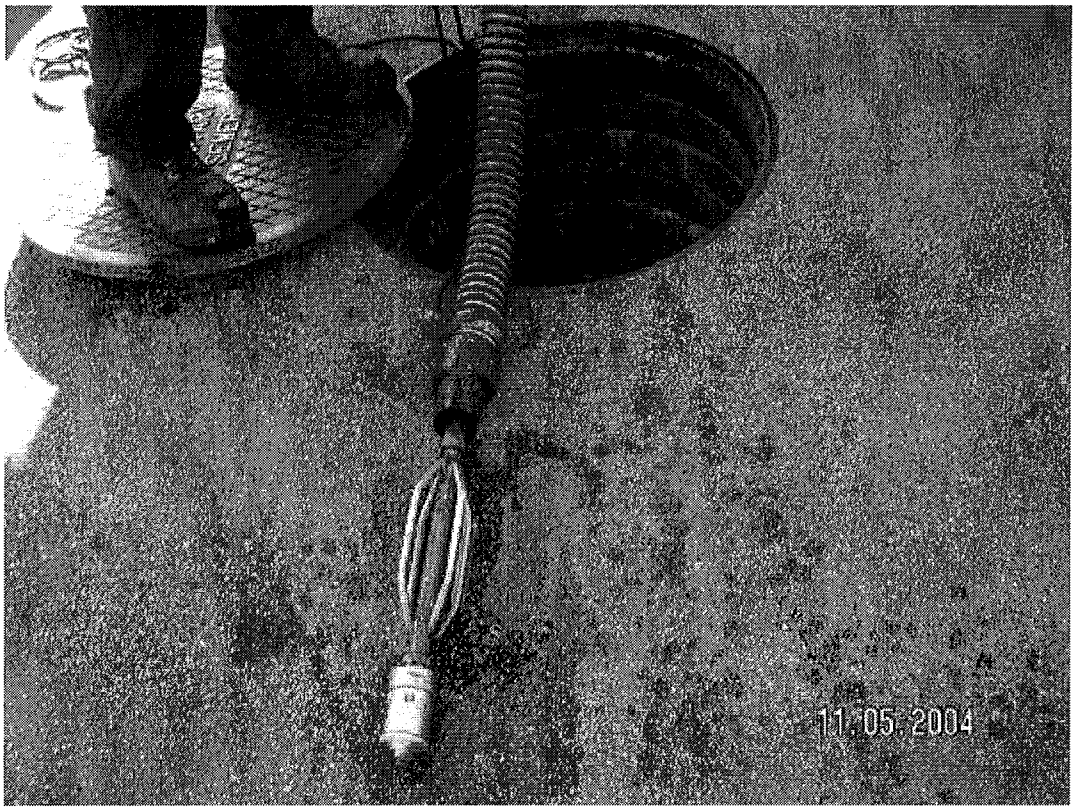


Photo 40: SAM - cleaning truck jet nozzle

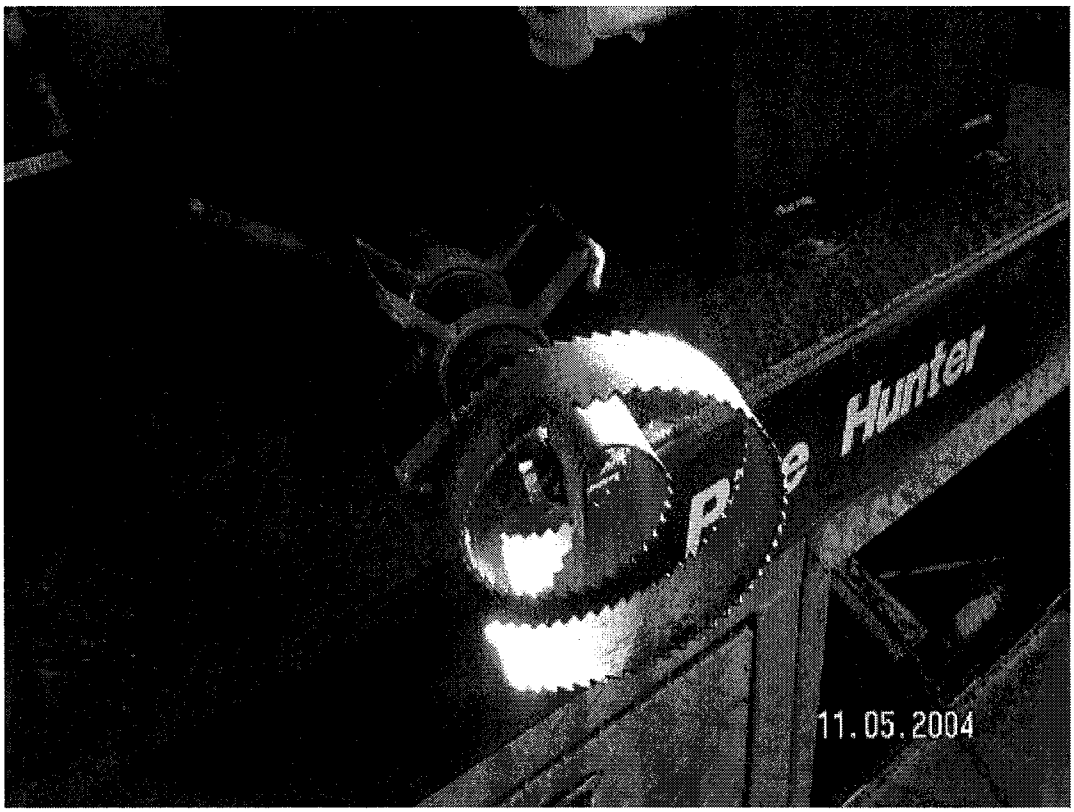


Photo 41: SAM - cleaning truck root cutting nozzle

Attachment 2
Sanitary Sewer Overflows During the Period 2000 through 2005

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
12/27/2005	161 Kelly	HMB	On to ground	No	5	Lateral			lateral
12/24/2005	Pembroke Court	HMB	Into storm drain	Yes	80	Roots			roots
12/23/2005	618 Alsace Lorraine	HMB	On to ground	No	2	Possible offset in lateral			lateral
11/22/2005	423 Francisco	GSD	On to ground	No	15	Roots			roots
11/19/2005	570 Vermont	MWSD	On to ground	No	75	Grease			grease
11/1/2005	506 Portola Ave	GSD	On to ground	No	50	Grease			grease
10/22/2005	1045 Tamarind	MWSD	Into Home	No	30	Roots			roots
10/16/2005	478 El Granada Blvd	GSD	On to ground	No	75	Roots			roots
9/29/2005	Ocean Colony	HMB	Golf Course Lake	Yes	750	Grease			grease
9/10/2005	906 Sevilla	GSD	On to ground	No	50	Rocks in Mainline			rocks
8/30/2005	La Piazza, Main Street	HMB	On to ground	No	90	Broken lateral			lateral
8/17/2005	4 Terrace	MWSD	On to ground	No	80	Grease			grease
7/24/2005	180 Los Banos	MWSD	On to ground	No	90	Roots			roots
7/23/2005	423 Francisco	GSD	On to ground	No	20	Roots			roots
7/13/2005	115 Los Banos	MWSD	On to ground	No	25	Broken forcemain			forcemain break
6/26/2005	Main Street	MWSD	On to ground	No	75	Grease			grease
6/21/2005	Corner of Beach and Park	MWSD	On to ground	No	5	Forcemain separation			forcemain break
5/18/2005	Corner of Miramar and Purisima	GSD	On to ground	No	100	Unknown			unk
5/12/2005	10th Fairway, Ocean Colony Golf Club	HMB	On to ground	No	50	Air release valve stuck open			equipment failure
5/2/2005	366 11th Street	MWSD	On to ground	No	10	Broken mainline			main break
4/12/2005	838 Ferdinand	GSD	On to ground	No	50	Broken mainline			main break

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
4/12/2005	160 Delores	GSD	On to ground	No	2	Roots			roots
3/13/2005	2nd Street	MWSD	On to ground	No	1,000	Roots			roots
2/23/2005	525 Metzgar	HMB	On to ground	No	20	Roots			roots
2/9/2005	Corner of Fir and Harte	MWSD	On to ground	No	900	Roots			roots
2/5/2005	211 San Mateo Rd	HMB	On to ground	No	20	Broken lateral			lateral
1/18/2005	146 Patrick Way	HMB	On to ground	No	10	Broken lateral			lateral
1/16/2005	146 Patrick Way	HMB	On to ground	No	10	Paper stoppage			debris
1/5/2005	861 Railroad	HMB	On to ground	No	1	Mud in lateral			lateral
12/27/2004	Date Harte Lift Station	MWSD	Montara Creek	Yes	2,410	Rain event			capacity
12/27/2004	Montara Pump Station	SAM	Pacific Ocean	Yes	83,970	Rain event			capacity
12/27/2004	Portola PS Magellan/Mirada and 560 Obispo Ave	SAM	Pacific Ocean	Yes	19,020	Rain event			capacity
11/3/2004	Ocean Colony Lift Station	HMB	Golf course pond	Yes	9,773	UPS failed, leaving controller and alarm system without power.			equipment failure
10/9/2004	Airport PS El Granada Mobile Home Park	MWSD	On to ground	No	400	Lift Station Failure. Suspected low voltage tripped both pumps. We have been unable to re-create the problem. The generator breaker was also tripped. While we could not re-create the problem with the generator breaker	Area mainline was thought to be plugged. When investigated, it was decided to check lift station. When lift station was found not operational, maintenance staff was called in. Electrical vender and San Mateo County Health Services official were called		equipment failure
9/18/2004	1107 Columbus	GSD			100	Roots And Offsets In Line	Rootsawed And Flushed Mainline	Mainline Has Numerous Offsets Advise CCTV To Determine Extant Of Defects	roots
9/16/2004	416 Granelli	HMB			15	Grease And Rags	Flushed Main And Broke Plug	Mainline Should Be Televised	comb

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
9/4/2004	762 Buena Vista	MWSD	On to ground	No	500	Plug In Main Line 200 ft Mostly Paper	Flushed Mainline 200 ft Finding Plug Consisting Of Paper (Possible Belly In Line) Told Homeowner To Contact One Of Sewer Cleanup Places / Then Call MSD TO Report Problem	Owner Contact Fire Dept First/Then They Went Thru County Com Approx 45mins Till Sam Got Called Sewage Visible Throughout Downstairs Of House Paper/Debris Sewerage Under house Also	debris
8/17/2004	Nurseryman's Exchange	GSD			100	Paper	Flushed Main		debris
8/6/2004	471 Francisco	GSD			30	Roots Possible Offset	Flushed Main 230ft Finding Roots, Snaked Service Line 16ft Finding Mud Possible Offset		roots
7/29/2004	Ocean Colony PS	HMB	On to ground	No	450	Force Main Cracked	Shut Off Pump At Ocean Colony Pump Station, Contracted With A-1Septic to Haul Waste Water From Pump Station, Andrini Bros. Excavated And Repaired the Force Main	Adv Paul Nag, Charlie Voos, With City HMB	pipe
6/5/2004	North End of Purissima St	HMB	On to ground	No	80	Grease	Flushed Mainline		grease
5/26/2004	50 Portola on Isabella	GSD			5	Paper	Flushed main		debris
3/19/2004	200 Sevella	GSD	On to ground	No	10	Possible Offsets	Flushed to clear. Lateral that overflowed on to lawn		pipe
3/12/2004	643 Isabella	GSD			30	Roots	Rootsawed main		roots
3/8/2004	130 11th Street	MWSD			30	Bucket in mainline	Flushed mainline Removed bucket		debris
3/7/2004	725 Johnston	HMB			50	Paper - Grease	Flushed main will return for clean up of main 3-8		comb
3/1/2004	11th Street	MWSD	On to ground	No	50	Roots	Flushed Mainline		roots
2/26/2004	1006 Birch	MWSD			5	Roots	Flushed mainline	Returned 2/27/04 - cleared roots from mainline	roots
2/18/2004	540 Lancaster Blvd.	MWSD	Into storm drain	Yes	1,000	Mainline plug that backed up into house	Flushed mainline and took pictures		unk
2/16/2004	4 greenbrier Court	HMB	On to ground	No	30	Roots in manhole and mainline.	Root saw main line and clean roots from manholes		roots
2/14/2004	1006 Birch Street	MWSD	On to ground	No	Unknown	Rags	Flush Main, break plug and clean up area.		debris
2/12/2004	214 De Monte	GSD			30	Roots in mainline	Flushed mainline removed root mass	SSO had stopped by the time we arrived will return 2-13 am to check	roots
1/24/2004	1020 Bancroft	HMB	On to ground	No	10	Grease	Flushed		grease

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
1/20/2004	Nurseryman's Exchange	GSD			50	Paper Solids	Flushed line 26-25		debris
12/30/2003	2651 N. Cabrillo Hwy.	GSD	On to ground	No	60	Solid build up due to excess flow in force main	Flushed line 26-25		debris
12/29/2003	Montara Pump/Storm Water Retention Station	SAM	Pacific Ocean	Yes	See additional Comments	Montara Pump station overflowed after filling Storm Water Retention Tank. The mid-Coastside area experienced heavy rain fall measuring 2.61" for the day as measured at the Sewer Authority Mid-Coastside Treatment Facility.	Monitored system to minimize overflow. Pumped to Portola pump station as much as possible without causing an overflow at the Portola site.	Originally estimated in the field at 120,000 gallons, revised to 80,000 gallons based on Carollo report dated January 22, 2004, further revised to 63,000 per Carollo report to Board of August 19, 2004; written report to be prepared by Carollo and distributed to reporting agencies.	capacity
12/27/2003	1006 Birch	MWSD	On to ground	No	10	Roots	Roots sawed mainline	Lamp hole needs to be raised in backyard at 1006 Birch. Mainline needs televised suspect offset-break in main.	roots
12/26/2003	338 Alameda Street	GSD	On to ground	No	10	Roots	Flushed Lateral and Main		roots
12/25/2003	Columbus and Isabella	GSD			5	Roots	Flushed Main - Washed down gutter		roots
12/24/2003	546 Isabella Road	GSD	pond	Yes	50	Mainline plug	Flushed mainline to stop the flow		unk
12/24/2003	Cypress	MWSD	On to ground	No	25	Main Line plug	Flushed main line to stop the flow		unk
12/24/2003	North side of Vallemar Street Cul-de-sac, Montara	SAM	storm drain to Pacific Ocean	Yes	10,000	Force main appurtenance malfunctioned, letting water escape from the system	Vactored manhole to uncover air release valve. Repaired force main appurtenance - replaced damaged parts		equipment failure
12/17/2003	570 Vermont, Montara	MWSD	On to ground	No	50	Grease Blockage	Flushed Main Line		grease
12/12/2003	Sunshine Valley Station	MWSD	On to ground	No	70	Roots grease in main line	Root sawed main line		comb
11/15/2003	Cedar	MWSD	On to ground	No	750	Roots in Mainline	Flushed mainline		roots
11/11/2003	Ave Cabrillo	GSD	On to ground	No	100	Roots in main line 200"	Flushed main line/debris		roots
11/10/2003	Main Street at Stone pine	HMB	storm drain to Pillarcitos Creek	Yes	300	Mainline Stoppage	Flush mainline to remove stoppage		unk
11/9/2003	720 Edison	MWSD	On to ground	No	10	Roots in Mainline 280'	Flushed mainline 280"		roots

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
11/8/2003	839 Columbus	GSD	On to ground	No	100	Roots/Mainline	Hose down area		roots
9/28/2003	Filbert Myrtle	HMB	On to ground	No	10	Roots, Grease, and rags	Flushed mainline 750'		comb
9/22/2003	466 El Granada Boulevard	GSD	On to ground	No	15	Roots in service at mainline	Flushed to clear	Copy to GSD	roots
9/2/2003	471 El Granada Boulevard	GSD	On to ground	No	500	Mainline Plug	Flushed the mainline		unk
9/1/2003	Main Street, Montara	MWSD	On to ground	No	1,000-2,000	Manhole overflow due to roots in main line. Wastewater escaped system and ran into open ditch storm drain. Storm drain went to Montara State Beach where wastewater soaked into sand at the end of drain area (about 50 yards from water's edge)...	Used different heads on flusher truck trying to clear blockage from both ends of main line. Finally got through with root saw to clear stoppage.		roots
8/13/2003	1191 Cedar	MWSD	On to ground	No	500	Heavy grease accumulation	roots/flush heavy greases overflow from c/o in front yard		grease
8/10/2003	612 Magnolia	HMB	On to ground	No	100	Grease rags causing under house flooding	root sawed line to remove grease rags		comb
8/2/2003	475 Virginia Avenue	MWSD	On to ground	No	50	Flush Main Line	Washed down back into manhole		unk
6/14/2003	Cypress	MWSD	On to ground	No	75	Roots	Flushed Main Line 40' Roots		roots
6/6/2003	150 Winkie Way, Moss Beach	MWSD	On to ground	No	10	Main line block probably roots and drop line in manhole	Flushed main and broke plug		roots
6/5/2003	1035 Tamarand	MWSD	On to ground	No	20	Roots	Flushed main line		roots
6/5/2003	223 Palma Street	GSD	On to ground	No	5	Paper	Snaked / Cleaned out		debris
6/1/2003	445 Oak Ave, Half Moon Bay	HMB	on to ground and Pilarcitos Creek	Yes	9,000+	Grease and debris blockage around B-132A caused an overflow from manhole B2-123 onto surrounding field and Pilarcitos Creek. Note: This line was flushed (maintained) approximately two weeks ago.	Relieved stoppage with hydro flusher.		grease
5/31/2003	178 Wienke Way, Moss Beach	MWSD	On to ground	No	3	Main Line plugged (grease)	Flushed main line and broke plug		grease
5/30/2003	604 Grove Street	HMB	On to ground	No	5	Main line plug (lot of grease)	Flushed main line and broke plug		grease

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
5/20/2003	807 Mill Street	HMB	On to ground	No	40	Mainline Plug	Flush Mainline and broke the plug		unk
4/23/2003	345 Ave Cabrillo	GSD	On to ground	No	10	Lateral and or Main Fail	Flushed the mainline and the lateral		pipe
4/20/2003	324 Main Street	HMB	Into Home	No	3,232	Line Collapse causing blockage at Mill & Church	Arrive on scene Fire and Police were already there. Found blockage ASAP and flushed with jetter to clear blockage	Sewage backed up into lower room at 324 Main. Tenant contacted Ideal clean up Co. to clean effected area. Also took pictures of effected area. Line was last cleaned in Feb 2002. No problem was apparent at that time.	pipe
4/19/2003	650 Isabella	GSD	On to ground	No	10	Paper-roots	Flushed mainline 100'		comb
3/21/2003	Buena Vista	MWSD	On to ground	No	80	Roots in main line	Flushed		roots
3/11/2003	2205 Carlos Street	MWSD	On to ground	No	20	County knocked off manhole . dropping in debris	Flushed main multiple times then realized the way this manhole ties into main line in not at all right	This manhole should be moved over so it ties into the main line correctly	debris
3/9/2003	455 El Granada Boulevard	GSD	On to ground	No	10	unknown	flush line to make sure clear, plug has broken itself		unk
2/27/2003	Princeton PS Princeton and WestPoint	SAM	Pacific Ocean	Yes	5,000	Pump station failure. Investigation revealed a bad local start/stop switch.	Restart pumps and replace failed start/stop switch		equipment failure
2/18/2003	Cabrillo	GSD	On to ground	No	20	Mainline plug	Flushed the mainline to clear the plug		unk
2/17/2003	960 Wave Avenue	MWSD	On to ground	No	10	Roots at main line	Flushed main line and pulled lot of roots		roots
2/15/2003	Chart House Lift Station	MWSD	Pacific Ocean	Yes	10,000-15,000	Control circuit tripped. No alarm received.	Reset circuit, pumped down station to halt overflow.		equipment failure
2/4/2003	Manhole @ Fairway Drive	HMB	Water Hazard/Pond	Yes	500	Mainline stoppage, grease	Hydro-flushed mainline		grease
1/26/2003	170 & 174 Wienke Way, Moss Beach	MWSD	Pacific Ocean via storm drain	Yes	500	Main line blockage due to roots and grease	Flushed main to clear blockage		comb
1/18/2003	265 Francisco	GSD	On to ground	No	10	Flushed to clear roots	No solids, rinsed grass		roots
1/11/2003	618 Alsace Lorraine	HMB	On to ground	No	10	Possible flat line	Picked up solids, Rinsed Are		pipe
12/19/2002	2002 Avignon Place	GSD	Into storm drain	Yes	50	Manhole Overflowing	None - No Debris		unk
12/19/2002	First/Grove	HMB	Into storm drain	Yes	500	Heavy rain/local flooding, main lines full	Check manholes down stream for problems		capacity

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
12/19/2002	Portola PS Magellan/Mirada	GSD	Pacific Ocean	Yes	5000-	Heavy rain. Portola Pump Station rapidly overwhelmed due to erratic pump controller while on generator power.	Pump down station in manual mode, open Montara diversion tank and rush in programmer to trouble shoot and repair controller code. Tested updated code multiple times (on generator), working well.		equipment failure
12/20/2002	Seal Cove 4 146 La Grade	MWSD	On to ground	No	100	Power failure, when PG&E restored power the controller in SC#4 did not reset and the station was overwhelmed by SC#3 pumping into it. The sewage was then directed into 146 Grand and the manhole across the street from the house	I Arrived and reset SC#4 to get it pumping again		equipment failure
12/14/2002	Ocean Colony PS Miramonte Point Road	HMB	Golf Course Pond and Pacific Ocean	Yes	1,000-10,000	Power loss, due to generator trip, at local lift station (Ocean Colony) resulted in no sewage pumping. Area believed to have experienced rapid back and forth PG&E failures. Generator has worked well since.	Did not witness any overflow in progress, but did see debris indicative of an overflow.		equipment failure
12/9/2002	416 Grove Street	HMB	On to ground	No	30	Flushed Mainline	Wash down Backyard Area		unk
11/24/2002	408 Casa Del Mar	HMB	On to ground	No	5	Offset/Paper	Snake Mainline 40"		debris
10/29/2002	515 Paloma Ave	GSD	On to ground	No	20	Mainline stoppage, dirt	Flushed mainline to relieve stoppage		debris
10/21/2002	Colony Club Golf Course	HMB	Pond near manhole	Yes	500	Manhole was overflowing into pond	Flushed mainline to clear blockage, grease was cause of blockage.		unk
9/3/2002	431 The Alameda	GSD	On to ground	No	20	Mainline Stoppage	Flushed mainline and lateral		unk
8/20/2002	1 Terrace Ave	MWSD	On to ground	No	50	Mainline stoppage	Flushed mainline		unk
8/15/2002	320 14th Street	MWSD	On to ground	No	20	Mainline stoppage	Hydro-flushed mainline		unk
8/13/2002	1 Terrace	MWSD			30				unk
7/2/2002	180 Los Banos	GSD	On to ground	No	10	Mainline stoppage, roots that looked like they were cut upstream and let down pipe	removed roots		roots

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
7/2/2002	Pilarcitos	HMB	Into storm drain (not into waterway)	Yes	150	Heavy Grease Accumulation	Root sawed grease to clear stoppage	over 100 gals in storm drain did not make water way due to dry conditions.	grease
7/1/2002	570 Vermont	MWSD	On to ground	No	50	Mainline stoppage, grease	Relieve stoppage with flusher truck		grease
6/14/2002	719 Johston Street between 725 and 719.	HMB	On to ground	No	10	Mainline Plug	Flushed mainline		unk
6/13/2002	523 Ave Alhambra	GSD	Into storm drain	Yes	50	Mainline stoppage, grease and grit	Hydro-flushed mainline	Input on 10/8/02. Paper report indicated that 50 gallons went into storm drain while responders were present and 50 gallons went onto the ground. Discussed with John Caughlin to determine if this should have been a reportable. If so, will report to RWQCB.	grease
5/14/2002	330 Sonora Ave	GSD	On to ground	No	50	Construction to mainline	Called Mike - With Woods Construction		const
4/28/2002	918 Columbus	GSD	On to ground	No	20	Root Stoppage	Root sawed line		roots
4/20/2002	213 Miramontes Ave	HMB	Into storm drain	Yes	500	Manhole overflow just below B1-121. Steady stream from manhole down both sides of the street and into the storm drains at Miramontes/ Valdez	Flushed line and broke through plug. Cleaned line		unk
4/19/2002	424 St. Joseph	HMB	Into storm drain	Yes	30	Manhole overflow, grease	Flushed main		grease
4/18/2002	Bloom Lane	HMB			50	Manhole overflow	Flushed main		unk
4/15/2002	Main	HMB			Unknown	Manhole overflow	Flushed main line		unk
4/14/2002	445 Oak Ave	HMB	Pillarcitos Creek	Yes	9,000+	Grease & Debris blockage around B3 - 132A caused an overflow from manhole B2-123 onto surrounding field and Pilarcitos Creek	Root sawed through grease plug using manhole through plug and past manhole. The above line was then flushed at high pressure using flusher truck		comb
4/13/2002	435 El Granada Blvd	GSD			100	Irrigation hose (5') and stick blocking line	Arrived with flusher truck, broke plug and removed obstruction with fork		debris
4/1/2002	751 1st Street	HMB			30	Main line stoppage	Root sawed main		unk
3/29/2002	676 Sierra	MWSD			50	Mainline stoppage	Flushed main		unk

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
3/25/2002	11th Street	MWSD			250	Main line stoppage, roots	Flushed main		roots
3/22/2002	Grand View Blvd.	HMB	On to ground	No	100	Manhole overflow, grease	Flushed manhole		grease
3/18/2002	1007 San Carlos	GSD			100	Lateral stoppage	Power snaked lateral, flushed main		lateral
3/5/2002	1123 Columbus	GSD			100	Main line stoppage, roots.	Flushed main		roots
2/28/2002	846 Columbus	GSD	On to ground	No	400	Lateral stoppage	Power snaked lateral		lateral
2/28/2002	Hwy 1 between 6th & 7th Streets	MWSD	On to ground	No	500	Main line stoppage	Flushed main		unk
2/27/2002	525 Kelly Avenue	HMB			25	Main line stoppage	Flushed main, grease		unk
2/23/2002	SW End of Cedar Street @ 1390	MWSD	Echo Creek	Yes	250	Grease accumulation cause by pump station operating at high level backing flow in to mainline causing grease and solids to block flow in mainline. Maintenance crew found large quantities of grit in wetwell.	Flushed to clear. Notified mechanic to address problem of wetwell operating at high level.		grease
2/26/2002	Chart House Lift Station	MWSD	On to ground, into creek	Yes	100,000	Staff discovered the Charthouse lift station over flowing. The station was found to have both motor starters tripped and had been overflowing since about 17:00 the evening before (2/19/2002) ***** SEE WRITTEN OVER FLOW REPORT - CHART HOUSE LIFT STATION	Immediately restart pumps (see description of event)		equipment failure
2/16/2002	411 Bayhill Road	HMB	Into storm drain	Yes	80	Manhole overflow, grease, defective trough	Flushed manhole		grease
2/8/2002	534 Grove	HMB			10	Main line stoppage	Flushed main		unk
1/18/2002	880 Lincoln	MWSD			25	Main line stoppage, plug	Flushed main		unk
12/18/2001	746 The Alameda	GSD	On to ground	No	20	Main line stoppage, roots and grease.	Power snaked lateral and flushed main.		comb
12/2/2001	Montara Pump Station, etc.	SAM	Pacific Ocean	Yes	Unknown	Rain related pump station overflow. Station pumped at full capacity and did well throughout the event	Monitored system for maximum through put		capacity

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
12/1/2001	Montara Pump Station, etc.	SAM	Pacific Ocean	Yes	Unknown	Rain related pump station overflow. Station pumped at full capacity and did well throughout the event	Monitored system for maximum throughput		capacity
11/28/2001	410 Valencia	GSD	On to ground	No	10	Mainline stoppage	Snaked lateral and flushed mainline		unk
11/1/2001	747 The Alameda	GSD	Into storm drain	Yes	50	Mainline Stoppage	Flushed mainline to dislodge stoppage		unk
10/22/2001	416 Grove St	HMB	On to ground	No	4,000 (1,000net)	Main line blockage causing service line to overflow into backyards	Flushed main line to clear blockage	Bonnie also responded to location. 2000 gallons picked up with slurry trailer, 1000 pack to system from channeling, 1000 soaked into ground.	unk
10/3/2001	200 block of Miramontes	HMB	Into storm drain	Yes	200	Mainline overflow, grease	Root sawed mainline to dislodge stoppage		grease
9/11/2001	301 Grove St	HMB	On to ground	No	20	Mainline stoppage	Flushed mainline		unk
9/11/2001	552 7th st	MWSD	On to ground	No	50	Mainline stoppage, Roots & Grease	Flushed mainline to dislodge stoppage		comb
9/10/2001	411 Bayhill Rd	HMB	On to ground	No	400	Mainline stoppage, grease	flushed to clear		grease
8/28/2001	Pilarcitos, North of Kehoe	HMB	Into storm drain	Yes	3,000	Mainline stoppage due to grease and flow metering equipment which fell into pipe/manhole	Dislodge stoppage and remove fallen equipment		debris
8/20/2001	557 Isabella	GSD	On to ground	No	25	Mainline stoppage, Roots	Flushed Mainline to dislodge stoppage		roots
8/18/2001	Pilarcitos. South of Kehoe	HMB	Storm drain/Grou nd	Yes	1,000	Sewer stoppage in difficult access area	Flush lines from opposite directions to dislodge stoppage	Thought to be less than 1000 gallons but later decided that it may be marginal and to report.	unk
8/12/2001	154 Madrona	GSD	On to ground	No	50	Mainline or lateral stoppage (unsure)	Flushed mainline and snaked lateral		unk
7/30/2001	462 Portola	GSD	On to ground	No	800	Mainline stoppage, Roots	Flushed mainline to dislodge stoppage		roots
7/18/2001	San Pablo PS	GSD	On to ground	No	3,000	Force main cracked at joint	Used vactor trailer to capture all leakage until vactor truck arrived to enable lift station shut down. Captured roughly 1500 gallons of total spill		pipe
6/22/2001	2936 Alameda	GSD	On to ground	No	250	Mainline stoppage, grease	Flushed mainline		grease
6/16/2001	Nevada	MWSD	On to ground	No	50	Mainline stoppage, grease	Flushed mainline to dislodge stoppage		grease
6/11/2001		MWSD				lateral plug/mainline partial plug	flushed mainline 300' - grease, septic sewage	mainline appears to have a belly and grease problem.	unk

Attachment 2
SSOs Reported by SAM
1/2000 - 12/2005

Date	Location Of Overflow	District/ Owner	Receiving Waters	Into Waterway ?	VolumeOf Overflow	Description Of Event	Description Of Response	AdditionalComments	Cause
6/9/2001	Pillar Point RV Park	GSD		No		Grease caused SSO	Root saw mainline. Police, Fire, Harbor Dist and Fish & Game were on site. Environmental Health came out and said it looked ok.		grease
5/19/2001	Francis State Beach	HMB				Outfall relief valve foaming over	hose down area		equipment failure
4/29/2001	273 6th Street	MWSD					flushed main line	flushed main - no problem.	unk
4/18/2001	#1 Fairway area of Golf course	HMB	On to ground	No	25	Mainline stoppage	Upon arrival mainline was flowing fine. Plug cleared itself.		unk
3/27/2001	250 Grove St	HMB	drainage ditch	Yes	2,000	Lateral overflow backyard. Plugged mainline (roots/grease)	flushed mainline		comb
3/8/2001	18 Arnold Way	HMB	On to ground	No					unk
3/4/2001	Ocean Colony Lift Station, Fairway Drive, HMB	HMB	Pacific Ocean	Yes	3,700	Pumps at lift station tripped out on overload and alarm company failed to notify personnel on call when alarm occurred.	Reset station and pumped station down, checked for solids and paper in area of overflow.		equipment failure
3/1/2001	Valdez @ Railroad	HMB	Into storm drain	Yes	300	Mainline stoppage due to stick in manhole	Relieve stoppage		debris
2/19/2001	546 Isabella	GSD	Into storm drain	Yes	2,200	Mainline plugged with roots overflowed from c/o. Running downhill to storm drain.	Root sawed to clear stoppage		roots
1/29/2001	120 San Pedro	GSD	On to ground	No	50	Water bubbling out of cleanout in backyard	Flushed mainline		unk
1/20/2001	736 Pilarcitos	HMB	On to ground	No	1,000	main line blockage, grease	flushed main line eto clear blockage		grease
1/13/2001	466 El Granada Blvd	GSD	On to ground	No	800	Mainline stoppage, Roots	Rootsaw and flush mainline		roots
1/6/2001	521 A The Alemeda	GSD	On to ground	No	Unknown	Mainline stoppage - Roots	Dislodge stoppage with flusher truck		roots
1/6/2001	Plaza Alhambra/Avenue Alhambra	GSD	Into storm drain	Yes	100	Rush of water from higher manhole that was plugged dislodged some grease and roots and temporarily plugged line.	Cleaned up area, picked up solids and washed area down. Broke up grease and pulled out roots.		grease
12/27/2000	Greenbriar	HMB	Pond	Yes	2,000	Mainline stoppage	Flushed to dislodge stoppage		unk
12/23/2000	270 Francisco	GSD	On to ground	No	10	Mainline stoppage - Roots	Snake Lateral sewer to dislodge stoppage		roots
12/1/2000	522 Columbus	GSD	On to ground	No	200	Cleanout overflow	Root sawed mainline		unk

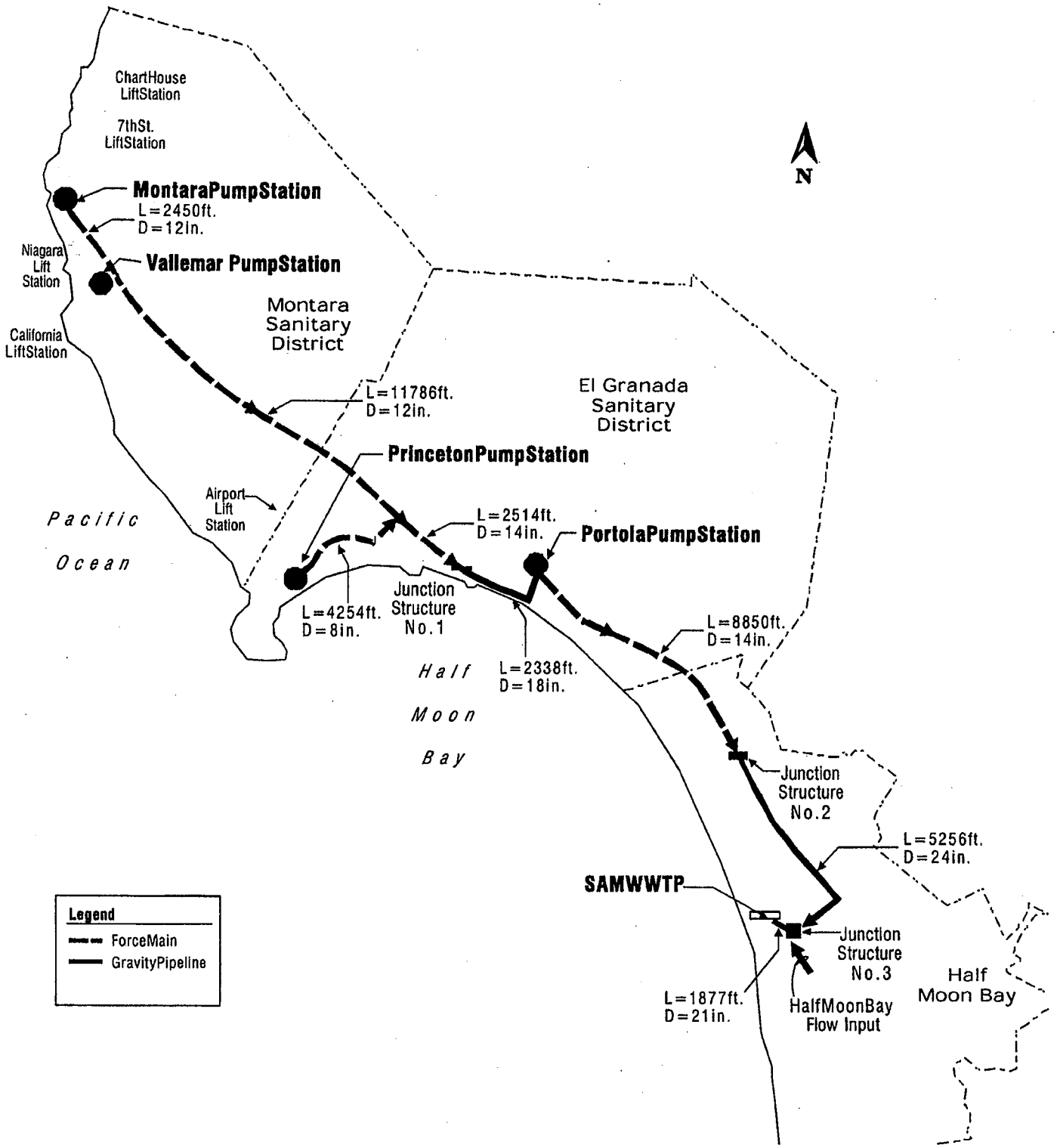
Attachment 3
Pump Stations Characteristics

Attachment 3
Pump Station Details

Station	Owner	Storage Time	No. Pumps	Standby Power	Notes
Bell Moon Lift Station	HMB		2	No	Serves carwash, businesses, 1 house
Ocean Colony Lift Station	HMB		2	Yes	Has 2 wetwells
Pelican Point Lift Station	HMB		2	Yes	Serves mobile home and trailer parks
San Pablo Lift Station	GSD		2	Yes	
Airport Lift Station	MWSD	3 hours	2	Yes	
California Lift Station	MWSD	Very limited	2	Temporary	
Chart House Lift Station	MWSD	Has overflow tank	2	Yes	
Date Harte Lift Station	MWSD	Limited	2	Yes	
Distillery Lift Station	MWSD		2	No	Serves restaurant and 2 houses
Fifth Street Lift Station	MWSD	24 hours	2	No	Serves 3 houses
Niagara Lift Station	MWSD		2	Yes	Standby power from Montara PS
Seal Cove 1 Lift Station	MWSD		2	No	
Seal Cove 2 Lift Station	MWSD		2	No	
Seal Cove 3 Lift Station	MWSD		2	No	
Seal Cove 4 Lift Station	MWSD		2	No	
Seventh Street Lift Station	MWSD		2	No	Serves 6 houses
Vallemar Lift Station	MWSD	Very limited	2	Yes	
Montara Pump Station	SAM	Has overflow tank	2	Yes	
Portola Pump Station	SAM		4	Yes	Has surge tank
Princeton Pump Station	SAM		2	Yes	

Information from SAM's "Operations Manual for the Wastewater Pump Stations and Storage System"

Attachment 4
Map Showing Intertie Pipeline



SEWER AUTHORITYMID-COASTSIDE(SAM)

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Submarine discharge of nutrient-enriched fresh groundwater at Stinson Beach, California is enhanced during neap tides

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Abstract

The influence of fortnightly spring–neap tidal variability on submarine discharge of fresh and saline groundwater was examined at Stinson Beach, California. Stinson Beach is a residential community that utilizes on-site systems for wastewater disposal. Fresh, shallow groundwater at the site contains high concentrations of nutrients (dissolved inorganic nitrogen [DIN], soluble reactive phosphate [SRP], and silicate) and human fecal bacteria. A groundwater-derived freshening and nutrification of the surf zone during neap tides was observed, followed by a 4-d increase in chlorophyll *a* concentrations. Analytical models and a freshwater budget in the surf zone were used to estimate the saline and fresh discharge of submarine groundwater. We estimate fresh groundwater discharge between 1.2 and 4.7 L min^{-1} m^{-1} shoreline during neap tides compared with 0.1 and 0.5 L min^{-1} m^{-1} during spring tides. This compares with 15.9 and 22.0 L min^{-1} m^{-1} saline groundwater discharge (forced by waves and tides) during neap and spring tides, respectively. Despite the smaller total (fresh + saline) flux of groundwater during neap compared with spring tides, the larger fresh discharge component during neap tides raises surf zone silicate, DIN, and SRP by 14%, 35%, and 27%, respectively, relative to spring tides. This observed fortnightly pulsing of fresh groundwater-derived nutrients was consistent with seaward hydraulic gradients across the fresh part of the beach aquifer, which varied due to aquifer overheight near the beach face. Darcy–Dupuit estimates of seaward fresh groundwater flow in this area agreed well with the fresh discharge results of the mass balance.

Submarine groundwater discharge (SGD), defined as fresh and saline groundwaters discharging along the coastline at the land–sea interface (Burnett et al. 2006), can contribute nutrients, metals, pollutants, and freshwater to the coastal environment (Johannes 1980; Bone et al. 2007). Driving forces of SGD include meteoric hydraulic head, tide and wave pumping, seasonal evapotranspiration cycles (Michael et al. 2005), and variations in groundwater density. Additional factors influencing the timing and magnitude of SGD include regional geology, climate, and human activities along the coast such as groundwater pumping and artificial recharge. The importance of combinations of factors controlling SGD vary from site to site, and site-specific studies are often required to fully understand SGD in a given region. Although a large body of literature has documented the existence and variability of SGD along the world's coastlines (Taniguchi et al. 2002), we are still working to understand the many factors that influence and modulate discharge rates.

Human activities along coasts can influence the quality of SGD (Kroeger et al. 2006). Nutrients emanating from fertilizers applied to residential lawns or agricultural fields may percolate through the vadose zone and increase concentrations in surficial aquifers (Valiela et al. 1992). In some coastal regions, households utilize cesspools or septic systems with leach fields for sewage disposal. These practices can recharge surficial aquifers with freshwater contaminated with pathogens, pharmaceuticals, nitrogen, and phosphorous (Robertson et al. 1991; Scandura and Sobsey 1997; Swartz et al. 2006). Several studies have investigated SGD in areas where on-site wastewater treatment is prevalent and have shown that SGD can contribute substantial nutrient loads to coastal waters (Giblin and Gaines 1990; Lapointe et al. 1990; Weiskel and Howes 1991). To protect human and ecosystem health, it remains important to continually improve our understanding of the magnitude and timing of SGD in areas where septic systems are used for wastewater disposal.

A limited number of studies have documented the importance of spring–neap tides on total SGD (Kim and Hwang 2002; Taniguchi 2002; Boehm et al. 2004) but not on the fresh component of SGD specifically. A single study (Campbell and Bate 1999) has examined fortnightly variations in fresh SGD. The present study explores the influence of the fortnightly spring–neap tidal cycle on submarine discharge of fresh groundwater from an unconfined, septic effluent-affected coastal aquifer in

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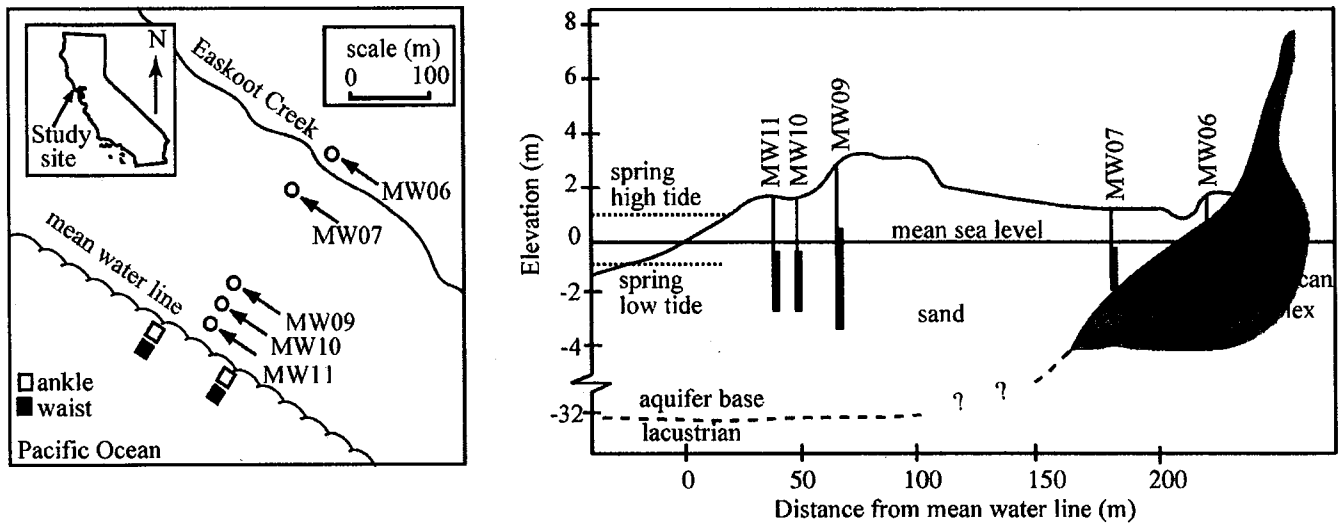


Fig. 1. Map of study area (left) and regional hydrogeology (right). Question marks in right panel indicate that contacts between geologic units in this region are uncertain.

Central California. Using a multifaceted approach that couples analytical models, hydraulic head measurements, and a nearshore freshwater budget, we document a neap tide pulsing of fresh, nutrient-enriched SGD. We link this enhanced neap tide discharge to fortnightly changes in seaward hydraulic gradient across the aquifer induced by aquifer overheight—the buildup or mounding of the water table near the land–sea interface as a result of tidal variation, wave setup, and wave run-up (Nielsen 1990; Turner et al. 1997; Horn 2006)—near the beach face. Using field data and a controlled mesocosm experiment, we explore the potential role of nutrient-enriched groundwater in causing increases of chlorophyll *a* (Chl *a*) in the coastal ocean at the site.

Methods and materials

Study site—Fieldwork was conducted from 14 through 28 July 2006 to characterize SGD from the unconfined aquifer over a spring–neap cycle at Stinson Beach, a small residential community 30 km north of San Francisco, California (37°53′58.387″N, 122°38′45.384″W, Fig. 1). The beach is an open-ocean, southwest-facing, reflective beach with mixed semidiurnal tides, a spring tide range of 2.4 m, typical breaker heights of 0.5–1.5 m, and a high energy surf zone. During the study, neap tide (17 July) preceded the spring tide (24 July).

The climate is Mediterranean with 60 to 120 cm of annual average rainfall occurring predominately between October and April (SBCWD 1998). During the dry season, Bolinas Lagoon (37°54′24.811″N, 122°40′54.732″W), a tidally influenced lagoon, and Webb Creek (37°53′7.332″N, 122°37′43.392″W), a nearby freshwater stream, are the only potential sources of fresh surface water to the nearshore marine environment within 7 km of Stinson Beach. There had been no precipitation in the watershed for approximately 2 months at the onset of the study, and no rainfall occurred during the study (data not shown). Easkoot Creek, a seasonal groundwater-fed creek, runs parallel to the shoreline through the field site approximately 200 m from the shoreline (Fig. 1). The creek discharges to Bolinas Lagoon and contains very little freshwater during the dry season.

Human development occupies 5% of the 29.3 km² Stinson Beach watershed and is primarily contained within 100 m of the coastline (geographic information system analysis not shown). Households use on-site septic systems and holding tanks exclusively for wastewater disposal. The areal density of standard gravity leach fields in the study area is approximately one leach field per 650 m² (SBCWD 1998).

The unconfined aquifer in the experimental area is composed primarily of beach and dune sands (Fig. 1, SBCWD 1998). At the beachhead, the sands are underlain by lacustrian clay at a depth of approximately 32 m below mean sea level (MSL) (Bergquist 1978). The unit overlies the Franciscan Complex, an assemblage of highly fractured sandstone, limestone, and shale (SBCWD 1998).

In systems with a high-energy surf zone, such as Stinson Beach, direct measurement of discharge with seepage meters is not possible (Libelo and MacIntyre 1994; Burnett et al. 2006). Breaking waves dislodge seepage meters and strong currents can induce flow through the seabed when passing over the objects (Huettel et al. 1996). This presents a unique challenge in the measurement of SGD in high-surf areas, and may explain the paucity of studies conducted on high-energy, open ocean coastlines in California and elsewhere. At Stinson Beach, we estimate SGD by combining three indirect methods: measurements of hydraulic head and Darcy–Dupuit calculations, a freshwater budget in the surf zone, and analytical models.

Hydraulic head measurements—Three permanent long-screen monitoring wells (MW06, MW07, and MW09) and two temporary piezometers (MW10 and MW11) were installed into the beach to create a cross-shore array (Fig. 1). Well construction details are shown in Table 1.

Table 1. Well construction details for the wells used in the study. Elevations are given in meters above mean sea level. Distances are given in meters from the mean water line.

Well ID	Diameter (cm)	Distance from mean water line (m)	Top of casing elevation (m)	Top of screen elevation (m)	Bottom of screen elevation (m)
MW06	10.16	223	1.46	−3.11	−4.63
MW07	10.16	178	1.36	−0.16	−1.69
MW09	10.16	70	3.10	0.05	−3.00
MW10	3.81	48	2.13	−0.92	−1.38
MW11	3.81	36	2.07	−1.13	−1.58

Beach topography and well elevations were surveyed relative to MSL. Measurements of hydraulic head were recorded in each well at 1-min intervals using pressure transducers (Solinst). The <1% of head measurements known to be misrepresentative of true aquifer conditions (hydraulic recovery after well installation and sampling) were removed and estimated by interpolation. All head measurements presented herein are presented as equivalent freshwater head. In the fresh part of the aquifer where hydraulic gradients are shallow (MW06 to MW09), the Dupuit assumptions are made. Namely, we assume that the hydraulic gradient is equal to the slope of the water table, and streamlines are horizontal and equipotential lines are vertical (Fetter 2001). Fortnightly average hydraulic heads at each well were calculated from head measurements collected during the entire experiment. Neap- and spring-tide head measurements were calculated by averaging measurements taken during the lunar day following the quarter (17 July) and new (24 July) moons, respectively.

Water sampling—At the low-low and high-high tide approximately every other day (n = 42 and 32, respectively), surf zone samples were collected at ankle and waist depths (0.2 and 0.7 m, respectively) along two cross-shore transects extending from the water line out into the surf zone adjacent to the well network (Fig. 1). Transects were approximately 100 m apart in the alongshore direction. At low-low tides only, the groundwater immediately adjacent to the water line was characterized by sampling from shallow pits dug into the beach approximately 10 m back from the water line (n = 19). In addition, subaerial seepage faces were sampled when they developed at the lowest tides (n = 17). Groundwater was sampled from the five wells approximately every 7 d ($2 \leq n \leq 5$ for each well). Surface offshore ocean water samples were obtained 180 m, 870 m, and 1,615 m from the shore in a cross-shore transect from our sampling site on the days of the third-quarter and new moons (n = 2 for each offshore location). The ebb flow from Bolinas Lagoon was sampled approximately every 4 d (n = 4). In all cases, clean, triple-rinsed 20-liter collapsible low-density polyethylene containers were used for water collection. A total of 100 liters for ocean and lagoon samples and 20–80 liters for groundwater samples were composited. A 1-liter subsample from large-volume samples was collected in clean triple-rinsed bottles and used for all chemical and biological analyses.

Tide elevation measurements were obtained from a National Oceanic and Atmospheric Administration tide gage at Point Reyes, approximately 30 km from Stinson Beach (http://tidesandcurrents.noaa.gov, Sta. ID 9415020, 37°59′48.12″N, 122°58′30″W). Data were recorded at 6-min intervals. Daily tidal range was calculated from daily maxima and minima.

Sand analysis for hydraulic conductivity (K_h) determination—A 2-m continuous core was collected near MW09, homogenized, and analyzed for grain size distribution using American Society for Testing and Materials standard C136. Hydraulic conductivity (K_h) was estimated from grain size distribution using the method of Hazen (1911).

Salinity, dissolved oxygen, and nutrient analysis—Salinity and dissolved oxygen were measured in situ using a hand-held probe (Hydrolab). Salinity is reported according to the unitless Practical Salinity Scale and is accurate to ±0.01. A 30-mL aliquot of each sample was filtered with 0.45-μm pore size filter and stored at −20°C for nutrient analyses. The concentrations of soluble reactive phosphate (SRP), silicate, nitrate, nitrite, and ammonia were measured by standard methods with a nutrient autoanalyzer (Lachat QuikChem 8000). Samples were diluted as necessary to be within the machine's detection limits for each nutrient. Concentrations reported herein reflect both the required sample dilution and the precision of the analytical method. Dissolved inorganic nitrogen (DIN) was determined by adding molar concentrations of nitrogen species. Five percent of nutrient samples were analyzed in duplicate.

Chlorophyll a analysis—Waist-deep seawater samples were analyzed in duplicate for chlorophyll *a* using a modified version of Environmental Protection Agency (EPA) method 445.0 (Arar and Collins 1997). Samples were filtered immediately after collection through Whatman GF/F glass filters and stored at −80°C. Samples were analyzed approximately 7 months after collection, longer than the EPA-suggested holding time of 3 weeks. We assume that negative effects related to holding time are distributed equally across all samples, allowing intrastudy comparison. During analysis, filters were added to 10 mL of 90% acetone in water, shaken vigorously for 60 s, and steeped at 4°C for 18 to 24 h. Samples were then centrifuged and the supernatant was analyzed on a fluorometer (Turner Designs), acidified, and reanalyzed, as specified in the EPA method. The precision, on the basis of analysis of duplicates, is 5%.

Mesocosm experiments—Experiments were conducted to assess whether the addition of fresh groundwater to seawater promoted increases in Chl *a*. Stinson Beach seawater, collected from within the surf zone, was filtered through a 250-μm sieve to remove large zooplankton grazers (Pederson and Borum 1996). Groundwater from MW09 was 0.2 μm filtered to remove particulates. Filtered groundwater was added to sieved seawater to final concentrations (v/v) of 0%, 4%, and 8%. Mesocosms were run in duplicate in 3.5-liter clear plastic bottles. Bottles

were spaced evenly under constant fluorescent light with illuminance 200 lm m^{-2} and incubated at 15°C for 2 d. Samples were collected and analyzed every 4 to 8 h via EPA method 445.0 for in vivo fluorescence. A subset of samples was also analyzed for in vitro Chl *a* by the same method. A best-fit curve was used to estimate the concentrations of Chl *a* from in vivo fluorescence for those samples for which only fluorescence had been measured. No more than 10% of bottle volumes was removed over the course of the experiment. Data collected on the final day of the experiment were averaged for determining final Chl *a* concentrations.

Fecal indicator bacteria analysis—Water samples were analyzed for fecal indicator bacteria to determine the degree of contamination by human waste. Fifty milliliters of each sample were collected in a sterile container, and immediately stored on ice. *Escherichia coli* (EC) and enterococci (ENT) were quantified from 10 mL of water diluted with 90 mL of Butterfield buffer (Weber Scientific) using Colilert-24 and Enterolert (IDEXX), respectively, within 6 h of collection. Tests were implemented in a 97-well format following manufacturer's direction and allowed for the detection of EC and ENT concentrations between 10 and 24,192 most probable number (MPN) $(100\ mL)^{-1}$. Note that the units MPN $(100\ mL)^{-1}$ are the standard units for reporting indicator bacteria concentrations in water. No duplicate samples were analyzed.

*Enterococcal surface protein (*esp*) gene analysis*—A subset of ENT-positive samples was analyzed for the *esp* gene, a putative human-specific marker in ENT (Scott et al. 2005). Media from positive IDEXX wells was removed using a 21 1/2 gauge needle and syringe, and pooled for each sample. One milliliter of pooled media was enriched in tryptic soy broth for 4 to 6 h at 41°C. DNAs were extracted from a 1-mL aliquot of enrichment media using QIAamp DNA Mini Kit (Qiagen). Polymerase chain reactions (PCRs) containing 3 μL of template were run using the conditions, primers, and buffers described by Scott et al. (2005), except we used Platinum Taq (Invitrogen). PCR products were run on a 1.5% agarose gel and stained with SYBR Gold (Invitrogen). Positive and negative PCR and extraction controls were run in conjunction with unknowns.

Data analysis—Pearson correlation coefficients (r_p) between measured parameters were determined using SPSS. Groups of data were compared using Student's *t*-test. Correlations were deemed significant if $p < 0.05$.

Flux calculations—Total SGD (D) can be expressed as $D = D_t + D_w + D_m + D_s + D_d$ (modified from Li et al. 1999) where D_t and D_w represent saline outflow from tidal- and wave-driven circulation of seawater through the beach aquifer, respectively, D_m represents SGD of meteoric and artificially recharged fresh groundwater, D_s represents saline SGD forced by the seasonal recharge–evapotranspiration cycle (Michael et al. 2005), and D_d represents the outflow of density-driven saline waters. We will not consider contributions from D_s or D_d in our estimates for D, and the reasons for and implications of these omissions will be discussed.

The outflow seepage rate driven by wave setup per unit alongshore distance, D_w, can be expressed as follows (Longuet-Higgins 1983):

$$D_w = K_h S_w L \tag{1}$$

where K_h is hydraulic conductivity of the beach aquifer media, S_w is the slope of the wave setup, and L is the surf zone width defined as the distance between the breaker line and the wave run-up line. Expressions for S_w and L can be calculated from the local oceanographic and geologic conditions including breaker height H_b, beach slope S_b, and wave period T_w (Li et al. 1999).

Li et. al. (1999) used Nielsen's solution predicting the height of the water table with time in response to tidal forcing to estimate the tidally driven groundwater outflow seepage rate per alongshore distance (D_t). The resulting discharge rate is tidally averaged, implies quasi-steady-state conditions, and should be viewed as a first-order approximation. Following Nielsen (1990, eq. 31) and Li et. al. (1999),

$$D_t = \frac{n_e A}{\kappa T_t}\exp(-\alpha)(\cos(\alpha) - \sin(\alpha)) + \frac{\sqrt{2} n_e A^2}{s_b T_t}\exp\left(-\sqrt{2}\alpha\right)\cos\left(\sqrt{2}\alpha\right) + \frac{n_e A^2}{s_b T_t} \tag{2a}$$

with

$$\kappa = \sqrt{\frac{n_e \omega}{2K_h H}} \tag{2b}$$

and

$$\alpha = \frac{\kappa A}{s_b} \tag{2c}$$

In Eq. 2a–c, A corresponds to the tidal amplitude, T_t the tidal period, ω the tidal frequency, n_e the effective porosity of the beach sand, and H the aquifer thickness.

Input parameters required for calculating D_w and D_t at our study site are as follows. Beach slope was calculated from surveyed beach topography ($s_b = 0.0378$). Tidal amplitude (A) was set to 0.80 m and 1.12 m for neap and spring tides, respectively. The tidal period ($T_t = 12.42$ h) and frequency ($\omega = 1.41 \times 10^{-4}$ rad s^{-1}) of the M_2 harmonic were used. During the study, the period of the dominant swell (T_w) was 9.6 s (http://cdip.ucsd.edu, Sta. ID 029). Breaking wave heights (H_b) were approximately constant during the study and estimated to be 0.8 m from observations in the field. Porosity was estimated to be 0.4 by displacement of a known volume of sediment in water in a volumetric flask; all porosity was assumed to be effective porosity (n_e). The hydraulic conductivity (K_h) of the sand was measured in the lab with aquifer material and determined to be 3.85×10^{-4} m s^{-1}, as described earlier.

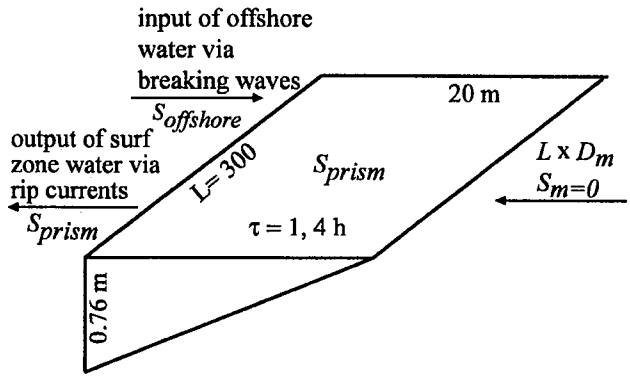


Fig. 2. Surf zone prism used as a control volume for the freshwater budget. Variables are defined in the text.

The unconfined aquifer thickness H was estimated to be 34 m from cores collected in the area, with an aquifer base approximately 32 m below sea level (Bergquist 1978; SBCWD 1998).

A mass balance was applied to the surf zone to calculate D_m at neap and spring tides using salinity as a tracer (Fig. 2). The surf zone adjacent to the well network was treated as a triangular prism with alongshore length (L) 300 m (typical distance between rip currents) and a right triangular cross-shore section of width 20 m (distance from shoreline to just beyond breakers) and offshore depth $20s_b$ (0.76 m). The salinity in the prism (S_{prism}) was determined for neap and spring tides by averaging all surf zone samples collected during the two lunar days before and after the quarter and new moons, respectively (two transects, both ankle and waist measurements, $n = 16$ and $n = 32$ for neap and spring tide, respectively). Although salinity measurements did not extend past 10 m in the offshore direction, surf zones are typically well mixed (Inman et al. 1971), so the calculated average salinity applied to the entire 20-m-wide prism. Water samples collected at 1,615 m offshore on the days of the third-quarter and new moons, which were the most saline and also the furthest from shore, were chosen as the offshore end member salinities ($S_{offshore}$). A salinity of 0 was assigned to the fresh groundwater end member. The following equation was used to estimate D_m per unit length of shoreline:

$$D_m = \frac{(S_{offshore} - S_{prism})V_{prism}}{S_{offshore}L\tau} \quad (3)$$

where D_m is meteoric water flux in units of volume per time per unit length of beach, τ is the cross-shore residence time of water in the rip cell, L is the length of the shoreline of the prism (a single rip cell), V_{prism} is the volume of the prism, and S_{prism} and $S_{offshore}$ were defined previously. Following Boehm et al. (2004), we estimate the cross-shore residence time of water in a rip cell to be 1 to 4 h. Equation 3 assumes that D_m is small compared with the input of offshore waters into the surf zone via breaking waves (Fig. 2), and thus does not affect the water balance.

Estimation of fresh groundwater discharge across the land–sea interface is complicated by variations in fluid density, the existence of a seepage face, and the effects of tidal pumping. Our monitoring network is not as dense as would be needed for direct, accurate calculation of fresh and saline groundwater flux through the interface using Darcy's law. However, insight into the rate of fresh groundwater flow toward the land–sea interface, and thus the potential variation in freshwater discharge to the sea between neap and spring tides, can be provided by calculating groundwater flow through a landward section of unconfined aquifer using Darcy's law and the Dupuit assumptions (given previously), which are combined in the Dupuit equation (Fetter 2001):

$$Q' = -\frac{1}{2}K_h\left(\frac{h_1^2 - h_2^2}{Y}\right) \quad (4)$$

In Eq. 4, Q' is the flow per unit length of shoreline, K_h has been defined previously, and h_1 and h_2 are the saturated thicknesses at a distance Y apart. Flow was calculated between MW07 and MW09, the two furthest inland monitoring wells in the network installed in the unconfined aquifer, which are 178 and 70 m from the mean water line, respectively. The nature of the boundary between the unconfined aquifer and the highly fractured Franciscan Complex basement rock is uncertain, and for the purpose of this estimate we assume that the lacustrian clay at 32 m below MSL extends underneath the unconfined aquifer through this area, and that groundwater is fresh throughout the section. The flow through the landward part of the aquifer may not be exactly equal to D_m. Rather, since short-period (diurnal) tidal effects on head are small at MW07 and MW09 relative to effects of long-period (fortnightly) tides (data not shown), this flow rate can be thought of as the fresh groundwater entering the tidally pumped zone where density effects and vertical flow become important. It can also be considered a check on the mass balance-based estimates of D_m.

The "potential flux" (F_p) of nutrients to the surf zone via SGD was calculated as follows:

$$F_p = C_{fresh}D_m + C_{sal}(D_t + D_w) \quad (5)$$

where C_{fresh} and C_{sal} represent the end-member constituent concentrations in fresh and saline groundwaters, respectively. C_{fresh} and C_{sal} were estimated with mixing diagrams of salinity vs. nutrient for all groundwater samples (wells, pits, and subaerial seeps, $n = 55$), which were fit with a linear regression. The regression equation was extrapolated to fresh (0) and average offshore marine salinity (32.12) to determine C_{fresh} and C_{sal}, respectively. Multiplying groundwater end-member concentrations by SGD rates, as in Eq. 5, is a common method for estimating nutrient fluxes to the coastal ocean via SGD (Charette et al. 2001; Hwang et al. 2005*b*; Hays and Ullman 2007). However, the method assumes that the nutrient of interest behaves conservatively as it travels through the subsurface from aquifer to sea. In fact, sorption of SRP in groundwater systems is common (Slomp and Van Cappellen 2004) and the potential for nitrification and denitrification in the subterranean estuary has been demonstrated (Santoro et al. 2006, 2008). Therefore, Eq. 5 should be considered a first-order approximation of the true flux of nutrients.

Table 2. Arithmetic means for chemical concentrations and log-transformed bacterial concentrations in MPN (100 mL)$^{-1}$ for sample groups. Ninety-five percent confidence intervals are given in parentheses. For bacterial calculations, samples below the detection limit of 10 MPN (100 mL)$^{-1}$ were substituted with 5 MPN (100 mL)$^{-1}$. The *esp* gene column indicates how many of analyzed samples were positive.

Sample group	*n*	Salinity (-)	DO (mg L^{-1})	SRP (μmol L^{-1})	Silicate (μmol L^{-1})	log EC	log ENT	*esp* gene
MW06	4	0.22 (0.00)	4.1 (0.6)	0.7 (0.0)	409 (31)	0.7 (0)	0.7 (0)	-
MW07	4	0.97 (0.30)	1.5 (0.3)	9.2 (4.0)	447 (50)	4.38 (0)	4.38 (0)	2 of 4
MW09	6	3.44 (3.87)	2.5 (0.9)	18 (3)	436 (29)	3.48 (0.74)	2.29 (0.91)	-
MW10 & MW11	5	11.86 (5.84)	3.0 (0.2)	16 (17)	230 (77)	1.45 (0.49)	1.19 (0.69)	-
Pits	19	31.75 (0.24)	3.4 (0.2)	2.8 (0.1)	141 (8)	0.82 (0.09)	1.14 (0.3)	3 of 3
Seeps	17	30.22 (1.39)	5.8 (0.1)	2.4 (0.2)	102 (9)	0.79 (0.08)	0.82 (0.14)	-
Surf zone	84	32.02 (0.05)	6.6 (0.1)	1.7 (0.1)	44.9 (1.2)	1.08 (0.1)	0.96 (0.1)	0 of 2
Offshore	6	32.09 (0.09)	7.0 (0.5)	1.6 (0.2)	40.8 (3.2)	N/A	N/A	-
Bolinas Lagoon	4	32.34 (0.51)	6.0 (0.9)	1.6 (0.1)	45.9 (3.5)	2.32 (0.45)	1.29 (0.88)	1 of 1

Sample group	*n*	NO_3^- (μmol L^{-1})	NO_2^- (μmol L^{-1})	NH_3 (μmol L^{-1})	DIN (μmol L^{-1})
MW06	4	76 (2)	0.0 (0.0)	1.1 (0.6)	78 (2)
MW07	4	1.4 (1.6)	1.9 (2.4)	530 (80)	530 (80)
MW09	6	8 (4)	0.3 (0.0)	36 (70)	44 (66)
MW10 & MW11	5	160 (110)	7.6 (6.4)	40 (34)	210 (80)
Pits	19	21 (6)	4.0 (1.0)	2.4 (1.2)	27 (5)
Seeps	17	14 (5)	2.6 (1.0)	5.3 (1.8)	22 (5)
Surf zone	84	15 (1)	0.4 (0.0)	4.1 (0.4)	19 (1)
Offshore	6	14 (3)	0.3 (0.0)	3.1 (0.6)	18 (3)
Bolinas Lagoon	4	11 (1)	0.3 (0.0)	4.5 (1.7)	16 (2)

We used the calculated nutrient discharge values (F_p) to examine if observed changes in surf zone nutrient concentrations could be attributable to SGD. The following expression, which includes mass fluxes from all SGD components, excluding D_s and D_d, was used to predict the equilibrium concentration of DIN, SRP, and silicate in the surf zone, C_{prism}, under spring and neap tidal conditions:

$$C_{prism} = [C_{fresh}D_m + C_{sal}(D_w + D_t) + C_{offshore}(V_{prism}/\tau - D_m - D_w - D_t)] \quad (6)$$
$$(\tau/V_{prism})$$

D_m estimated from the freshwater budget was used. Surf zone residence times (τ) of 1 and 4 h were used. We then determined the predicted percentage change of each constituent in the surf zone during neap relative to spring tides and compared this with the constituent's actual change.

Results

Groundwater and coastal ocean water quality—The fresh groundwater in the unconfined aquifer at Stinson Beach contains high concentrations of fecal indicator bacteria, silicate, DIN, and SRP (Table 2). The presence of the *esp* gene in a subset of groundwater samples is consistent with their being affected by septic discharge (Table 2). A nutrient and fecal indicator bacteria-rich freshwater signature dissipates from inland wells (MW06, MW07, MW09) through the brackish mixing zone (MW10, MW11, pits and subaerial seeps) to the open ocean (surf zone and offshore samples). Fresh groundwater has, at most, 10, 130, 10, and 2,500 times higher silicate, DIN, SRP, and fecal indicato bacteria, respectively, compared with surf zone waters.

Tide range was positively correlated to salinity in the surf zone (Fig. 3, $r_p = 0.81, p < 0.01$), indicating a freshening of the surf zone during the neap tide. Tide range was negatively correlated to silicate, DIN, and SRP in the surf zone (Fig. 3, $-0.71 \leq r_p \leq -0.57, p < 0.01$, respectively), indicating nutrient enrichment in the surf zone during neap tides. Silicate, nitrate, DIN, and SRP concentrations were significantly negatively correlated to salinity (Fig. 3, $-0.73 \leq r_p \leq -0.49, p < 0.01$), supporting the idea that the freshening of the surf zone is caused by input of nutrient-enriched freshwaters and not by other large-scale saltwater nutrient sources such as upwelling, which can act on similar timescales.

The fresh component of discharges from Bolinas Lagoon and Webb Creek had little or no effect on the salinity in the surf zone at the experimental site. The salinity measurements taken during Bolinas Lagoon ebb flow were marine and were not significantly different ($p > 0.05$) from salinities in the surf zone at the study site. An 800-m alongshore transect of ankle-depth surf zone samples extending from the study site toward Webb Creek indicated that salinity was not decreasing with distance toward the creek (data not shown), indicating that the creek's freshwater plume does not substantially influence salinity of the surf zone at our site. Given these observations, we attribute the freshening of the surf zone during neap tides to discharge of fresh groundwater across the land–sea interface, and the corresponding nutrient increase . consequence of discharge of fresh groundwater to the coastal ocean from the surficial aquifer.

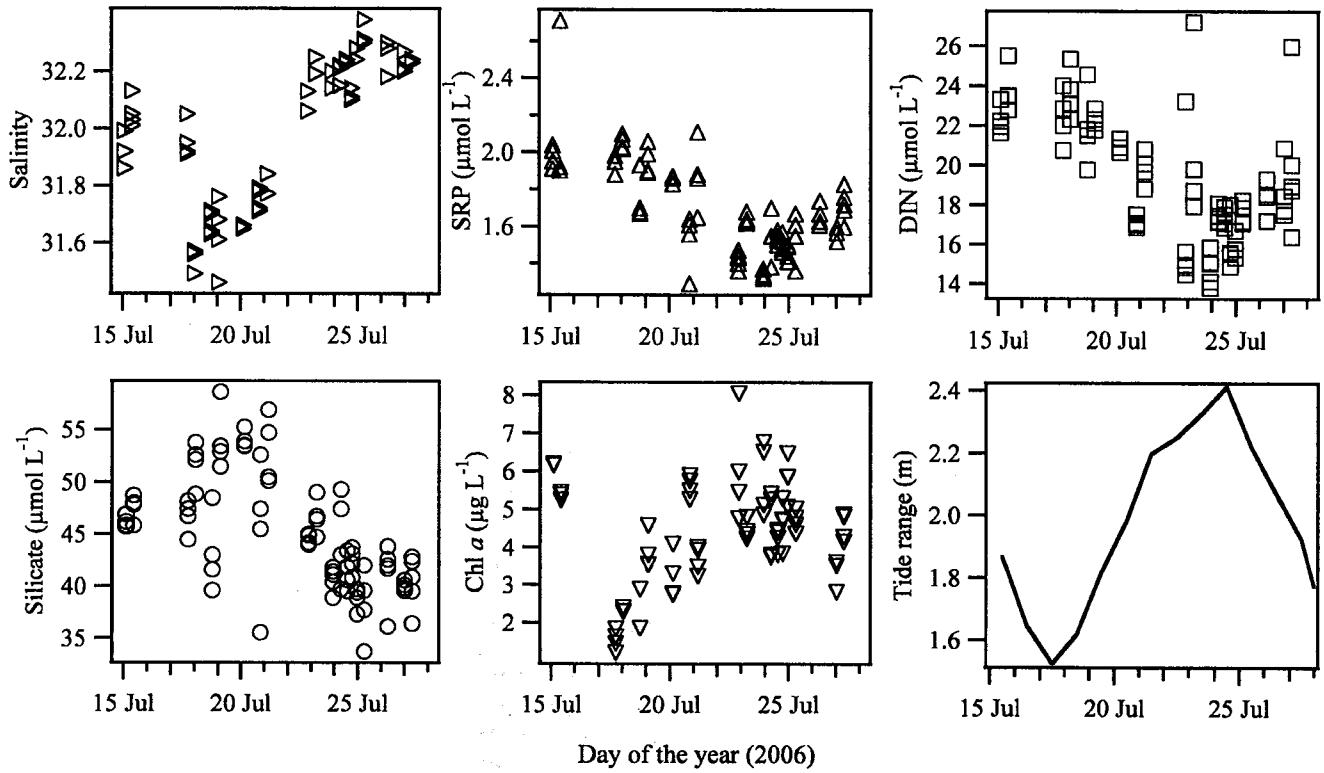


Fig. 3. Surf zone concentrations of salinity, SRP, DIN, SiO_4, Chl *a*, and tidal range plotted vs. time during the experiment.

Chl *a* concentrations in the surf zone increased substantially after the third-quarter moon. A least-squares regression of all Chl *a* measurements from 17 July (third-quarter moon) to 21 July with time ($r_p = 0.86$, $p < 0.05$) indicates an increase of over 1 $\mu g\ L^{-1}\ d^{-1}$.

Fecal indicator bacteria densities in the surf zone did not correlate significantly to salinity ($r_p = 0.16$, $p = 0.17$ for EC, and $r_p = 0.03$, $p = 0.79$ for ENT) or tide range ($r_p = 0.17$, $p = 0.13$ for EC, and $r_p = 0.01$, $p = 0.97$ for ENT). Despite the high concentrations of fecal indicator bacteria observed in fresh groundwater, they do not appear to be discharged with the fresh, nutrient-rich groundwater, indicating that they may be filtered as groundwater moves through the sand (Hijnen et al. 2005; Bolster et al. 2006).

Mesocosm experiment—Average Chl *a* with 95% confidence intervals at the start of the experiment (day 0, $n = 4$) and on the final day of the experiment (day 2, $n = 16$) are shown in Fig. 4. After incubation for 2 d, Chl *a* concentrations in bottles containing 4% and 8% groundwater exhibit significant ($p < 0.001$ in each case) increases relative to the seawater control. This experiment illustrates that a dissolved constituent present in the fresh groundwater at Stinson Beach, or a combination thereof, promotes the growth of phytoplankton in seawater when light and temperature are held constant.

Hydraulic head measurements—The head varied over a smaller range at the most inland wells compared with the wells closer to the sea (Table 3). The average hydraulic head over the fortnight at the well farthest from the sea, MW06, the only well installed into the bedrock at the landward boundary, the surficial beach aquifer, was higher than average heads at other wells installed into the beach

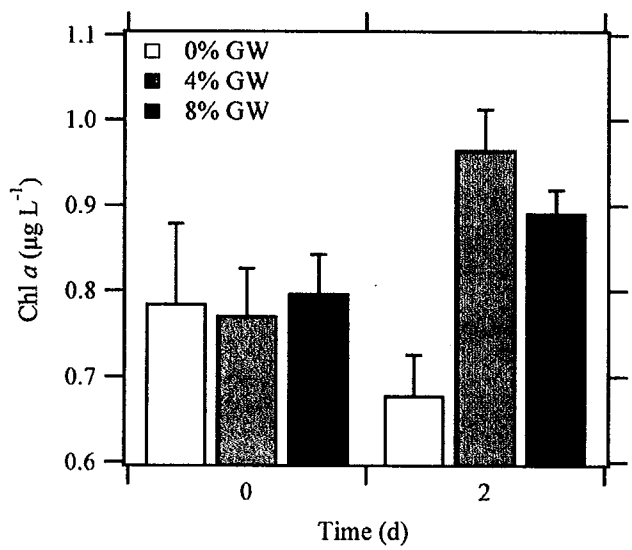


Fig. 4. Average and 95% confidence intervals of Chl *a* concentrations at time 0 and on day 2 of the mesocosm experiment for treatments (4% and 8% v/v groundwater and seawater) and control (0%). Concentrations in 4% and 8% treatments show significant increases above concentrations at time 0 and above control at day 2, suggesting that a dissolved constituent in groundwater is promoting growth of phytoplankton.

Table 3. The maximum and minimum equivalent freshwater hydraulic head (m) measured relative to mean sea level is shown for each well. Also shown are average heads during the fortnight, and during neap and spring tides. Sea level maximum, minimum, and average values are shown for comparison.

Well ID	Minimum (m)	Maximum (m)	Fortnight average (m)	Neap tide average (m)	Spring tide average (m)
MW06	1.26	1.39	1.32	1.33	1.28
MW07	0.41	0.55	0.48	0.49	0.44
MW09	0.24	0.56	0.42	0.37	0.44
MW10	0.08	1.03	0.45	0.26	0.55
MW11	0.08	1.01	0.43	0.39	0.49
Sea level	−1.28	1.18	0.09	0.11	0.18

aquifer (Table 3). This indicates that there was net flow from the bedrock to the surficial aquifer and out toward the sea, assuming a hydraulic connection. At the inland side of the unconfined aquifer, the hydraulic head in wells MW06 and MW07 was approximately 1 cm above the fortnight average during the neap tide and 4 cm below the fortnight average during the spring tide (Table 3). The reduction in head from neap to spring tide at these wells may be attributed to lagged response to low-frequency tidal constituents (Li et al. 2000; Raubenheimer and Guza 1999), or to the slow seasonal dropping of the water table during the summer months due to discharge and evapotranspiration. Changes to hydraulic head at the seaward side of the aquifer had an opposite and more substantial fortnightly trend. Neap tide average heads at wells MW09, MW10, and MW11 were 5, 19, and 4 cm below the fortnight averages, respectively, whereas spring tide heads at the same wells were 2, 10, and 6 cm, respectively, above the fortnight averages (Table 3). This illustrates an increase in aquifer overheight, or mounding of water at the land–sea interface during spring relative to neap tides.

SGD estimates—On the basis of the freshwater budget in the surf zone, D_m varies between 1.2 and 4.7 L min^{-1} m^{-1} of shoreline at neap tide to between 0.1 and 0.5 L min^{-1} m^{-1} at spring tide (range reported for 1- and 4-h residence times, Table 4). By comparison, estimates of discharge, on the basis of measurements in the fresh part of the aquifer, using the Dupuit equation are 1.2 L min^{-1} m^{-1} (neap tide) and 0.1 L min^{-1} m^{-1} (spring tide). Thus, agreement is excellent between the Dupuit freshwater discharge calculations and the mass balance estimates of D_m calculated with a 4-h residence time.

We calculate that D_w = 7.2 L min^{-1} m^{-1} of shoreline (constant throughout study) and D_t = 8.7 (neap) and 14.8 (spring) L min^{-1} m^{-1} of shoreline, respectively (Table 4). The sum of these estimates shows that total SGD (D) during spring tides (D_{spring}) is greater than SGD during neap tides (D_{neap}), which is consistent with results from other studies in unconfined aquifers, including those done with seepage meters (Kim and Hwang 2002; Taniguchi 2002; Boehm et al. 2004). Assuming a 1-h residence time 2.2% of D_{spring} is fresh groundwater, whereas 22.8% of D_{neap} is fresh groundwater, or 0.5% vs. 7.0%, respectively, assuming a 4-h residence time (Table 4).

Discussion

Fortnightly trends in surf zone nutrients and salinity at Stinson Beach can be linked to changes in the meteoric (fresh) component of total SGD, which in this environment appears to be controlled by tide- and wave-driven aquifer

Table 4. (A) Dupuit equation estimates of seaward groundwater discharge in the fresh part of the unconfined aquifer. (B) Model estimates of D_m, D_t, D_w, D, F_p SiO_4, F_p SRP, and F_p DIN. Estimates vary for 1- and 4-h residence times. (C) Predicted C_{prism} for nutrients predicted using Eq. 6. Actual nutrient concentrations in the surf zone are reported for neap and spring tides for comparison.

(A)	Neap tide	Spring tide
Fresh discharge (L min^{-1} m^{-1})	1.2	0.1

(B)	Neap tide		Spring tide	
	1 h	4 h	1 h	4 h
D_m (L min^{-1} m^{-1})	4.7	1.2	0.5	0.1
D_w (L min^{-1} m^{-1})	7.2	7.2	7.2	7.2
D_t (L min^{-1} m^{-1})	8.7	8.7	14.8	14.8
D (L min^{-1} m^{-1})	20.6	17.1	22.5	22.1
F_p SiO_4 (μmol min^{-1} m^{-1})	3,780	2,303	2,697	2,528
F_p SRP (μmol min^{-1} m^{-1})	101	55	62	56
F_p DIN (μmol min^{-1} m^{-1})	1,677	949	1,072	989

(C)	Neap tide			Spring tide		
	1 h	4 h	Actual	1 h	4 h	Actual
C_{prism} Silicate (μmol L^{-1})	66	97	49	56	98	43
C_{prism} SRP (μmol L^{-1})	2.6	2.3	1.9	1.9	2.4	1.5
C_{prism} DIN (μmol L^{-1})	30	41	23	25	39	17

overheight in the unconfined beach aquifer. Increased fresh groundwater discharge at neap tide corresponded with a drop in aquifer overheight at the land–sea boundary and a steepening of the seaward hydraulic gradient in the fresh part of the aquifer. Similarly, increased aquifer overheight near the beach face during spring tide corresponded with a shallowing of the hydraulic gradient in the fresh part of the aquifer, and reduced fresh groundwater discharge to the coastal ocean. Fresh groundwater at the field site is substantially enriched in nutrients; thus the freshening of the surf zone during neap tide is accompanied by nutrification of the surf zone.

The discovery of fecal indicator bacteria and *esp*-positive ENT in monitoring wells at the site suggests that high nutrient concentrations in fresh groundwater are due at least in part to contamination by septic effluent. This is not surprising given the high density of septic systems at the field site. Our field observations indicate that nutrients from fresh groundwater can be transported from the land to the sea through the subsurface, affecting coastal water quality. Interestingly, increased surf zone concentrations of groundwater-derived nutrients were not associated with an increase in fecal indictor bacteria concentrations, although fresh groundwater at the site is enriched with these organisms. This indicates that attenuation of bacteria in the unconfined beach aquifer at Stinson Beach is efficient. Future work will concentrate on quantifying attenuation rates of effluent-derived fecal indicator bacteria, pathogens, in particular viruses, and nutrients in individual septage plumes at the site.

During the 4 d after the nutrient pulse that occurred at neap tide at Stinson Beach, Chl *a* concentrations in the surf zone increased from approximately 2 μg L^{-1} to 6 μg L^{-1}. Numerous studies have implicated SGD in causing algal blooms in the coastal ocean (LaRoche et al. 1997; Hwang et al. 2005*a,b*), with some specifically linking SGD-derived nutrient inputs from septic systems to growth of algae in canals and coastal watersheds (Lapointe et al. 1990; Valiela et al. 1992; Charette et al. 2001). The mesocosm experiments illustrated that the addition of nutrient-rich fresh groundwater from well MW09 (average nutrient concentrations in Table 2) to seawater promoted significant increases in Chl *a* relative to a control with no addition. Although we are unable to definitively conclude that nutrification of the coastal ocean by fresh SGD during the neap tide caused the increase in Chl *a* in the coastal ocean soon thereafter, our field observations and mesocosm experimental results are consistent with this linkage. Other possible causes of the increased Chl *a* in the surf zone include changes in resuspension of benthic diatoms (Demers et al. 1987), turbidity (May et al. 2003), water column stability and light penetration (Comeau et al. 1995), and upwelling (Labiosa and Arrigo 2003).

For the purposes of testing whether the observed changes in nutrient concentrations in the surf zone could have been caused by the estimated changes to SGD across the fortnight, theoretical spring- and neap-tide nutrient concentrations (C_{prism}) were estimated using the calculated potential nutrient fluxes (Eq. 5). On the basis of groundwater mixing diagrams of salinity vs. nutrient concentration, groundwater end-member nutrient concentrations were 422 μmol L^{-1} silicate, 208 μmol L^{-1} DIN, and 13 μmol L^{-1} SRP for fresh groundwater, and 113 μmol L^{-1} silicate, 44 μmol L^{-1} DIN, and 2.5 μmol L^{-1} SRP for saline groundwater (mixing diagrams not shown). Using these end members with the corresponding discharge estimates, the potential flux F_p ranges from 2,303 to 3,780 μmol min^{-1} m^{-1} silicate, 949 to 1,677 μmol min^{-1} m^{-1} DIN, and 55 to 101 μmol min^{-1} m^{-1} SRP, depending on residence time and tidal condition (spring vs. neap) (Table 4). Variation in F_p between neap and spring tides is due to the different proportions of D_m and D_t in total SGD (D).

Using F_p, we calculated C_{prism}, the theoretical concentration of nutrients in the surf zone during neap and spring tides. For each nutrient constituent C_{prism} is greater than the actual measured concentration in the surf zone during both tidal conditions (Table 4). This is not surprising given that nutrients do not behave conservatively in the subsurface, although our calculation of F_p assumes they do. However, comparisons of the projected change in C_{prism} between spring and neap tides with the actual change in surf zone concentrations agreed reasonably well assuming a 1-h residence time: C_{prism} increases 18% (silicate), 20% (DIN), and 37% (SRP) during neap relative to spring tides, as compared with the measured increases of 14% silicate, 35% DIN, and 27% SRP. Thus, it appears that if we use the low-end residence time estimate, the fortnightly changes in the flux of fresh and saline groundwater from the beach aquifer to the coastal ocean can account for an increase in surf zone concentrations of nutrients during neap tides. If the residence time is instead 4 h, then our model predicts higher nutrient concentrations during spring compared with neap tides presumably due to increased saline discharge at spring tide. This is counter to our observations, and may indicate that the nutrient flux attributed to the saline groundwater discharge is overestimated by our model.

Neither the seasonal component D_s nor the density-driven component D_d was included in flux calculations. Seepage metering was instrumental in investigating D_s at a low wave-energy field site at Waquoit Bay, Massachusetts (Michael et al. 2005). In systems with a high-energy surf zone such as Stinson Beach, seepage metering is problematic if not impossible (Libelo and MacIntyre 1994; Burnett et al. 2006), and for this reason D_s was not included in our estimate of D. However, since it oscillates on a yearly timescale, we can assume that D_s would have been approximately constant across the 14-d study. We contend that had D_s been included in our formulation of D, the percentages of fresh SGD of total reported above would be reduced but the relative differences and our general conclusions would remain the same. The variability and role of D_d at Stinson Beach is uncertain, but we suggest that because the fresh groundwater at the site is so substantially enriched in nutrients relative to the saltwater end members, the nutrification effects attributed to D_d variability would be small compared with those attributed by the large changes in fresh groundwater flux across the fortnight.

To ground-truth our discharge results, it is useful to compare them with those made in similar environments. At Tomales Bay, a 21-km-long embayment along the San Andreas Fault approximately 27 km to the northwest of Stinson Beach, Oberdorfer et al. (1990) estimated D_m using both Darcy's law and a soil moisture budget approach. Saline discharge was not investigated. D_m estimates for the two methods were 6.6×10^3 m^3 d^{-1} and 25.3×10^3 m^3 d^{-1}, respectively, or 0.12 L min^{-1} m^{-1} and 0.44 L min^{-1} m^{-1} given the approximate length of shoreline along the bay (40 km). During a multiday experiment, Mulligan and Charette (2006) used Darcy's law and radon-based methods and estimated fresh discharge to Waquoit Bay, Massachusetts, at 2.8 L min^{-1} m^{-1} and 3.9 L min^{-1} m^{-1}, respectively. Kroeger et al. (2007) used Darcy's law and a water budget to estimate fresh SGD from the Pinellas Peninsula in Tampa Bay, Florida. D_m was estimated at 2.0 L min^{-1} m^{-1} and 0.8 L min^{-1} m^{-1} using the two methods, respectively. Hays and Ullman (2007) dammed subaerial seepage faces that developed during 16 spring tide monitoring events across an 18-month period at Cape Henlopen, Delaware, and measured D_m directly with a weir. They calculated annual average D_m during the study of 0.9 ± 0.4 L min^{-1} m^{-1}. The range of D_m presented in our study is consistent with the values reported above.

SGD field studies have specifically investigated neap–spring tidal forcing of SGD. Taniguchi (2002) used seepage meters in Osaka Bay, Japan, and found that total SGD increased from neap to spring tide. At a monitoring station in Korea's Yellow Sea, Kim and Hwang (2002) found that groundwater-derived ^{222}Rn and CH_4 concentrations near the seafloor increased sharply from neap to spring tide. Boehm et al. (2004) also found an increase in total SGD between neap and spring tides using radium isotopes as tracers. In all three cases, the results indicate a greater total discharge during spring tide relative to neap tide, and are consistent with the results presented herein. The only study that examined spring–neap variation in fresh SGD, specifically, was conducted in South Africa. Campbell and Bate (1999) used a Darcy's law approach to quantify the flux of fresh groundwater from a South African sand dune complex, and estimated D_m to be 0.11 L min^{-1} m^{-1} during spring tide and 0.23 L min^{-1} m^{-1} during neap tide. The increase in neap tide D_m vs. spring tide D_m is also consistent with the results presented here.

The precise physical explanation of the neap tide pulsing phenomenon is unknown, though two numerical experiments have been conducted to examine D_m and D_t at a hypothetical beach under varying tidal amplitude scenarios and no wave action (Ataie-Ashtiani et al. 2001; Robinson et al. 2007), both of which offer some insights.

Ataie-Ashtiani et al. (2001) simulated constant-density steady-state D_m and D_t from a thin isotropic aquifer with a constant-head landward boundary under zero, low-, and high-tidal amplitude scenarios. They showed that increasing tidal range (as would be expected during spring tides) increased both D_t and aquifer overheight at the boundary, and decreased D_m. Despite differences between the simulated and Stinson Beach environments, the results of the simulation are consistent with the results of our study.

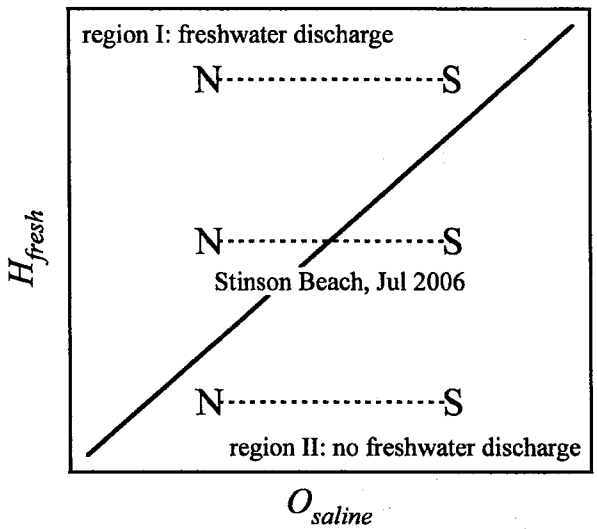


Fig. 5. A framework for understanding the timing of freshwater discharge at beaches similar to Stinson Beach. The dashed, horizontal lines connect the aquifer overheight (O_{saline}) during neap (N) and spring (S) tides at hypothetical beaches with varying hydraulic heads behind the overheight (H_{fresh}). The solid diagonal line separates regions I and II. In region I the aquifer overheight at the beach face is lower than the inland hydraulic head; fresh groundwater discharges to the coastal ocean. In region II, the aquifer overheight is higher than the inland hydraulic head; no freshwater discharge occurs. Fortnightly pulsed fresh groundwater discharge occurs when a beach straddles regions I and II.

Robinson et al. (2007) simulated variable-density steady-state D_m and D_t from a thick isotropic aquifer with a constant-flux fresh landward boundary and multiple tidal ranges. They showed that a saline tidally driven circulation cell develops approximately between the high and low tide lines. Under certain conditions, a freshwater "tube" discharges seaward of the tidal circulation cell near the low tide line. As tidal amplitude is increased, the depth and width of the saline circulation cell increase and the freshwater tube is forced to flow deeper in the aquifer and discharge further offshore. It is possible that during our study, fresh groundwater discharged to the surf zone at neap tide but discharged beyond the surf zone at spring tide, thereby producing a freshening of the surf zone at neap tide. Although we cannot rule out this possibility, no data collected at the site to date indicate a freshening of nearshore waters beyond the surf zone during spring tides (Table 2, additional data not shown).

Given the results described here, we present a qualitative framework for understanding the relationship between tide- and wave-driven overheight and the magnitude and timing of freshwater discharge from unconfined beach aquifers similar to that at our field site (Fig. 5). We introduce two variables, H_{fresh} and O_{saline}, where H_{fresh} is the hydraulic head in the fresh portion of the aquifer and O_{saline} is the hydraulic head due to overheight in the saline portion of the aquifer near the beach face. The magnitude of O_{saline} is controlled by several factors including wave setup, wave run-up, tidal height, and meteoric hydraulic pressure. H_{fresh} is measured just beyond the influence of

tides and waves and, thus, controlled entirely by meteoric hydraulic head.

In Fig. 5, O_{saline} (horizontal axis) is plotted against H_{fresh} (vertical axis). The dashed, horizontal lines represent neap (N) and spring (S) tide conditions at hypothetical beaches where H_{fresh} is relatively constant but O_{saline} varies with tide range, as it does at Stinson Beach. If H_{fresh} is higher than O_{saline} during all tidal conditions, the system is in region I of Fig. 5 and shallow fresh groundwater continuously discharges throughout the fortnightly tidal cycle. This may be the case at Waquoit Bay, a site with small tidal range and minimal wave action where researchers have described freshwater discharging to the coastal ocean under a variety of conditions (Michael et al. 2003; Mulligan and Charette 2006). If H_{fresh} is low relative to O_{saline} at both neap and spring tides, then shallow fresh groundwater does not discharge over the fortnightly cycle, and the system is in region II. This likely was the case in Huntington Beach, California (Boehm et al. 2006), where very little to no fresh groundwater discharge occurred despite the presence of fresh groundwater just landward of the high tide berm. At Stinson Beach, H_{fresh} is higher than O_{saline} during neap tide but lower during spring tide; thus, the system straddles regions I and II, resulting in a pulsing of fresh groundwater during neap tides with little or no discharge during spring tides.

It is conceivable that at Stinson Beach and elsewhere, aquifers may occupy regions I or II (or both) during different parts of the year as seasonal waves of meteoric hydraulic pressure force fresh groundwater though the beach and interact with the wave- and tide-driven overheight at the boundary. It is also conceivable that variable wave conditions across neap–spring cycles may interfere constructively or destructively with the neap–spring overheight cycle described herein. For these reasons and numerous others, we expect that not all tide- and wave-driven systems will fit into the above classification scheme. Future work including field experiments and numerical modeling will explore this concept more fully.

This study illustrates the importance of fortnightly variation in aquifer overheight in tide- and wave-driven systems and presents a qualitative framework for categorizing fresh groundwater discharge from beach aquifer systems similar to Stinson Beach with respect to overheight at the land–sea interface. Understanding the interactions of mechanisms forcing SGD is particularly important in systems similar to Stinson Beach, where fresh submarine groundwater discharge from a polluted unconfined aquifer poses potential risk to nearshore ocean ecosystem health. Further work should be done to examine the importance of neap–spring tides on submarine groundwater discharge in other environments.

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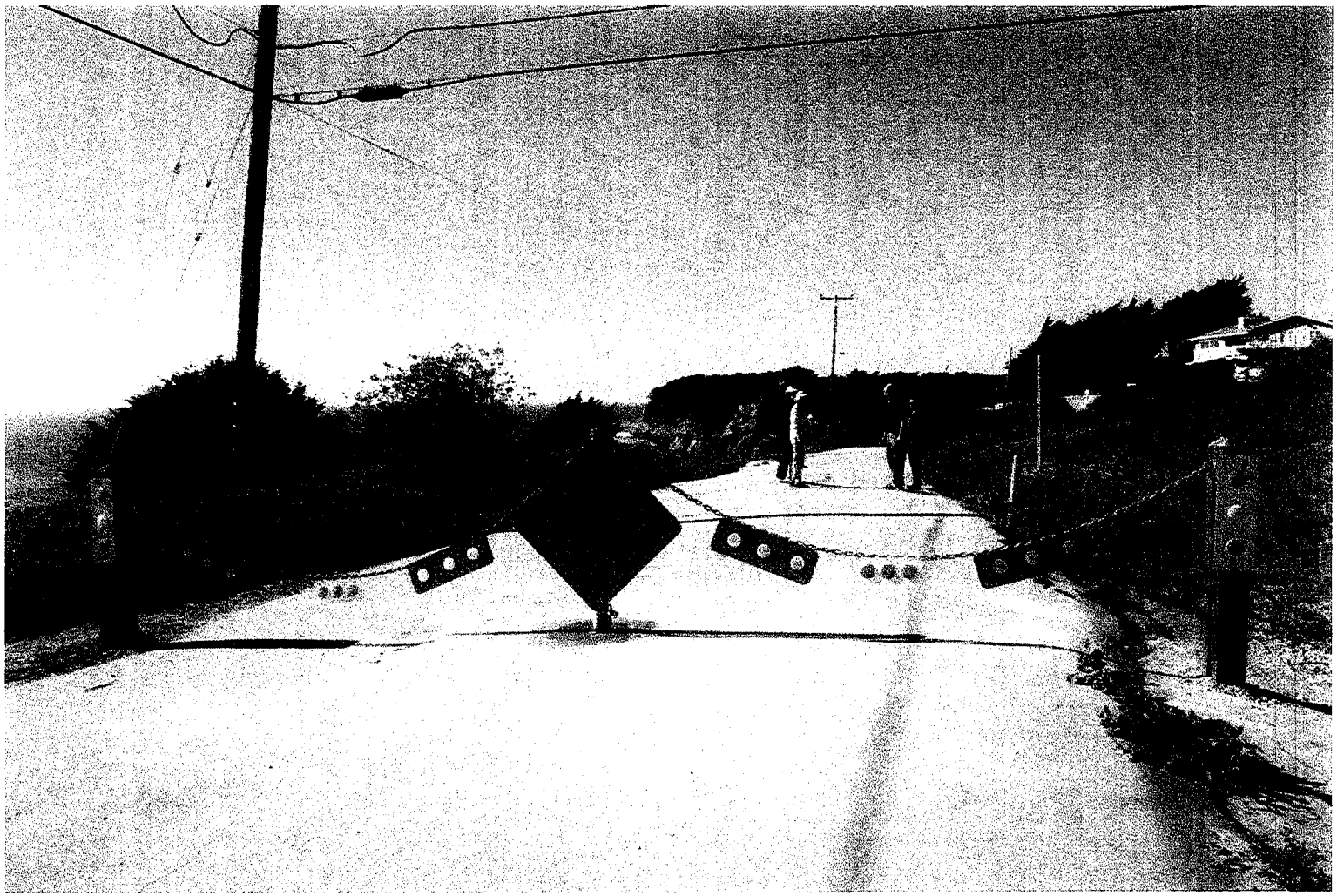
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Accepted: 29 January 2008
Amended: 13 February 2008

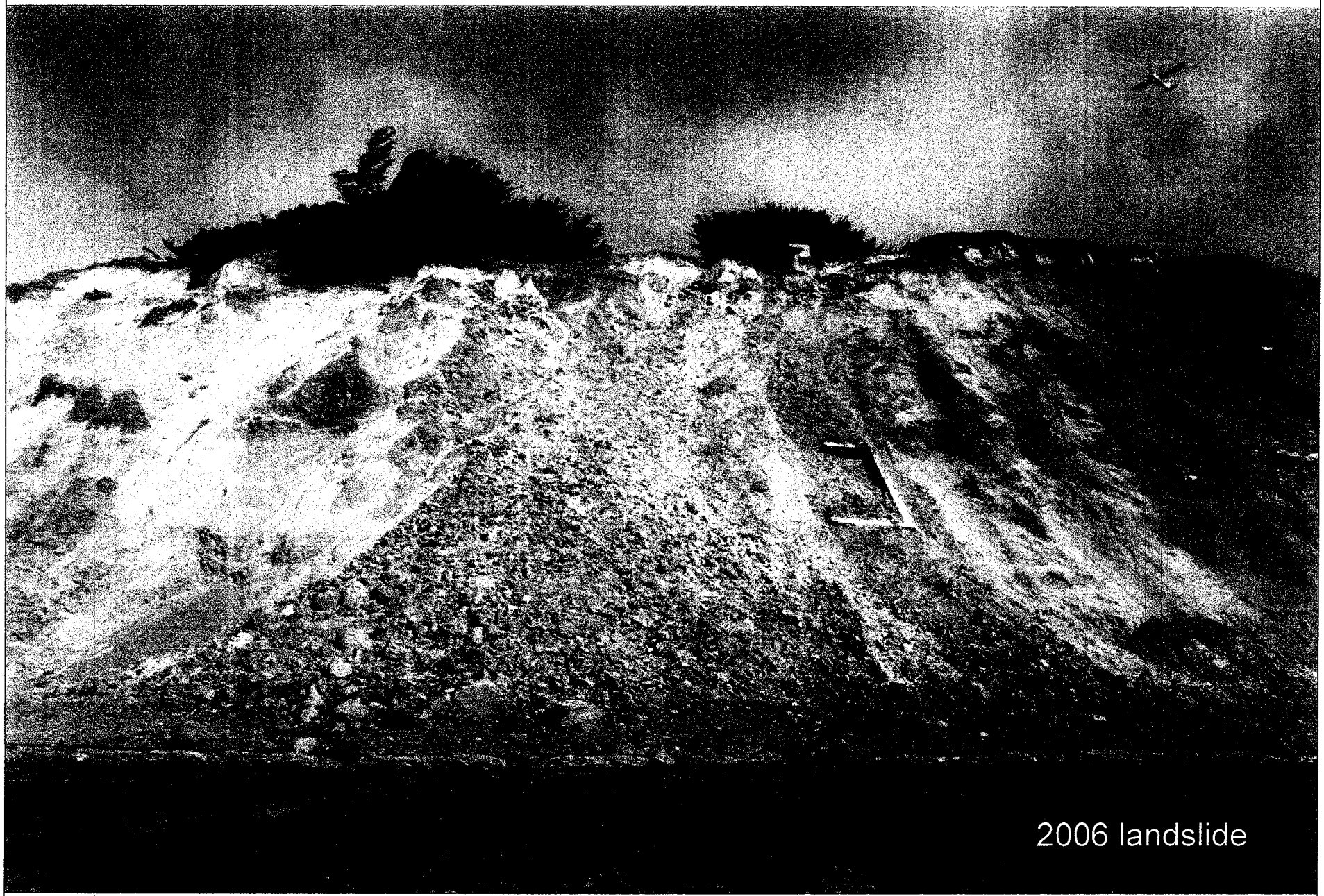
APPENDIX F

INFORMATION SUBMITTED BY SEAL COVE AND PILLAR RIDGE HOME OWNERS, DATED DECEMBER 24, 2009

RECEIVED
DEC 24 2009
San Mateo County
Planning Division

Seal Cove Road Closures




2006 landslide

Jean F. DeMouthe's recommendations include:

- Abandon those sections of Ocean Boulevard and Los Banos Avenue that are currently impassable. **Make the barriers permanent**, and discourage any traffic through this area.

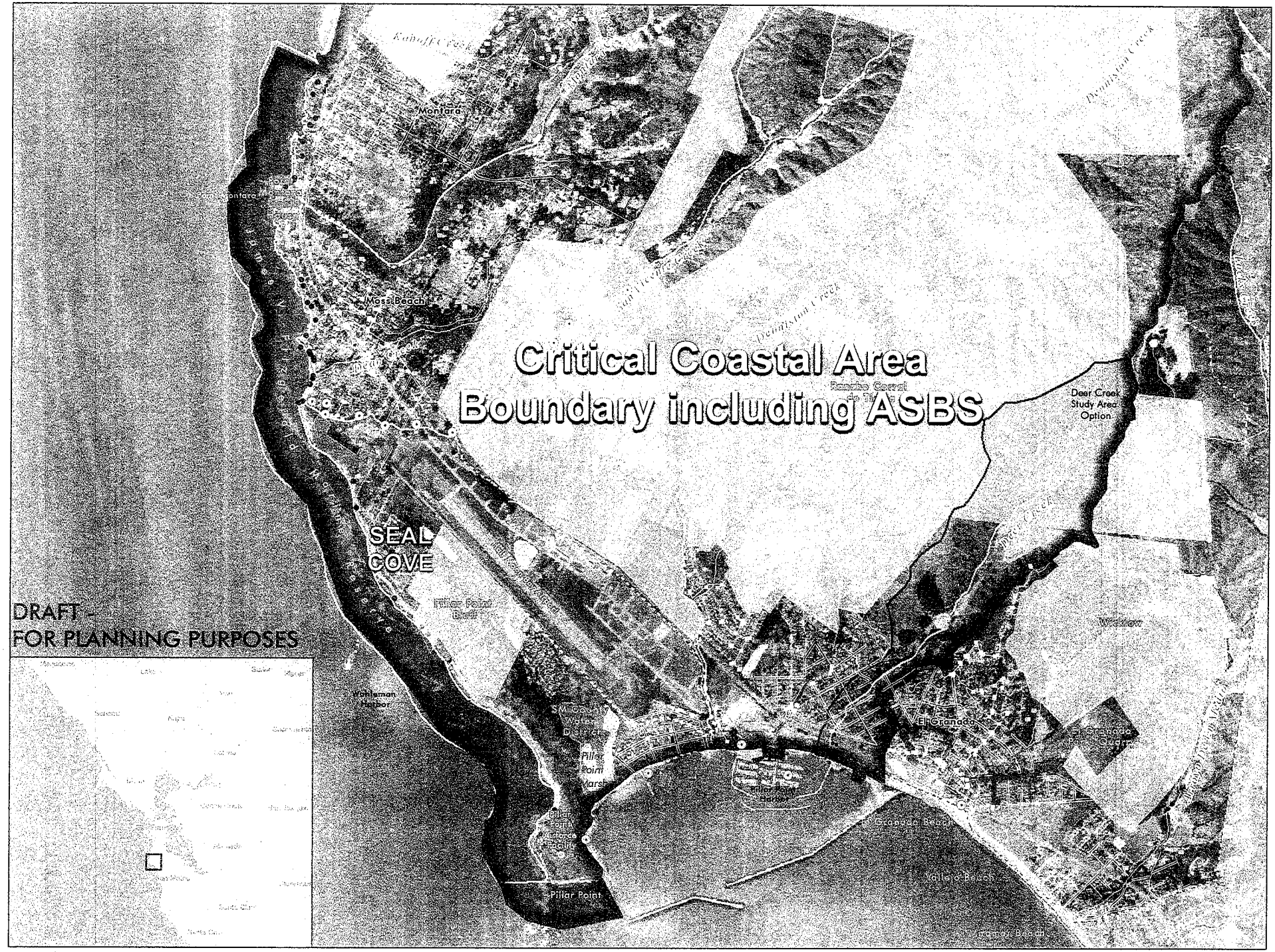
- Remove paving and other structures, and regrade the slope into a natural form, with a positive grade towards the sea.

- Revegetate the area with plants that are native to the area and that can survive with no care or additional water.

- Require the utility companies responsible for the line of poles that are currently along the west side of Ocean Boulevard to relocate them to the east, outside the active landslide zone. **COMPLETED FALL 2009**

- Provide control of drainage from the paved and developed portions of the Seal Cove area away from the two landslides. Failure to do this will probably result in continued movement in these areas, and possible headward migration of the scarps.


Fitzgerald Marine Reserve
decommissioned asphalt and chip-seal

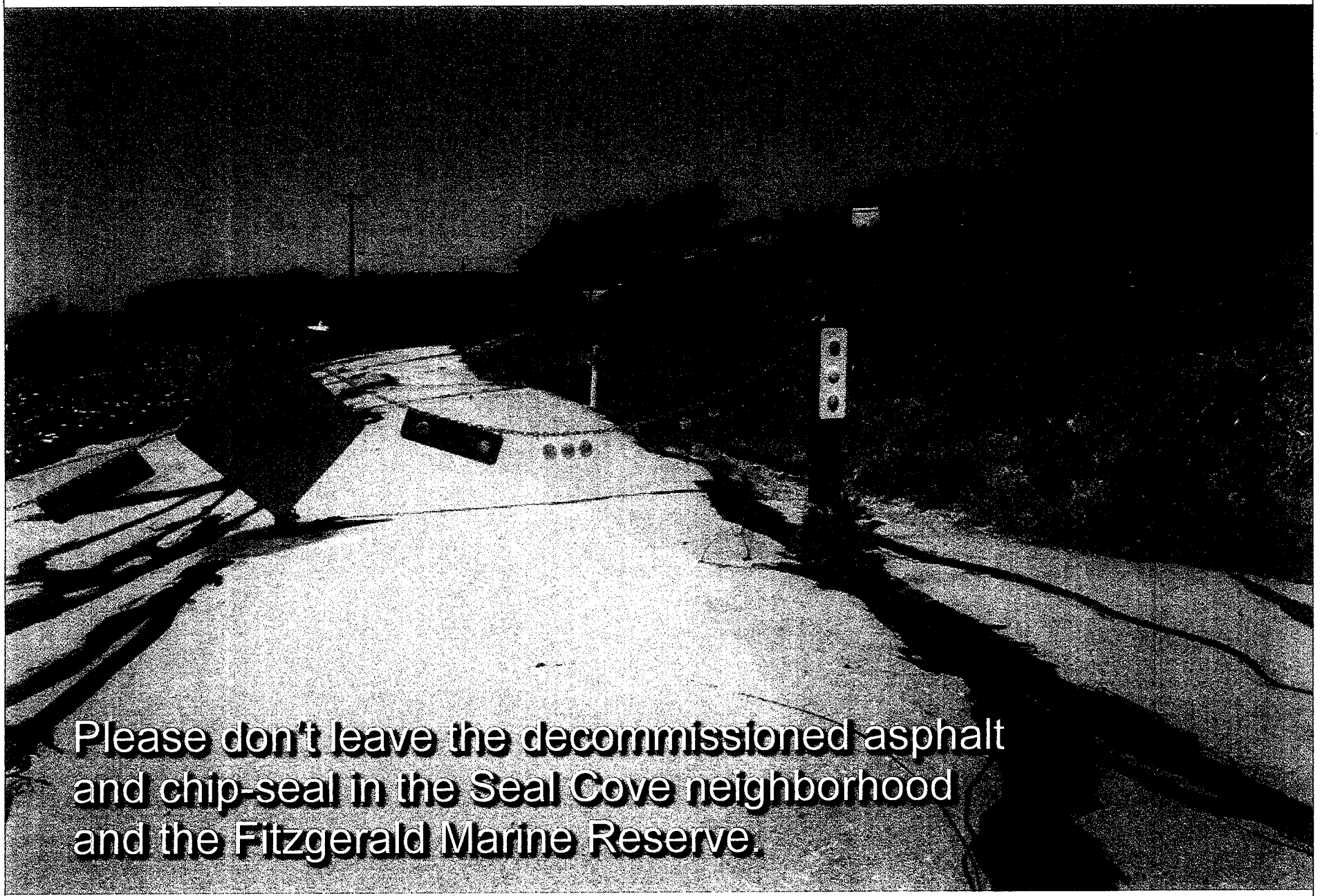

Critical Coastal Area
Boundary including ASBS
DRAFT -
FOR PLANNING PURPOSES
SEAL
COVE
Montara
Moss Beach
Deer Creek
Study Area
Option
Pillar Point
Bluff
Princeton
Miramar
El Granada
Pillar Point
Marsh
Pillar Point
Harbor
Half Moon Bay
Pillar Point
Wavecrest
Coastside
Farms
Denniston Creek
Rancho Corral
de Tierra

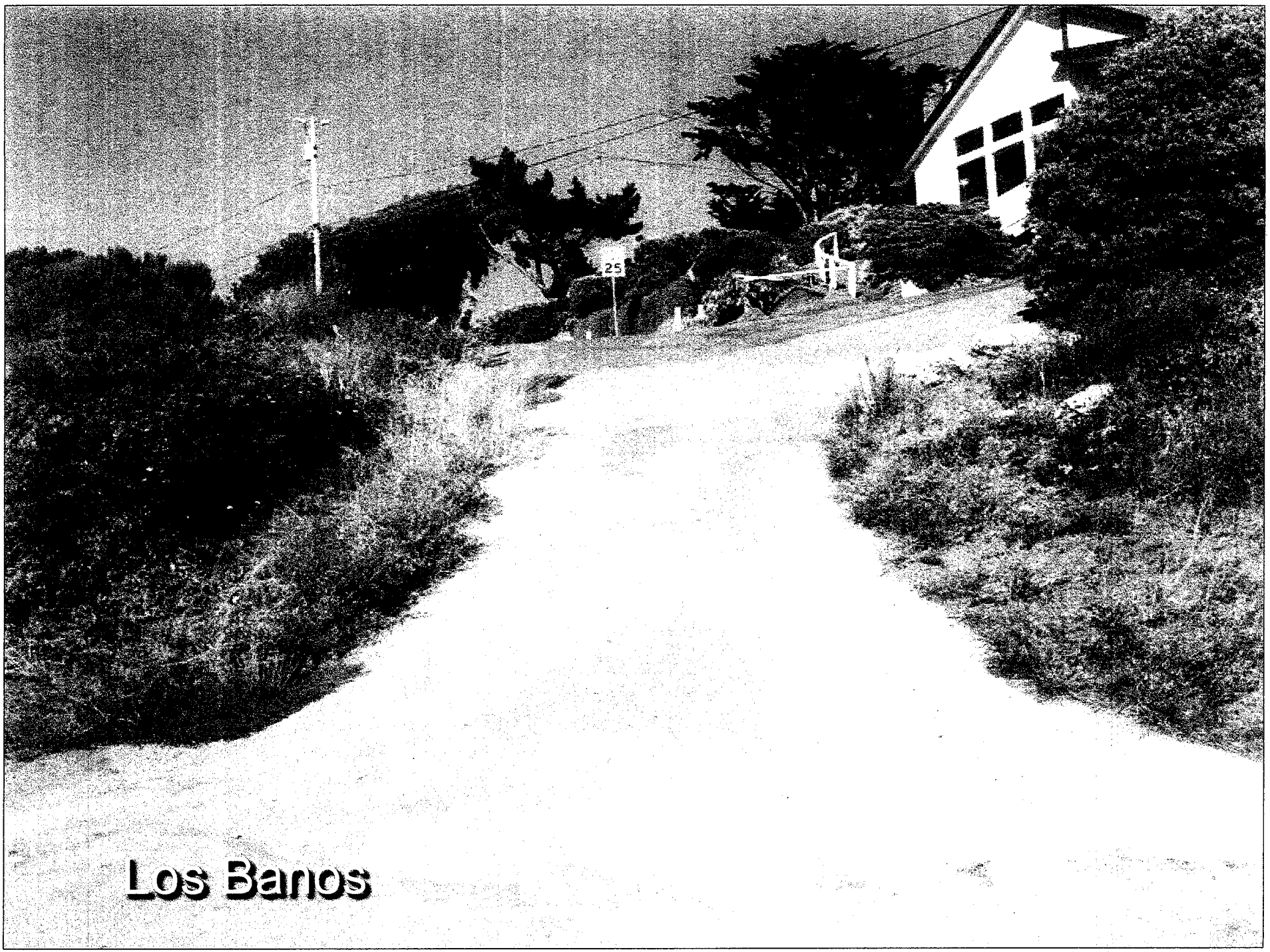
decommissioned
asphalt

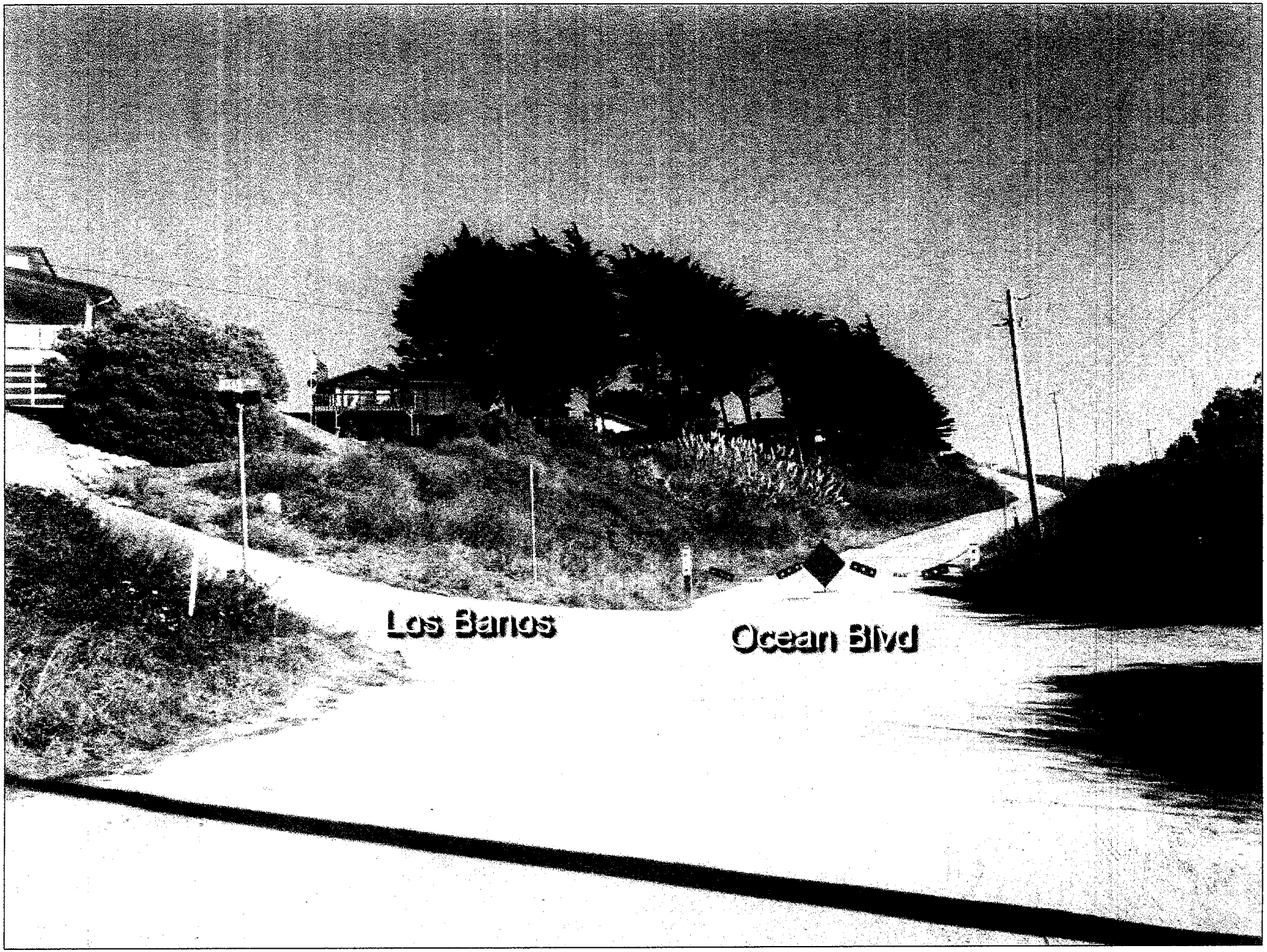


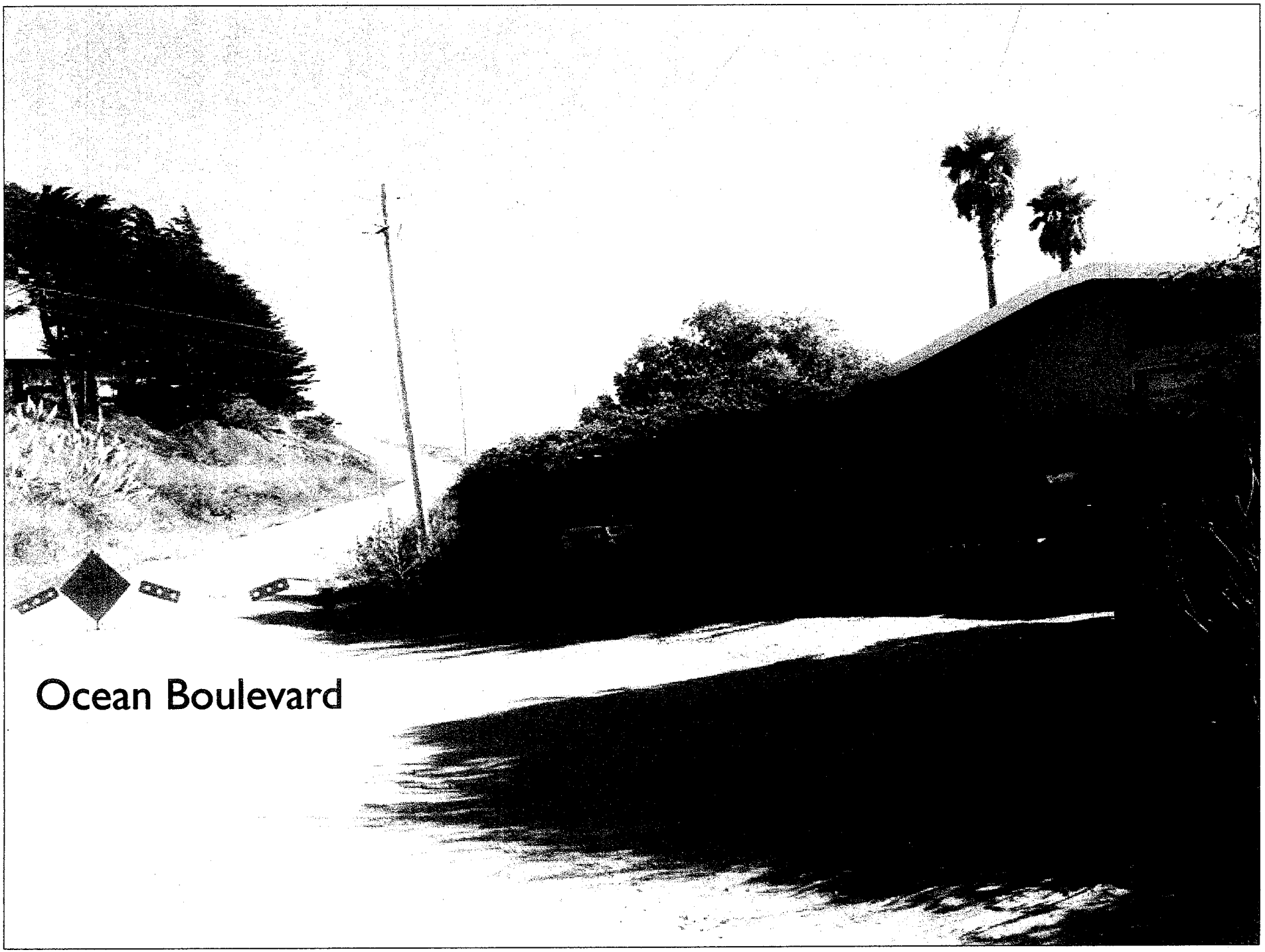


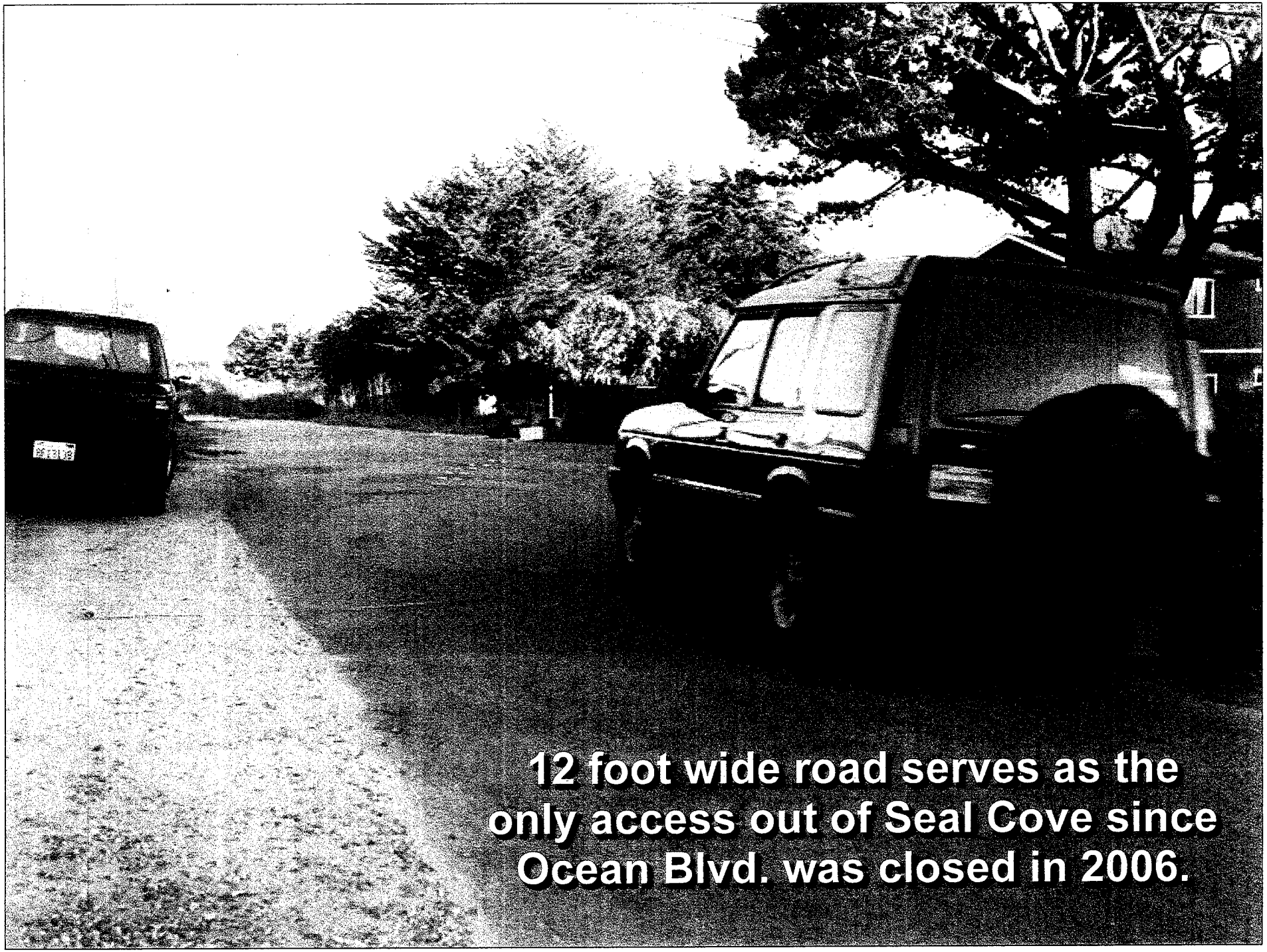


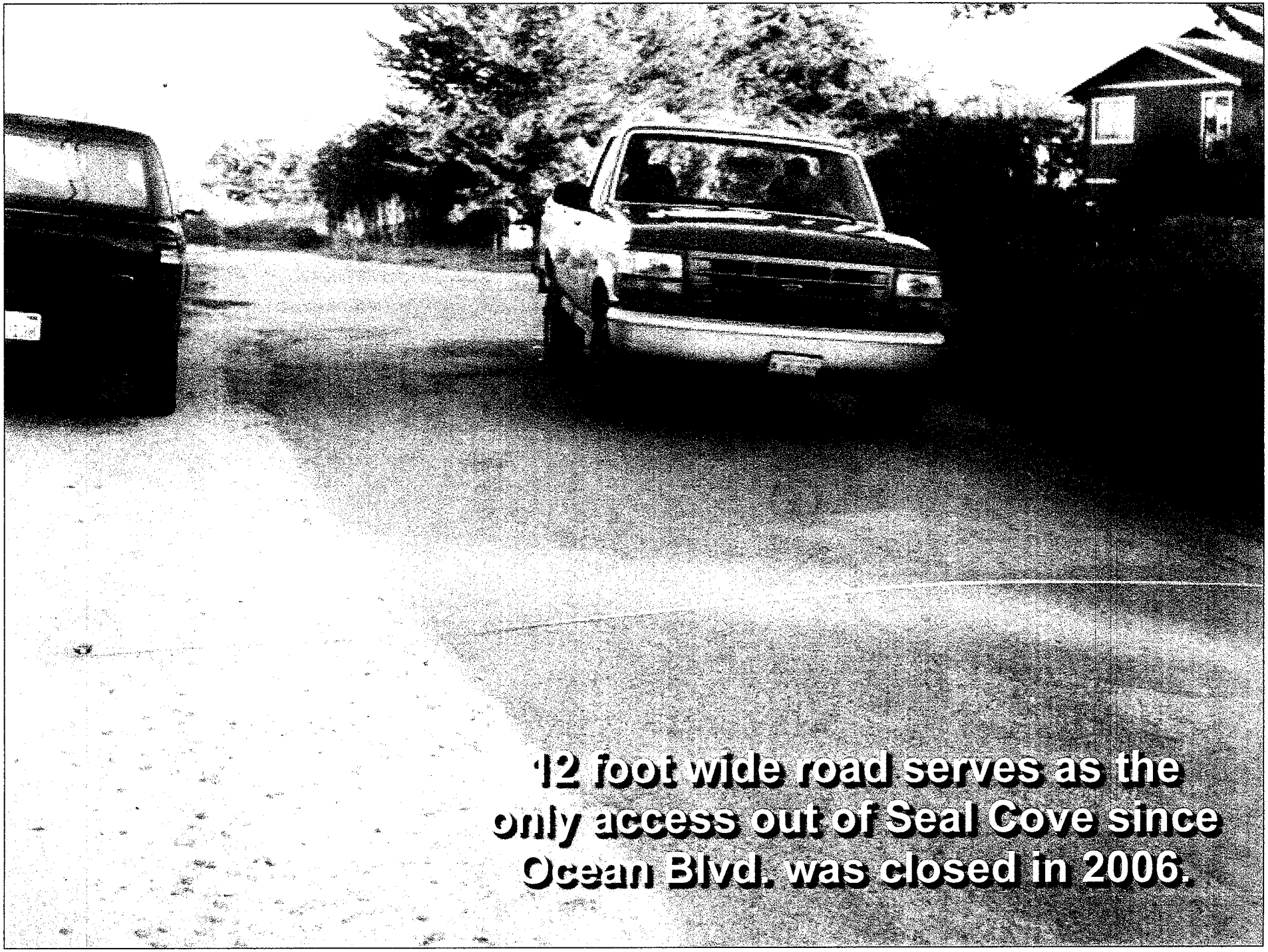

Please don't leave the decommissioned asphalt
and chip-seal in the Seal Cove neighborhood
and the Fitzgerald Marine Reserve.


25
Los Banos

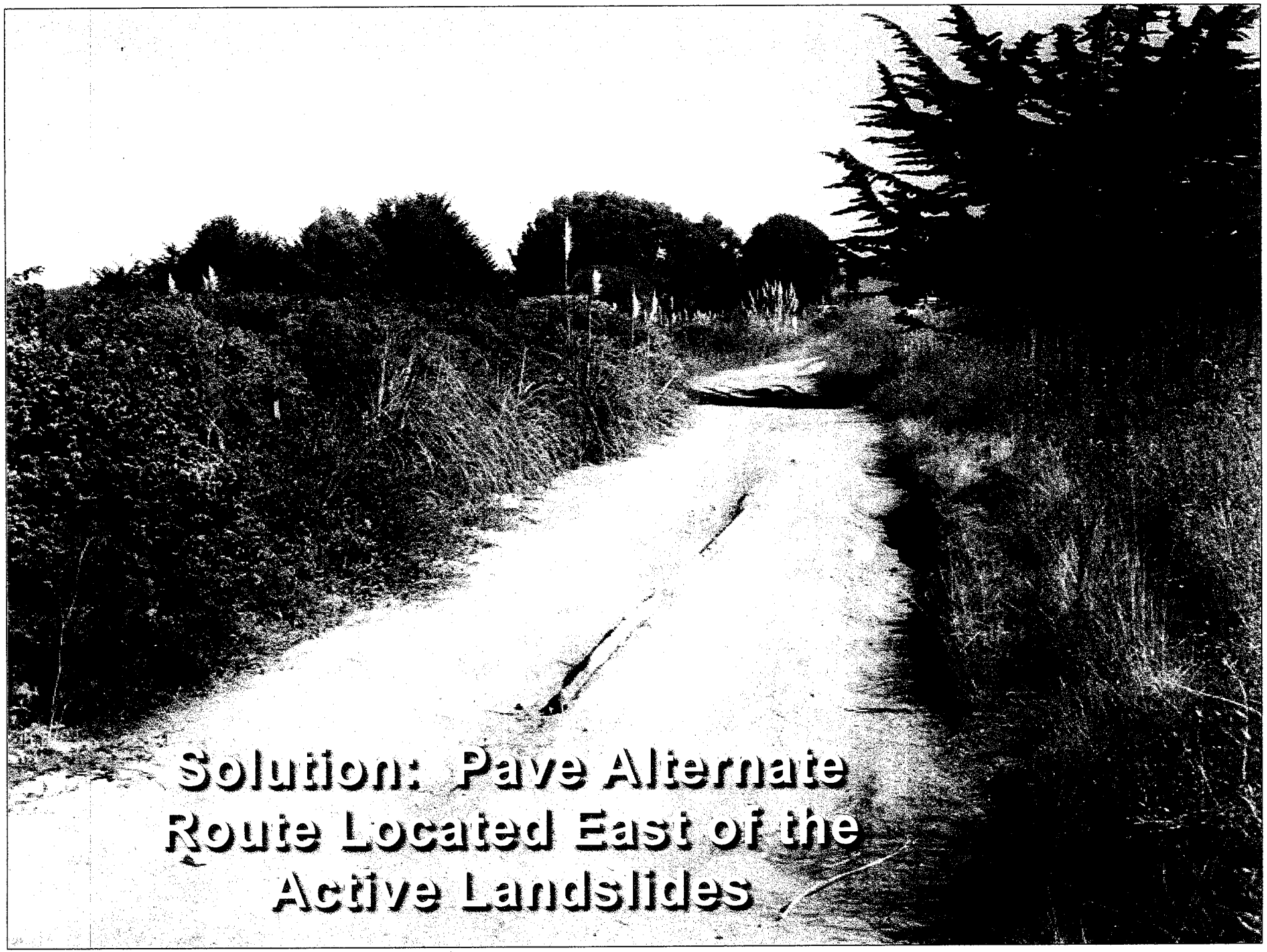

Los Banos
Ocean Blvd


Ocean Boulevard


12 foot wide road serves as the only access out of Seal Cove since Ocean Blvd. was closed in 2006.

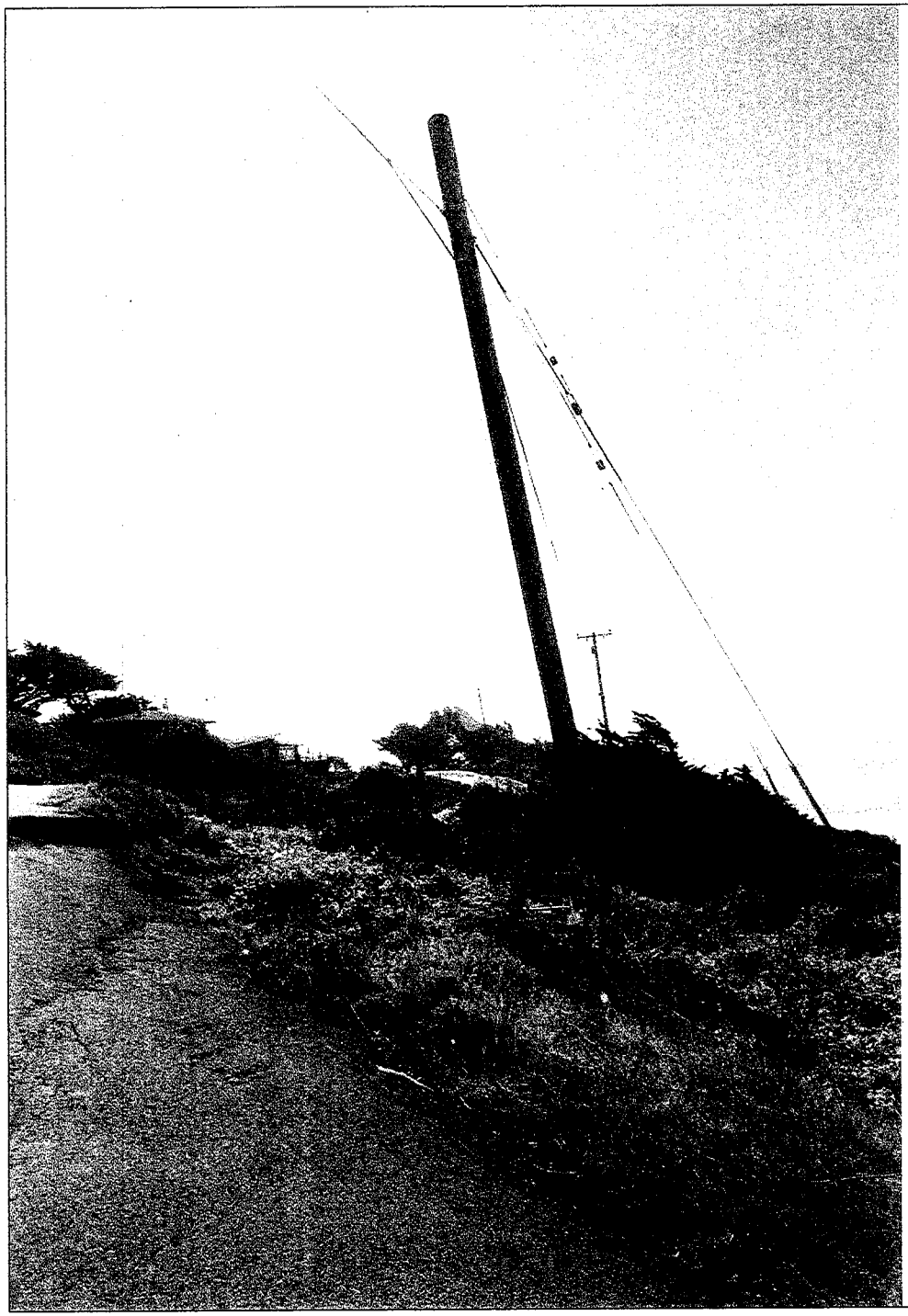

12 foot wide road serves as the
only access out of Seal Cove since
Ocean Blvd. was closed in 2006.


Ocean Boulevard
Public Meeting
June 18th 2008

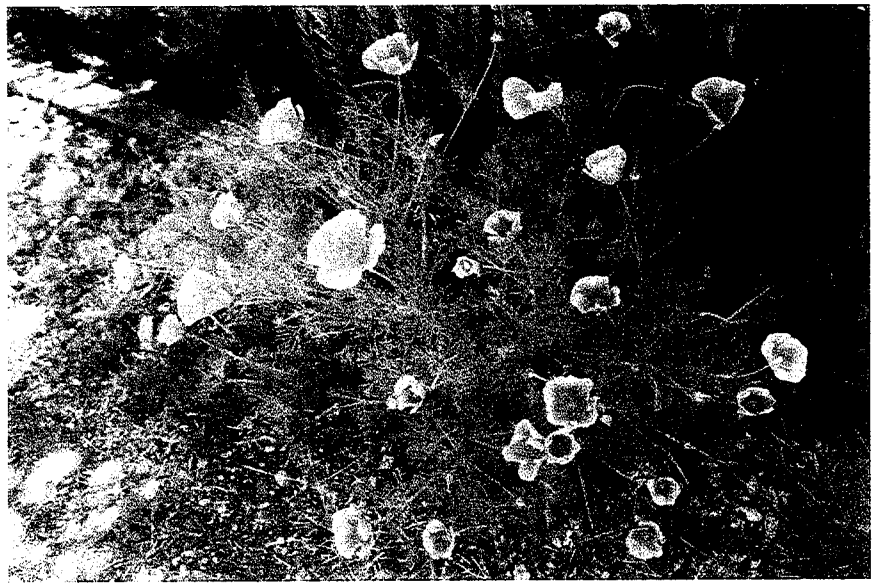

Solution: Pave Alternate
Route Located East of the
Active Landslides

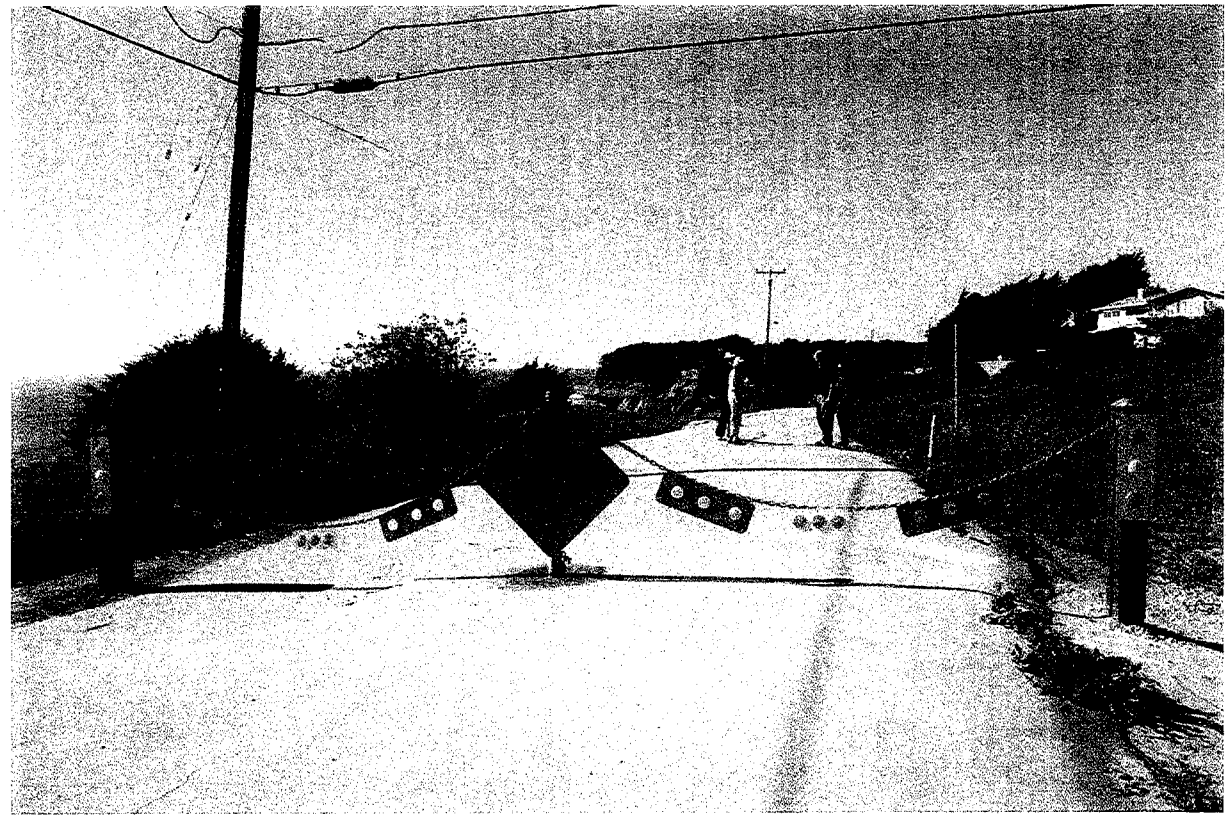
Ocean Boulevard
California Coastal Trail





Thank you
Department of Public Works
for removing the power lines!





Thanks for your consideration.

Sabrina Brennan
165 La Grande Avenue, Moss Beach, CA 94038

RECEIVED

DEC 24 2009

San Mateo County
Planning Division

March 26, 2009

Camille Leung, Project Planner
San Mateo Co. Planning and Building Dept.
455 County Center, 2nd Floor
Redwood City, CA 94063

Re: Big Wave Facilities Plan Draft 2

Ms Leung,

The undersigned Pillar Ridge and Seal Cove residents support the comments made by the Midcoast Community Council in the letter sent to the Planning and Building Department on February 14, 2009 regarding the Big Wave Facilities Plan. We ask that the Planning and Building Department consider the following comments:

Traffic
The Facilities Plan estimates 3787 car trips per day, which would negatively impact Hwy 1. The addition of 225,000 sq. ft. of office space to the Coastside would draw commuters from other parts of the Bay Area which would have significant negative impacts on traffic through Devils Slide (tunnels) and the already congested Hwy 92.

The narrow access roads at Cypress and through Princeton would become congested with commuter traffic. We have not yet seen the full effect of Harbor Village on Capistrano Rd. traffic (known locally as the bottleneck) because the new shopping center and hotel are mostly vacant.

Pedestrian and bicycle safety on Cypress, Airport and through Princeton is already a major problem due to narrow streets, lack of sidewalks and speeding cars, particularly on Airport. Increased traffic and on-street parking overflow from the development would exacerbate the safety issues.

Emergency Evacuation
The proposed project site is in the Tsunami evacuation zone. The evacuation route is north on Airport Blvd, to Cypress Ave, to Hwy 1. Pillar Ridge, Princeton and Seal Cove residents would tax the capacity of this escape route and it would become completely inadequate with the additional number of cars evacuating the Big Wave site.

Aesthetics
The height of the proposed Office Park, at 51-1/2 feet on top of a raised grade, is completely out of scale with its surroundings. To the west of the site are preserved wetlands, and permanent open space coastal bluff. To the east are the open, sometimes farmed, fields of the airport. To the north is the one-story residential neighborhood of Pillar Ridge. To the south in Princeton, buildings do not exceed 36 feet high and most are smaller.

The view of the newly preserved bluffs would be blocked from Hwy 1. The pristine view from the beach on the harbor trail out to Mavericks, looking over the marsh toward Montara Mountain would be marred by the out-of-scale office park buildings. Views of the harbor and bay may be blocked from POST's new Pillar Point Bluff trails off Airport St. The plan to mitigate by screening the buildings with a narrow row of fast-growing trees not native to this area would not solve the problem.

We request story poles at an early point in the application process, in order for the community to accurately evaluate the effects of the unprecedented height and mass of these buildings.

Wellness Center Location
We recognize the need to provide more services for the developmentally disabled on the Coastside and we have concerns about the appropriateness of the proposed location, which would leave them segregated from general interaction with the community. The site is separated from schools, grocery stores, library, community parks, shopping and other residential support services by the Princeton warehouse district, Hwy 1, and long distances with spartan bus service. Developmentally disabled pedestrians might be forced to negotiate loading trucks, forklifts and other industrial hazards in an area that does not have sidewalks or paths. There is the additional safety concern of being next to an earthquake fault and in a tsunami zone. The site is approximately 500 feet from the airport runway and noise may be a particular problem for these residents. The opinion of a health services expert regarding these concerns would be appreciated.

Financial Feasibility
This proposed project would double the office space on the Coastside. Most of the commercial space in the nearby Harbor Village is currently vacant. We would like to request that an independent analysis of economic feasibility be required using updated economic data.

The residential units are designated for low income and ultra-low income people. What agency will oversee compliance with this requirement? We recommend that this information be included in an independent analysis.

Airport Overlay
The site of the proposed development is in close proximity to the Half Moon Bay Airport runway. We recommend the County take the latest FAA safety standards into consideration when reviewing the project.

Natural Resources
- No permitting agency wetland determination is included in this document and should be completed as soon as possible.
- What will be done to protect the groundwater, the Pillar Ridge water supply and Pillar Point Marsh from saltwater intrusion?
- Does this area contain archaeological sites?
- Should a project of this scale be built next to the Fitzgerald Marine Reserve an Area of Special Biological Significance (ASBS) and part of the federally protected Monterey Bay National Marine Sanctuary?

We hope a comprehensive EIR will address these issues in detail and that the County will require concrete answers prior to going forward.

Thank you for your consideration and the opportunity to comment,

Pillar Ridge and Seal Cove Residents

Signature	Name	Street, Moss Beach 94038
Lisa Ketcham	Lisa Ketcham	175 Culebra
Brigid O'Farrell	Brigid O'Farrell	1001 Ocean Blvd
Sabrina Brennan	Sabrina Brennan	165 LaGrande Ave
Judy Macias	Judy Macias	871 San Ramon Ave.
[illegible]	[illegible]	115 CULEBRA ST.

Camille Leung, Project Planner
San Mateo Co. Planning and Building Dept.

Re: Big Wave Facilities Plan Draft 2
March 26, 2009

Signature	Printed Name	Street, Moss Beach 94038
Jennifer Celestre	Jennifer Celestre	151 Barranca Ave.
TJ Glauthier	TJ Glauthier	1001 Ocean Blvd
Dorothy Norris	Dorothy Norris	112 Codo Ave
	Ty Wood	114 Codo
Patti Gallinetti	PATTI GALLINETTI	864 PARK AVE
Marilyn Handler (NO ADDRESS)	MARILYN HANDLER	SAN LUCAS AVE
	Steven M. Beardsley	140 Precita
Alan Hogg	ALAN HOGG	122 Bonita.
Susan Madonick	Susan Madonick	55 Precita Ave
Iris B Rogers	Iris B. Rogers	149 Barranca MB P.O. Box 1587 El Granada
Kent Roberts	KENT ROBERTS	180 SAN LUCAS MOSS BEACH
"Cid" Carlyle Young	Carlyle A Young	180 San Lucas Ave MB
Ma del Carmen Salcedo	Maria Salcedo	115 Retro LN
Steve Holmquist	STEVE HOLMQUIST	110 SAN LUCAS AVE
R. L. Harding	Rick Harding	864 Park Av. MB
	Lothar Tuppan	855 San Ramon Ave moss Beach
	Jan Dilbur	855 San Ramon Ave, M.B.
Sergio Mata	Sergio Mata	156 Culebra Moss B.
John Flannigan	JOHN FLANNIGAN	170 Los Banos Av. M.B. 94038
	Gregory Collins	873 Ocean Bl.
Cynthia Trujillo	Cynthia Trujillo	1065 Park Way
	BRYAN TRUJILLO	1065 PARK WAY
Elizabeth Hawkins	ELIZABETH HAWKINS	885 San Ramon Ave
Maureen Hawkins	MAUREEN HAWKINS	PO BOX 853 150 MADRONE MB 94038
	KEVIN L. COOKE	111 DERECHO MOSS BEACH CA 94038
	Gene Lindsey	112 La Granada

Camille Leung, Project Planner
San Mateo Co. Planning and Building Dept.

Re: Big Wave Facilities Plan Draft 2
March 26, 2009

Signature	Printed Name	Street, Moss Beach 94038
	Vanessa Castro	104 Barranca LN
	Lenore Sacco	164 Culebra LN
	PATRICIA A STEVENSON	123 RETIRO LN
	Elizabeth Daly Caffell	171 Madrone Ave
	MOIS MACIAS	871 San Ramon Ave
	GREG SARAB	14 CULEBRA
	Tony DeMello	171 Culebra
	Deborah L. Wong	122 Barranca Ln.
	MICHAEL A. WONG	122 BARRANCA LN.
	Giuliana Peterson	166 Culebra LN.
	LAUREN SHUBA	110 RETIRO LN.
	JIMMIE KARSGARD	111 Retiro
	Joseph m. TAMEZ	105 BARRANCA LN.
	ROBERTO E. TAMEZ	105 BARRANCA LN
	George H. Horbal	134 Codo Ln
	BILL SCHRADER	111 CODO LN
	Debra Leach	111 CODO LANE
	ROBT F. BROWN	110 LA GRANADA LN
	Richard Selke	FOLDOOR00@YAHOO.COM 139 Barranca
	Patricia L Blue	119 Barranca Ln.
	ELAINE M. SWANSON	115 LA GRANADA LN
	Roberta Vespremi	125 Precita Ave
	David Vespremi	125 Precita Ave.
	ELLEN JAMES	111 SAN LUCAS AVE
	Patricia Lauritzen	836 Park Ave
	Clarke Simm	131 La Grande

Camille Leung, Project Planner
San Mateo Co. Planning and Building Dept.

Re: Big Wave Facilities Plan Draft 2
March 26, 2009

Signature	Printed Name	Street, Moss Beach 94038
	Robert A Stevenson	123 Retiro Lane
	Rebecca k. Clark	P.O. Box 236/685 Sierra St.
	Ken V.R. Clark	P.O box 236 Moss Beach, Ca
	LOUISE F LAZZARI	PO B 370515 MONTARA
	CARLA BARNER	860 Linda Vista MB
	Pamela Eakins	847 San Ramon Moss Beach CA
	John IVAZES	961 Ocean BL
	ALICE LYMAN MILLER	50 Bernal Ave. MB
	DIANE L. BROSIN	65 BERNAL AVE M.B.
	Timothy Macleod	"
	VICTORIA CORSENTINO	131 SAN LUCAS AV, MB
	Aimee Luthringer	165 La Grande Ave, M.B.
	Ellen Moore	160 Los Banos Ave, MB
	Rona Goldstein	160 Los BANOS AV, MB
	HOWARD PERRY GRACE JR	195 LOS BANOS AVE MB
	Jay P. Hush	195 Los Banos Ave MB
	Hollie Dunham	142 ORVAL AVE. MB
	Bobbey Evans	471 CYPRESS AVE MB
	MARY DUFF	1030 AIRPORT MB.
	Dana Tywoniak	135 Orval Ave M.B.
	Richard Tywoniak	135 Orval Ave M.B.
	DENNIS BRODERICK	816 PARK AVE M.B.
	LAWRENCE M BAKER	185 ORVAL AVE, M.B.
	Susan Broderick	816 Park Ave, M.B.
	CAROL GUION	89 SAN LUCAS MB
	Nadia B. Popyack	919 Ocean Blvd. Moss Beach

Camille Leung, Project Planner
San Mateo Co. Planning and Building Dept.

Re: Big Wave Facilities Plan Draft 2
March 26, 2009

Signature	Printed Name	Street, Moss Beach 94038
Barbara Masek	BARBARA MASEK	121 SAN LUCAS AVE MB, CA
	Dean Lauritzen	836 Park Ave. Moss Beach, CA
Ed Bierdeman	Ed Bierdeman	106 Los Banos
Cary Phillips	Cary Phillips	196 Marine Blvd
Denise Phillips	Denise Phillips	196 Marine Blvd
	Greg Aysley	171 Alton Ave, MB
	Denise Aysley	171 Alton Ave MB
Mark Glenn	Mark Glenn	1025 Park Way MB
	Karen Sone	1025 PARK WAY MB
Alan Brennan	Alan Brennan	180 Orval Ave Moss Beach
Marie Brennan	Marie Brennan	180 Orval Ave Moss Beach
Neil Murray	Neil Murray	151 Orval Ave Moss Beach
Wendy Ferrari	Wendy Ferrari	118 Celebra, Moss Beach
	Molly Rice	856 Park Ave
Scott Meyer	Scott Meyer	856 Park
Karen Gonzales	Karen Gonzales	226 Cypress Ave

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DEC 2 4 2009

San Mateo County
Planning Division

PRINTED MATERIALS 12.23.09

1. Map of the Peninsula showing major faults:
http://pubs.usgs.gov/of/2005/1127/chapter8.pdf

2. USGS Table A-1. Database of Potential Sources for Earthquakes Larger than Magnitude 6 in Northern California:http://quake.usgs.gov/prepare/ncep/a_andreas.html

3. CA.gov Earthquake and Tsunami Info and Maps:
http://myhazards.calema.ca.gov/
Type in the Big Wave Project zip code, 94038 to see the hazard and inundation areas.
- PRINT SCREAN SHOT WITH MAP OF 94038 ZOOMED IN ON BIG WAVE SITE

4. Grand Jury Report - Tsunami Alert and Evacuation On the San Mateo County Coast:http://www.sanmateocourt.org/grandjury/2006/reports/TsunamiReportFinal.pdf

5. Half Moon Bay Tsunami Brochure: http://www.half-moon-bay.ca.us/Tsunamis_Brochure.pdf

6. Seven Principles for Planning and Designing for Tsunami Hazards:
http://www.calema.ca.gov/WebPage/oeswebsite.nsf/ClientOESFileLibrary/Plans%20and%20Publications/$file/DesignForTsunamis.pdf

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7. Fitzgerald Marine Reserve Historical Ecology:http://www.sfei.org/cca/Docs/phase2HE/Fitzgerald_MarineReserve_CCA_lowres_v3.pdf

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8. May 2009 REPORT: The Impacts of Sea-Level Rise on the California Coast:
http://www.pacinst.org/reports/sea_level_rise/report.pdf

Sea-level Rise MAPPING:
9.
http://www.pacinst.org/reports/sea_level_rise/PDF/Fig16_Population_Inundation_CA.pdf
10.
http://www.pacinst.org/reports/sea_level_rise/gmap.html
- PRINT SCREAN SHOT WITH MAP OF 94038 ZOOMED IN ON BIG WAVE SITE

11. December 2009 REPORT: Report on Sea Level Rise Preparedness:
http://www.slc.ca.gov/home_page_docs/SEA_LEVEL_Report.pdf

12. 2009 California Climate Adaptation Strategy: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF

13. Eroding cliff prompts Pacifica evacuation
http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2009/12/17/BA601B5QLH.DTL&tsp=1#ixzz0ZysciXIF

We need a way to cross Highway 1 safely in Moss Beach and Montara:

14.http://coastsider.com/index.php/site/news/safe_highway_1_crossing_in_moss_beach_and_montara_should_a_caltrans_priorit/091208/

15.http://www.halfmoonbayreview.com/articles/2009/12/03/news/breaking_news/doc4b186ea60f3f6571872691.txt

Developmental Disabilities

16. GOLDEN GATE REGIONAL CENTER – POLICY
GUIDELINES: http://www.ggrc.org/documents/BoD%20Policies%2007.pdf

17. http://www.disabilityrightsca.org/Pubs/701901.pdf

18. http://www.archrespite.org/archfs36.htm

19. http://www.buildingpartnershipsma.com/about.htm

20. http://www.napas.org/Decade_of_Little_Progress_Implementing_Olmstead.pdf

21. http://www.napas.org/media/default.htm

22. http://www.napas.org/issues/an/rs/resources.htm#assum

23.http://www.nctsnet.org/nctsn_assets/pdfs/reports/traumatic_stress_developmental_disabilities_final.pdf

24. http://www..wsf.org/behavior/guidelines/sexualabuse.htm

25. http://disabilities.temple.edu/programs/justice/docs/bibliographyScans/Davis%203.pdf

The San Andreas and San Gregorio Fault Systems in San Mateo County

Selected Field Trip Destinations in the Northern Santa Cruz Mountains and Along the Coast

Trip Highlights: San Andreas Fault along the I-280 and Skyline Boulevard corridor, and at Mussel Rock Park; Calero Limestone at Rockaway State Beach; Devil's Slide; Montara Mountain granite; Seal Cove Fault, the San Gregorio Fault System, and geologic structures exposed along the coast at Montara State Beach, James V. Fitzgerald Marine Reserve, and at Pillar Point on Half Moon Bay

This field trip focuses on the geology in the northern Santa Cruz Mountains and the coast in San Mateo County. Selected stops highlight landscape features and bedrock along the San Andreas and San Gregorio fault zones, and other localities that reveal information about the geologic evolution of the landscape. The field trip follows a loop route that begins near Crystal Springs Reservoir on I-280. The route follows I-280 and Highway 35 (Skyline Boulevard) north, then follows Highway 1 south along the San Mateo Coast before returning east on Highway 92. back to I-280.

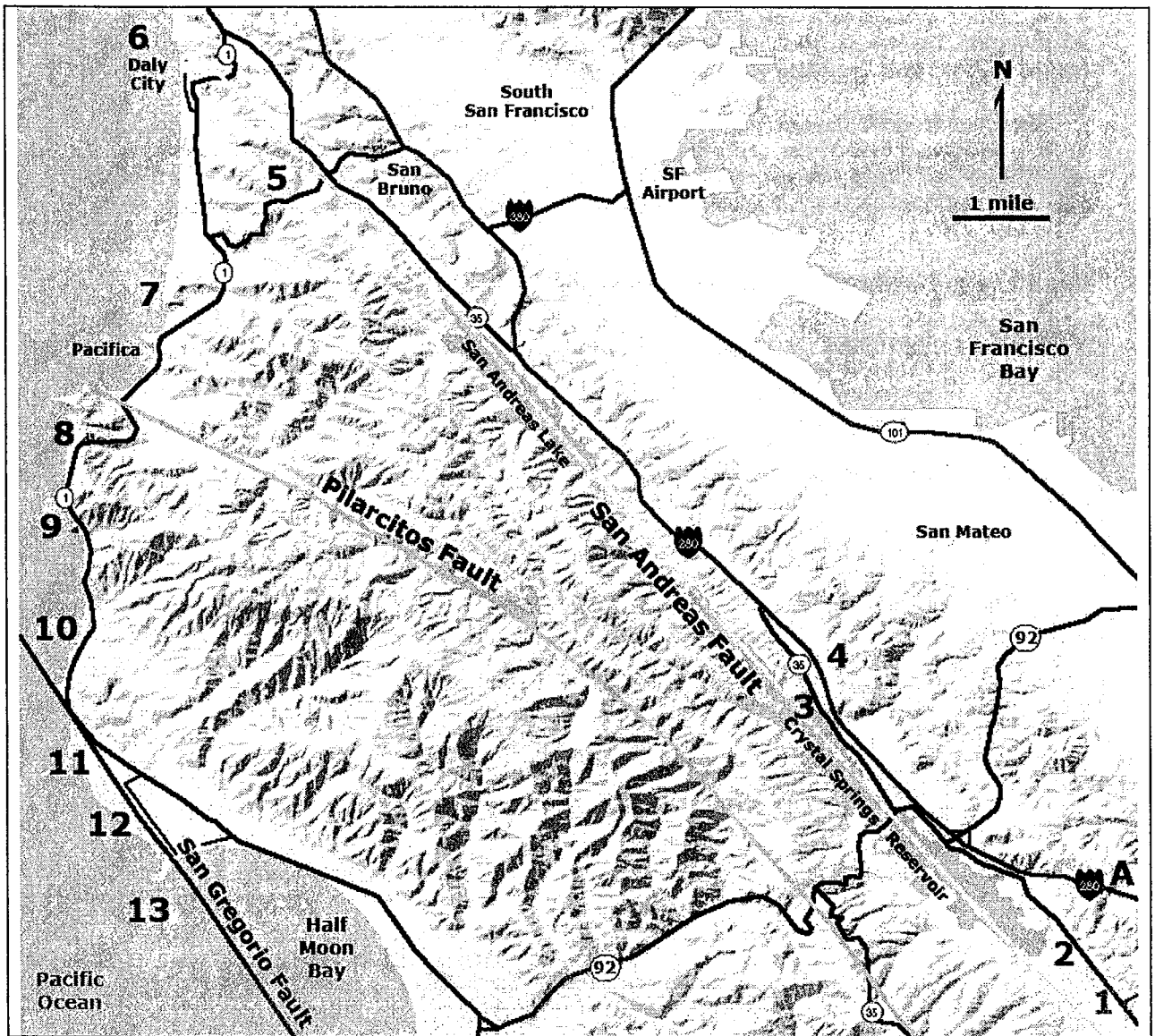


Figure 8-1. Map of the Peninsula showing major faults in the northern Santa Cruz Mountains in San Mateo County. Stops include: A) I-280 Vista Point, 1) Filoli Center, 2) Pulgas Water Temple, 3) Crystal Springs Dam, 4) I-280 Rest Area, 5) Milagro Ridge, 6) Mussel Rock Park, 7) Pacifica Quarry, 8) San Pedro Mountain and Devil's Slide, 9) Montara Mountain, 10) Montara Beach, 11) James V. Fitzgerald Marine Preserve, 12) Half Moon Bay Airport, and 13) Pillar Point and Mavericks.

Planning Your Fieldtrip

A field trip along the San Andreas Fault and to the coast in San Mateo County should be planned according to time limiting factors: tide conditions and trip destination interests. You will not want to attempt to visit coastal localities described in this guide during high tide or during inclement weather. The field trip described here starts at the Park and Ride at the Edgewood Road exit on I-280 where extra cars can be left during the field trip. The road log presented below follows a recommended route for **when low tide occurs in the mid afternoon.** Many websites provide tide information; search "tides" and "Half Moon Bay" on the World Wide Web to find a reasonable low tide estimate for the coast. Also, be sure to check weather forecasts and projected wave heights. The San Mateo beaches and tide pool areas are extremely dangerous places during high surf. High waves can occur unexpectedly.

More stops are provided than could be reasonably visited in one day without rushing. Optional stops are included in this guide to help plan the best trip for specific group interests or time constraints. For instance, although the Filoli Center is a wonderful trip destination, it is both fairly expensive and a time consuming venture that requires advanced planning and should be considered for a separate trip. Groups in a hurry might consider at least one stop along I-280 for the first part of the trip. The recommended northbound route presented below includes the all-important restroom stop at the northbound I-280 Rest Area (Stop 4 described below).

If low tide occurs in the morning, plan to head directly to Half Moon Bay, but consider stopping first at the I-280 Vista Area (Optional Stop A) just north of the Edgewood exit before taking Highway 92 west. Be sure to take a detailed map of San Mateo County with you on the trip. Two other geology and engineering field trips in this region include Andersen and others (2001), and Williams (2001); Brabb and others (1998) provide a geologic map of the area.

Road Log to Northbound Trip: San Andreas Rift Valley and San Mateo Coast

Mileage	Description
0.0	**Park and Ride** (east side of I-280 at Edgewood Road). This is a good location to carpool from (but do not leave valuables in cars). The Edgewood Road/Cañada Road exit on I-280 is located 4 miles north of Woodside Road (Highway 84) and is six miles south of the Highway 92 exit for Half Moon Bay. Drive west on Edgewood Road.
0.7	Turn right (north) on Cañada Road. Note that Cañada Road runs roughly parallel to the San Andreas Fault through its rift valley. Outcrops of Franciscan sandstone (greywacke), greenstone, and some serpentinite can be seen along the road and in bedrock exposures along the shoreline of Crystal Springs Reservoir.
2.0	**Stop 1 – Filoli Center** (optional stop; see description below). Continue north on Cañada Road.
2.4	**Stop 2 – Pulgas Water Temple** (optional stop; see description below). Continue north on Cañada Road.
4.7	Intersection of Cañada Road and Highway 92. Bear left (west at the stoplight).
5.4	Turn right (north) on Skyline Boulevard (Highway 35). The San Andreas Fault crosses the west end of the Highway 92 causeway. A small east-facing scarp reveals the trace of the fault along a low hill on the eastern shore of the reservoir just north of Highway 92.
6.3	Intersection of Bunker Hill Drive. Continue north on Skyline Boulevard.
6.8	Cross Crystal Springs Dam and proceed to the parking area to the left on the north side of the dam.
6.9	**Stop 3 – Crystal Springs Dam** (see description below).
7.5	Return south on Skyline Boulevard to Bunker Hill Drive. Turn left on Bunker Hill Drive.
7.6	Turn left (north) on I-280.
8.0	**Stop 4 – I-280 Rest Area [northbound only] (see description below).** Restrooms are available. **Reset mileage to zero.** Continue north on I-280.

5.5	Exit on Skyline Boulevard (Highway 35 – Pacifica exit).
6.0-7.0	Note the topography along this scenic route between I-280 and San Bruno Boulevard. Skyline Boulevard follows Buri Buri Ridge along the east side of the San Andreas Rift valley northward to Daly City. Look to the west to get a glimpse of San Andreas Reservoir, the original home of San Andreas Lake, a historic natural sag pond from which the name of the San Andreas Fault was derived. Sweeney Ridge is on the west side of the Reservoir. Skyline Boulevard follows and crosses the San Andreas Fault (or splay of faults) in a number of places along the route.
9.0	Turn left on Sharp Park Drive.
9.7	Turn right to the park access lane to Milagra Ridge just past College Drive.
9.9	**Stop 5 – Milagra Ridge** (part of Golden Gate National Recreation Area [GGNRA]) (see description below). Return east to Skyline Boulevard (Highway 35). Turn north on Skyline.
14.4	Exit on Highway 1 South.
15.9	Exit at Palmetto Drive. It is a hard-right turn onto Palmetto Drive.
16.7	Bear left of Westline Drive.
17.2	**Stop 6 – Mussel Rock Park** (see description below). **Reset mileage to zero.** Return north on Westline Drive. Bear Right on Palmetto.
1.3	Continue straight on Palmetto past the McDonald's.
1.8	Take Highway 1 South.
4.3	Mori Ridge (GGNRA) parking area on the right; however, continue south on Highway 1 past the large field in the abandoned Pacifica limestone quarry area on the right.
5.7	Turn right on San Marlo Way (this small road takes you into the Rockaway Beach Shopping Area). Proceed to a parking area at the north end of Rockaway Beach.
5.9 0.0	**Stop 7 - Rockaway Beach and Pacifica Quarry** (see description below). Restaurants and public restrooms are available in the Rockaway Beach Shopping Center. **Reset mileage to zero** at the main intersection for the shopping center on Highway 1. Continue south on Highway 1.
1.1	Highway 1 crosses San Pedro Creek. The creek follows the approximate trace of the Pilarcitos Fault.
1.8-3.2	**Rolling Stop 8 – San Pedro Mountain and the Devil's Slide** (see description below). (Note: "rolling stop" means keeps driving to a more recommended stop locations described below, but observe features in the surrounding landscape as you drive by.)
3.2-	**Rolling Stop 9 – Montara Mountain** (see description below).
4.1	McNee Ranch State Park/Gray Whale Cove State Beach parking area is on the east side of Highway 1. An old railroad cut near the parking area is a good place to look at the weathered Montara Granite. An even better place to look at the Montara Granite is at Stop 11.
5.5	**Stop 10 – Montara State Beach** (see description below). Restrooms are available. Continue south on Highway 1.
7.5	Turn right (west) on California Avenue.
7.9	**Stop 11 – James V. Fitgerald Marine Preserve** (see description below). Restrooms are available. Return via California Avenue to Highway 1 and continue south.
8.6	Turn right (west) on Cypress Avenue.
9.1	Turn left (south) on Airport Avenue.
9.2-11.2	**Rolling Stop 12 – Seal Cove Fault along Airport Avenue** (see description below). Continue south on Airport Avenue into Princeton on Half Moon Bay.
11.3	Turn right on Harvard Avenue.
11.4	Turn right on West Point Avenue.
11.7	Turn left into the Pillar Point Marsh Preserve (GGNRA) just before the entrance to the Pillar Point Airforce Station.
11.8	**Stop 13 – Pillar Point and Mavericks** (see description below). Restrooms are available. Return north into Princeton. Follow Harvard Avenue east.

12.8	Turn right on Capistrano Road.
12.9	**Half Moon Bay Brewing Company** (and restaurant) is on left. Continue south on Capistrano Road.
13.0	Turn right on Highway 1 South.
17.3	Turn left (east) on Highway 92.
22.4	Turn right (south) on I-280.
26.5	Exit at Edgewood Road to return to the Park and Ride. **End of field trip.**

San Andreas Rift Valley in San Mateo County

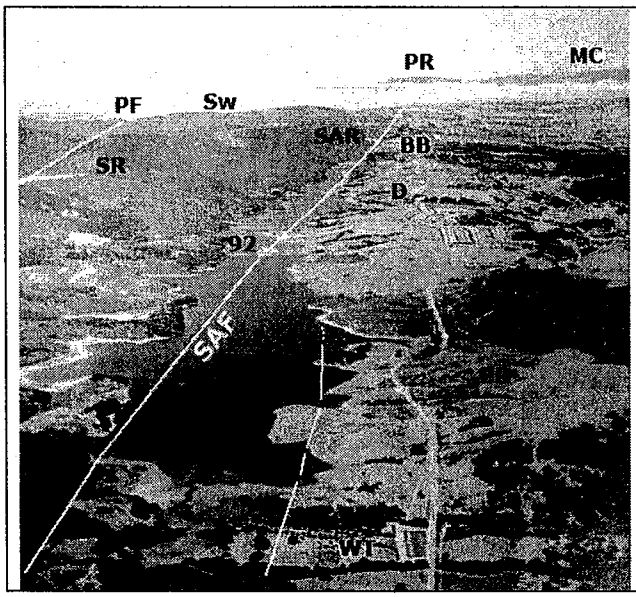


Figure 8-2. This oblique aerial view is looking north along the rift valley of the San Andreas Fault (SAF) in the vicinity of Crystal Springs Reservoir (CSR). The photograph was taken from about a mile above the Filoli Estate. The Pulgas Water Temple (WT) is in the foreground. The Highway 92 causeway (92) bisects the reservoir (*Lower* and *Upper* reservoirs, with Upper in the foreground). Sawyer Ridge (SR) and Sweeney Ridge (Sw) run between the San Andreas Rift valley and a valley along the Pilarcitos Fault (PF) in the northern Santa Cruz Mountains. Crystal Springs Dam (D) was built across a narrow gorge cut by San Mateo Creek through the eastern shutter ridge along the San Andreas Fault. This gap divides Pulgas Ridge [PR] and Buri Buri Ridge [BB] near San Andreas Reservoir [SAR]. Fog covers the Golden Gate. Higher peaks of Point Reyes (PR) and Marin County (MC) are in the distance beyond the Gulf of the Farralones. This photograph was taken before the construction of I-280. A similar view appears in Wallace, 1990.

Optional Stop A. I-280 Vista Point of Crystal Springs Reservoir

Stop highlights: San Andreas Rift Valley, shutter ridge, serpentinite, greenstone

For groups in a hurry, to take advantage of morning low tide along the coast, consider taking a brief orientation stop at the I-280 Vista Point located 0.5 miles north of the Edgewood Road exit. The Edgewood Road exit is located 2 miles south of the Highway 92 (Half Moon Bay exit). Note that the Vista Point is accessible only on the north-bound lane of I-280. Southbound travelers should take the Edgewood Road exit on I-280, cross to the other side of the Interstate, then return northward to the Vista Point exit. Parking for about a dozen vehicles is typically available.

The I-280 Vista Point provides an excellent location for an introductory overview about the regional geology of the San Andreas Fault and the northern Santa Cruz Mountains. The Vista Point provides a sweeping view of the San Andreas Rift Valley along the central portion of the Peninsula segment of the fault. Crystal Springs Reservoir floods the lower portion of the linear rift valley (see figs. 8-1, 8-2, and 8-3). Although published estimates vary, and are often disputed, roughly 300 km of offset occurred along the mid-section of the San Andreas Fault (south of the Bay Area). In the Bay Area, this amount of offset is divided by the regional fault system. About 174 km of offset in the Bay Area has occurred along the East Bay fault system, whereas 127 km of offset has occurred along the San Andreas Fault/Pilarcitos fault system in the Santa Cruz Mountains on the San Francisco Peninsula. Only about 22 km has been absorbed on the modern Peninsula segment of San Andreas after 100 to 105 km of offset occurred on the Pilarcitos Fault (McLaughlin and others, 1996; Jachens and others, 1998). Pilarcitos Fault (or Pilarcitos/Montara Fault) is located in the valley on the west side of Sawyer Ridge—shown in figs. 8-1, 8-2 and 8-3. Additional regional right-lateral fault displacements that may total in the range of hundreds of kilometers occurred along the San Gregorio Fault and other fault systems along the west side of the Santa Cruz Mountain and offshore.

Boulders of serpentinite and greenstone can be viewed along the paths and in the walls around the Vista Point. Serpentinite (or more technically, serpentinized-ultramafic rock) is derived from the mantle or lower oceanic crust and probably originally formed beneath a mid-ocean ridge spreading center. Massive serpentinite bodies in the Bay Area are part of the Coast Range Ophiolite of Jurassic age. The greenstone is from the Franciscan Complex of Cretaceous age and is abundant throughout the northern Santa Cruz Mountains. The Franciscan Complex represents rocks from the upper ocean crust and consists of rocks formed from submarine volcanism and from deep marine sediments. Greenstone forms from the low-temperature metamorphic alteration of basalt. The original basalt probably accumulated as intrusions or flows on ancient submarine volcanoes on the seafloor. Other sediments that accumulated on the sea bed became layered chert, shale, greywacke sandstone, and limestone. Some of these deposits eventually were metamorphosed into metachert, slate, schist, metasandstone (including metagreywacke), and marble. Over a 100-million year period, these rocks migrated great distances from their place of origin, carried by the tectonic plates on which they were deposited. These rocks were wedged against the North American plate along the subduction zone that existed here at the time amd were accreted onto the western North American continental margin. Slivers of serpentinite are found within the Franciscan Complex. Wahrhaftig and Murchey (1987), and Elder (2001), provide discussions about the geology of the Franciscan Complex in Marin County in the headlands west of the Golden Gate.

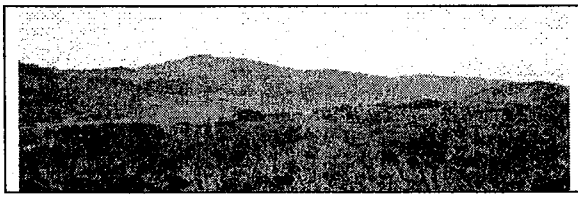


Figure 8-3. View of Crystal Springs Reservoir in the rift valley of the San Andreas Fault. This view is from the northwest end of the I-280 Vista Point looking northwest toward Sawyer Ridge beyond the reservoir. The Interstate is not shown in the foreground. The Pilarcitos Fault is in the valley on the west side of Sawyer Ridge.

Stop 1. Filoli Center (optional stop on Cañada Road)

Stop highlights: San Andreas Rift Valley, offset alluvial fan deposits, sidehill bench, historic estate and gardens

The Filoli Center is a 654-acre estate with a Georgian-style mansion surrounded by 16 acres of formal gardens. The Filoli Estate was built for the family of William Bowers Bourn II. The building was designed by Mr. Bourn's friend and San Francisco architect, Willis Polk, who also designed the nearby Pulgas Water Temple. Mr. Bourn amassed a fortune from the Empire Gold Mine, a bedrock gold mine in the Mother Lode in Grass Valley, California. He was also owner and president of the Spring Valley Water Company that comprised Crystal Springs Lake and surrounding lands (now managed by of the San Francisco Water Company). The Bourns were supposedly severely traumatized by the San Francisco's great disaster of 1906. The failures of the water system in San Francisco contributed to the massive fire damage after the earthquake. However, the Bourns had their country mansion built ten years after the 1906 disaster, probably without the knowledge of the proximity of the great earthquake fault nearby. After Mr. Bourn's death in 1936, the estate was purchased by the Willam P. Roth family (owners of the Matson Navigation Company). Mrs. Lurline B. Roth donated 125 acres of the estate (including the mansion and gardens) to the National Trust for Historic Preservation in 1975, and it is now operated by the Filoli Center.

Many geologic and paleoseismic investigations have been conducted in the Filoli area because landscape features and sedimentary deposits along the San Andreas Fault are well preserved and relatively undisturbed by human activity. The main trace of the fault passes through the undeveloped Filoli Center grounds several hundred meters to west of the mansion and gardens. The fault created an escarpment and sidehill bench in the area southeast of the mansion where the fault runs through a pre-historic Ohlone (Native American) habitation site. Nearby, Spring Creek crosses the fault where an embankment reveals alluvial fan sediments that are offset by the fault, including slip from the 1906 earthquake. In 1993 to 1994, trenches were dug in a meadow and sag pond area near the creek about a half mile south of the mansion. The trenches were dug to evaluate the fault and its paleoseismicity (Wright and Hall, 1996). Hall and others (1995) interpreted a total slip from the 1906 earthquake in the range of 2.5 m in the fault zone in the Filoli area. The M 7.0 earthquake of 1838 also produced about 1.5 m of offset along the fault. Nearby in vicinity of a ranger's residence, a row of mature cypress trees is offset where it crosses the fault.

Please note that the significant geologic features associated with the San Andreas Fault are not accessible via the general public estate and gardens area of the Filoli Center. Guided trips to look at natural features on the non-public grounds require an escort by Filoli volunteer staff and reservations are required well in advance. See the Filoli website for hours, access fees, and other information (http://www.filoli.org).

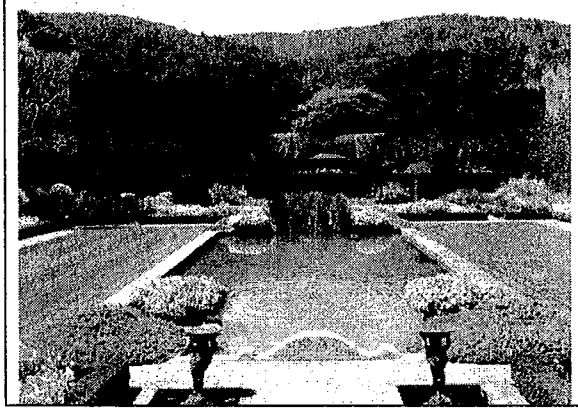


Figure 8-4. The Filoli Center (estate and formal gardens) is located on Cañada Road west of I-280 near the Edgewood Road exit. The San Andreas Fault runs through the forest west of the developed estate grounds where it offsets alluvial fan deposits. Skyline Ridge is in the distance.

Stop 2. Pulgas Water Temple (optional stop on Cañada Road)

Stop highlights: San Andreas Rift Valley, Franciscan Complex sandstone, greenstone, serpentinite

The Pulgas Water Temple is located along Cañada Road between the Filoli Estate and the southern end of Crystal Springs Reservoir. The Pulgas Water Temple was designed by San Francisco architect, Willis Polk and has a Roman temple style. The temple was constructed in 1934. The temple marks the western terminus of the water pipeline and tunnel system that drains from the Hetch Hetchy Reservoir in the Sierra Nevada and supplies the City of San Francisco and other municipalities with water stored in Crystal Springs Reservoirs and San Andreas Lake. The Pulgas Water Temple was renovated in 2004; the parking area serves as a trailhead for Fifield-Cahill Ridge Trail. Note that the parking area is closed on the weekends except for special events.

The drive northward along Cañada Road provides a less-stressful way of viewing the San Andreas Rift Valley and Crystal Springs Reservoir than driving along along Highway 280. Outcrops of Franciscan sandstone, greenstone, and some serpentinite can be seen in the field and road cuts along Cañada Road between Filoli and Highway 92, and along the shore of Crystal Springs Reservoir.

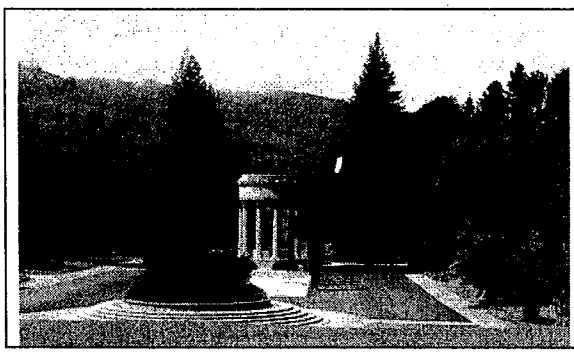


Figure 8-5. The Water Temple is located along Cañada Road just north of the Filoli Center. The trace of the San Andreas Fault that ruptured in the 1906 earthquake runs along the base of the mountainside in the distance.

Stop 3 – Crystal Springs Reservoir Dam

Stop Highlights: a high dam constructed near the San Andreas Fault, shutter ridge, Crystal Springs Canyon

Crystal Springs Dam is accessible along Skyline Boulevard between the Half Moon Bay exit for Highway 92 (west) and Haynes Road exit on I-280. Skyline Boulevard runs parallel to I-280 on the east side of Crystal Springs Reservoir. Parking for the dam and the shoreline Sawyer Trail is located along Skyline Boulevard just north of the dam. Outcrops of serpentinite can be seen along the road near the dam. Serpentinite soils in the vicinity host a manzanita scrub forest along the shore of the reservoir. Note that the reservoir shoreline and surrounding watershed area is closed to public access.

Construction of Crystal Springs Reservoir began in the 1870s with removal of all vegetation and manmade structures from a 9 mile stretch along upper San Mateo Creek valley. The reservoir was part of the extensive water system designed by the Spring Valley Water Company of San Francisco to help quench the demands of the rapidly growing city. Construction of the dam across Crystal Springs Canyon was completed in 1889 and heavy rains of the following year filled the reservoir to capacity in a little over a year (nearly a decade sooner than was anticipated). At the time of its construction the dam was the largest in the world, designed to hold back 32 billion gallons of water. The dam is made of cement and was originally about 120 feet high. The dam was raised to 145 feet in 1890 and to 149 feet in 1911. It is 120 feet thick at its base and about 20 feet thick at the top. Crystal Springs Reservoir is bisected into Lower and Upper reservoirs by the causeway traversed by Highway 92. The Crystal Springs Dam is on the Lower Reservoir.

Crystal Springs Dam is located ominously close to the San Andreas Fault; the fault trace runs parallel to the dam several hundred feet to the west and submerged beneath the reservoir. Crystal Springs Canyon is a narrow gorge cut through the eastern shutter ridge of the San Andreas Fault. Buri Buri Ridge is north of the canyon and Pulgas Ridge is south of the canyon. The dam survived both the 1906 and 1989 earthquakes with no apparent damage. The drainage tunnel of the San Andreas Lake (reservoir) dam to the north and upstream of Crystal Springs Reservoir was offset and severely damaged by motion along the San Andreas Fault during the 1906 earthquake, but the earth-fill dam itself survived undamaged. It is interesting to note that the significance of the San Andreas Fault was unknown at the time of the dam's construction.

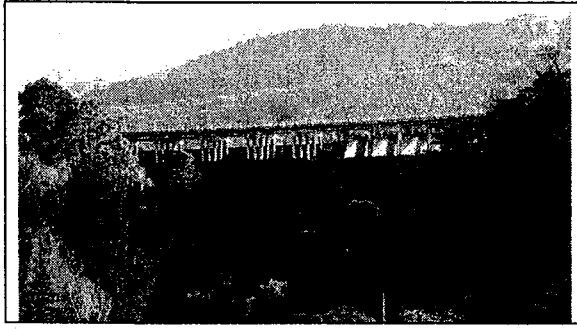


Figure 8-6. This view of Crystal Springs Reservoir Dam is from along Crystal Springs Road beneath the I-280 bridges over Crystal Springs Canyon. Skyline Boulevard crosses the dam. Sawyer Ridge is in the distance.

Stop 4. I-280 Northbound Rest Area

Stop Highlights: San Andreas Rift Valley overlook, Crystal Springs Reservoir, serpentinite

The northbound I-280 is another optional fieldtrip stop that provides a sweeping vista of the San Andreas Rift Valley, Sawyer Ridge, and Crystal Springs Reservoir. A walkway leads to an overlook area around a statue of Junipero Serra, the founding father of the California Missions. Walls along the path and of the restroom facility are made of serpentinite and greenstone from local sources (see discussion for Stop A above).



Figure 8-7. Franciscan Padre Junipero Serra (1713-1784) is accredited for founding the Mission which led to the Spanish colonization of California. He was appointed to establish the Missions in *Alta* (upper) California in 1767 and spent the rest of his life pursuing that effort. He aided an expedition in locating San Francisco Bay, and before he died he founded nine of the California missions.

Although Serra's statue at the rest area on northbound I-280 should probably be pointing at the bay, instead it points across the Interstate toward the San Andreas Fault!

Northern San Mateo County

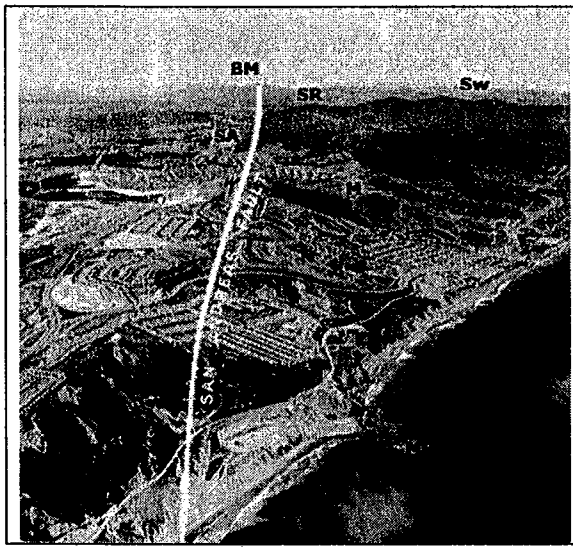


Figure 8-8. Aerial view of the San Andreas Fault in the northern Santa Cruz Mountains in San Mateo County. This view is looking south toward the coast at Mussel Rock Park and neighborhoods of Daly City. Labeled features include Mussel Rock (MR), Milagra Ridge (M), San Andreas Lake (SA), Sawyer Ridge (SR) and Sweeney Ridge (Sw). Black Mountain (BM) in northern Santa Clara County is in the distance. This photograph was probably taken in the early 1960s when most of the residential construction was nearly completed in the Daly City region. Note the trace of Highway 1 along the sea cliffs in the Mussel Rock area. A massive landslide is near the "SAN" of the San Andreas Fault label on the image. Today, very little remains of the trace of the highway due to coastal erosion and landsliding (see fig. 8-10). The landscape east of Mussel Rock is underlain by the Merced Formation. The Merced Formation is a mile thick sequence of poorly-consolidated sedimentary materials that accumulated in coastal and nearshore marine environments during the late Pliocene and Pleistocene epochs.

Stop 5 – Milagra Ridge (Golden Gate National Recreation Area)

Trip highlights: San Andreas Rift Valley, coastal view of Pacifica region, butterfly preserve

Milagra Ridge offers a good view of the urbanized area along the San Andreas Fault and along the coast. The preserve is a "habitat island" – a remnant of coastal prairie now surrounded by urban development. In the past, the area was used by native Ohlone people. The land was then later claimed by Spanish settlers and Mexican rancheros. A gun battery was installed on the ridge during World War II, and a Nike missle station was installed during the Cold War. Extensive urban development of the surrounding area began in the late 1950s. In 1984 the land was added to the Golden Gate National Recreation Area. The parkland is a preserve for threatened and endangered species—the Mission blue and San Bruno elfin butterflies, and the California red-legged frog.

Parking is extremely limited on a small access road via Sharp Park Road opposite the College Drive access to Skyline College. A short uphill trail that starts at the parking area leads to an overlook of the Pacifica area and headlands along the coast. On the east side of the ridge, the rift valley of the San Andreas Fault is clearly visible as it runs through the urban setting adjacent to Skyline Boulevard. Sweeney Ridge to the south is also part of the Golden Gate National Recreation Area. It was on Sweeney Ridge in 1769 that Spanish explorer Captain Gaspar de Portola recorded in his diary an account of the first sighting of what would become the busy seaport harbor and metropolitan region around San Francisco Bay. For more information, see the National Park Service websites for Milagra Ridge (http://www.nps.gov/goga/clho/miri/) and for Sweeney Ridge (http://www.nps.gov/goga/clho/swri/).



Figure 8-9. View of the San Andreas Rift Valley on the west side of Milagra Ridge.

Stop 6 – Mussel Rock Park

Trip highlights: Quaternary Merced Formation, Franciscan greenstone, landslides, coastal erosion, urban geohazards

Mussel Rock Park is situated along the northern San Mateo Coast at Daly City. The Peninsula segment of the San Andreas Fault runs out to sea at just north of Mussel Rock (figs. 8-7, 8-8, and 8-10). The fault trace is obscured by landslide deposits and an old garbage dump, now filled, in the park area. However, the presence of the fault can be seen in the bedrock contrast from Cretaceous age greenstone of the Franciscan Complex of Mussel Rock itself located west of the fault, and the late Pliocene to Quaternary-age sediments of the Merced Formation west of the fault. Current theory is that the epicenter of the 1906 earthquake probably occurred along the offshore segment of the San Andreas Fault several miles north of Mussel Rock in the region offshore from Ft. Funston at 37°70'N, 122°50'W (location data from California Geological Survey website: *Anniversaries of Notable California Earthquakes*): http://www.consrv.ca.gov/CGS/rghm/quakes/eq_calendar.htm). The northern end of the Peninsula segment of the San Andreas Fault experienced about 4 meters of right-lateral displacement and experienced near the full intensity of the ~8 M of the 1906 earthquake. However, the area along the fault was essentially undeveloped at the time of the great earthquake.

The San Andreas Fault runs through urbanized areas of San Bruno and Daly City. Although developers were probably aware of the fault's location, construction of many residential homes and businesses proceeded because earthquake fault zone assessment and zoning laws were not yet established. The Alquist-Priola Earthquake Zoning Act of 1973 set forth the minimum fault investigation and approval requirements for all California cities and counties. The Act requires fault investigations for developments of four or more houses and subdivisions of five or more parcels. No structure subject to the provisions can be placed closer than 50 feet to a fault unless studies approved by a local authority support a lesser setback, but no structure can cross the trace of a fault with established earthquake potential. An additional hazard to property and structures in this area is from landsliding. A number of homes have been destroyed or severely damaged because they were built too close to the sea cliff on unstable ground.

Use caution when exploring the landslide area, the greenstone outcrops near Mussel Rock, or the beach below the sea cliffs. Do not attempt to go on the beach during high tide or during high surf. There is not enough space along the upper beach to escape from rogue waves, and material is constantly sloughing off the cliff. The same is true of the cliffs along the upper landslide escarpment. Open fractures occur throughout the landslide area and may not be visible beneath vegetation cover.

Only the lower part of the Merced Formation crops out in the Mussel Rock Park area. These sandstone beds are steeply dipping near the fault zone, but dip more gently northward along the coast at Thornton State Beach (north of Mussel Rock Park). The Merced Formation consists of interbedded sandstone and shale and contains some fossiliferous marl and conglomeratic beds. These deposits accumulated in marine shelf, intertidal, and coastal sedimentary environments as sea level rose and fell during the ice ages of the Quaternary Period. As the modern strand of the Peninsula segment of the San Andreas Fault developed, the land steadily rose in late Quaternary time, eventually elevating the once marine sediments to their present elevation of 750 feet in the bluffs along the San Andreas Fault Zone at Mussel Rock Park. A better place to visit the Merced Formation is at Fort Funston located several miles north of Mussel Rock Park. The geology of the Merced Formation is described by Clifton and Hunter (1987) and Andersen and others (2001). For more information about Fort Funston, see the National Park Service website at http://www.nps.gov/goga/fofu/.

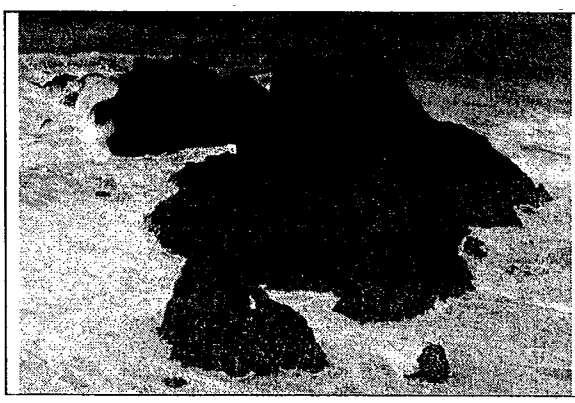


Figure 8-10. Mussel Rock is part of a large outcrop belt of greenstone that forms a small promontory and sea stacks on the San Mateo coast in Daly City. This belt of greenstone of the Cretaceous Franciscan Complex is on the west side of the San Andreas Fault.

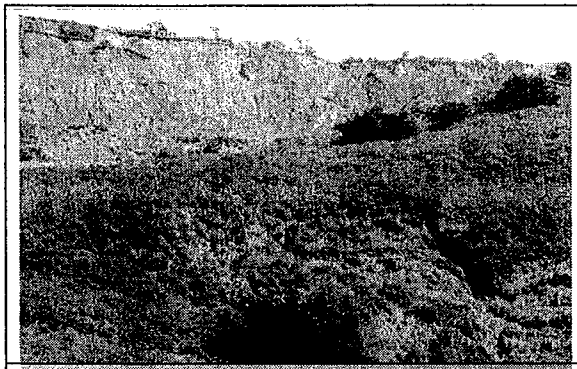


Figure 8-11. A massive landslide complex at Mussel Rock Park masks the main trace of the San Andreas Fault. Note the high, barren slump escarpment in the background. Ongoing coastal erosion at the toe of this slide area promotes the landward migration of the high wall of the landslide escarpment. Numerous homes have been destroyed, damaged, or condemned along this coastal slide area of Daly City.

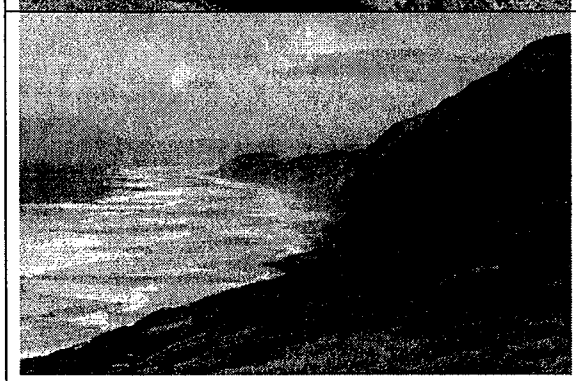


Figure 8-12. View looking northward from Mussel Rock Park along the sea cliffs at Thornton Beach State Park. The rolling hill slope in the foreground is part of the toe area of the large landslide complex at Mussel Rock Park. The sea cliffs are exposures of the Merced Formation. The Ocean Shore Railroad built along this section of coast in 1905 to 1906 was severely damaged by the 1906 earthquake. Because of ongoing troubles due to landsliding, the rail line was abandoned in 1920. In the 1930s, the rail line was widened to accommodate Highway 1. However, shortly after the M 5.3, March 22, 1957 earthquake the route was once again abandoned. Today only a trace of the highway cut can be seen about midway up the sea cliff. See fig. 8-8 for comparison.

Stop 7 – Pacifica Quarry and Rockaway Beach

Stop highlights: Permanente Terrane, Calera Limestone, Pilarcitos Fault, coastal headlands

Rockaway Beach is a good place to view the headlands along the northern San Mateo Coast and to access the Pacifica Quarry. The Rockaway Beach Shopping Center usually has ample parking. However, fieldtrip participants should be given a time to meet at the northwest end of the rip-rap beach wall (as the beach and shops grow more crowded during the mid-day it will probably not be possible to park vehicles together near the beach).

From the rip-rap seawall area it is possible to see a geomorphic expression of the Pilarcitos Fault along the north facing flank of the San Pedro Point headlands to the south of Rockaway Beach (see fig. 8-13). Unfortunately, there are no bedrock exposures along the Pilarcitos Fault that are accessible to the public. The presence of the fault is revealed by a change in bedrock lithology. On the east side of the fault, the bedrock conisits of Franciscan Complex (mostly greenstone and sandstone exposed in the Rockaway Point headlands). The bedrock on the west side of the fault consists of interbedded sandstone and shale (turbidites) of Paleocene age. These turbidites are exposed in Highway 1 road cuts south of Pacific Beach and in the San Pedro Headlands and (see figs. 8-16 and 8-17 described in Stop 8).

Pacifica Quarry is an inactive limestone and greenstone mine on the south end of the Mori Point headlands at the north end of Rockaway Beach. Small-scale limestone mining began in the Pacifica area in the early 19th century when lime was used primarily for whitewash for buildings in the Presidio district of San Francisco. The larger quarry began operation in 1904, a year before the Ocean Shore Railroad was established. Much of the limestone mined at the site was probably used for cement in San Francisco's reconstruction after the 1906 earthquake. Shortly after the city of Pacifica was incorporated in 1957, the community voted to donate much of the undeveloped coastal land, including Mori Point, to the National Park Service (Golden Gate National Recreation Area) in an effort to prevent further development. Efforts in the late 1990s were made to develop the abandoned quarry into housing and a convention center, but local environmental groups have so far prevented this effort. The restored Calera Creek is considered habitat for the endangered California red-legged frog. The Rockaway Beach Quarry Trail crosses through the quarry area.

The Calera Limestone Member of the Franciscan Complex is about 70 m thick. The Calera Limestone is part of the Permanente Terrane, a split-up block of Franciscan rocks that also crops out in the foothills along the San Andreas Fault in Santa Clara County, including at El Toro Peak in Morgan Hill, Calero County Park, and in the Permanente Quarry in

the Permanente Creek area of the larger Stevens Creek watershed near Cupertino, California. The Calera Limestone Member consists mostly of a dark gray, fine-grained (micritic) limestone locally recrystallized to crystalline calcite masses and contains interbedded nodular layers of chert. The Calera Limestone is also locally cut by greenstone dikes (originally of basalt composition).

The Calera Limestone formed by the diagenetic and metamorphic alteration of the original lime ooze sediments (including planktonic forams and coccoliths) deposited on the ocean floor. Fossils indicate a middle Cretaceous age (Albian to mid-Cenomanian stages, about 105 to 94 million years ago). The presence of tropical microfauna suggests that the calcium-carbonate deposits of the Calera Limestone have been transported a significant distance from their place of origin by plate-tectonic movement (Tarduno, 1985). In the modern ocean, the carbonate-compensation depth (CCD) is typically around 4 km deep in tropical latitudes. Below the CCD, carbonate material (such as plankton skeletal material) tends to dissolve in cold water conditions before it can be incorporated into sediments. However, in low-latitude regions carbonate sediment generation is more rapid, and carbonate ooze accumulates on the deep-ocean seabed, particularly on elevated platforms or seamounts and is purest where it is far from terrigenous sediment sources. Calcium carbonate is also generated by ocean-derived fluids reacting with ultramafic rocks in the formation of serpentinite, and large modern deposits of deep-sea carbonates associated with seafloor springs have been discovered in association with warm-water vents on the sea bottom (Fruh-Green and others, 2003; Schroeder, 2002). However, these deep-sea vent deposits are typically associated with rough ocean bottom terranes and have a different microfossil and invertebrate fauna than those observed in the more evenly-bedded Calera Limestone, and have a high concentration of magnesium carbonate.

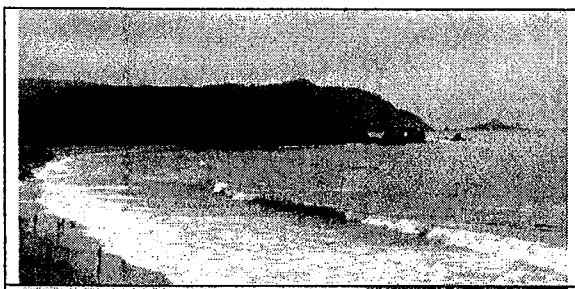


Figure 8-13. View looking south along Rockaway Beach towards Rockaway Point and the more distant San Pedro Point headlands and Pedro Rock (a sea stack in the distant right). Cretaceous-age sandstone and greenstone of the Franciscan Complex crop out on the Rockaway Point headlands. Pacifica State Beach is in the bay to the south of Rockaway Point. San Pedro Creek, at the south end of Pacifica Beach, follows the trace of the Pilarcitos Fault and runs out to sea along the north side of the San Pedro Point headlands (far distance, right).

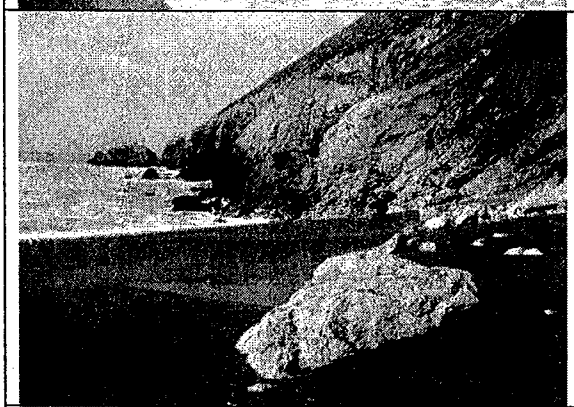


Figure 8-14. Calera Limestone forms the Mori Point headlands at the north end of Rockaway Beach. Calera mean *limestone quarry* or *limekiln* in Spanish. Mori Point is now part of Golden Gate National Recreation Area.



Figure 8-15. The Calera Limestone was mined in the Pacifica Quarry. The rock is a dark, layered limestone and marble, with interbedded layers of chert. Locally, the rock contains some small greenstone dikes and veins of calcite. Large blocks of this material can also be examined in the rip-rap seawall at the parking area at Rockaway Beach.

Stop 8 – San Pedro Mountain and the Devil's Slide (rolling stop)

Stop highlights: Paleocene turbidites, coastal headlands, landslide hazards

In the Devil's Slide area, most of the roadside pull offs along Highway 1 are posted "no stopping" for good reason. The spaces are too narrow and small, and the traffic is too heavy and fast to be considered safe for a field trip stop. However, notable geologic features can be seen along the highway.

South of Pacifica State Beach, Highway 1 crosses the Pilarcitos Fault (near San Pedro Creek) and climbs to the crest of San Pedro Ridge through a eucalyptus forest. Near the crest of the ridge, steeply dipping and folded layers of shale, sandstone, and calcareous marl of Paleocene age crop out in road cuts along the highway (fig. 8-16). These same units are exposed in Pedro Rock at the northwest end of San Pedro Point. Paleocene-age conglomerate and granitic megabreccia in the roadcut rests unconformably on Mesozoic-age granitic rocks and gneiss of Montara Mountain (Salinian basement complex) to the south. The sedimentary units formed as deep-sea fans deposits (inner- and mid-fan channels, channel margin, and interchannel settings) that accumulated as turbidity flows into a restricted, deep, tectonically active basin setting (Nilsen and Yount, 1987). Mineral clasts in arkosic, lithic, and unusual calcareous marl and sandstones within the turbidite sequence suggest that sediments were derived from Salinian basement, with the calcareous material derived from marble roof pendant structures in the granitic terrane, similar to carbonate rocks exposed in the Ben Lomond Mountain and Fremont Peak areas to the south.

The Devil's Slide area begins just west of the pass on the west side of San Pedro Ridge and extends for about 0.8 mile along Highway 1 on the northwest flank of Montara Mountain. The landslide is occurring where steeply dipping, faulted, and folded Paleocene rocks are slipping above a steeply inclined surface of underlying weathered Mesozoic granitic bedrock of Montara Mountain. Several landslide chutes and failure zones are present in the area, and the glide planes of the slump blocks extend as much as 150 feet below the surface. The landslide extends from 900 feet high on the mountain down to sea level (Williams, 2001).

The landslide complex at Devil's Slide has a long and expensive history. Landslide failures disrupted travel along the first road built across the slide area in the late 1890s and was eventually abandoned. Starting in 1905, the Ocean Shore Railroad attempted to operate a rail line across the area below the present road level, but was abandoned in the 1920s because of the chronic troubles with landsliding at Devil's Slide and elsewhere along this coastal route. The State Department of Highways completed the first version of the coastal highway along the abandoned rail line in 1936, and this route in part is Highway 1 today. However, landsliding and road closures have constantly plagued the route, and millions of dollars have been extended into endless repairs. CalTrans is currently evaluating plans to construct a 4,000 foot tunnel through Montara Mountain to bypass the slide area. For more information, see the discussion by Williams (2001) about the engineering geology of the Devil's Slide.

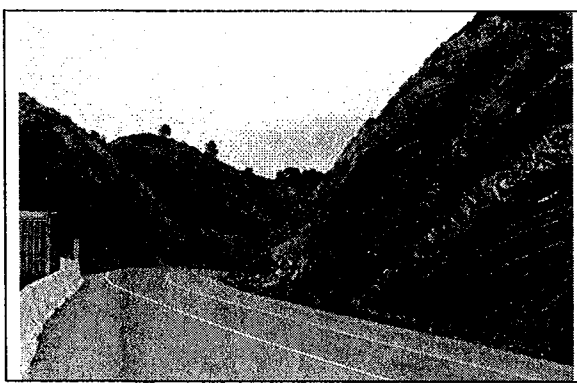


Figure 8-16. Road cuts along Highway 1 expose interbedded layers of Paleocene-age deep sea fan deposits (turbidites). This view is looking east from a small pull off at the top of the ridge of San Pedro Mountain. Note that this pull off is not recommended as a fieldtrip stop because of high traffic volume along the highway. Coastal travelers can more safely access similar deposits of Cretaceous age at Bean Hollow State Beach or near Pigeon Point south of Half Moon Bay.

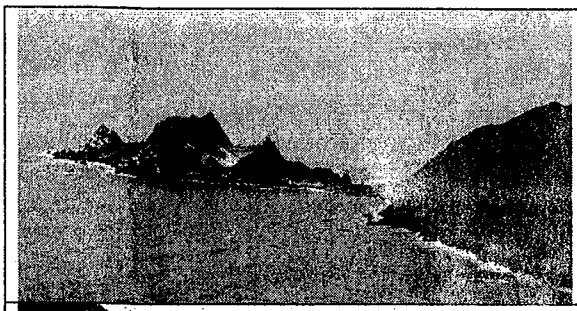


Figure 8-17. Pedro Rock at the south end of Point San Pedro consists of steeply dipping beds Paleocene-age sandstone and shale (covered locally with bird guano). Darrow (1963) described unconformable relations between the Paleocene sedimentary rocks and sedimentary rocks of late Upper Cretaceous beds on San Pedro Point (to the right). Whether these Upper Cretaceous sediments are in conformable contact with the Salinian granite is unclear. A remnant of the old Ocean Shore Railroad bed is visible along the shore (lower right).



Figure 8-18. Devil's Slide. This view is looking south from one of the small roadside pull off along Highway 1. Portions of the San Mateo Coast south of Shelter Cove (including San Pedro Rock) have been incorporated in the Golden Gate National Recreation Area. A ruin of a WWII era gun emplacement is visible on top of a headland at the south end of Devil's Slide.

Stop 9 – Montara Mountain (rolling stop)

Stop highlights: Salinian granite, coastal headlands

Cretaceous-age granitic rocks of the Salinian Block are exposed in coastal headlands and cuts along Highway 1 on Montara Mountain. Granitic rock is exposed along the shore at Gray Whale Cove State Beach and along trails and in a historic Ocean Shore Railroad cut in McNee Ranch State Park. Note that the granitic rock is deeply weathered except in eroding exposures along the beaches. This gives the Montara Mountain granitic bedrock a rusty-orange appearance, whereas the fresh exposures along the beach are pale gray (fig. 8-19). Quartz-rich dikes and dark mafic dikes cross cut the granitic rock in many locations. The rock was originally named the Montara Granite, and later renamed the Montara Quartz Diorite (by Lawson, 1895a, Lawson, 1895b, and Lawson, 1914).

The Salinian Block is a 40,000 km^2 fault-bounded block of granitic and metamorphic basement along California's coastline, west of the San Andreas Fault (fig. 8-20). The block is structurally isolated from other Cordilleran granitic terranes of the West Coast by large-scale, right-lateral movements including at least 300 km on the San Andreas Fault System. The Salinian Block is surrounded by oceanic crust basement (Franciscan Complex and Coast Range Ophiolite) along most of its length. The Salinian Block is in itself split into several smaller, structurally complex blocks. The granitic exposures on Montara Mountain are part of a northern block that includes disjointed exposures such as the Farallon Islands, Point Reyes, and Bodega Head. The granitic exposures on Ben Lomond Mountain, the Monterey Peninsula, Santa Lucia Range, and the Gabilan Range are within a central block. chemical and petrographic characters of the Salinian Block granitic rocks and their metamorphic frameworks suggest that the crystalline basement rocks originated somewhere within the Cordilleran volcanic arc in southern California or possibly from a similar setting much farther to the south. These rocks moved northward to their present location along fault systems that predate the San Andreas Fault, and then along the San Andreas Fault from its time of inception starting about 23 million years ago to the present. Radiometric ages of the granitic rocks in the Salinian Block range from about 70 to 120 million years (within the Cretaceous Period), but radiometric ages of granitic samples from Montara Mountain are in the range of about 82 to 95 million years (Ross, 1983; Mattinson, 1990, Kistler and Champion, 1997).

Please note that it is advised not to stop along the Highway 1 on Montara Mountain or attempt to cross the busy highway into parking areas. Instead, consider using the Stop 10 (Montara State Beach) locality described below.

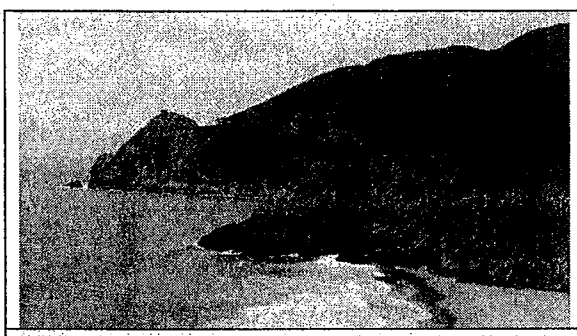


Figure 8-19. Headlands along the coast side of Montara Mountain. Cretaceous-age Salinian granitic rocks make up the core of Montara Mountain. This view is looking north from a small pull off on Highway 1 north of Gray Whale Cove State Beach.

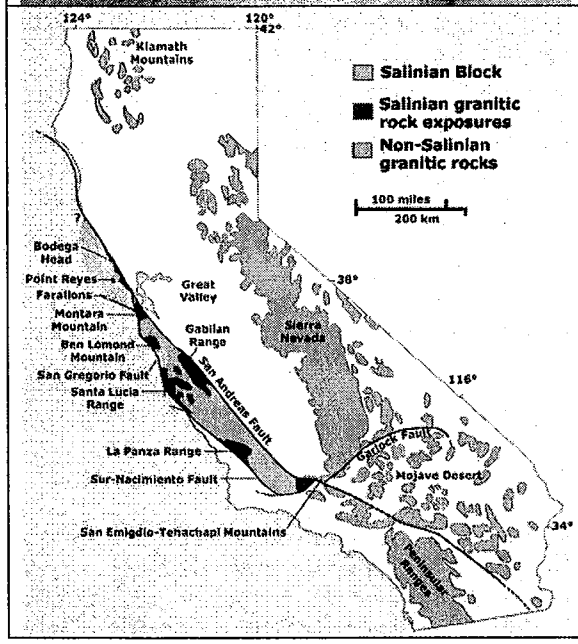


Figure 8-20. Map showing granitic bedrock provinces of California highlighting the extent of the Salinian Block. Exposures of granitic bedrock in the Salinian Block are shown in red. The Salinian Block extends offshore to the shelf margin to some undetermined extent north and west of the San Francisco Bay Area. The block is bounded on the east by the San Andreas Fault and on the west in the southern part by the Sur-Nacimiento and San Gregorio Fault Systems. The western side of the northern Salinian Block is probably bounded by faults in the offshore region along the continental shelf margin.

Stop 10 – Montara State Beach

Stop highlights: Salinian granite, offset Quaternary marine terraces, lignite deposits

Montara State Beach is in a cove between the Montara Mountain headlands to the north and headlands by the town of Montara to the south. A northwest trending fault zone runs offshore at the northern end of Montara Beach along the southwest side of Montara Mountain. Another northwest trending fault, the Montara Fault, extends offshore in the rocky headlands at the south end of the beach. A small fault with some apparent thrust offset is exposed in the sea cliff displaces Salinian granite over marine terrace deposits of Quaternary age (fig. 8-21).

Three marine terraces are recognized along the coast between Montara Beach and Half Moon Bay (to the south) and were described by Jack (1969). These marine terraces are, from oldest to youngest, the San Vicente, the Montara, and the Half Moon Bay. The ages of the terraces are still being debated, and their correlation to terraces elsewhere along the coast is made difficult by the complexity of fault motion relative to marine terrace development in the area, as well as a lack of datable materials.

San Vicente Terrace Deposits

The San Vicente marine terrace deposits are exposed in a faulted block near sea level at the south end of Montara State Beach (see fig. 8-21). These deposits rest unconformably on an irregular wave-cut bench surface on underlying Salinian granitic rocks. The terrace deposits consist of a basal pebble conglomerate of marine origin that contains clasts (pebbles to cobbles) of mafic volcanic rock and other materials derived from the Franciscan Complex (these are not present in the younger terrace deposits). It also contains material derived from the local granite with some pieces ranging to boulder size. Some cobbles in the San Vicente preserve marine pelecypod (*Pholad*) borings.

Terrace deposits with pebbles of Franciscan derivation also occur 200 to 560 feet above sea level in the region south of Montara Beach. This variation in elevation suggests that the San Vicente terrace has experienced significant post-depositional tectonic tilting and/or faulting. In addition, erosion has highly degraded any surface expression reminiscent of younger marine terraces, such as those preserved along the coast near the Davenport area in Santa Cruz County (Weber and Allwardt, 2001). Cross-cutting relationships in the sea cliff exposures suggest that some of the tectonic tilting and faulting took place before deposition of the next younger Montara marine terrace. The age of the San Vicente marine terrace is not well determined, but is likely older than 300,000 to 500,000 years.

Montara Terrace Deposits

Deposits of the Montara marine terrace are well exposed in the sea cliff below the parking area at Montara State Beach (fig. 8-22). The terrace deposits consist of (from youngest to oldest):

a well sorted eolian sand facies,
a lignite bed,
an upper arkosic, alluvial gravel facies (containing Montara Mountain granodiorite),
a lower beach and shallow marine member containing material of local granitic rock derivation.

At Montara State Beach the Montara terrace deposits rest unconformably on San Vicente terrace deposits. At Montara Point (about a mile south of the beach), slip along the Point Montara Fault displaces the Montara marine terrace at 18 feet elevation north of the fault, and 95 feet south of this fault (Jack, 1969). The age of the Montara Terrace is also disputed, but is probably in the range of 200,000 to 300,000 years.

The Half Moon Bay Terrace

The Half Moon Bay terrace is only clearly preserved south of Point Montara. The terrace is only slightly dissected by subsequent stream erosion. Terrace deposits consist of reworked material from the Montara Terrace. The Half Moon Bay marine terrace is likely equivalent in age to the Highway 1 terrace on Ben Lomond Mountain described by Weber and Allwardt (2001) that has a disputed age in the range of 50-150 thousand years.

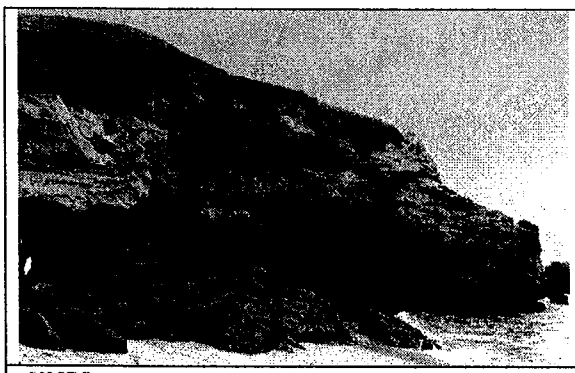


Figure 8-21. An apparent thrust fault places Montara granitic rock over Quaternary marine terrace deposits. The basal conglomerate of the San Vincente terrace deposits rests unconformably on an irregular wave-cut bench surface of weathered granite. Thrust faulting (with possibly more significant strike-slip offset) occurred after the San Vicente terrace deposits had accumulated.

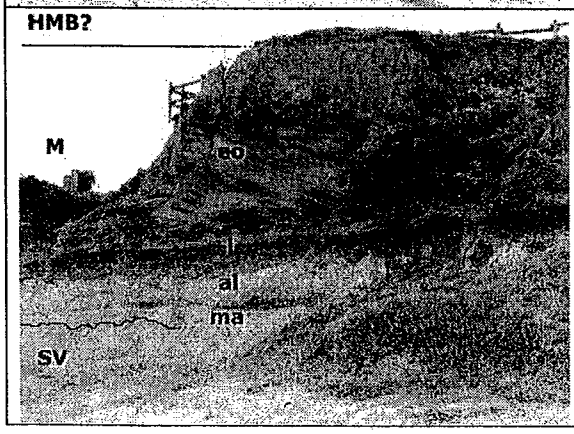


Figure 8-22. Quaternary terrace deposits are exposed in the beach cliff below the Montara State Beach parking area. San Vicente marine terrace deposits (SV) are unconformably overlain by the Montara terrace deposits (M). The Montara deposits consist of a thin lower marine gravel layer (ma), a layer of alluvial channel gravels (al), a lignite [coastal swamp] layer (l), and cross-bedded eolian dune sand (eo). Whether the upper surface along Highway 1 is the Half Moon Bay terrace (HMB?) is unclear. This is unlike the Ben Lomond Mountain area, where Marine terraces grow progressively older higher on the mountain. At Montara Beach, the marine terrace deposits are stacked on top of each other. To the south at Ben Lomond Mountain the land has been rising, but at Montara State Beach the land has been relatively stationary relative to sea level.

Stop 11 – James V. Fitzgerald Marine Preserve

Stop highlights: Seal Cove Fault, San Gregorio Fault System, syncline, Purisima Formation, fossils, tide pools

The tide pools at the James V. Fitzgerald Marine Preserve are an extremely popular destination for fieldtrips, and for good reason. The preserve is one of the closest tide pool areas to the city. Steeply dipping, folded rock layers are exposed on a broad wave-cut bench. At low tide an extensive network of tidal channels and pool areas are exposed. Because of the popularity of this destination, the area is highly protected. Please read the preserve's rules to help reduce impact on the fragile tide pool environment. Collecting of any kind of natural materials is prohibited. Rangers and volunteer naturalists are usually available for assistance. It is advisable to bring a wildlife field guide such as the *Audubon Guide to Seashore Creatures* or the *Audubon Guide to California* to help enjoy wildlife observation. The tide pools contain a diverse fauna including seaweed, crabs, urchins, sea anemones, mollusks, starfish, fish, and other shelled and soft-bodied invertebrates.

The James V. Fitzgerald Marine Preserve is also a special geologic preserve. The Seal Cove Fault, considered by many geologists to be a strand of the greater San Gregorio Fault System, crosses the shoreline in the preserve at Moss Beach. The fault cuts through sedimentary rocks of the Purisima Formation of late Miocene to Pliocene age. The fault goes offshore just south of the parking area on California Avenue. Unfortunately, the fault is covered by rip-rap on the cliff and cannot be seen. Bathymetry shows a submerged ridge bounded on the northeast by the Seal Cove Fault. The submerged ridge extends northward along the coast for about two miles north of Moss Beach.

In the tide pool area north of the Seal Cove Fault, the Purisima Formation consists of greenish gray sandstone, marl, mudrock, and some conglomeratic beds. The beds are only accessible during low tide; they locally contain an abundance of fossil mollusk shells, mostly large clams. Powell (1998; 2003) suggests that the layered rock units of the Purisima Formation north of the fault were deposited in intertidal depths to about 10 meters and the the rocks are about 2 to 4 million years old (Pliocene) based on a comparison with modern species. South of the fault, the rock formation has a more massive character and shell fossils are not as abundant. The rocks on the southwest side of the fault are part of an older unit within the Purisima Formation and were probably deposited in subtidal water depths of 100 to 700 meters. Bones of marine mammals, microfossils and rare invertebrate remains have been recovered from this portion of the Purisima Formation. They are older than the rocks to the north, but in the 3 to 5 million-year range.

Ongoing tectonic activity associated with the Seal Cove (San Gregorio) Fault System is responsible for the Moss Beach Syncline, a large fold that is exposed at low tide (fig. 8-23). Deposits of the Half Moon Bay Terrace are also exposed along the sea cliffs at Moss Beach (with an age of roughly 125,000 years). These elevated marine terrace deposits unconformably overlie the Purisima Formation. Boulders in the basal unit of the marine terrace display boring from marine pelecypods (*Pholad*). Look for fault offsets in the marine terrace deposits.

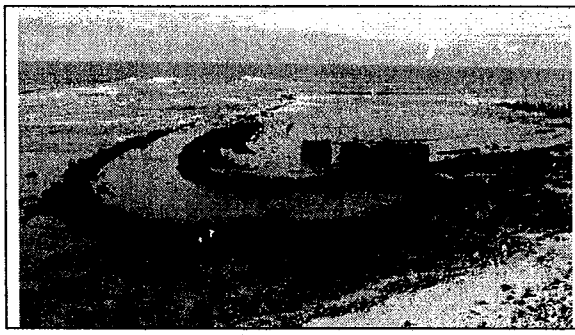


Figure 8-23. The Moss Beach Syncline, a broad fold, is exposed at low tide in the James V. Fitzgerald Marine Preserve. Folded sedimentary layers of the plunging syncline consist of fossilerous sandstone and mudrocks of the Purisima Formation (Miocene to Pliocene age). The Seal Cove Fault scarp is associated with a submerged ridge located near where the waves break just offshore of the syncline.

Stop 12 – Seal Cove Fault Near the Half Moon Bay Airport (rolling stop)

Stop highlights: fault scarp, offset Quaternary marine terrace, San Gregorio Fault System

The Seal Cove Fault is considered by many geologists to be an on-shore strand of the greater San Gregorio Fault System. Many questions remain unresolved about the San Gregorio Fault System; it is one of the least understood major fault systems in California partly because so little of it is exposed onshore. Geophysical and oceanographic data suggest it

is part of the greater fault system that bounds the western margin of the Salinian Block (see fig. 8-20). The San Gregorio Fault System extends for about 230 km from the Big Sur region south of Monterey Bay and northward to where it merges with the San Andreas Fault System near Bolinas Bay north of San Francisco. Strands of the fault come onshore only in San Mateo County between Año Nuevo and Pescadero, and again between Pillar Point and Moss Beach (the latter is the Seal Cove Fault). Like the San Andreas Fault, the San Gregorio Fault displays significant late Quaternary offset. Based on geologic and geophysical evidence, total right-lateral offset along the fault from late Miocene time to the present is estimated between 115 km (Graham and Dickenson, 1978) and 156 km (Clark and others, 1984). Paleoseismicity studies show that the fault is still active. Trench studies along the Seal Cove Fault show that displacements of between 3 and 5 m occurred in the pre-Colonial era (sometime between 1270 and 1775 AD). These fault ruptures probably produced earthquakes of M=7 or greater (Simpson and others, 1997).

Continuing activity along the Seal Cove Fault is ominously revealed by a fault scarp that offsets the young Half Moon Bay Terrace near the Half Moon Bay Airport (fig. 8-24). The elevation of the airport runway is about 40 feet, whereas the high point west of the fault scarp is about 175 feet (fig. 8-25). The Half Moon Bay marine terrace formed when coastal erosion cut a broad bench during a Late Quaternary marine transgression. The flat, wave-cut surface of the marine terrace became exposed as sea level fell and the shoreline retreated seaward about 85,000 years ago. The marine terrace has remained exposed as the coastline (and the entire Santa Cruz Mountains) has progressively continued to rise. The Half Moon Bay Terrace is actually folded into a northwest trending, gently-plunging syncline (Lajoie, 1986). Since the marine terrace became exposed, the vertical component of offset along the Sea Cove Fault has produced the 140 foot high scarp that is visible today. The fault places latest Quaternary deposits adjacent to Pliocene-age marine mudstones of the Purisima Formation. Note that the rate of horizontal slip on the fault is probably ten to twenty times as great compared to the vertical offset during the same time period.



Figure 8-24. Scarp of the Seal Cove Fault, a strand of the San Gregorio Fault System, forms a linear ridge along the west side of the Half Moon Bay Airport.

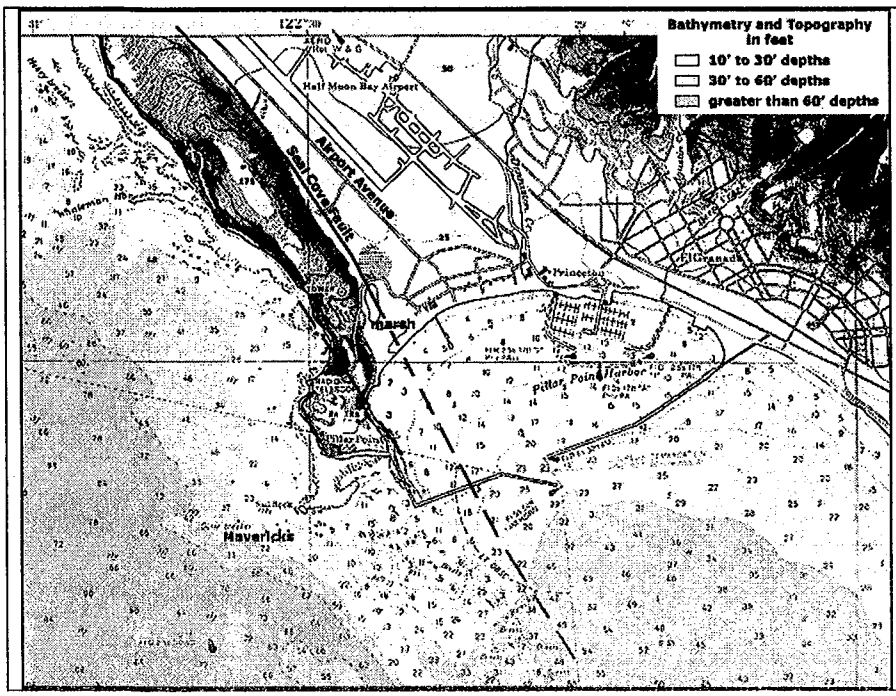


Figure 8-25. Bathymetry and topography along the Seal Cove Fault at Half Moon Bay. The Seal Cove Fault runs along the east side of a linear ridge along the coast between Moss Beach to the north (not shown) and near Pillar Point to the south. Rolling stop 12 is along Airport Avenue, and the parking area for stop 13 is located near the marsh label on the map. The map base is modified from NOAA Chart 18682.

Stop 13 – Pillar Point and Mavericks

Stop highlights: offset marine terrace, San Gregorio Fault System, small faults in sea cliffs, surfing large waves

Pillar Point is a headlands promontory that juts seaward at the west end of Half Moon Bay Harbor. A coastal access trail begins at a parking area next to Pillar Point Marsh. The trail provides access to an extensive wave cut bench with tide pools that extend seaward of the Pillar Point headlands. The marsh and the tide pool area are part of the James V. Fitgerald Marine Preserve. The marsh itself is part of a pull-apart basin (sag) associated with the Seal Cove Fault (labeled "marsh" on fig. 8-25). The marsh is a famous bird watching locality, especially during migration periods. **Warning!** Do not attempt to climb around the point beyond the end of the trail during high tide or during inclement weather.

The sea cliffs at Pillar Point consist of sand and mudstone of the lower Purisima Formation (late Miocene to Pliocene age). Rare fossils, mostly mollusks and marine mammal bone, have been observed in the rock (Powell, 1998, 2003). Pillar Point proper lies west of a fault that runs parallel approximately 450 meters to the southwest of the Seal Cove Fault. Other small faults that offset sandstone beds are exposed in the sea cliffs along the trail and around the point (fig. 8-26). Seaward of Pillar Point, a broad wave-cut platform and submerged rock reef extends seaward. A break in slope roughly follows the 10 fathom (60 feet) contour offshore (fig. 8-25). This rock reef extends offshore nearly a mile on the south side of the point. The high wave belt known in the surfing world as Mavericks is located along this westward-extending submerged promontory.

Mavericks is considered one of the most challenging wave surfing areas of the world, and professional surfers fly in from around the world to attempt to catch monster waves that frequently develop along the outer reef track area offshore of Pillar Point (labeled "Mavericks" on fig. 8-25). Typically several times a year, large weather systems in the northern Pacific Ocean create large wave trains that propagate across the ocean. Buoy and weather satellite data are used to make predictions as to when large wave conditions may occur, giving surfers and the watchful media time to gather at Pillar Point to catch the action. During high seas, waves in the 20 to 30 foot range are not uncommon, and waves in the 40 foot and higher range occur on rare occasions. Local legend tells of waves as high as 100 feet have been observed. Other hazards to surfing at Mavericks, in addition to at least one documented shark attack, are large rocks exposed along the reef or just below the surface where waves curl and crash, or in the chaotic surf shoreward of Mavericks. Although traditionally, surfers will paddle out to catch waves, many professional surfers attempt the higher and most dangerous waves only by being towed into harm's way behind a jet ski. However, despite the danger, very few people have been killed or severely injured at Mavericks. It is difficult to see surfers in action in the high waves from the shore. Movies featuring big wave surfing at Mavericks, however, are playing constantly at the nearby Half Moon Bay Brewing Company in Princeton by Half Moon Bay Harbor.

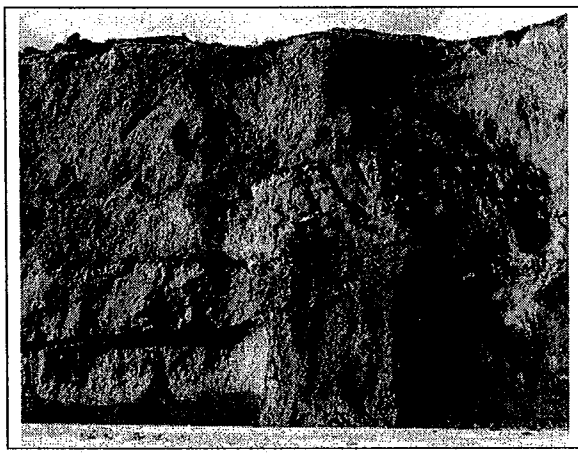


Figure 8-26. Sea cliffs on the south side of Pillar Point consist of mudstone and sandstone of the lower Purisima Formation. A high angle reverse fault in the middle of this image offsets a massive sandstone layer by about 10 feet.

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Northern California Earthquake Potential
Abstract and Introduction
Methodology
Fault Zones
Discussion and Conclusions
Appendix: Fault Zone Database
- San Andreas and San Gregorio fault data
- Hayward fault data
- Calaveras fault data
- Great Valley thrust fault data
- Minor fault data in the San Andreas system
- Northeastern California fault data

Acknowledgments and References
Figures and Tables

Table A-1. Database of Potential Sources for Earthquakes Larger Than M6 in Northern California (simplified)

code	fault or source name	M_w	t_e effective recurrence time, yr	seismic moment rate, 10^{19} Nm/yr	r slip rate mm/yr	±	d slip m	l length km	w km	h^* km	dip °	fault type †	method ‡	summary
A1	**San Andreas, 1906 rupture**	**7.9**	**210**	3700	**24**	3	4.4	470	13	0	90	RL	2	Slip rate after *Niemi and Hall* [1992]; *Prentice and others* [1991], north of Golden Gate. Average slip in 1906 north of Golden Gate was 5-6 m [*Thatcher and others*, 1997] Lower slip, 2-4 m, south of Golden Gate
A2	**San Andreas, Peninsula-independent**	**7.1**	**400**	150	**17**	3	1.6	88	14	0	90	RL	2	Segment between 1989 rupture and 2-km right step at Golden Gate [*Cooper*, 1973], where 1906 slip dropped 5-6 m to 2-3 m [*Thatcher and others*, 1997] Recurrence in text. Rate limits: local [*Hall and others*, 1995], regional [*Lienkaemper and others*, 1991]
A3	**San Andreas, Santa Cruz Mts -indep.**	**7.0**	**400**	80	**14**	3	1.6	37	18	0	90	RL	2	Patch size after *Lisowski and others* [1990], but use 90° dip as more characteristic of right-lateral events. Slip rate 17 mm/yr [*Lienkaemper and others*, 1991] less 3 mm/yr on Sargent fault. Balances recurrence of great SAF and San Gregorio fault events
A4	**San Gregorio**	**7.3**	**400**	290	**5**	2	2.0	129	15	0	90	R-RL	1	Preliminary rates: 3-9 mm/yr, Año Nuevo [*Weber and Nolan*, 1995] ; Seal Cove, >5mm/yr (14 ka), <4.5 mm/yr (~8.5 ka [G. D. Simpson and others, W. R. Lettis & Assocs., 1995, writ. com.] SE-end, 2-3 km right stepover. Reverse slip <1 mm/yr [*Anderson and Menking*, 1994]
A5	**San Gregorio, Sur region**	**7.0**	**400**	86	**3**	1.5	1.2	79	12	0	90	R-RL	1	Slip rates from San Simeon and Hosgri faults to southeast. Latest Quaternary geologic rate >1-3 mm/yr [*Hanson and Lettis*, 1994; *Hall and others*, 1994] and <6-9 mm/yr*Weber* [1981] VLBI rate of broad zone 3.1 ± 0.8 mm/yr [Feigl and others, 1993]
A6	**Sargent**	**6.8**	**330**	57	**3**	1.5	1.0	53	12	0	90	R-RL	1	Creep rate is 3 mm/yr [*Prescott and Burford*, 1976] over southern ~1/3 of fault; northern 2/3 converges with San Andreas fault at depth thus may not be independent source of earthquakes
A7	**San Andreas, creeping zone**	--	**0**	0	**34**	5	0.0	124	12	0	90	RL	-	Creep releases most strain. No M>6 events observed historically between Parkfield and San Juan Bautista (T. Toppozada, oral communication, 1996). Possible M>6 covered as background, not as discrete sources

*h, assumed depth to top of earthquake source †fault type: N, normal; R, reverse; RL, right-lateral ‡method, see Table A-2

Hayward fault data ➡

U.S. Geological Survey, Earthquake Hazards Program
URL http://quake.wr.usgs.gov/prepare/ncep/andreas.html
Contact: webmaster@ehznorth.wr.usgs.gov
Last modification: December 5, 2000

California Emergency Management Agency | Hazard Mitigation Portal

MyHazards

Helping reduce your risks from natural disasters

Cal EMA
CALIFORNIA EMERGENCY MANAGEMENT AGENCY

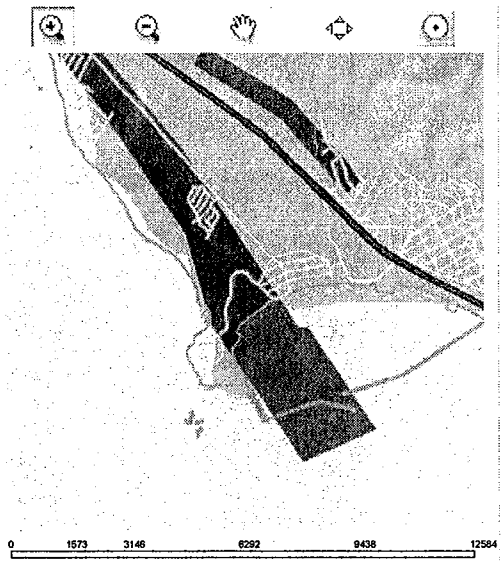
Moss Beach, CA, USA Map Search Clear Search

Contact Us Link Print E

Instructions Earthquake Flood Fire Tsunami

click on tabs above to change from earthquake, flood and fire

Showing: Earthquake Hazard Map



Earthquake Hazard

YOU ARE IN OR NEAR THE FOLLOWING:

- **HIGH Ground Shaking**
  This map shows the potential level of ground shaking hazard from earthquakes that geologists and seismologists agree could occur in California. It takes into consideration the uncertainties in the size and location of earthquakes and the resulting ground motions that can affect a particular location. (more information at http://www.conservation.ca.gov/cgs/rghm/psha/index.htm)

YOU ARE OUTSIDE THE FOLLOWING:

- **Earthquake-Induced Landslide Hazard zone***
  Earthquakes can trigger landslides that may cause injuries and damage to many types of structures. (more information at http://www.conservation.ca.gov/CGS/shzp/SHMPfact.htm)
- **Liquefaction Seismic Hazard zone***
  Earthquakes can cause certain types of soils to lose strength and behave like liquid. This can severely damage buildings and other structures. (more information at http://geomaps.wr.usgs.gov/sfgeo/liquefaction/aboutliq.html)
- **Earthquake Fault zone***
  Active earthquake faults may pose a risk of surface fault rupture hazard. Surface rupture can damage buildings. (more information at http://www.conservation.ca.gov/cgs/rghm/ap/index.htm)

Fault-rupture hazard zone
Earthquake-induced liquefaction area
Earthquake-induced landslide area
High earthquake shaking probability
Moderate earthquake shaking probability

Sources:
California Geological Survey, US Geological Survey

Search Radius
Approx. Location

Earthquake Checklist

WHAT SHOULD I DO?

Based on the above results, use the following mitigation checklist and information to reduce injuries, protect your life and those of others, and reduce damage to your home and property.

Recommended Actions for your Ground Shaking Intensity:

	ACTION	RECOMMENDATION
☐	Secure your water heater	**recommended**
☐	Secure your tall furniture and bookcases	**recommended**
☐	Secure your TVs, computers, and electronics	**recommended**
☐	Secure your kitchen cabinets	**recommended**
☐	Secure wall-mounted objects	**recommended**
☐	Secure objects on opens shelves or table tops	**recommended**
☐	Secure natural gas appliances	**recommended**
☐	Secure garage items and hazardous chemicals	**recommended**
☐	Secure your unreinforced masonry chimney	**recommended**
☐	Reinforce your home	**recommended**
☐	Secure propane tanks	**recommended**

Grand Jury
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(650) 599-1711; Fax (650) 363-4698

Summary of Tsunami Alert and Evacuation On the San Mateo County Coast

Issue

To what extent are the San Mateo County coastal communities adequately prepared for a tsunami?

Summary

A tsunami could cause significant loss of life along the San Mateo coast, particularly if it occurs when the beaches are crowded. The West Coast & Alaska Tsunami Warning Center (WCATWC) will typically be able to provide a few hours warning of an impending tsunami. The San Mateo County Office of Emergency Services (OES) has developed a detailed and comprehensive plan outlining the County response in the event of such a warning and has identified 15 potential inundation areas in the County.

In June 2005, WCATWC issued a warning that was in effect for 72 minutes. The event both exposed communication problems with implementing the plan at the local level, and revealed different levels of preparedness among the coastal communities.

This report focuses on certain San Mateo County coastal communities (the cities of Half Moon Bay and Pacifica and unincorporated communities of Montara, El Granada, Princeton and Pescadero) but does not include potential tsunami impact on the Bayside communities. The recommendations, however, are generally applicable to all shoreline communities.

The San Mateo County Civil Grand Jury recommends that coastal communities within potential areas of inundation from Daly City south to Pescadero upgrade their tsunami education programs. Pacifica has a comprehensive plan that, together with the National Oceanic and Atmospheric Administration's TsunamiReady plan, can serve as a useful model for other shoreline communities.

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Tsunami Alert and Evacuation On the San Mateo County Coast

Issue

To what extent are the San Mateo County coastal communities adequately prepared for a tsunami?

Background

The California coast is exposed to tsunamis caused primarily by sub-oceanic earthquakes around the Pacific basin, mainly in Alaska, Japan, Chile, and off the coast of Oregon and Washington. In 1946, a tsunami generated in the Aleutian Islands produced wave heights of 12 to 16 feet at Half Moon Bay, caused loss of life at Martins Beach and significant property damage on the essentially undeveloped San Mateo County coast. In 1960, a tsunami generated in Chile caused over $1 million in damages along the California coast, and in 1964, a magnitude 9.2 earthquake in Alaska generated a tsunami that killed 12 in Northern California and caused $15 million in damages. The wave crested at 21 feet in Crescent City and wave oscillations in San Francisco Bay lasted more than 12 hours, causing $200,000 in damages. Because most tsunamis that are likely to affect Northern California are generated around the Pacific Basin, most will take hours to reach our coast, allowing significant warning time. The December 2004 Sumatra tsunami demonstrated how destructive and costly in human life a tsunami can be.

The San Gregorio fault, just off the San Mateo County Coast, has the potential of causing a tsunami with essentially no warning time. While there is no recent history of a tsunami generated by rupture of this fault, the San Mateo County Office of Emergency Services (OES) advises that members of the public who are in low-lying areas immediately head for high ground when an earthquake occurs.

The West Coast & Alaska Tsunami Warning Center (WCATWC) provides tsunami warning guidance for British Columbia and all U.S. coastal states except Hawaii. If the United States Geological Survey (USGS) detects an earthquake of magnitude seven or greater in the northern Pacific Ocean, it alerts the WCATWC, which monitors pressure sensors within the ocean and tidal gauges along the coast. The WCATWC then alerts the

appropriate emergency service organizations on the West Coast, initially the California OES in Sacramento, then the San Mateo County OES operated by the Sheriff's Office in the Hall of Justice in Redwood City. The County OES, in turn, alerts the coastal community fire and law enforcement agencies (including State Parks, Red Cross and harbor authorities) which inform local government and other local first responders. If a tsunami is not detected by the deep-sea monitors and tidal gauges, a cancellation is issued first to the State OES which then notifies the County OES and the coastal communities.

On June 14, 2005, a magnitude 7.2 earthquake off the shore of Humboldt County triggered a warning to the West Coast. Only a minor tsunami was detected and the warning was cancelled 72 minutes after the event was announced. Although the warning was in effect for only 72 minutes, the 2005 event provided a test case for assessing the adequacy of warning and cancellation procedures. In that event the National Weather Service placed warning messages that scrolled along the bottom of television screens. This notified the public, sometimes prior to the alert getting to local authorities, and resulted in some coastal community confusion.

The County of San Mateo and the 20 incorporated cities therein have established a unified emergency organization referred to as the Emergency Services Organization (ESO) "for the purpose of preparing and carrying out coordinated plans for the protection of persons and property in the event of a disaster". The governing body of this Organization is the Emergency Services Council (ESC), which consists of one member of the Board of Supervisors and one Councilmember from each of the participating cities. Paragraph B.4. of the agreement establishing the ESO reads:

"*It shall be the duty of the Area Emergency Services Council . . . to review and recommend for adoption by the board of supervisors and the city council of each of the cities, such emergency plans, programs and agreements, . . . as are necessary to carry out the purposes of the Emergency Services Organization.*"

Investigation

To investigate the tsunami preparedness of San Mateo County, the San Mateo County Civil Grand Jury (Grand Jury) met with representatives of the OES, the local chapter of the American Red Cross, and the police departments of Half Moon Bay and Pacifica. The Grand Jury also reviewed the OES draft plan (available at "OES://OA Tsunami Annex July 2006"), the State of California document "The Tsunami Threat to California (CSSC 05-03)", the National Oceanic and Atmospheric Administration (NOAA) Tech Memo ERL PMEL-112, the Pacifica Tsunami Alert brochure and the NOAA TsunamiReady Program.

Findings

The OES has a detailed plan that outlines how the office should respond to a tsunami warning. For the purposes of planning, a two-hour warning and a maximum tsunami of 42 feet are assumed. Maps of inundation zones based on the 42 foot assumption have been prepared for the major population centers on the coast, except for the southern

section at Pescadero (Appendix A and B) Approximately 5,000 people live in the 15 inundation zones. This number could increase considerably, depending on the timing of the tsunami. The population of Half Moon Bay is particularly volatile, swelling from 12,000 to 100,000 at times during the year, and the visitors are less likely than residents to know what to do in the event of a tsunami.

Command responsibilities have been assigned for each inundation zone (police, fire and city managers), and community contacts identified. The Red Cross is responsible for activating previously designated shelters (primarily at public schools) in each community. On receiving a tsunami warning, the County OES initiates the alert process throughout the County by informing fire, law enforcement and other agencies using several independent methods (radio, phone and internet). Two new systems for notifying emergency workers and members of the community are currently being tested and should be operational throughout the County by 2007. One system, ROAM Secure, will alert wireless devices, such as cell phones and pagers. The other system, a "neighborhood call system," will call landline telephone numbers in the impacted area. The County OES also notifies media sources including local radio and television stations. Local law enforcement agencies are responsible for informing other local government agencies of the event. Then, the local OES procedures are executed per the County emergency response plan. Law enforcement agencies are responsible for alerting citizens to evacuate threatened areas. The current plan is to communicate using loudspeaker warnings from police cars on a street-by-street basis.

If evacuation is anticipated, local community support groups, such as the Red Cross, are activated by the County OES. The Red Cross is not involved in the tsunami warning and ensuing evacuation process, but will provide temporary living support (food, shelter, first-aid, etc.) in the event of an evacuation. Each major coastal community has Red Cross resources, including a trailer with stored blankets and 100 cots. Experienced volunteers, some with specialized expertise in nursing and mental health, are also available. Red Cross Shelters will be set up at local designated public schools in each coastal community. The Red Cross also has representation in six neighboring counties that can pool resources to assist the San Mateo Coast, although, if a tsunami occurred, movement along Highways 92 and 1 may be severely impacted, and hinder emergency assistance.

The involvement of special water and sewer districts is not clearly defined in the OES plan, but they are responsible for system integrity and damage assessment and repair.

Local level preparedness within the county is mixed. The City of Pacifica, with three of the 15 identified inundation zones, has developed a comprehensive plan consistent with the County OES plan. For the last 10 years the city has participated in the Community Alert Network (CAN) that, in the event of an emergency, alerts all citizens who have enrolled in the program. This alert system has been used successfully in the past during a major sewage leak. The service is privately operated and the city is charged only when it is used at approximately 20 cents per participant contact. Pacifica is also formalizing a "residents in need" list using local social organizations, labor unions, churches, etc., to assure that elderly and disabled residents are identified. In conjunction with County OES, the city is actively researching a siren warning system and finalizing plans to install

tsunami-warning signs in vulnerable areas. A Pacifica-specific tsunami warning and informational brochure is available and widely distributed throughout the city. In their new police department facility, Pacifica has facilities for several volunteer amateur radio operators. They have also prepared a tsunami presentation that is given to community groups on a regular basis. Other communities in San Mateo county are less well prepared than Pacifica. Isolated beaches such as Martins Beach, where there was loss of life in 1946, are particularly vulnerable. In addition, there are no inundation maps for the county's southernmost coast (Pescadero).

When the tsunami alert was issued in 2005, many coastal residents did not learn of the warning until after it was cancelled and many of those that did hear the warning did so first through the National Weather Service announcement on TV. This resulted in some confusion and lack of local coordination. Since then, local police departments have acquired the NOAA weather radios that can provide comprehensive information for tsunamis and other emergencies. Due to the brief period (72 minutes) that the 2005 warning existed, no broadcast was made either at the beaches or through community streets. The Half Moon Bay City Manager was not directly informed of the warning, nor was the local Red Cross volunteer leader; both learned of it indirectly as did other local residents. The cause of the apparent discrepancy between what should happen according to the County OES plan and what actually happened remains unclear, although part of the problem in Half Moon Bay was that the local police commander did not follow procedures and failed to inform appropriate personnel, including the City Manager. Certainly the brief period of the warning and the need to avoid unnecessary citizen response were mitigating factors, but there were clearly communication issues.

Because the San Mateo County coast represents 68 miles of International border, the County OES has been able to acquire Homeland Security funds to apply toward the installation of a siren/beach broadcast system. A photograph of a siren post is shown in Appendix C.

The National Weather Service has developed the Storm Ready and Tsunami Ready programs to help communities guard against the ravages of severe weather and potential tsunami damage. StormReady and Tsunami Ready are voluntary programs offered to provide guidance and incentive to communities that want to improve their hazardous weather and tsunami hazard operations. These programs are designed to help develop the communication and safety skills necessary to save lives and property.

On September 21, 2006 the San Mateo County Office of Emergency Services and Homeland Security received notification that they had achieved StormReady recognition for the County of San Mateo. As of October 2006, San Mateo County is one of only four counties in California and 603 counties in the nation to achieve this distinction.

San Mateo is working hard to become designated as TsunamiReady. This program promotes tsunami hazard preparedness as an active collaboration among federal, state, and local emergency management agencies. To be recognized as TsunamiReady and StormReady, a community must:

- Establish a 24-hour warning system and emergency operations center;

- Have more than one way to receive tsunami and severe weather warnings and forecasts to alert the public;
- Create a system that monitors local weather conditions;
- Promote the importance of public readiness through community seminars;
- Develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises
- Define Tsunami evacuation areas and evacuation routes, and install evacuation route signs.

Tsunamis are very rare compared to hazardous weather events in the United States. As a result tsunami hazard awareness and preparedness is apt to be insufficient, even in areas such as the San Mateo County coast, which have a history of damaging tsunamis. A recent event underscores the potential hazards of these rare events. On October 14, 2006, a major earthquake occurred in Hawaii during the annual Pumpkin Festival in Half Moon Bay. On that day there were an estimated 100,000 visitors crowded into this small city. Fortunately, due to the depth of the earthquake, no tsunami was generated.

Conclusions

To paraphrase NOAA, "It is critical that individuals in high-risk areas be educated about and prepared for tsunamis before the waves strike, because ultimately it is up to each individual to take appropriate actions for protection (i.e., moving inland and to higher ground). All the warnings and information in the world will not do much if the public does not get, know how to use and/or act upon this information." (NOAA Magazine Online, story 158, p.2, http://www.magazine.noaa.gov/stories/mag158.htm)

San Mateo County has a comprehensive plan to respond to a tsunami warning. The response to the June 2005 warning revealed problems in implementing the plan at the local level. The most important objective of the plan is to communicate the warning of an impending tsunami to citizens at risk and to advise them how to respond. While the County OES is developing appropriate tsunami signage and researching the effectiveness of a possible siren/broadcasting system, the 2005 experience suggests that the County needs to take a more aggressive approach to educating the local communities and beach visitors about the dangers of a tsunami and what they should do in the event of an alert.

The population of Half Moon Bay can swell from 12,000 to 100,000 at times throughout the year. Visitors are less likely to know what a siren or other alert system means and what to do in the event of an alert. Signs should be posted in public areas, particularly public beaches, to educate the public on the danger of tsunamis, how to recognize an alert and what to do should an alert be broadcast.

The County Tsunami Annex draft (OES://OA Tsunami Annex July 2006) lists contacts, indicates responsibilities, and outlines procedures to be followed throughout the county should a tsunami alert be issued by the WCATWC. The draft must be completed and approved for implementation.

The Red Cross has limited supplies stored in the coastal communities. Expectations are that they could draw on neighboring communities if needed. After a tsunami, however, it is likely that traffic on Highways 92 and 1 would be seriously impacted and movement of supplies inhibited.

Recommendations

1. The Grand Jury recommends that the Emergency Service Council (ESC) direct the OES staff to work closely with San Mateo County communities to assist them in becoming certified TsunamiReady locations. More specifically, the ESC and OES should use the TsunamiReady plan as a model to help Pacifica, Half Moon Bay and the unincorporated coastal communities accomplish the following:

    1.1 Develop an emergency tsunami response plan for each community that specifies how the public and emergency service providers are to be informed of an alert and what their responses should be.

    1.2 Educate the public on the dangers of a tsunami, how the alert system works, and what to do in the event of an alert.

    1.3 Obtain approval and permits from the appropriate government agencies (Coastal Commission, CalTrans and State Parks) for tsunami warning signage and a siren/broadcast system and install same.

    1.4 Acquire inundation maps for the entire San Mateo County coast.

    1.5 Ensure that the resources of the Regional Office of the Red Cross are sufficient and appropriately distributed.

    1.6 Acquire the resources and technology to make San Mateo County StormReady/TsunamiReady by December 31, 2007.

2. The Grand Jury recommends that the Half Moon Bay City Council direct the City Manager to:

    2.1 Work closely with the ESC to accomplish the goals 1.1 through 1.6 listed above;

    2.2 Identify hazardous areas, safe zones and evacuation routes within Half Moon Bay;

    2.4 Identify "residents in need" who may need help in case of an emergency;

    2.5 Activate a Community Alert Network or its equivalent to alert residents in case of an emergency.

3. The Grand Jury recommends that the Pacifica City Council direct the City Manager to work closely with the ESC to accomplish goals 1.1 through 1.6 listed above.

4. The Grand Jury recommends that the Board of Supervisors direct the County Manager to:

    4.1 Work with the ESC to accomplish goals 1.1 through 1.6 listed above for the unincorporated areas;

    4.2 Develop a tsunami alert and evacuation plan for unincorporated coastal communities, including Princeton, El Granada, Martins Beach and Pescadero;

    4.3 Identify "residents in need" living in unincorporated coastal communities who may need help in case of an emergency;

    4.4. Activate a Community Alert Network or its equivalent to alert residents in unincorporated coastal communities in case of an emergency;

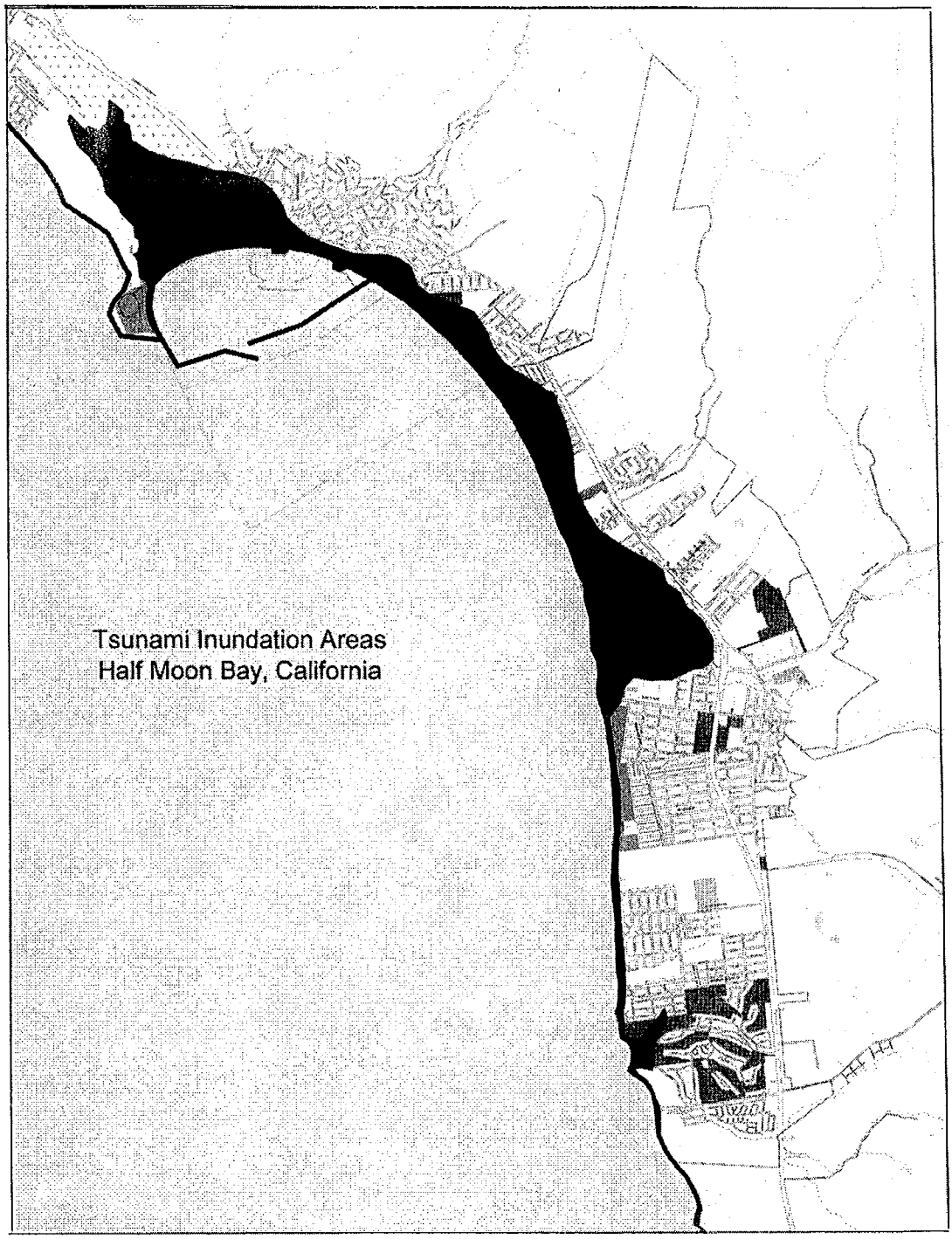
    4.5. Act on the July, 2006 County Tsunami Annex Draft by December 31, 2006.

5. The Grand Jury recommends that the Sheriff instruct the OES to:

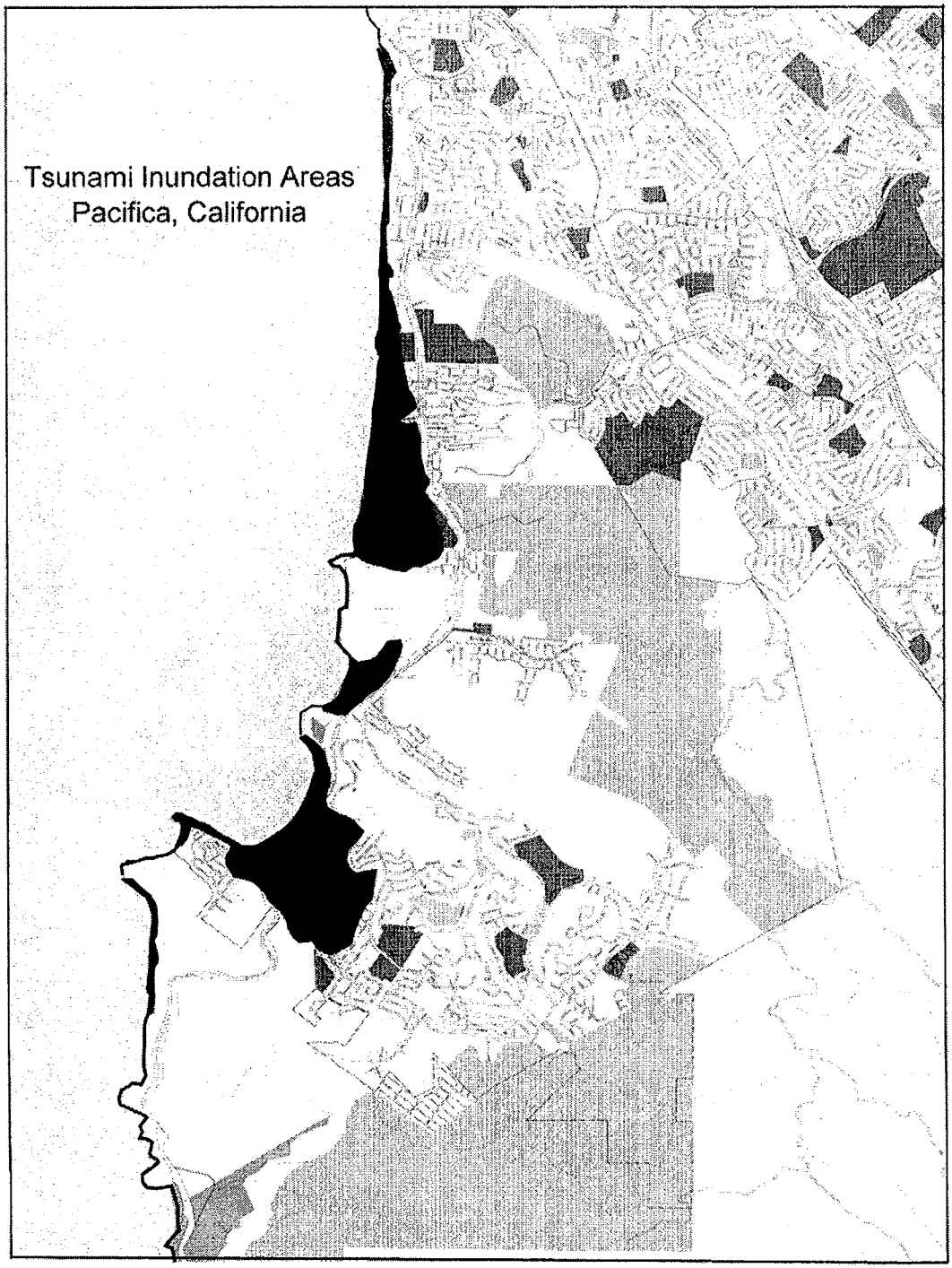
    5.1 Provide advice and guidance for the development of tsunami alert and evacuation plan for the rural coastal communities.

    5.2 Work with the ESC to accomplish goals 1.1 through 1.6 listed above.

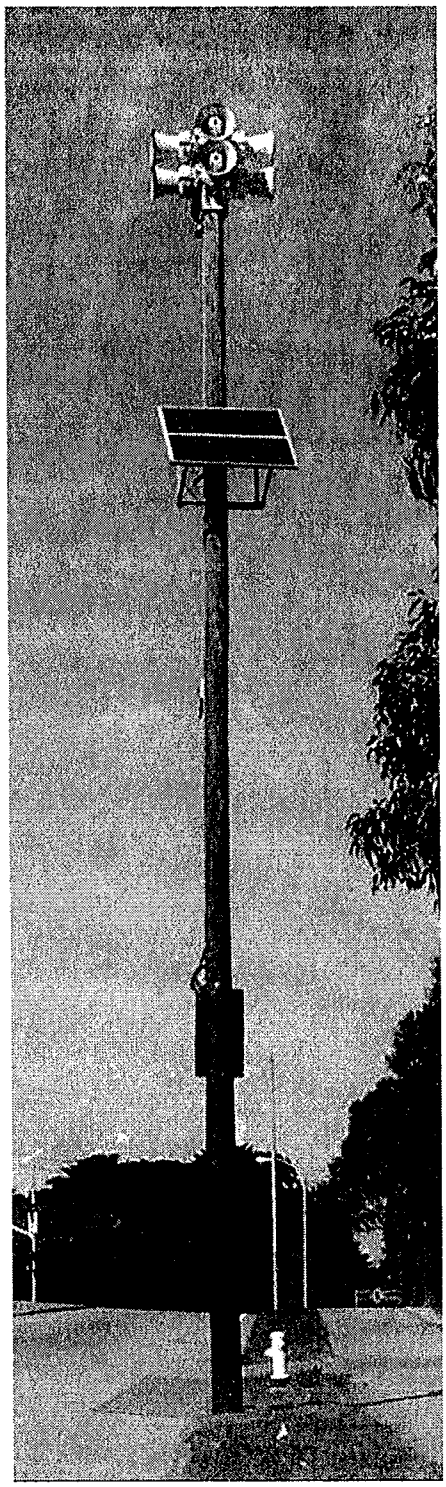
Appendix A. Potential tsunami inundation areas of Half Moon Bay and the Midcoast (shown in black). This is for planning purposes only and based on worst case assumptions as described in the text



Appendix B. Potential tsunami inundation areas of Pacifica (shown in black). This is for planning purposes only and based on worst case assumptions as described in the text.



Appendix C. Example of an emergency siren system.



COUNTY OF SAN MATEO
Inter-Departmental Correspondence

County Manager's Office

DATE: February 5, 2007
BOARD MEETING DATE: February 13, 2007
SPECIAL NOTICE: None
VOTE REQUIRED: None

TO: Honorable Board of Supervisors

FROM: John L. Maltbie, County Manager

SUBJECT: 2006-07 Grand Jury Response

Recommendation
Accept this report containing the County's responses to the following 2006-07 Grand Jury report: Tsunami Alert and Evacuation on the San Mateo County Coast.

VISION ALIGNMENT:
Commitment: Responsive, effective and collaborative government.
Goal 20: Government decisions are based on careful consideration of future impact, rather than temporary relief or immediate gain.

This activity contributes to the goal by ensuring that all Grand Jury findings and recommendations are thoroughly reviewed by the appropriate County departments and that, when appropriate, process improvements are made to improve the quality and efficiency of services provided to the public and other agencies.

Discussion
The County is mandated to respond to the Grand Jury within 90 days from the date that reports are filed with the County Clerk and Elected Officials are mandated to respond within 60 days. It is also the County's policy to provide periodic updates to the Board and the Grand Jury on the progress of past Grand Jury recommendations requiring ongoing or further action. To that end, attached is the County's response to the Grand Jury report on Tsunami Alert and Evacuation on the San Mateo County Coast issued November 22, 2006.

Tsunami Alert and Evacuation on the San Mateo County Coast

Findings:

Staff is in general agreement with the Grand Jury's findings.

Recommendations:

The Board of Supervisors should direct the County Manager to:

4.1 Work with the ESC to accomplish goals 1.1 through 1.6 for the unincorporated areas (these recommendations were issued separately to the Sheriff's Office and ESC):

1.1 Develop an emergency tsunami response plan for each community that specifies how the public and emergency service providers are to be informed of an alert and what their response should be.

1.2 Educate the public on the dangers of tsunami, how the alert system works, and what to do in the event of an alert.

1.3 Obtain approval and permits from the appropriate government agencies (Coastal Commission, CalTrans, and State Parks) for tsunami warning signage and a siren/broadcast system and install the same.

1.4 Acquire inundation maps for entire San Mateo County Coast.

1.5 Ensure that the resources of the Regional Office of the Red Cross are sufficient and properly distributed.

1.6 Acquire the resources and technology to make San Mateo County Storm Ready/Tsunami Ready by December 31, 2007.

Response: Concur. Separate responses to Grand Jury recommendations 1.1 through 1.6 have been issued by both the Sheriff's Office of Emergency Services (OES) and the Emergency Services Council (ESC). The County Manager's Office concurs with these responses and will coordinate with both the OES and ESC in their ongoing efforts in these areas.

4.2 Develop a tsunami alert and evacuation plan for unincorporated coastal communities including Princeton, El Granada, Martins Beach, and Pescadero.

Response: Concur. The County Manager will direct OES to comply with this recommendation. OES/Homeland Security has a goal of reaching "Tsunami Ready" status—a program sponsored by the National Weather Service—by December 31, 2007. This program requires evacuation routes and safety zones to be clearly marked. Two Alerting Systems have been purchased with Homeland Security funds. One is a digital text messaging system, which is up and running in several

jurisdictions while others are in the training and orientation phase. The second is a Telephone Emergency Notification System (TENS) telephone calling system that that will make a telephone voice message to each home or business in the alert areas. This system also has the capability to interact with several sirens to be placed in and around the Tsunami inundation areas to alert visitors as well as residents. The computer servers that will support the TENS system are in place and mapping of alert areas is underway. The first County-wide training session was held on January 26, 2007. OES/HS is working with the Planning Departments in San Mateo County, Half Moon Bay, and Pescadero to ensure proper permits are obtained for the siren installations.

4.3 Identify "residents in need" living in unincorporated coastal communities who may need help in case of an emergency.

Response: Concur. The County Manager will direct OES to comply with this recommendation and coordinate its implementation with the Human Services Agency and the Health Department.

4.4 Activate a Community Alert Network or its equivalent to alert residents in unincorporated coastal communities in case of an emergency.

Response: Concur. The County Manager will direct OES to comply with this recommendation. As indicated in the response to Recommendation 4.2 above, two Alerting Systems were purchased with Homeland Security funds—a text messaging system that has been installed in several jurisdictions, and a telephone calling system that is currently under installation.

4.5 Act on the July, 2006 County Tsunami Annex Draft by December 31, 2006.

Response: Concur. The County Manager will direct OES to comply with this recommendation. The Tsunami Annex Draft, which is an addition to the emergency Operations Plan, is currently under revision as new threats and capabilities are discovered. Since November of 2006, OES/HS has facilitated three meetings between first responders to discuss issues and jurisdictional responsibilities. One "end to end" Tsunami exercise was held in association with the National Weather Service. OES/HS will have an adopted plan prior to December 31, 2007.

CITY OF HALF MOON BAY

City Hall, 501 Main Street
Half Moon Bay, CA 94019

December 26, 2006

Honorable John L. Grandsaert
Judge of the Superior Court
Hall of Justice
400 County Center; 2nd Floor
Redwood City, CA 94063-1655

Dear Judge Grandsaert,

Thank you for the opportunity to review the 2006-2007 San Mateo County Civil Grand Jury's report on Tsunami Alert and Evacuation on the San Mateo County Coast.

After reading the report, we feel that the recommendations in the Grand Jury's report (1., 1.1 through 1.6, 2., 2.1 through 2.5) are both reasonable and forward thinking. We are in agreement on all the suggested points.

In response to the Grand Jury's findings:

1) In the Grand Jury report it was stated that coastal residents did not learn of the tsunami warning until after it was cancelled and many of those residents that did hear the warning did so first through the National Weather Service announcement on television. The report further states that no broadcast was made either at the beaches or through community streets. The report also states that the Half Moon Bay City Manager and the Red Cross volunteer leader were not notified. The report goes on to state that part of the problem was that the Half Moon Bay Police Commander did not follow procedures and failed to inform the appropriate personnel.

2) It should be noted that police staff did in fact check the wrong tsunami website, in that the Pacific Tsunami Warning Center (Which was clear of any tsunami activities) instead of the Alaskan Tsunami Warning Center website was checked. This was an error on our part that has been corrected with training of staff.

According to the Governor's Office of Emergency Services, Preliminary Internal Review report (dated June 27, 2005) of the June 14th Tsunami warning incident, the report states that the Tsunami Warning issued by National Oceanic and Atmospheric Administration (NOAA) contained language and format that was unclear or obscured critical information. California State Warning Center actions were appropriate, but the NOAA messages may have confused local government responders. There was also message or coding confusion for the NOAA Hazard Radio system and with the Emergency Alert System, which are used to alert the public, but not emergency officials.

In the Grand Jury report it states that movement of supplies would be inhibited. The Tsunami Response Plan calls for the California Highway Patrol to shut down traffic at State Route 92 at the lower lakes (Highway 35). Only emergency personnel would be allowed access, thus State Route 92 would be freed up for emergency personnel and supplies coming into Half Moon Bay.

In response to the Grand Jury report recommendations:

1.1 Develop an emergency tsunami response plan that specifies how the public and emergency service providers are to be informed of an alert and what their responses should be.

Presently, the Half Moon Bay Police Department is working on developing a comprehensive Tsunami Response Plan for the City of Half Moon Bay. The plan is open ended, as it will continually be reviewed, updated, and improved.

A. The public will be informed of a tsunami alert by different means.

1) Two siren systems are scheduled to be installed within the city limits of Half Moon Bay (to be installed in 2007).
2) ROAM Alert system, which will alert those citizens, who sign up for the free service, of the tsunami warning by cellular telephone text message, smart telephone text message and pager text message.
3) NOAA Tsunami Alert system which will alert those citizens who sign up for the free service, of the tsunami warning by internet e-mail or e-mail to those internet capable cellular telephones.
4) The public Emergency Broadcast System when activated will broadcast the tsunami alert on local television stations and AM/FM radio stations.
5) Local Comcast Cable Television will broadcast the tsunami alert message on its channel 6, local broadcast station.
6) Those citizens with NOAA radios will be alerted to the tsunami alert by the NOAA, National Weather Service alert system.
7) Citizens will be advised to move to high ground (East of State Route 1)
8) Presently, San Mateo County OES is working on another method of notifying citizens of an emergency situation. This is commonly called "a reverse 911" or neighborhood call system. This system would call all of the citizens of Half Moon Bay listed in the A.T. & T. telephone directory. The system would call residences and businesses using "hard line or land line" telephone lines. This system would not call cellular telephones or other non-A.T. & T telephones. A computer-generated message would then be transmitted when the telephone is picked up. As of September 2006, OES has received three bid proposals. Funding for this program is being funded by a US Department of Homeland Security grant.

B. The emergency service providers will be informed as follows.

1) The Alaska Tsunami Warning Center will issue one of four different tsunami bulletins in regards to earthquake and tsunami incidents.
   a. Information Statement
   b. Tsunami Advisory
   c. Tsunami Watch
   d. Tsunami Warning

2) Only in incidents of a Tsunami Watch or Tsunami Warning will San Mateo County Communications be notified by County Office of Emergency Services (OES)

3) San Mateo County Communications will then notify the on duty Half Moon Bay Police Department supervisor or senior officer. He/she will in turn notify the Chief of Police or Commander. The Chief of Police shall then notify the City Manager, Public Works Director, and Finance Director. The Chief of Police and City Manager shall then activate the city's Emergency Operations Center.

4) Officers shall then be assigned duties as needed for the incident.

5) For further information refer to the Half Moon Bay Police Department Tsunami Response Plan.

1.2 Educate the public on the dangers of a tsunami, how the alert system works, and what to do in the event of an alert.

1) The City of half Moon Bay has already started an education process for citizens in regards to tsunamis. On the city's Internet website there is a link for "emergency preparedness information." After clicking on that link, it takes you to another page, which has more links and general emergency information. Citizens are able to go to the county's ROAM Alert web page. They are able to go to the Governor's Office of Emergency Services web page detailing "preparing your family for an Emergency." Citizens are able to go to the American Red Cross web pages, "Preparing to make a plan and Tsunamis." There is also a link for the Alaska Tsunami Warning Center Internet website. (See attached)

There are six other links to various other Internet websites, which include San Francisco Office of Emergency Services, FEMA, US Department of Homeland Security, ARES Group, National Hurricane Center, and the Smart Communities Network.

There is also a link to the Half Moon Bay Tsunami Brochure. This brochure contains general safety and emergency preparedness information. The brochure also contains the Half Moon Bay Tsunami evacuation map. (See attached brochure).

Half Moon Bay Police along with members of the San Mateo County Office of Emergency Services are presently developing a structured plan for providing tsunami and emergency preparedness information to the citizens of Half Moon Bay. Six inundation areas have been identified within the city limits of Half Moon Bay; Surfers Beach area, the Miramar Area, the Kehoe /Casa del Mar Area, the Strawflower area, the Arletta Park area and the Ocean Colony /Ritz Carlton Hotel area. The Half Moon Bay Tsunami Brochure will be printed and distributed to residents in those areas.

Tsunami and emergency preparedness information will be provided to all of the citizens of Half Moon Bay using different methods of media: the local newspaper and local public access channel (Channel 6) on Comcast Cable TV.

There are plans to hold Emergency Preparedness fairs and seminars at the Adcock Center where citizens can receive tsunami and emergency preparedness information and talk with emergency providers one on one. Tsunami and Emergency Preparedness will also be stressed in the local Neighborhood Watch program. At neighborhood watch meetings in those neighborhoods in the inundation areas, the residents will be informed of emergency preparedness and what to do in case of a Tsunami watch/warning.

The Half Moon Bay Fire Protection District has already scheduled Citizen Emergency Response Teams (CERT) classes where local citizens can be trained to assist in emergency situations. The first CERT class has been tentatively scheduled for some time in January.

Emergency preparedness handouts are available at both the Half Moon Bay Police Department and the Half Moon Bay City Hall. Tsunami inundation maps are also displayed at both locations.

Citizens of Half Moon Bay who reside in any of the tsunami inundation areas will be provided tsunami and emergency preparedness information. Those citizens will be advised to move to higher ground, (Any location east of State Route 1) in the event of a major earthquake or tsunami watch/warning. Those citizens who live outside of the tsunami inundation areas will be advised to shelter in place until the emergency ceases.

1.3 Obtain approval and permits from the appropriate government agencies for tsunami warning signage and a siren/broadcast system and install same.

1) Presently, the San Mateo County Office of Emergency Services is working on purchasing and installing an outdoor warning system (siren system). Plans call for two sirens to be placed in the Half Moon Bay city

jurisdiction. Possible locations for the sirens could be: placement of one siren in the Miramar area and the other siren placed in the Kehoe/Casa del Mar area. An additional siren will be placed in the Princeton area, which will cover the Surfers Beach area. Hormann America Inc. has been chosen to be the vendor for the siren system. This company has experience in emergency siren systems having placed siren systems in the Martinez/Concord area. These sirens will be solar powered and will have both siren and voice capabilities. The installation of the siren system is planned for sometime in 2007. (See attached)

2) Presently, San Mateo County OES is researching and designing signage to be placed on all beach areas and in the tsunami inundation areas. Signage from Tsunami prepared areas such as Hawaii and Crescent City, California, are being examined as examples. OES will meet with Half Moon Bay City officials to plan and design signage to be placed in inundation areas. OES will work with California State Parks to plan and design signage, which will place at all state park beaches. Installation of the signage is planned for 2007 (See attached signage examples).

1.4 Acquire inundation maps.

The City of Half Moon Bay Planning Department, with assistance from the San Mateo County Public Works Department, using GIS database has produced a tsunami inundation map. A large map has been displayed at the Half Moon Bay Police Department and the City of Half Moon Bay City Hall. Smaller, mid-size maps have been produced for citizens to take and are available at the city hall counter. A mid-size map has also been given to the Half Moon Bay Public Library for display there. 8 1/2 by 11 inch maps have also been produced and are available as handouts for interested citizens. They are available at the police department. and city hall.

The Half Moon Bay Police Department has produced detailed maps of the six inundation areas. These maps show the areas of the Surfers Beach area, the Miramar Area, the Kehoe/Casa del Mar Area, the Strawflower area, the Arletta Park area and the Ocean Colony area. The maps show city streets, their names and the inundation in each of the areas. These maps will be reproduced for distribution to citizens of Half Moon Bay and will be available at the police department and city hall.

1.5 Ensure that the resources of the regional office of the Red Cross are sufficient and appropriately distributed.

Two Half Moon Bay residents are volunteer emergency shelter/volunteer liaisons. A Red Cross trailer is parked at the Cabrillo School District Office year, 498 Kelly Ave, Half Moon Bay. The trailer is equipped with

cots and general emergency supplies. The Red Cross warehouses emergency supplies in different locations within the county and bay area. Other supplies are warehoused in regional, state and national Red Cross offices, which, can be transported to effected areas. San Mateo County Red Cross also has access to Red Cross emergency vehicles and trailers, which, can be used during emergency incidents in Half Moon Bay.

1.6 Acquire the resources and technology to make San Mateo County Storm Ready / Tsunami Ready by December 31, 2007.

The City of Half Moon Bay together with San Mateo County Office of Emergency Services are working together to make the City of Half Moon Bay, Storm ready/Tsunami Ready. San Mateo County has already met the requirements of the Storm Ready program. The county met the program requirements in September of 2006. Being Storm ready is a prerequisite for the Tsunami Ready program. The City of Half Moon Bay will continually work towards achieving the goal of Tsunami Ready until the goal is achieved.

2.1 Work closely with the Emergency Service Council (ESC) to accomplish the goals 1.1 through 1.6.

Elected officials in Half Moon Bay are members of the ESC. As described above, the City of Half Moon Bay is continually working to accomplish these goals.

2.2 Identify hazardous areas, safe zones and evacuation routes within Half Moon Bay

1) The only hazardous area identified in the inundation area is the SAM Plant (water sewage treatment plant). In the event of tsunami, the plant could be covered by wave action. Also, the sewer and drainage system could become overloaded. The plant has a plan in effect to deal with this situation. California State Parks, San Mateo County Health Department., San Mateo County Environmental Heath Department, and the Pillar Point Harbormaster say raw sewage and waste water may flow directly from the treatment plant westward and into the ocean. After the wave and flooding subsides the beach and ocean waters will need to be checked for contamination.

2) Safe zones have been determined to be those areas east of State Route 1 or those areas not in the identified inundation areas. Citizens will be directed to move eastward and east of State Route 1. The primary emergency shelter has been identified as the Half Moon Bay High School.

3) Evacuation routes have been identified and determined to be eastward out of those identified inundation area neighborhoods. OES along with

Half Moon Bay City officials are developing signage, which will identify and guide citizens and tourists out of the inundations areas. The signage will be clearly labeled and not only will the evacuation routes be labeled but safe zones will be identified and marked.

2.3 Identify "residents in need" who may need help in case of an emergency.

Two Half Moon Bay Police Department personnel are members of the local Coastside Disaster Preparedness Committee. The committee is made up of members of local non-profit groups such as the Red Cross, the Cabrillo School District, local churches, and San Mateo County health organizations, ARES, Rotary club, and Senior Coastsiders. The committee has a wide range of membership and not only represents organizations, groups, and citizens of Half Moon Bay, but also the Coastside itself. One of the goals of the committee is for each group involved to identify those members within their groups that may be residents in need and may require special assistance during an emergency situation (Tsunami, earthquake, etc.).

2.4 Activate a Community Alert Network or its equivalent to alert residents in case of an emergency.

The City of Half Moon Bay along with the San Mateo County Office of Emergency Services is working on different methods of notifying the citizens of Half Moon Bay, whether it be from a natural emergency (Tsunami, earthquake etc) or man made emergency (Gas leak, oil spill, major accident). The public will be informed by different means:

1) Two emergency warning sirens are scheduled to be placed within the jurisdiction of the City of Hall Moon Bay and should be in place by the beginning of 2007.
2) ROAM Alert system, which will alert those citizens, who sign up for the free service, of the tsunami warning by cellular telephone text message, smart telephone text message and pager text message.
3) NOAA Tsunami Alert system which will alert those citizens who sign up for the free service, of the tsunami warning by internet e-mail or e-mail to those internet capable cellular telephones.
4) The public Emergency Broadcast System when activated will broadcast the tsunami alert on local television stations and AM/FM radio stations.
5) Local Comcast Cable Television will broadcast the tsunami alert message on its channel 6, local broadcast station.
6) Those citizens with NOAA radios will be alerted to the tsunami alert by the NOAA, National Weather Service alert system.
7) Presently, San Mateo County OES is working on another method of notifying citizens of an emergency situation. This is commonly called "a reverse 911" or neighborhood call system. This system would call all of

the citizens of Half Moon Bay listed in the A.T. & T. telephone directory. The system would call residences and businesses using "hard line or land line" telephone lines. This system would not call cellular telephones or other non-A.T. & T telephones. A computer-generated message would then be transmitted when the telephone is picked up. As of September 2006, OES has received three bid proposals. Funding for this program is being funded by a US Department of Homeland Security grant.

The City of Half Moon Bay is committed to providing the citizens of San Mateo County with the highest level of safety and security in preparation and response to an emergency such as a Tsunami.

Thank you again for allowing us to review and respond to the report prepared by the San Mateo County Civil Grand Jury and please pass on my thanks to them for the outstanding work that they perform.

Sincerely,

Marcia Raines
City Manager
City of Half Moon Bay

cc: City Council, Clerk of the Court, Executive Officer, Judge Grandsaert, Grand Jury Website, & City Clerk of Half Moon Bay

COUNTY OF SAN MATEO
OFFICE OF THE SHERIFF

GREG MUNKS
SHERIFF

CARLOS G. BOLANOS
UNDERSHERIFF

400 COUNTY CENTER ▫ REDWOOD CITY ▫ CALIFORNIA 94063-1662 TELEPHONE (650) 599-1664 WWW.SMCSHERIFF.COM

ADDRESS ALL COMMUNICATIONS TO THE SHERIFF

January 22, 2007

Honorable John L. Grandsaert
Judge of the Superior Court
Hall of Justice
400 County Center, 2nd Floor
Redwood City, CA 94063

Re: 2006-2007 Grand Jury Report: Tsunami Alert and Evacuation on the San Mateo County Coast

Dear Judge Grandsaert:

We wish to acknowledge the efforts of the Civil Grand Jury with this report regarding the Emergency Services Council and our Office of Emergency Services and Homeland Security (OES/HS). We feel the report is accurate, and depicts an understanding and appreciation by the members of the Grand Jury regarding issues relating to Tsunami impact on the San Mateo County coast.

The Office of Emergency Services and Homeland Security fully supports the findings of the Civil Grand Jury and appreciates a partnership in alerting residents and visitors to the very real, and often potential danger of a tsunami striking San Mateo County.

Recommendation One:

1. The Grand Jury recommends that the Emergency Services Council (ESC) direct the OES staff to work closely with San Mateo County communities to assist them in becoming certified Tsunami Ready locations. More specifically, the ESC and OES should use the Tsunami Ready plans as a model to help Pacifica, Half Moon Bay, and the unincorporated coastal communities accomplish the following:

1.1 Develop an emergency tsunami response plan for each community that specifies how the public and emergency service providers are to be informed of an alert and what their response should be.

1.2 Educate the public on the dangers of tsunami, how the alert system works, and what to do in the event of an alert.

1.3 Obtain approval and permits from the appropriate government agencies (Coastal Commission, CalTrans, and State Parks) for tsunami warning signage and a siren/broadcast system and install same.

1.4 Acquire inundation maps for entire San Mateo County Coast.

1.5 Ensure that the resources of the Regional Office of the Red Cross are sufficient and properly distributed.

1.6 Acquire the resources and technology to make San Mateo County Storm Ready/Tsunami Ready by December 31, 2007.

Response:

The Emergency Services Council has been briefed on the issues regarding tsunami issues regarding San Mateo County. The ESC is aware that OES/HS is actively involved and addressing the issues brought forth by the Civil Grand Jury and supports the ongoing efforts of OES/HS. Sheriff Munks also supports the ongoing efforts of OES/HS to follow the guidelines in a timely and effective manner to better prepare our residents for a tsunami event.

Recently OES/HS acquired two alert systems for public notification: the first being a digital alert system that alerts "text messaging" devices (cell phone text messaging, digital pagers, and e-mail). The second system is a Telephone Emergency Notification System (TENS), which would call each home or business in the effected area. This second system also offers either an audible siren or voice speaker alert system. Only six sirens/speakers are funded through OES/HS for the inundation areas so the three jurisdictions will need to find further funding through either general fund or other sources to increase the number of sirens necessary to alert all of the residents and visitors in the inundation areas.

Education efforts are constantly underway. OES/HS developed a written pamphlet of information that was adopted by Pacifica, Half Moon Bay, and unincorporated areas. Each jurisdiction has distributed this information to the public.

Several focus groups of emergency responders have already been held to address issues related to tsunami and will continue to dialog on the threat issues.

The three jurisdictions of San Mateo County, Pacifica, and Half Moon Bay started discussions regarding the permitting issues of both sirens and signage for the Tsunami Ready Program. All three jurisdictions are open to the idea and are willing to support the effort to the California Coastal Commission.

OES/HS requested the United States Geological Survey to survey the entire San Mateo County coast and the Bay Side of San Mateo County as to the rise in sea water as it relates to tsunami inundation.

OES/HS is in constant contact with the American Red Cross, also including other service providers such as the Salvation Army, Second Harvest Food Bank, and the State of California Office of Emergency Services as it relates to shelter support for the coast.

OES/HS received the distinct honor of the National Weather Service "Storm Ready" certification on September 21, 2006. This is a vital first step to achieve Tsunami Ready Certification. OES/HS believes it can reach the Tsunami Ready criteria by December 31, 2007.

Recommendation Five:

5. The Grand Jury recommends that the Sheriff instruct OES to:

5.1 Provide advice and guidance for the development of tsunami alert and evacuation plan for the rural coastal communities.

5.2 Work with the ESC to accomplish goals 1.1 through 1.6 above.

Response:

Sheriff Munks concurs with the recommendations of the Grand Jury and supports the efforts OES/HS, as mentioned above.

Once again, the San Mateo County Sheriff's Office of Emergency Services and Homeland Security thanks the Civil Grand Jury for researching the effects of a tsunami related event in San Mateo County. Working together to prepare and educate both the public and government agencies is of the utmost importance in addressing this constant threat to our communities.

Sincerely,

Greg Munks, Sheriff

cc: The Honorable Board of Supervisors
Grand Jury Website

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www.ci.pacifica.ca.us

Scenic Pacifica

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February 16, 2007

Honorable John L. Grandsaert
Judge of the Superior Court
Hall of Justice
400 County Center; 2nd Floor
Redwood City, Ca 94063-1655

Subject: Grand Jury Report –Tsunami Alert and Evacuation on the San Mateo County Coast

We would like to take this opportunity to thank you and the Civil Grand Jury for their efforts and research in evaluating the Tsunami Alert & Evacuation plans for the San Mateo Coast. We agree with the findings and recommendations of the Grand Jury as noted in their report dated, November 22, 2006.

Grand Jury Recommendations:

1.1 Develop an emergency tsunami response plan for each community that specifies how the public and emergency service providers are to be informed of an alert and what their response should be.

1.2 Educate the public on the dangers of a tsunami, how the alert system works, and what to do in the event of the alert.

1.3 Obtain approval and permits from the appropriate government agencies (Coastal Commission, Ca Trans and State Parks) for tsunami warning signage and a siren/broadcast system and install same.

1.4 Acquire inundation maps for the entire San Mateo County Coast.

1.5 Ensure the resources of the regional Office of The Red Cross are sufficient and appropriately distributed.

1.6 Acquire the resources of and technology to make San Mateo County StormReady/Tsunami Ready by December 31, 2007

Response:

The City of Pacifica has had a good working relationship with San Mateo County Office of Emergency Services. For several years now the City of Pacifica has had a draft Tsunami Response Plan, which corresponds with the county plan. Most recently and for the past year there has been an aggressive effort to coordinate and stream line the plan for coastal communities within San Mateo County. OES has played a key role in facilitating this plan and this is a work in progress, which will include a planned and coordinated effort to inform emergency response personnel and the community in case of an evacuation.

The City of Pacifica strongly supports public education in Disaster Preparedness. Several years ago, the City of Pacifica's Emergency management team created a Tsunami brochure that informs the community of the dangers in this type of event. This brochure, which describes the characteristics of a Tsunami, provides information on how to respond to a Tsunami event. For example, the brochure depicts the Tsunami Inundation areas with the City of Pacifica and gives a brief description of the recommended evacuation routes. We agree with the Grand Jury recommendation that further education for the community in how an alert works and what to do in either of these cases is critical. Staff From OES recently met with our staff and provided us with an orientation in the ROAM SECURE NETWORK. Membership of this system provides community members and law enforcement the opportunity to circulate information to staff and the community via digital devices. This information, which will be posted on our web site under Disaster Preparedness, will allow citizens to sign up on the Roam Secure Network at their leisure. The implementation of this community education process will be coordinated with the installation of the Tsunami sirens as noted below. It is anticipated that all the majority of our emergency response personnel and department heads will be registered with the Roam Secure system by April 2007.

Currently, the City of Pacifica Planning Department is in the process of reviewing any permit issues that might become an issue with the installation of the tsunami siren and warning systems that were acquired from OES. In addition, preliminary steps have been taken to identify

signage needs within the City of Pacifica. It is anticipated that Signs and sirens will be installed by December 31, 2007.

The City of Pacifica has the most current Tsunami inundation maps for the San Mateo County Coast that are available from OES. These maps list the areas at risk as Sharp Park, Rockaway and Linda Mar.

The City of Pacifica has two locations, which are designated shelters for the City of Pacifica. We are fortunate to have a liaison for the American Red Cross who serves on the City of Pacifica's Emergency Preparedness & Safety Commission. We have a Red Cross trailer, which is stationed at the Linda Mar Fire Station. This trailer is equipped with cots, blankets and various emergency supplies. The Red Cross also has other trailers located within the county that would be available in case of a tsunami event.

For the past year, the City of Pacifica has taken steps to acquire StormReady status from the National Weather Service. Several steps have been taken to meet the criteria for this status, but this is a work in progress. For example, in the past year a sophisticated weather instrument was installed in the Police Communications Center. In addition, a NOAA weather instrument was installed in the communications center to provide the most current weather information available. It is also anticipated that the City of Pacifica will have this process completed by December 31, 2007.

Response:

Once again, we would like to thank you and the Grand Jury for your interest in providing a safer community for the citizens of Pacifica.

Sincerely,

William C. Norton

William Norton, City Manager

Cc: City Council
Jim Saunders, Chief of Police.
Ron Meyers, Fire Chief, North County Fire Authority

January 29, 2007

Honorable John L. Grandsaert
Grand Jury Judge
Hall of Justice and Records
400 County Center
Redwood City, CA 94063

Re: 2006-2007 Grand Jury Report: Tsunami Alert and Evacuation on the San Mateo County Coast

Dear Judge Grandsaert;

We wish to acknowledge the efforts of the Civil Grand Jury with this report regarding the Emergency Services Council (ESC). We feel the report is accurate, and depicts an understanding and appreciation by the members of the Grand Jury regarding issues relating to Tsunami impact on the San Mateo County coast.

The Emergency Services Council is in general agreement and fully supports the findings of the Civil Grand Jury The ESC appreciates a partnership in alerting residents and visitors to the very real and often potential danger of a tsunami striking San Mateo County.

Recommendations:

1. The Grand Jury recommends that the ESC direct the OES staff to work closely with San Mateo County communities to assist them in becoming certified Tsunami Ready locations. More specifically, the ESC and OES should use the Tsunami Ready plans as a model to help Pacifica, Half Moon Bay, and the unincorporated coastal communities accomplish the following:

1.1 Develop an emergency tsunami response plan for each community that specifies how the public and emergency service providers are to be informed of an alert and what their response should be.

1.2 Educate the public on the dangers of tsunami, how the alert system works, and what to do in the event of an alert.

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1.4 Acquire inundation maps for entire San Mateo County Coast.

1.5 Ensure that the resources of the Regional Office of the Red Cross are sufficient and properly distributed.

1.6 Acquire the resources and technology to make San Mateo County Storm Ready/Tsunami Ready by December 31, 2007.

Response:

The Emergency Services Council concurs with each of the recommendations. The ESC has been briefed of the issues regarding tsunami issues regarding San Mate County. The ESC is aware that OES/HS is actively involved and addressing the issues brought forth by the Civil Grand Jury and supports the ongoing efforts of OES/HS. The ESC also supports the ongoing efforts of OES/HS to follow the guidelines in a timely and effective manner to better prepare our residents for a tsunami event.

Recently OES/HS acquired two alert systems for public notification: the first being a digital alert system that alerts "text messaging" devices (cell phone text messaging, digital pagers, and e-mail). The second system is a Telephone Emergency Notification System (TENS), which would call each home or business in the effected area. This second system also offers either an audible siren or voice speaker alert system. Only six sirens/speakers are funded through OES/HS for the inundation areas so the three jurisdictions will need to find further funding through either general fund or other sources to increase the number of sirens necessary to alert all of the residents and visitors in the inundation areas.

Education efforts are constantly underway. OES/HS developed a written pamphlet of information that was adopted by Pacifica, Half Moon Bay, and unincorporated areas. Each jurisdiction has distributed this information to the public.

Several focus groups of emergency responders have already been held to address issues related to tsunami and will continue to dialog on the threat issues.

The three jurisdictions of San Mateo County, Pacifica, and Half Moon Bay started discussions regarding the permitting issues of both sirens and signage for the Tsunami ready program. All three jurisdictions are open to the idea and are willing to support the effort to the California Coastal Commission.

OES/HS requested the United States Geological Survey to survey the entire San Mateo County coast and the Bay Side of San Mateo County as to the rise in seawater as it relates to tsunami inundation.

OES/HS is in constant contact with the American Red Cross, also including other service providers such as the Salvation Army, Second Harvest Food Bank, and the State of California Office of Emergency Services as it relates to shelter support for the coast.

OES/HS received the distinct honor the National Weather Service "Storm Ready" certification on September 21, 2006. This is a vital first step to achieve Tsunami Ready Certification. OES/HS believes it can reach the Tsunami Ready criteria by December 31, 2007.

Once again the San Mateo County Emergency Services Council thanks the Civil Grand Jury for researching the effects of a tsunami related event in San Mateo County. Working together to prepare and educate both the public and government agencies is of the utmost importance in addressing this constant threat to our communities.

Sincerely,

Rose Jacobs Gibson
President, San Mateo County Board of Supervisors
Chair, San Mateo County Emergency Services Council

For All Tsunamis:

1. In coastal areas, if you feel a strong earthquake, go immediately to high ground, inland, or a designated evacuation site.
2. Follow the evacuation orders given by local officials. This may involve evacuating by foot if advised to do so.
3. Monitor radio (KCBS 740 AM or 88.5 FM), television, or NOAA Weather Radio for official information. En Espanol KSJO 92.3 FM.
4. If tsunami warning sirens sound, monitor the radio and be prepared to quickly evacuate.
5. Stay away from low lying areas (beaches, bluffs, etc.).
6. If you need help with evacuation, tie a large WHITE sheet or towel to your front door knob so that it is visible from street. This will alert people that you need assistance.

Be Prepared:

ASSEMBLE AN EMERGENCY "GO KIT" TO TAKE WITH YOU WHEN EVACUATING. MINUTES COUNT! INCLUDE IN YOUR KIT:

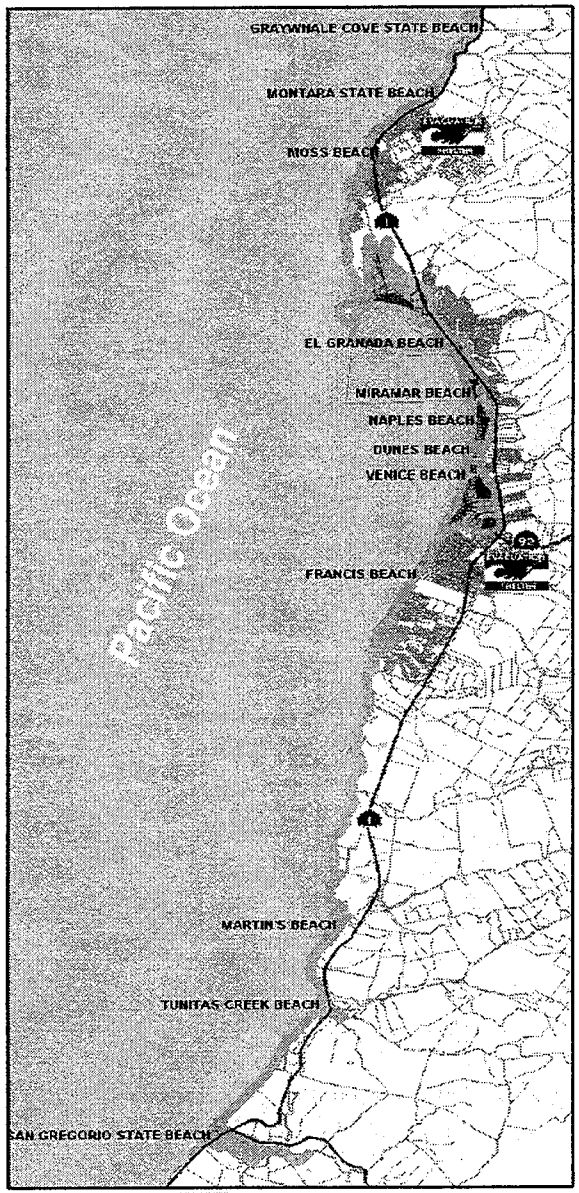
- First aid kit and reference guide for its use
- Bottled water
- Food (packaged), snacks
- Blankets or sleeping bags
- Essential medications
- Cash
- Food for pets
- Portable radio, flashlight, and batteries.

FOR MORE INFORMATION CONTACT:

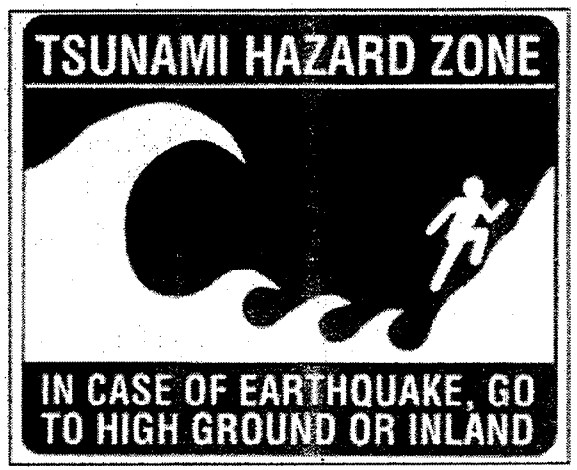
Half Moon Bay Police Department
537 Kelly Ave
Half Moon Bay, CA. 94019
(650) 726-8288
E-Mail: policedept@coastside.net

In case of tsunami evacuate to the east to an Evacuation Site or to high ground.

Central San Mateo County Coast
Tsunami Hazard Areas



City of Half Moon Bay



TSUNAMI INFORMATION

If you feel a strong earthquake . . . Do not wait for official warning . . . a tsunami may be coming in a few minutes. Large waves may continue to come ashore for several hours.

- Protect yourself until the earthquake is over – duck, cover, and hold
- Go to high ground or inland immediately
- Go on foot if at all possible
- Wait for an ***"all clear"*** from local emergency officials before returning to low-lying areas or the beach
- Where posted, follow signs to evacuation sites or evacuation shelters

Brochure Funding provided by California Office of Homeland Security

This information could save your life.

About Tsunamis

A tsunami is a series of sea waves usually caused by the displacement of the ocean floor by an undersea earthquake or landslide. As tsunamis enter shallow water near land, they increase in height and can cause great loss of life and property damage.

Research suggests that tsunami's have struck the California coast many times in the past. They can occur any time, day or night. Typical wave heights from tsunamis occurring in the Pacific over the last 80 years have been 20-45 feet at the shoreline. Local conditions can sometime produce even larger waves.

We distinguish between a tsunami generated by a seismic event near the California coast **(LOCAL SOURCE TSUNAMI)** and one that occurs in another area of the Pacific Ocean **(DISTANT SOURCE TSUNAMI).**

A **LOCAL SOURCE TSUNAMI** could come onshore within 15-20 minutes after the earthquake-before there is time for official warning from a national warning system.

Ground shaking from the earthquake may be the only warning you have. In the event of a strong earthquake (strong enough to make it difficult to stand) evacuate quickly to a safe area!

A **DISTANT SOURCE TSUNAMI** may take several hours to come ashore. A distant source tsunami would allow time for officials to issue an official **Tsunami Warning** and carry out a full evacuation of the hazard areas.

About Warning

If a tsunami warning is issued, it will be announced over the Emergency Alert System (EAS) on commercial radios and televisions. It will also be sent over the NOAA weather, all-hazard radio system.

In some areas of the county, tsunami warning sirens are in place or are being installed. If you hear **a steady 3-minute siren**, tune your radio to 740 AM or listen to your NOAA weather radio for official information.

San Mateo County emergency officials are also implementing other warning systems. These include an automated telephone notification system that will call phones in the tsunami hazard areas. Your telephone number and address must be listed in the public directory in order to receive this automated notification.

A second system will send a warning in the form of a text message to cellular phones, email addresses, and pagers. You can sign up for this free service on the internet by going to **www.smcalert.info** and follow the instructions for "new users".

In isolated areas along the beaches of San Mateo County you may not hear a warning. **A SUDDEN CHANGE IN SEA LEVEL** such as a rapidly receding sea should prompt you to go to high ground or inland immediately. Then, listen to your radio, television, or NOAA weather radio for official information.

About Evacuation

If you live or work in one of the tsunami hazard areas shown on the map in the pamphlet, you should be prepared to evacuate in a tsunami emergency.

Remember: In case of a strong earthquake do not wait for official instructions, evacuate quickly to a safe area then listen to the radio for official information and instructions.

Some communities have identified **Tsunami Evacuation Sites.** These are safe areas that you can quickly move to in the event of a local source tsunami. Evacuation Sites are just safe areas and do not offer any logistical services. However, they can serve as an assembly point for families and neighbors. Evacuation Sites are marked with this sign.



In the event of a distance source tsunami, residents in the hazard areas will be instructed to go inland or to an official **Evacuation Shelter** and remain there until told it is safe to return. This could be several hours. Designated evacuation shelters include:

- Half Moon Bay High School
- Pescadero High School

Other facilities may be opened as shelters as the need arises. These will be announced over the Emergency Alert System. Evacuation shelters will offer basic logistical services. But remember, it will take some time for the shelter staff to arrive and get set to receive evacuees.



Designing for Tsunamis

Seven Principles for Planning and Designing for Tsunami Hazards

March 2001

National Tsunami Hazard Mitigation Program

NOAA, USGS, FEMA, NSF, Alaska, California, Hawaii, Oregon, and Washington

Designing for Tsunamis

Seven Principles for Planning and Designing for Tsunami Hazards

March 2001

A multi-state mitigation project of the National Tsunami Hazard Mitigation Program (NTHMP)

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U.S. Geological Survey (USGS)
Federal Emergency Management Agency (FEMA)
National Science Foundation (NSF)
State of Alaska
State of California
State of Hawaii
State of Oregon
State of Washington

Funding for this project was provided by the U.S. Department of Commerce and the National Oceanic and Atmospheric Administration (NOAA).

The opinions and recommendations contained in this report do not necessarily represent those of the member agencies of the National Tsunami Hazard Mitigation Program Steering Committee.

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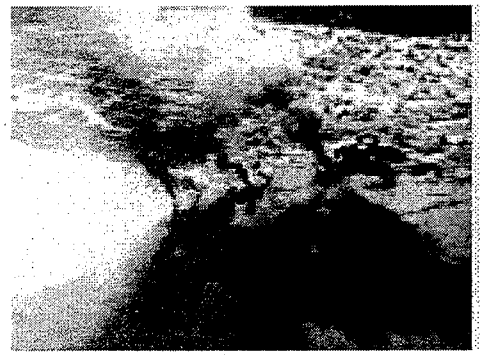
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INTRO

Introduction



Burning petroleum storage tanks along the Seward, Alaska, waterfront after the 1964 tsunami and earthquake. Credit: Anchorage Museum of History and Art

"Seward was...attacked by the main tsunami waves...as the wave traveled along the shore, it spread burning oil...the resulting fires engulfed the downtown...surge forces destroyed homes, docks, canneries, and the small boat harbor...virtually the entire downtown...was destroyed by fire."

Account of the effects of the 1964 Alaska earthquake and resultant tsunami in Seward, Alaska, in *Planning for Risk: Comprehensive Planning in Tsunami Hazard Areas.*

The Threat of Tsunamis to Coastal Communities

Tsunami waves generated by earthquakes, volcanic eruptions, or underwater landslides can reach 50 feet or more in height and devastate coastal communities. In recorded history, tsunamis worldwide have killed hundreds of thousands of people. Since 1946 six tsunamis have killed nearly 500 people and damaged hundreds of millions of dollars of property in Alaska, Hawaii, and along the West Coast of the United States.

Tsunamis are infrequent events but can be extremely destructive. While Hilo, Hawaii, suffered seven significant tsunamis in the last century, and Crescent City, California, experienced two damaging tsunamis in four years (1960 and 1964), many communities at risk in the Pacific region have no recent experience with tsunami damage and, hence, may have a false sense of security regarding the hazard.

An estimated 489 cities within the Pacific states of Alaska, California, Hawaii, Oregon, and Washington are susceptible to tsunamis; as many as 900,000 residents of these cities would be inundated by a 50-foot tsunami.

Beyond preparing for evacuation and emergency response, communities can reduce their tsunami risk by modifying their land use planning and development approval practices. Although planning for tsunamis will not be a top priority for most coastal communities, relatively small efforts to plan for this hazard can significantly increase community safety.

900,000 people in Alaska, California, Hawaii, Oregon, and Washington live in areas in danger of being inundated by a 50-foot tsunami.

Introduction

Purpose and Organization of the Guidelines

The purpose of these guidelines is to help coastal communities in the five Pacific states—Alaska, California, Hawaii, Oregon, and Washington—understand their tsunami hazards, exposure, and vulnerability, and to mitigate the resulting risk through land use planning, site planning, and building design. Emergency response and evacuation are addressed extensively in other publications and are only discussed in these guidelines as they relate to land use, siting, and building design and construction issues (see the references at the end of the guidelines concerning emergency response and evacuation planning for tsunamis).

These guidelines are intended for use by local elected, appointed, and administrative officials involved in planning, zoning, building regulation, community redevelopment, and related land use and development functions in coastal communities. The guidelines should also be helpful to state officials having similar responsibilities.

These guidelines are organized according to seven basic principles:

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

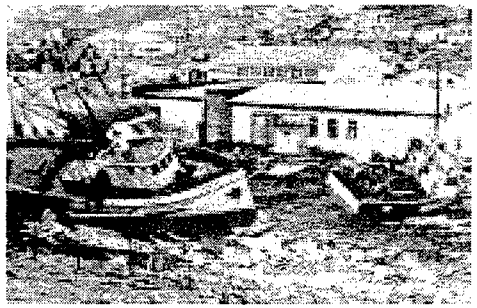
Principle 4: Design and construct new buildings to minimize tsunami damage

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Principle 7: Plan for evacuation

For each principle, the discussion includes background information on the topic, recommended process steps for implementing the principle, and specific how-to strategies. Several case studies in the guidelines illustrate how communities in the Pacific



Damage from the 1964 tsunami in Kodiak, Alaska. Credit: NOAA

Introduction

region are addressing tsunami hazards. The guidelines also contain references and contacts for obtaining further information about planning for tsunami hazards. More detailed information on each of the topics discussed in the guidelines is contained in a companion set of background papers that were compiled during the preparation of these guidelines.

The Regulatory Context

All development in coastal areas is subject to federal, state, and local policies and regulations. Understanding the regulatory context is critical to the successful implementation of a tsunami mitigation program.

State and Local Development Regulations

Every coastal community in the five Pacific states has a land use planning and regulation process that responds to state mandates or guidelines, which vary among the states:

- All five Pacific states require local land use planning, and all except Alaska have statewide planning guidelines. Alaska has statewide planning guidelines for coastal resource districts.
- Oregon and Washington require local plans to be consistent with statewide planning goals. California and Hawaii have statewide planning guidelines that are advisory only. Alaska requires a consistency review of coastal resource district plans with statewide standards and with other districts' plans.
- California, Oregon, and Washington require hazard mitigation as part of their general land use planning process. Alaska requires it for coastal resource district plans only. Hawaii only suggests that this topic be addressed.
- California, Oregon, and Washington require conformance with a state model building code based on the Uniform Building Code (UBC). Alaska only mandates adoption of a fire code, and Hawaii does not have a state-mandated building code. All of the counties in Hawaii and the larger cities in Alaska have adopted a version of the UBC.

A community's comprehensive plan is at the top of the local land use planning/regulatory process hierarchy. The comprehensive plan is implemented day-to-day through project review and permitting.

Introduction

Local governments typically require formal approvals for land divisions, the establishment of certain new uses ("conditional uses"), and the physical layout of new development.

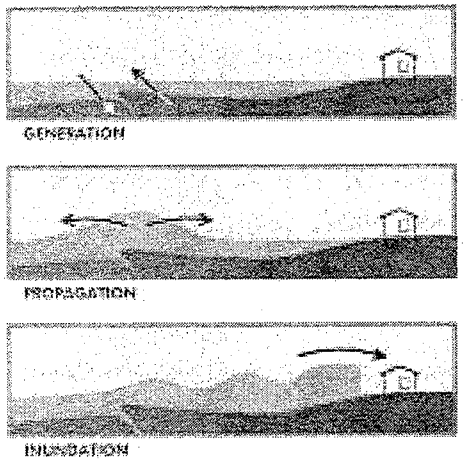
Federal Regulations and Programs

While the federal government has supported state and local planning through numerous programs over the years, there are no federal requirements for statewide or local land use planning. There are, however, two federal programs that are particularly important for land use planning in coastal areas.

The 1972 Coastal Zone Management Act (CZMA) established a voluntary partnership among the federal government, coastal states, and local governments to develop individual state programs for managing coastal resources. The state component consists of federally-approved Coastal Management Programs (CMPs) in 32 coastal states and territories, including the five Pacific states. The purpose of the CZMA is to promote the orderly development and protection of the country's coastal resources.

The National Flood Insurance Program (NFIP), established in 1968, is part of a comprehensive approach to reduce flood damage and to cope with the disastrous effect of floods. The NFIP is administered by the Federal Insurance Administration (FIA), a component of the Federal Emergency Management Agency (FEMA). The NFIP makes federally-backed flood insurance available in communities that adopt and enforce floodplain management ordinances to reduce future flood losses. NFIP requires projects to be located above the 100-year flood or inundation areas.

P•1 Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure



A tsunami is a series of long waves generated by a sudden displacement of a large volume of water.

Understanding your community's tsunami hazard, vulnerability, and exposure to damage is the foundation for land use and building strategies that can mitigate tsunami risk. While much remains to be learned about tsunamis, sufficient knowledge, technical information, and expertise already exist to assess the tsunami hazard and risk in all coastal communities.

The Nature of Tsunamis

A tsunami is a series of long waves generated by a sudden displacement of a large volume of water. Tsunamis are triggered by submarine earthquakes, submarine volcanic eruptions, underwater landslides or slumps of large volumes of earth, meteor impacts, and even onshore slope failures that fall into the ocean or a bay.

Most tsunamis originate in the Pacific "Ring of Fire," which is the most active seismic feature on earth. Tsunamis are typically classified as either local or distant. Locally-generated tsunamis have minimal warning times and may be accompanied by damage resulting from the triggering earthquake such as groundshaking, surface faulting, liquefaction, or landslides. Distant tsunamis may travel for hours before striking a coastline.

In the open ocean, a tsunami may be only a few feet high but can travel up to 500 miles per hour. As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. However, the first wave usually is not the largest. Several larger and more destructive waves often follow the first one. While tsunami waves slow upon reaching the coastline, they still travel faster than Olympic long-distance runners can run—faster than 15 miles per hour.

The configuration of the coastline, the shape of the ocean floor, and the characteristics of advancing waves play important roles in the destructiveness of the waves. A wave may be small at one point on a coast and much larger at other points. Bays, sounds, inlets, rivers, streams, offshore canyons, islands, and flood control channels may cause various effects that result in greater damage than many people

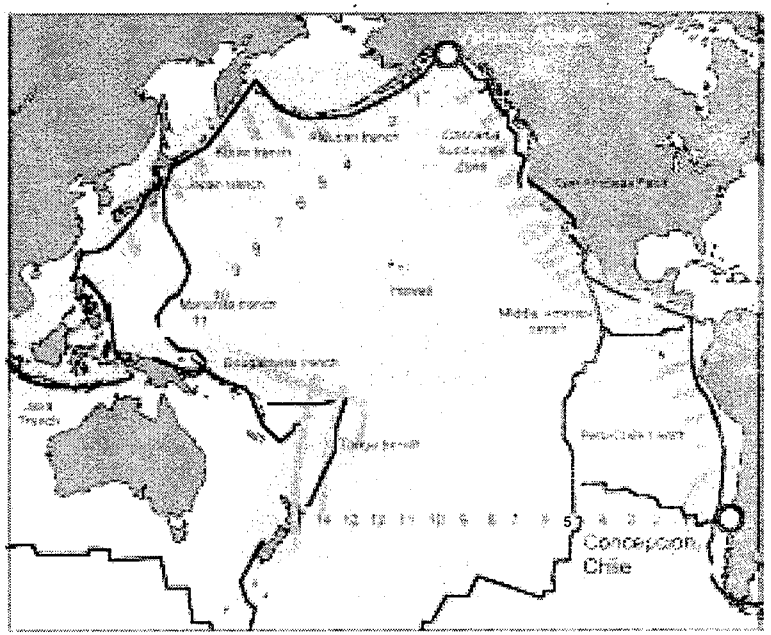
Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

would expect. It has been estimated, for example, that a tsunami wave entering a southern California flood control channel could reach a mile or more inland, especially if it enters at high tide. Offshore canyons can focus tsunami wave energy and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline.

Unlike earthquake shaking that can be damaging over large areas—hundreds of square miles is not unusual—tsunamis impact long, low-lying stretches of linear coastlines, usually extending inland for relatively short distances. Upon striking a coast, the wave reflects back to sea, and then can return to the coastline as a series of waves.

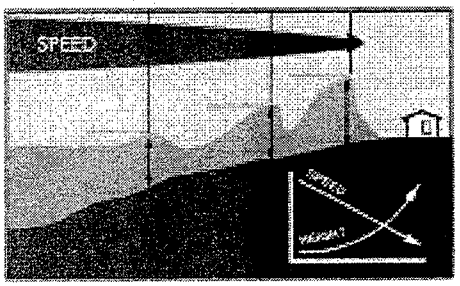
The first visible indication of an approaching tsunami may be recession of water (drawdown) caused by the trough preceding the advancing, large inbound wave crest. Rapid drawdown can create strong currents in harbor inlets and channels that can severely damage coastal structures due to erosive scour around piers and pilings. As the water's surface drops, piers can be damaged by boats or ships straining at or breaking their mooring lines. The vessels can overturn or sink due to strong currents, collisions with other objects, or impact with the harbor bottom.

Conversely, a rise in water level may be the first indication of a tsunami. The advancing tsunami may initially resemble a strong surge increasing the sea level like the rising tide, but the tsunami surge rises faster and does not stop at the shoreline. Even if the wave height appears to be small, three to six feet for example, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris. Boats and debris are often carried inland by the surge and left stranded when the water recedes.



The Pacific "Ring of Fire" is the most active seismic feature on earth. Tsunami waves triggered by seismic activity can travel across the Pacific Ocean at up to 500 miles per hour, striking distant coastal areas in a matter of hours. The figure shows the estimated number of hours for tsunami-generated waves to travel across the Pacific Ocean from Alaska and Chile, respectively.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure



As a tsunami approaches shore, it slows down and dramatically increases in height.

Outflow following inundation also creates strong currents, which rip at structures and pound them with debris, and erode beaches and coastal structures.

As tsunamis reach the shoreline, they may take the form of a fast-rising tide, a cresting wave, or a bore. The bore phenomenon resembles a step-like change in the water level that advances rapidly (from 10 to 60 miles per hour). Normal tidal bores at the Bay of Fundy, Canada, or the Yellow River, China, provide examples of this phenomenon.

The force and destructive effects of tsunamis should not be underestimated. At some locations, the advancing turbulent wave front will be the most destructive part of the wave. In other situations, the greatest damage will be caused by the outflow of water back to the sea between crests, sweeping all before it and undermining roads, buildings, bulkheads, and other structures. This outflow action can carry enormous amounts of highly damaging debris with it, resulting in further destruction. Ships and boats, unless moved away from shore, may be dashed against breakwaters, wharves, and other craft, or be washed ashore and left grounded after the withdrawal of the seawater.

The Destructiveness of Tsunamis

Though rare, tsunamis are devastating events for humankind. In recorded history, hundreds of thousands of people all over the world have died as a result of tsunamis. Some scholars believe that a tsunami resulting from the eruption of the volcano Thera destroyed the Minoan culture in the Mediterranean in 1628 B.C.

Since 1946, six destructive tsunamis have caused nearly 500 deaths and damaged hundreds of millions of dollars of property in Alaska, Hawaii, and along the U.S. West Coast.

The destructive potential of tsunamis was most dramatically illustrated by the 1960 Chile earthquake and the 1964 Alaska earthquake, two of the largest earthquakes ever measured.

The 1960 earthquake off coastal Chile devastated parts of Chile and almost instantly raised a California-sized piece of land on the ocean floor about 30 feet. Its companion series of tsunami waves resulted in further losses in many other Pacific Rim and island locations, including Hilo, Hawaii, and Japan.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Over 2,000 lives were lost, including 61 in Hawaii and 122 in Japan. The earthquake-generated tsunami waves registered on tide gauges for more than a week around the Pacific Rim.

The tsunamis generated by the 1964 Alaska earthquake also spread destruction around the Pacific Rim. In Alaska alone, waves and the effects of groundshaking and submarine landslides destroyed portions of numerous coastal communities. Whittier suffered losses to docks, oil facilities, and rail facilities with wave run-up noted at an elevation of 104 feet in a narrow passage. Kodiak suffered subsidence due to the groundshaking, followed by multiple tsunami waves that inundated the low-lying areas of town, destroying virtually all docking facilities and driving boats and other debris ashore. Valdez experienced submarine landslides triggering waves as high as 23 feet, destroying much of the town. Seward experienced 30- to 40-foot tsunamis and local submarine landslides, causing extensive damage to the docking areas and fires in petroleum storage facilities.

Exposure to Tsunamis

Coastlines have always been a favored location for human settlements. Because of the attractiveness of coastal locations and the long gaps between devastating tsunami events, coastal communities have continued to develop in recent times with new housing, maritime facilities, and resort developments. As a result, more people and facilities are threatened by the destructive force of tsunamis. According to one recent estimate, 489 cities in Alaska, California, Hawaii, Oregon, and Washington are susceptible to tsunami inundation, with an estimated 900,000 people living or working within areas that could be inundated by a 50-foot tsunami.

Understanding the Risk to Your Community

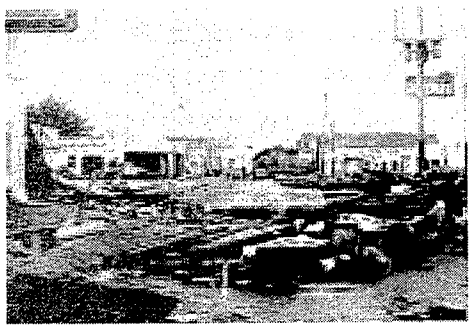
Understanding the tsunami threat is the first step in reducing potential losses. These guidelines repeatedly stress the importance of compiling and applying good local tsunami hazard information.

Potential destructiveness of tsunamis in the five Pacific states

State	Cities susceptible to tsunamis	Population endangered by a 50-foot tsunami
Alaska	53	47,000
California	152	589,500
Hawaii	123	131,000
Oregon	60	31,500
Washington	102	96,000
Total	489	895,000

Source: Tsunami Alert, v.2, no. 2, March/April, 2000. Terry Wallace, University of Arizona, Department of Geosciences

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure



Damage to Crescent City, California, from the 1964 tsunami. Nearly 900,000 people in the five Pacific states live in the inundation zone for a 50-foot tsunami. Credit: Del Norte Historical Society

Tsunami risk is a function of three factors: 1) the nature and extent of the tsunami hazard; 2) the vulnerability of facilities and people to damage; and 3) the amount of development or number of people exposed to the hazard.

There is no substitute for having a local evaluation of a community's hazard, vulnerability, and exposure. The information will help communities understand the causes and consequences of a tsunami in order to design specific loss-prevention measures and programs.

Process for Obtaining Local Tsunami Hazard Information

1) Prepare Tsunami Inundation Studies

The first step in understanding your risk is to estimate the extent and pattern of your community's potential tsunami inundation, tsunami frequency (recurrence interval), and the reliability of the estimate. In all five Pacific states, state agencies are conducting ongoing tsunami mapping programs. The methodologies used and the geographic coverage of efforts vary from state to state. Generally, the mapping programs involve some combination of computer modeling, historical research, and field confirmation. The current round of tsunami inundation mapping is designed primarily to support evacuation planning, but provides a good starting point for land use planning as well.

Because of the often simplistic assumptions that are made in a statewide study, local land use managers should conduct their own more refined assessments of tsunami inundation potential. Each level in the land use planning, site planning, and building design hierarchy requires a different level of refinement in the information concerning potential inundation and destructive effects. In many cases, it will only be possible to gather adequate information about the potential effects of local tsunamis because distant tsunamis are more difficult to model.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Tsunami studies should include:

- reviewing historic records and describing potential local and distant tsunami sources
- evaluating potential for ground failures and other geologic effects
- estimating number of waves, their heights, arrival times, and inundation depths
- calculating water velocities and debris loads
- estimating probabilities of occurrence and levels of certainty

Preparing these studies will ordinarily require the assistance of consulting specialists. Local governments may also want to create an advisory committee composed of members from nearby colleges and universities, government agencies, consulting organizations, and civic and professional organizations.

2) Prepare Tsunami Loss Scenario Studies

Knowing the extent and pattern of inundation allows communities to assess the potential damage such inundation would do to existing development and infrastructure. Scenario studies based on assumed conditions provide a graphic illustration of what can happen to a community, both during and after a destructive tsunami. These studies should also address other hazards, such as local earthquakes, that may cause concurrent damage. Local tsunamis pose unique problems for emergency planners since the facilities and infrastructure needed for evacuation may be damaged by the earthquake that triggers the tsunami.

Such scenarios typically assess potential losses to important buildings and structures, transportation systems, and utility systems. The resulting tsunami loss scenario study will provide the foundation for reducing potential losses. The most important principle is that the study be accepted as the best that could have been done within the constraints of funding, time, and knowledge. Because of the inherent limitations associated with loss studies, it will be important for all involved to reach consensus on the results. This will help ensure community and political acceptance–a key ingredient for establishing effective loss-reduction measures. However, consensus may be hard to reach in these



Wave generated by the 1946 tsunami in the Keaukaha area of Hilo, Hawaii. Credit: Pacific Tsunami Museum

studies, and differing interpretations or conclusions need to be identified and discussed.

The case study on page 14 describes an earthquake and tsunami scenario for the north coast of California, including damage probability and assessments for a variety of facilities, infrastructures, and services. The Federal Emergency Management Agency (FEMA) has developed a geographic information system (GIS)-based natural hazard loss estimation methodology, called HAZUS, that can be adapted to address tsunami hazards in scenario studies.

Release of any loss scenario study should be accompanied by briefings of key community groups and leaders, the media, elected and appointed officials, and others important to adopting and applying loss reduction measures.

Strategies for Applying Hazard Information to Reducing Future Losses

Strategy 1: Incorporate Hazard Information into Short- and Long-Term Planning Processes

One of the best ways to prevent future losses from natural hazards is to ensure the subject is addressed along with all other issues in short- and long-term comprehensive planning programs and project reviews. Some jurisdictions require that public safety considerations or specific hazards be addressed. The resulting information becomes part of the evaluation and decision-making processes. The scope of the hazard information will vary with the breadth or narrowness of the project, such as amending a growth management plan, reviewing a specific development proposal, or modifying a zoning ordinance.

The information should be used to evaluate major development proposals so that risk mitigation is factored into decisions, approvals, and permits.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Moreover, knowing that such information will be needed, owners and developers should be required to supply detailed hazards data and mitigation measures as part of their proposals. Communities should have specific administrative and review procedures to ensure the effectiveness of this process.

Strategy 2: Use Hazard Information to Build Public and Political Support for Mitigation Measures

Hazard information, loss estimates, and planning scenarios are powerful tools to create understanding and commitment to mitigation. They should be used to acquaint the populace with their exposure and vulnerability, empower them to take precautionary measures, build political consensus about acceptable risk-reducing policies and programs, and strengthen emergency preparedness and warning programs.

Moreover, hazard information, or procedures for consulting such information, should be included in other programs and processes affecting current and future development. This will ensure that risk management becomes a regular part of the decision-making processes leading to sustainable and more disaster-resistant communities.

Strategy 3: Estimate Reduced Future Losses by Evaluating the Effectiveness of Loss-Prevention Measures

One of the biggest challenges in preventing losses from natural hazards, especially for rare events such as tsunamis, is to show that mitigation measures would be effective. At the community level, the value of mitigation investments can be estimated by using scenarios and maps to evaluate actions taken to reduce vulnerability and exposure to tsunami hazards. Informed judgments can be made by quantifying the losses that likely would have occurred if such precautions had not been taken.

Strategy 4: Periodically Re-evaluate Community Vulnerability and Exposure

The tsunami hazard is unlikely to change over time, but communities are changing constantly. This dynamic process leads to changes in vulnerability and exposure. Effective long-term tsunami

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure



Damage from the 1960 tsunami in the Waiakea area of Hilo, Hawaii. Parking meters were bent by the force of the debris-filled waves. Credit: U.S. Navy

mitigation means that loss studies should be reviewed and revised periodically—at least every five years—to reflect changes in development patterns and demographics. Regular review and revision will ensure that the most current information is applied, and it could help to demonstrate the effectiveness of loss prevention.

Community vulnerability certainly should be re-evaluated following a disaster or other severe event, perhaps including comparable events in other locations around the world.

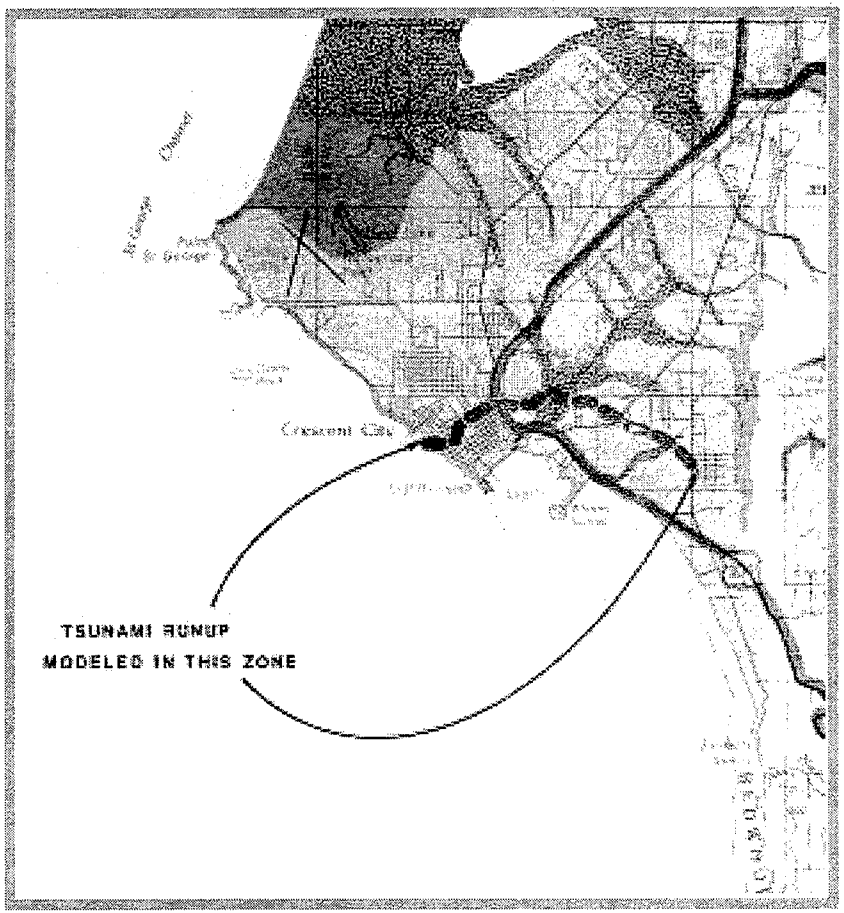
Principle 1: Case Study

Case Study: Planning Scenario for Humboldt and Del Norte Counties

In 1995, the California Division of Mines and Geology published Special Publication 115, entitled ***Planning Scenario in Humboldt and Del Norte Counties, California for a Great Earthquake on the Cascadia Subduction Zone.*** This report includes a description with supporting maps of the potential effects of a tsunami on the cities of Eureka (Humboldt County) and Crescent City (Del Norte County). This report is an example of local hazard and risk information that can be used to support mitigation efforts.

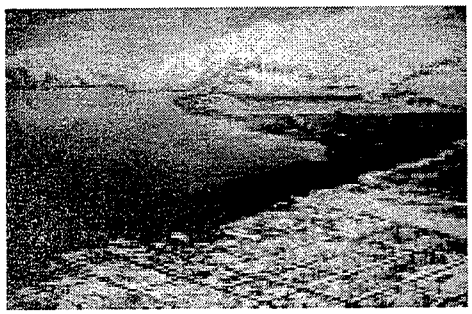
The scenario earthquake is assumed to generate a local tsunami that would arrive minutes after the earthquake. The maps depict potential structure and infrastructure damage and show locations likely to be flooded by a tsunami caused by a potential great earthquake (magnitude 8.4) occurring offshore on the Gorda segment of the Cascadia Subduction Zone.

The planning scenario includes damage probability and assessments for a variety of facilities, infrastructure, and services including: schools and colleges, hospitals, highways, airports, marine facilities, railroads, and facilities for electric power, natural gas, petroleum products, water supply, and wastewater. These assessments are intended to assist localities in planning for emergency response efforts and pre-disaster retrofitting and other risk mitigation efforts.



Excerpt from Scenario Map for Humboldt and Del Norte Counties

P•2 Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses



Aerial view of tsunami and earthquake damage to Valdez, Alaska, showing the extent of inundation along the coastline from the 1964 Great Alaska Earthquake. Coastal-dependent development can conflict with safety goals. Credit: U.S. Department of the Interior

Tsunami risk can be mitigated most effectively by avoiding or minimizing the exposure of people and property through land use planning. Development should be prevented in high-hazard areas wherever possible. Where development cannot be prevented, land use intensity, building value, and occupancy should be kept to a minimum. Where these strategies are not available and development will occur in possible tsunami inundation areas, planners and designers must look to mitigation through site planning techniques as discussed under Principle 3 or building construction techniques as discussed under Principle 4.

The Role of Land Use Planning in Reducing Tsunami Risks

Land use planning in communities guides the location, type, and intensity of development and can, therefore, be used to reduce the community's exposure to tsunami hazards. Principle 2 focuses on large-scale land use planning issues, such as those that are dealt with in comprehensive plans, zoning ordinances, and subdivision regulations. It focuses on the types, patterns, and densities of uses that could and should be allowed within potential tsunami inundation areas based on consideration of the risk. It is important to remember that the more locational mitigation (Principle 2) is used, the less design mitigation (Principles 3 and 4) is required.

Process for Implementing Land Use Planning Strategies

The following outlines the steps that can be taken when formulating a community land use strategy for tsunami risk mitigation.

1) Understand Locational Context

Opportunities for reducing tsunami risk differ depending on local circumstances, so a one-size-fits-all approach cannot be used. The presence or absence of development within tsunami hazard areas will determine the type of planning approach that is feasible. For example, vacant land conversion, such as expansion of an existing

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

community or development of a new community, will require different mitigation strategies than will other forms of development such as infill, redevelopment, reuse, or changes in occupancy (see Principle 5).

2) Understand Trade-Offs

Mitigation often means making trade-offs between or among competing goals when dealing with land use planning issues and tsunami hazards. For example, the public access emphasis in Coastal Zone Management (CZM) programs argues for locating visitor-serving development along the coastline; yet this access can be at direct odds with public safety goals for minimizing new development in tsunami inundation areas.

Coastal-dependent development such as ports and harbors that, by their nature, have to be situated on the coast can also conflict with safety goals. Other planning goals such as compact/dense downtowns can also result in increased risk.

These trade-offs need to be recognized in the planning process. The revision process for a comprehensive plan is a good time to weigh alternatives and to balance competing goals.

3) Review and Update Existing Safety Element

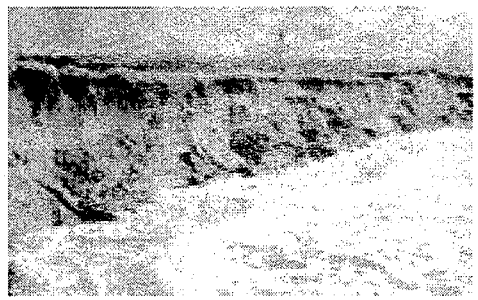
The existing safety or natural hazards element of the comprehensive plan should be reviewed to determine if it adequately recognizes tsunami hazards and how the risk is managed when decisions are made. The following information should be inventoried and updated, as necessary (see Principle 1):

- technical information such as inundation zones
- loss scenario information
- goals and policies

In addition, it should be recognized that tsunami hazards often overlap other hazards and that mitigation for other hazardous conditions can assist in mitigating tsunami risk. Such hazards might include riverine flooding, hurricanes/typhoons, landslides, coastal erosion, and earthquakes.

4) Review and Update Existing Land Use Element and Other Plans

The existing land use element, other comprehensive plan elements, and special plans should be reviewed to determine what changes are needed to address



Erosion along the Oregon coast. Mitigation for other hazardous conditions such as erosion, flooding, hurricanes, and seismic hazards can assist in mitigating tsunami risk. Credit: Oregon Department of Land Conservation and Development

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

the tsunami hazard, and be updated as necessary. Land use policies and programs should address tsunami hazards as part of a comprehensive tsunami mitigation program.

Such an update should focus on the location and vulnerability to damage of existing and planned land uses in the community, including the following:

- residential
- commercial/visitor-serving
- industrial (general)
- industrial (hazardous materials)
- public facilities (transportation and water systems)
- critical facilities and systems (communication, emergency response, electrical power, water supply, and natural gas systems)

5) Review and Update Existing Zoning, Subdivision, and Other Regulations

Existing zoning, subdivision, and other regulations should be reviewed and updated with an eye toward mitigating future tsunami losses. Requirements for consistency between the comprehensive plan and zoning and subdivision regulations vary among the states. In California, for example, the zoning code is considered part of the local coastal program (LCP) for coastal communities and is required to be consistent with the general plan.

6) Planning for Post-Tsunami Reconstruction

Disasters create the opportunity to eliminate nonconforming uses and reshape existing patterns of development to minimize future losses. On the other hand, they can also create enormous pressure to rebuild the community quickly and exactly as it was before the disaster. These rebuilding issues should be addressed through the land use planning process before a disaster strikes so that a community is prepared to deal with rebuilding issues in the event of a disaster.

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Specific Land Use Planning Strategies to Reduce Tsunami Risk

The following are specific recommended land use planning strategies that a community can use to reduce tsunami risk.

Strategy 1: Designate Tsunami Hazard Areas for Open-Space Uses

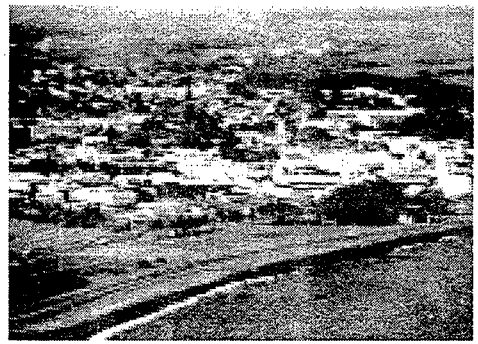
The designation and zoning of tsunami hazard areas for such open-space uses as agriculture, parks and recreation, or natural hazard areas is recommended as the first land use planning strategy to consider. This strategy is designed to keep development at a minimum in hazard areas. It is particularly effective in areas that have not yet experienced development pressure. It is obviously more difficult in areas that are already partially developed or that have strong development pressures.

Strategy 2: Acquire Tsunami Hazard Areas for Open-Space Uses

A second strategy is to acquire tsunami hazard areas for open-space uses. Open-space acquisition has several advantages over strictly regulatory approaches such as zoning. Acquisition ensures that the land will be controlled by a public agency or nonprofit entity, and it removes any question about a regulatory taking. The primary disadvantage to acquisition is cost.

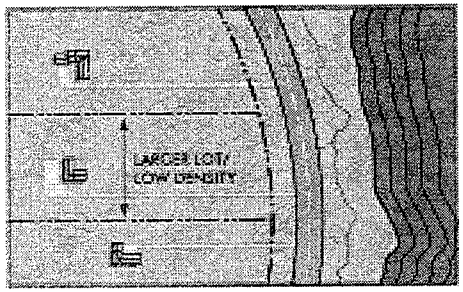
There are multiple approaches to acquisition. Since land ownership is in effect a bundle of rights, including the rights to sell, lease, and develop the property, some of these rights, such as the right to develop, can be sold separately from the rest of the property.

For example, a purchase of development rights (PDR) program is based on purchasing the right to develop land from the bundle of rights associated with the land. A PDR program involves the purchase of the development rights to a property, generally through the granting of a conservation, open-space, or scenic easement that restricts the uses to which the property owner may put the land. A PDR program can also be constructed to purchase a fee-simple interest in a property and then to resell the property with an easement restricting future

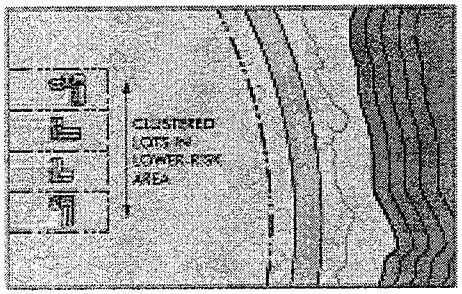


Park on the Hilo, Hawaii, waterfront. Open space uses such as parks can keep development at a minimum in hazard areas. Credit: County of Hawaii

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses



Large-lot zoning can ensure that only very low density residential uses are allowed in hazard areas.



Development can be clustered on site areas where risks are the lowest.

development. A similar result can be obtained through purchasing a fee-simple interest and then leasing the property with restrictions on use. PDR programs are more effective in preserving land from development where development pressure has not yet driven up land prices.

Strategy 3: Restrict Development through Land Use Regulations

In areas where it is not feasible to restrict land to open-space uses, other land use planning measures can be used. These include strategically controlling the type of development and uses allowed in hazard areas, and avoiding high-value and high-occupancy uses to the greatest degree possible.

For example, plan designations and zoning districts can use density restrictions or large-lot zoning (e.g., 10-acre minimum) to ensure that only very low-density residential uses are allowed in hazard areas. Another technique is to require clustering of development on site areas where risks are the lowest.

Strategy 4: Support Land Use Planning through Capital Improvement Planning and Budgeting

The capital improvement planning and budgeting process can be used to reinforce land use planning policies. A major factor in determining future development patterns is where a local jurisdiction chooses to extend sewer and water lines, roads, and other public facilities and services. Decisions can either discourage or encourage development in tsunami and other hazard areas.

Natural hazard risk mitigation should be integrated into infrastructure policy. Infrastructure policies by themselves will not preclude development in certain areas, but they can reinforce land use plans, and they can shape market forces to encourage development in less hazardous areas by not subsidizing infrastructure that serves a higher-risk hazardous area.

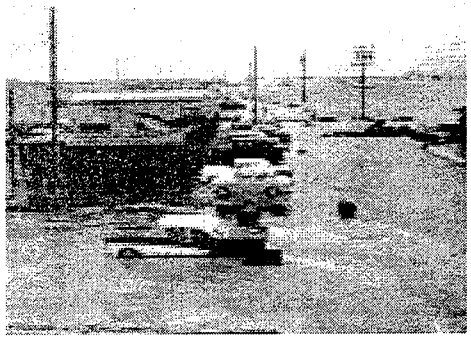
Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Strategy 5: Adapt Other Programs and Requirements

The safety element of a comprehensive plan and the zoning, subdivision, and other programs designed to implement the comprehensive plan may contain regulations that are applicable to tsunami risk mitigation even if tsunami hazards are not mentioned explicitly. Many of these programs and regulations can be adapted relatively easily to address tsunami hazards. For example, existing floodplain restrictions, hillside and landslide controls, and environmental, scenic, recreational, and wildlife-protection requirements can help address tsunami hazards and should be modified for that purpose.

P•3

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses



The waterfront area of Crescent City, California, flooded by the 1960 tsunami. Credit: USGS

When development is to be sited within a tsunami hazard area, the physical configuration of structures and uses on a site can reduce potential loss of life and property damage. This includes the strategic location of structures and open space areas, interaction of uses and landforms, design of landscaping, and the erection of barriers.

The Role of Site Planning in Reducing Tsunami Risk

Within the broader framework of a comprehensive plan, site planning determines the location, configuration, and density of development on particular sites and is, therefore, an important tool in reducing tsunami risk.

At the site planning level in the planning/regulatory hierarchy, the focus typically is on a single parcel or collection of parcels of land 2 to 200 acres in size, under the control of a single owner. This scale of planning provides limited opportunities for avoiding the tsunami hazard entirely, but can provide a broad range of opportunities to design a project to minimize tsunami damage.

Process for Implementing Site Planning Strategies

The following outlines the steps that can be taken when formulating a site planning strategy for tsunami hazard mitigation.

1) Create a Project Review Process that is Cooperative, Comprehensive, and Integrated

The most effective site planning in coastal areas includes a project review process that reflects the area's vulnerability and exposure to tsunami hazards, considers the broader policy and regulatory context, and is part of a larger mitigation strategy. An interactive and informed site planning and review process can save time for project sponsors and provide better mitigation solutions.

Communities interact with project proponents at various levels in the preparation and review of site plans. The level of review relates to the scale and context of a project. Some projects require site and concept review, while others require a review of fully developed designs. Community-level project

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

review can occur parallel to the design process in an interactive fashion. Alternatively, project site review can be more reactive based on predetermined criteria or plans.

Some communities have adopted comprehensive development policies for waterfront areas to ensure that site planning is part of a review process that implements a larger mitigation plan, economic objectives, and community design concepts. Without this broader framework, community-wide mitigation objectives can be overlooked in a site plan review process that involves different disciplines and multiple departments and decision-making bodies.

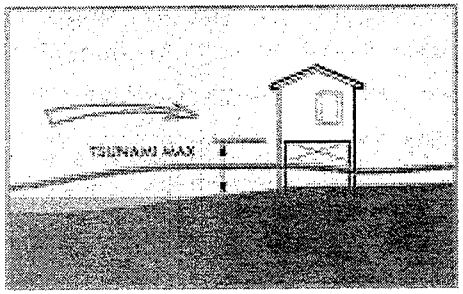
2) Understand Local Site Conditions

Local planning officials and project sponsors must develop mitigation strategies that reflect the character of the site and immediate context. This includes understanding how tsunamis impact different types of site geography, land uses and building types, and development patterns. The depth of tsunami inundation, speed of currents, presence of breaking wave or bore conditions, debris load, and warning time can vary greatly from site to site.

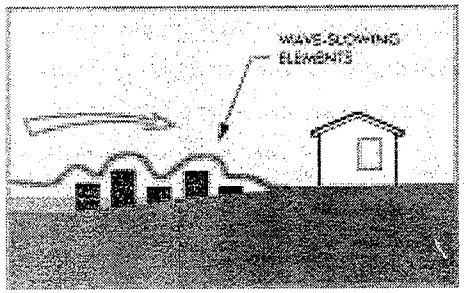
The site analysis phase can be used to establish site plan parameters for tsunami mitigation. Many communities have mapped hazard areas. Within these areas, communities may also have more detailed plans that include site analysis. The analysis typically includes geographic conditions, critical infrastructure (see Principle 6), area access and egress (see Principle 7), and existing and future development patterns. The analysis may also include economic feasibility and community design objectives.

Regional hazard maps can identify many of these at-risk areas, but typically they do not reflect the catastrophic potential of a tsunami that is accompanied by other disasters. Besides inundation, near-source earthquakes can cause damage and possibly lower the elevation of the entire region, causing flooding. Fires, broken infrastructure, liquefaction, mudslides, erosion, and other hazardous conditions can create scenarios that make communities even more vulnerable to tsunami waves. Therefore, each site assessment should identify other hazardous conditions besides elevation and shoreline configuration.

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses



Avoiding



Slowing

3) Choose a Mitigation Strategy for the Site

Many communities work with project sponsors to select a mitigation approach during the site planning process. Generally, this includes siting solutions that avoid, slow, steer, or block inundation. These can be blended with building design and engineering that provides hardened or passive ways of handling the force of a tsunami (see Principle 4).

Specific Site Planning Strategies to Reduce Tsunami Risk

There are four basic site planning techniques that can be applied to projects to reduce tsunami risk:

1) Avoid inundation areas

2) Slow water currents

3) Steer water forces

4) Block water forces

These basic strategies can be used separately or be combined into a broader strategy. The methods can be used in passive ways to allow tsunamis to pass through an area without causing major damage, or they can be used to harden structures and sites to withstand the force of a tsunami. The efficacy of these techniques depends on the intensity of the tsunami event. If the tsunami hazard is underestimated, development in the area may still be vulnerable to a larger event.

Strategy 1: Avoiding

Avoiding a tsunami hazard area is, of course, the most effective mitigation method. At the site planning level, this can include siting buildings and infrastructure on the high side of a lot or raising structures above tsunami inundation levels on piers or hardened podiums.

Strategy 2: Slowing

Slowing techniques involve creating friction that reduces the destructive power of waves. Specially designed forests, ditches, slopes, and berms can slow and strain debris from waves. To work effectively, these techniques are dependent on correctly estimating the inundation that could occur.

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

Strategy 3: Steering

Steering techniques guide the force of tsunamis away from vulnerable structures and people by strategically spacing structures, using angled walls and ditches, and using paved surfaces that create a low-friction path for water to follow.

Strategy 4: Blocking

Hardened structures such as walls, compacted terraces and berms, parking structures, and other rigid construction can block the force of waves. Blocking, however, may result in amplifying wave height in reflection or in redirecting wave energy to other areas.

Mitigation Strategies by Type of Development

The following describes various types of new development that may be exposed to tsunami damage and identifies possible mitigation strategies for these different types of development.

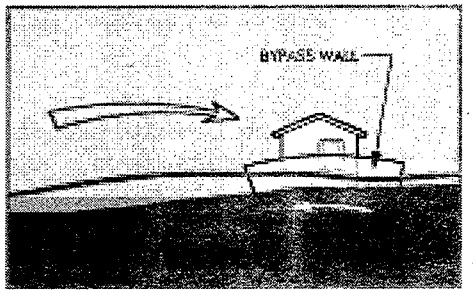
1) Infill Housing

In small communities, individual homes and infill housing are the most common forms of development. Often, there is great political pressure to allow development of smaller sites that do not permit locating development out of the hazard area. Communities can require that these smaller projects be raised above inundation levels and that engineering features be added to their design. However, they can still be vulnerable to damage from debris and other structures that may break free and collide with them. In some cases, new infill buildings can be sited on the high side of a lot to avoid being hit by another structure.

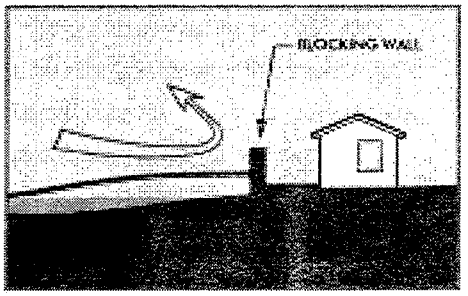
2) New Neighborhoods and Subdivisions

To reduce tsunami damage, the layout of new subdivisions in shoreline areas can include:

- providing maximum spacing between buildings
- elevating buildings above inundation levels
- placing houses behind a tsunami control forest or larger hardened buildings



Steering



Blocking

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses



Elevated restaurant in Hilo, Hawaii. Lower level is designed to allow waves to pass through. Credit: Mintier & Associates

- siting primary access roads outside inundation areas and secondary access roads perpendicular to the shore

3) High-Rise Hotels

New hotels in coastal areas are typically multi-level concrete frame structures. The lower levels of these buildings can be designed for public areas such as lobbies and support uses (such as parking) for upper level rooms. In Hawaii, for example, lower levels of hotels have been designed to allow waves to pass through the ground floor parking, lobby, and service spaces, leaving upper level rooms and meeting spaces undamaged. These buildings must be designed to withstand both tsunami and earthquake forces.

4) Resorts

Resorts can include a broad range of facilities and services, such as small-scale cottages, large hotels, tennis facilities, swimming pools, golf, and beach-related recreation. Resort planning can draw on a variety of mitigation methods, including open space and tsunami forests, elevating or locating structures above estimated inundation levels, and buffering smaller buildings with larger hotels and waterfront structures.

5) Community Commercial

The downtowns of most coastal communities are located adjacent to piers and beach areas. The primary access roads typically follow the coastline and are lined with commercial enterprises. Both of these development patterns are susceptible to damage by tsunamis. Strengthening and expanding harbor structures can help protect adjacent commercial areas. Depending on the tsunami, however, breakwaters can be swamped by the rising tide and be ineffective. New buildings can be elevated above inundation levels or hardened and designed to withstand tsunami forces.

6) Industrial

Dry docks, refineries, power plants, and other shoreline industrial facilities are of special concern. Destruction or flooding of industrial facilities can add another environmental dimension to a tsunami disaster with burning oil, toxic chemicals, and other hazardous materials. Floating buildings, debris, and

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

boats can crush pipes and tanks. Protecting industrial facilities with walls and stronger anchoring can help; however, locating these types of uses outside of inundation zones is the most effective mitigation technique.

7) Essential and Critical Facilities

Fire stations, power substations, hospitals, sewage treatment facilities, and other critical infrastructure generally should not be located in inundation zones. Relocation of these types of facilities out of inundation areas should be an integral part of any tsunami mitigation plan. Where essential service facilities such as fire stations or permanent lifeguard stations must be located in tsunami hazard areas, they should be designed or retrofitted to survive tsunami damage. This topic is discussed in more detail under Principle 6.



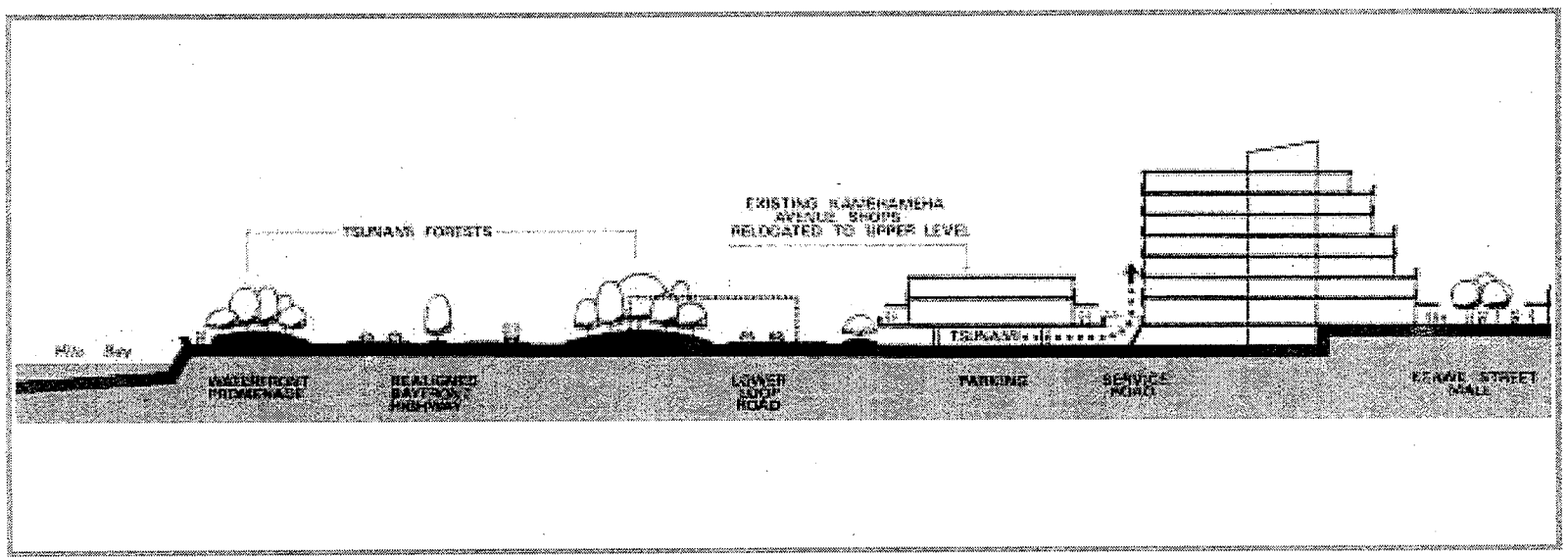
Damage to port facilities in Seward, Alaska, from the 1964 tsunami. Locating industrial facilities outside of inundation zones is the most effective mitigation technique. Credit: U.S. Army Corps of Engineers

Principle 3: Case Study

Case Study: Hilo Downtown Development Plan

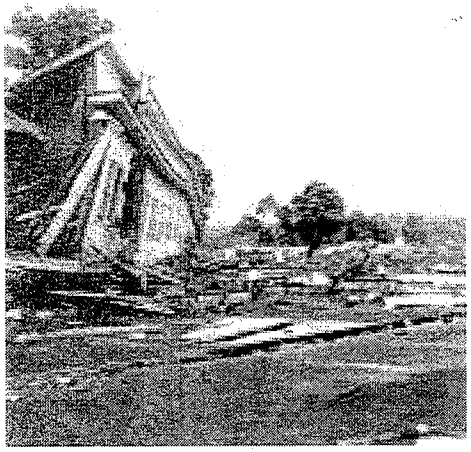
The Hilo Downtown Development Plan was adopted in 1974 to guide efforts to revitalize the downtown core of Hilo, Hawaii. The Plan established a Safety District based on the 1946 and 1960 tsunami inundation lines. All redevelopment in the Safety District was subject to urban design and building design standards. Any structure below the 20-foot elevation contour line was required to be designed to withstand the force of a major tsunami. A Parking District was also designated in the Plan to provide parking for downtown businesses and to use parking structures as a protective barrier from a tsunami for inland structures. Parking facilities have been constructed in accordance with the Plan.

In 1985, the Hilo Downtown Development Plan was superceded by the Downtown Hilo Redevelopment Plan under the authority of Chapter 27, Flood Control, of the Hawaii County Code.



A section through the lower downtown area from the *Hilo Downtown Development Plan*. Credit: County of Hawaii

P•4 Principle 4: Design and construct new buildings to minimize tsunami damage



Damage to building in Hilo, Hawaii, from the 1960 tsunami. Although there are engineering techniques and materials that can be used to resist tsunami forces and inundation, in cases of intense tsunamis, they will reduce losses but not prevent severe damage. Credit: Pacific Tsunami Museum

Where buildings are to be constructed in a tsunami hazard area, the design and construction of the buildings–including construction materials, building configuration, and tsunami-specific design features–can reduce loss of life and property damage.

The Role of Construction Design in Reducing Tsunami Risk

As discussed under Principles 2 and 3, in areas subject to tsunamis and damaging run-up, the most effective mitigation technique is to locate new buildings away from potential inundation areas. Where this is not possible, building design and construction will play a critical role in the performance of structures in the event of a tsunami.

Performance Objectives

A performance objective for a building depends upon several considerations:

- **location of the building and its configuration (size, shape, elevations, and orientation)**
- **intensity and frequency of the tsunami hazard selected for design**
- **structural and non-structural design standards**
- **choice of structural and finish materials**
- **reliability of utilities**
- **professional abilities of designers**
- **quality of construction**
- **level of confidence in these factors**

Hospitals, fire stations, and schools would be assigned higher performance objectives than those assigned to tourist accommodations.

Potential tsunami damage to buildings can be minimized during the early project design stage where performance objectives are decided, governing standards are reviewed, and the configuration of the building is chosen. These decisions govern the building's final design and its actual construction. However, while special engineering techniques and materials can be used to resist tsunami forces and inundation, in the case of an intense tsunami, they will reduce losses but not prevent severe damage.

Principle 4: Design and construct new buildings to minimize tsunami damage

Building Codes

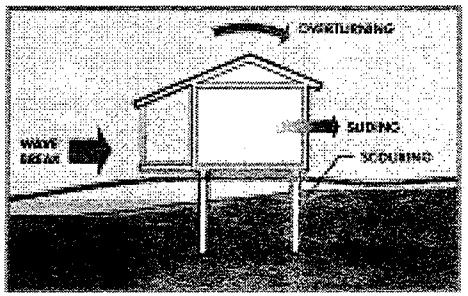
Building construction in the United States is governed at the local level by building codes. Building codes establish minimum acceptable requirements for protecting life, addressing property damage, and preserving the public health, safety, and welfare in the built environment. Building codes are applied to new construction as well as to existing buildings undergoing reconstruction, repair, rehabilitation, or alteration, or when the nature of the use is changed to a new occupancy that increases the risk or exceeds the structural capability of the building.

Process for Implementing Construction Design Strategies

1) Adopt and Enforce Appropriate Building Codes and Design Standards

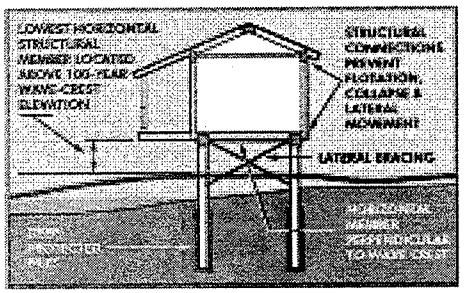
Most local building codes used in the Pacific states are based on the Uniform Building Code (UBC) prepared by the International Conference of Building Officials (ICBO). In California, Oregon, and Washington, the state governments mandate code adoption and enforcement at the local level. Alaska only mandates adoption of a fire code, and Hawaii does not mandate the use of a model code, leaving the option to county governments. All the counties in Hawaii and the larger cities in Alaska have adopted a version of the UBC. The states mandating the use of the UBC allow local government amendments that are more stringent than the mandated code provisions.

The UBC includes design requirements and standards for fire, wind, floods, and earthquakes, but it does not contain requirements for tsunami-resistant design. While a few communities have adopted tsunami-resistant building design standards, the vast majority of coastal communities have not. The City and County of Honolulu has adopted special requirements for floods and tsunamis as part of its Revised Ordinances. With appropriate modifications to reflect local conditions, these could serve as a general model for other states and municipalities. Guidance for architects and engineers in the design for tsunami forces is included in FEMA's *Coastal Construction Manual*, also known as FEMA 55. The manual deals with tsunamis in a manner similar to the Honolulu ordinance but uses more current information.



Forces on structures created by tsunamis

Principle 4: Design and construct new buildings to minimize tsunami damage



Design solutions to tsunami effects

2) Ensure That Codes and Standards Address the Full Range of Potential Hazards

While these guidelines emphasize tsunami loss prevention, other hazards such as earthquake groundshaking should, of course, also be addressed in the design of new buildings. Landslides, liquefaction, and other ground failures are potential problems in many coastal areas, as are seasonal floods where rivers and streams enter the ocean. Loss-prevention measures have already been adopted for most of these hazards, and it is important to recognize them in the effort to minimize direct tsunami losses.

3) Apply Locally Valid Tsunami Hazard Information

Where a tsunami hazard study has been prepared to inform local design decisions, the information can be used to decide whether to permit construction at a given site. If construction is to be permitted, the building design must address tsunami-related forces, including water pressure, buoyancy, currents and waves, debris impact, scour, and fire. The analyses will vary depending on location, building size, and type of construction, such as reinforced concrete, wood, light metal, and others.

4) Select the Intensity of Design Events

It is essential in the local hazard study to estimate tsunami intensity for various return intervals. Small tsunamis are less damaging, but they may be more frequent than occasional greater events. Smaller tsunamis might serve as the basis for designing most buildings. However, the rarer large events with higher water levels and stronger forces should be the basis for designing critical facilities, such as hospitals, fire stations, and refineries.

5) Define the Building's Performance Level

Performance levels describe expectations of owners, occupants, and regulators relative to the amount of damage a building could sustain from a tsunami and the building's ability following a tsunami event to support the uses for which it was intended. The design of a building to achieve a particular performance level involves a set of decisions that begins with determining the importance of the building and understanding the consequences of damage to the building.

Principle 4: Design and construct new buildings to minimize tsunami damage

There are four performance levels that can be considered for buildings: minimum, safety, reoccupancy, and operational levels.

Buildings located, designed, and constructed to the *minimum level* should withstand water forces without being moved off their foundations or sites, but they could still be damaged by debris, flooding, ground failures, or other effects.

Buildings constructed to perform at a *safety level* should withstand water forces, debris and wave-break impacts, earthquake shaking, ground failure, and fire without significant structural damage. People in taller buildings would be able to evacuate vertically above the level of wave action resulting from a locally-generated tsunami.

Buildings constructed to a *reoccupancy level* should meet the safety level of performance, but additional precautions should be taken so they can be reoccupied within a few days to weeks after cleanup, minor repairs, and the restoration of utilities. This level requires the careful choice of the building location and the use of flood-resistant materials.

Finally, the most demanding requirements are used to design buildings to meet the *operational level* of performance. These buildings should be capable of resisting all expected forces and hazards. They must also have backup emergency systems and utilities so they can be used immediately following a tsunami.

Specific Design and Construction Strategies to Reduce Tsunami Risk

Strategy 1: Choose Appropriate Design Solutions Based on Expected Tsunami Effects

Design and construction of new buildings should address forces associated with water pressure, buoyancy, currents and waves, debris impact, scour, and fire.

Substantially constructed buildings of concrete, masonry, and heavy steel frames are likely to perform fairly well in a tsunami unless compromised by earthquake shaking. Wood-frame buildings,



Damage to buildings in Hilo, Hawaii, from the 1946 tsunami. Credit: Pacific Tsunami Museum

Principle 4: Design and construct new buildings to minimize tsunami damage

manufactured housing, and light steel-frame structures at lower elevations close to the shoreline are likely to fare poorly in a tsunami. Not every area affected by tsunami run-up, however, will experience damaging forces. Buildings in less hazardous areas affected by shallow run-up water depths should survive with repairable damage if they are designed and constructed well. The force of currents and breaking waves, fast-moving waterborne debris, and scouring currents may exceed the resisting capabilities of most buildings unless the buildings are constructed with specific design elements and materials.

The table on page 35 lists the possible effects of tsunamis on structures (such as flooding, water pressures and forces, buoyancy, debris impacts, foundation scouring) and suggests possible design solutions for each of the potential effects (such as elevating and anchoring buildings; designing for water forces, pressures, and impact loads; and using deep piles or piers). As noted above, it is important that the design measures be based on the local hazard study so that expected forces determine the design solutions.

Strategy 2: Require Qualified Architects and Engineers to Design Large Buildings

Building design is governed by engineering principles and practices and by building codes that establish minimum standards relating to public health and safety; however, codes are no substitute for competent engineering, design, construction, and quality assurance.

Specialized expertise is often needed when designing and constructing large, complex, or unusually shaped buildings. Communities should identify proposed projects that require specially qualified and licensed professionals, see that the owning/developing organizations secure such assistance early in the project planning phase, and help locate sources of qualified assistance. Professional associations can help local officials find needed experts such as architects and geotechnical, coastal, and structural engineers who are familiar with coastal design and construction issues.

Some jurisdictions require that such professionals be involved in building design and be identified on the

building's plans and specifications. The use of such experts is especially important when codes and standards are absent or inadequate, or when the proposed building is intended to exceed the minimum life safety standards contained in commonly used codes and standards.

Strategy 3: Inspect Construction to Assure Requirements are Met

Construction inspection is important to ensure that buildings are constructed according to the appropriate standards. Independent inspections can be provided in several ways: 1) use of qualified permitting agency staff; 2) use of independent technical experts retained by the governing jurisdiction; or 3) requiring the owner to use such experts whose reports would be provided to the governing jurisdiction for review and acceptance. In some areas, licensed construction inspectors and consulting engineers provide these services.

Principle 4: Design and construct new buildings to minimize tsunami damage

Tsunami effects and design solutions

Phenomenon	Effect	Design Solution
Inundation	• Flooded basements	• Choose sites at higher elevations
	• Flooding of lower floors	• Raise the building above the flood elevation
	• Fouling of mechanical, electrical and communication systems and equipment	• Do not store or install vital material and equipment on floors or basements lying below tsunami inundation levels • Protect hazardous material storage facilities that must remain in tsunami hazard areas
	• Damage to building materials, furnishings and contents (supplies, inventories, personal property)	• Locate mechanical systems and equipment at higher locations in the building • Use concrete and steel for portions of the building subject to inundation
	• Contamination of affected area with wastewater pollutants	• Evaluate bearing capacity of soil in a saturated condition
	• Hydrostatic forces (pressure on walls caused by variations in water depth on opposite sides)	• Elevate buildings above flood level • Anchor buildings to foundations • Provide adequate openings to allow water to reach equal heights inside and outside of buildings • Design for static water pressure on walls
	• Buoyancy (flotation or uplift forces caused by buoyancy)	• Elevate buildings • Anchor buildings to foundations
	• Saturation of soil causing slope instability and/or loss of bearing capacity	• Evaluate bearing capacity and shear strength of soils that support building foundations and embankment slopes under conditions of saturation • Avoid slopes or provide setback from slopes that may be destabilized when inundated
Currents	• Hydrodynamic forces (pushing forces caused by the leading edge of the wave on the building and the drag caused by flow around the building and overturning forces that result)	• Elevate buildings • Design for dynamic water forces on walls and building elements • Anchor building to foundations
	• Debris impact	• Elevate buildings • Design for impact loads
	• Scour	• Use deep piles or piers • Protect against scour around foundations
Waves (break and bore)	• Hydrodynamic forces	• Design for breaking wave forces
	• Debris impact	• Elevate buildings • Design for impact loads
	• Scour	• Design for scour and erosion of the soil around foundations and piles
Drawdown	• Embankment instability	• Design waterfront walls and bulkheads to resist saturated soils without water in front • Provide adequate drainage
	• Scour	• Design for scour and erosion of the soil around foundations and piles
Fire	• Hazardous flammable materials and ignition sources in buildings	• Use fire-resistant materials • Locate flammable material storage outside of high-hazard areas

P•5 Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects



Astoria, Oregon, at the mouth of the Columbia River. Many of the tsunami risk mitigation techniques used for new development can be applied to existing development, but their application will be limited by site constraints and building conditions. Credit: Army Corps of Engineers

The challenges in protecting existing development from tsunami losses are many and complex. For coastal communities that are nearly built out, protecting existing development may be the only real mitigation option available. However, land uses, buildings, and infrastructure change over time, creating opportunities to incorporate tsunami (and other hazard) loss-prevention measures to help make communities less vulnerable in the future.

The Role of Renewal in Reducing Tsunami Risk

Efforts to renew communities can take many forms, including redefining permitted land uses, changing zoning standards, changing building uses and occupancies, retrofitting and rehabilitating buildings, and redeveloping districts to improve their economic vitality. There may also be special considerations in tsunami-vulnerable areas such as protecting landmarks and historic structures, creating scenic vistas, providing improved access to coastal amenities, improving services, and accommodating needed housing and commercial activities.

While many tsunami mitigation techniques used in new development can be applied to existing development, their application will be limited by site constraints and building conditions.

The reconstruction process following a disaster provides an opportunity to create or modify land uses, implement redevelopment plans, rehabilitate buildings, and vacate high-hazard lands subject to repetitive losses–all with the intent of reducing future losses.

Process for Reducing Vulnerability Through Renewal Efforts

1) Inventory At-Risk Areas and Properties

If not already available, an inventory should be completed of buildings, critical facilities, and infrastructure elements in the potential tsunami inundation area (see Principle 1 for a more detailed discussion of this topic). More than a simple tally, this inventory should take into account the type of structure, its age, size and configuration, construction material, and use.

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

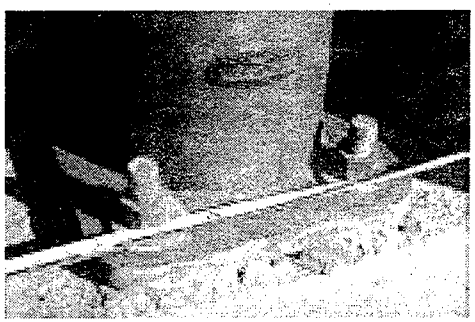
For risk-mitigation purposes, it is important to assess the condition of buildings and their construction characteristics. Significant deterioration may demand replacement, but retrofit and rehabilitation may be appropriate in other cases.

Some buildings are complex, having been modified or expanded over time. It is rare that adequate drawings of older buildings are available. This usually means that an engineering study is needed to determine the actual characteristics of the building before project-specific rehabilitation or retrofit plans can be made.

2) Evaluate and Revise Plans and Regulations to Address Redevelopment, Retrofit, and Reuse Issues

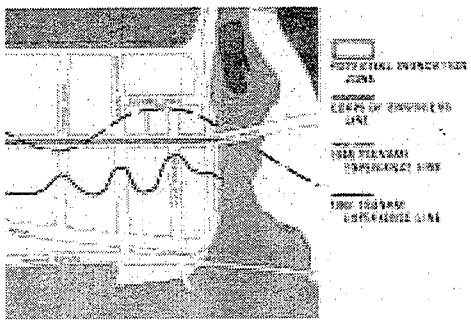
Periodically, communities perform an in-depth review and revision of their land use, comprehensive, and growth management plans. The periodic plan updates provide a broad context within which redevelopment and renewal policies and plans can be developed.

Building codes primarily address new construction; generally, they do not address renovations and retrofitting comprehensively or in detail. Local building codes should be amended to fully address risk mitigation in the context of building renovation. As a starting point, there are several examples of code amendments concerning retrofitting buildings for earthquake hazards that can be adapted for tsunami hazards. The Federal Emergency Management Agency (FEMA) sponsored the preparation of a multiple-volume guide on rehabilitating buildings to resist earthquake forces. Several states and communities have also adopted laws and ordinances governing the retrofitting and rehabilitation of existing buildings to reduce future losses from earthquakes.



Anchor bolts. Measures to resist earthquake shaking, such as anchoring and bracing buildings, can also help to reduce tsunami damages. Credit: Northridge Collection, Earthquake Engineering Research Center, University of California, Berkeley

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects



An excerpt from the tsunami inundation map in the *Hilo Downtown Development Plan*. Credit: County of Hawaii

Specific Renewal Strategies to Reduce Tsunami Risk

Strategy 1: Adopt Special Programs and Development Regulations

There is a variety of specific development regulations and programs that local communities can implement to minimize tsunami risk, including:

- redesignating and rezoning land in tsunami hazard areas for uses more consistent with the risk as non-conforming uses are phased out
- limiting additions to existing buildings in tsunami hazard areas
- buying specific properties in tsunami hazard areas and removing or relocating buildings

Strategy 2: Use Redevelopment Strategies to Reduce Tsunami Risk

Redevelopment land acquisition and financing powers can be used on a district-wide scale to reconfigure uses or infrastructure, retrofit specific buildings, or remove buildings altogether in tsunami hazard areas.

Strategy 3: Use Incentives and Other Financial Measures to Support Loss Prevention

One key to the success of redevelopment and other renewal measures is helping building owners bear the cost of the proposed changes. There are many commonly used incentives that help spur renewal, such as reduced property taxes, waiving of permit and inspection fees, and low interest loans. Local officials should ensure that whatever incentives are used include risk mitigation as an eligible purpose.

Strategy 4: Adopt and Enforce Special Provisions for the Retrofit of Existing Buildings

Retrofit of existing buildings should be encouraged when the effort will improve tsunami resistance to a level capable of meeting identified performance objectives, or to minimize floating debris that can damage nearby buildings. Retrofitting may be required for all buildings within a hazard zone, or may be mandated only when substantial modifications are made to existing structures or when there are changes in building occupancy.

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

The complexities associated with strengthening existing structures may require the development, adoption, and implementation of special codes, standards, and procedures. Moreover, special purpose requirements may exist, such as codes governing the rehabilitation of historic buildings, that may or may not contain provisions for protecting against hazards. Flexibility may be needed to ensure that effective mitigation techniques can be applied to such properties without seriously disrupting their original characteristics.

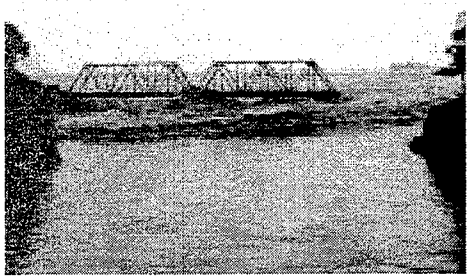
The standards for upgrading buildings involve the same factors as constructing new buildings; however, upgrading to achieve a selected performance objective is more expensive to implement after initial construction is completed. Dealing with the vulnerability of existing buildings is difficult because of the limited number of alternatives and cost of remedial measures that will withstand hydrodynamic and impact loads.

Measures that improve resistance to tsunamis in combination with other more frequently occurring hazards are more likely to be feasible. These include elevating buildings above the base flood elevation, improving foundations to resist scour and erosion, and anchoring and bracing the buildings to resist earthquake shaking. Although these measures can reduce tsunami damage, especially in the statistically more-frequent small tsunamis, they will not ensure that a building is able to withstand the intense forces associated with larger events.

Strategy 5: Require Qualified Architects and Engineers to Design Effective Measures to Protect Existing Development

As discussed under Principle 4, specialized expertise should be used to help design measures to reduce future losses. Such expertise is important when considering measures to strengthen existing development because of the complexities associated with such projects and the greater reliance placed on experience and judgment. Design professionals and engineers who specialize in rehabilitation and retrofit practices can be located through professional associations and contacts with local practitioners.

P•6 Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage



Bore advancing through the railroad bridge at the Wailuku River in Hilo, Hawaii, during the 1946 tsunami. Credit: Pacific Tsunami Museum

Certain facilities in a community deserve special attention in the planning and design process to minimize damage to them. Infrastructure such as transportation systems for people and goods, and utility systems such as communications, natural gas, water supply, power generation, and transmission/distribution systems are essential to the continued operation of a community and need to be functional—or easily and rapidly repairable—following a disaster.

Other facilities in the community are considered critical because of their occupants or the functions they contain. These include: 1) essential service facilities such as fire stations; 2) hazardous facilities such as chemical plants or fuel storage tanks; and 3) special occupancy structures with uses such as government functions important to sustaining a community, buildings with large numbers of occupants, or buildings such as convalescent homes with occupants who cannot evacuate the premises readily.

The Role of Infrastructure and Critical Facility Location and Design in Reducing Tsunami Risk

Infrastructure and critical facilities are often located on the coast within tsunami hazard areas. In some cases, such as fire stations, the facilities may need to be located in tsunami hazard areas; in other cases, they could just as easily be located outside the tsunami hazard area.

Because of the services these facilities provide—or the harm they could cause—to the community, their performance during natural hazard events is a community-wide concern that needs to be considered as part of a tsunami risk management effort.

Process for Implementing Infrastructure and Critical Facility Location and Design Strategies

1) Understand Tsunami Mitigation Responsibilities

Managing the tsunami risk is a responsibility shared by the government and private sectors. Depending

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

on the community, infrastructure systems and critical facilities may be owned and managed by local or state agencies, special districts, private companies, nonprofit organizations, federal departments and agencies, joint powers authorities, or others. Mitigation programs need to involve all participants in the planning process.

2) Understand and Describe the Nature and Extent of the Tsunami Hazards for Infrastructure and Critical Facilities

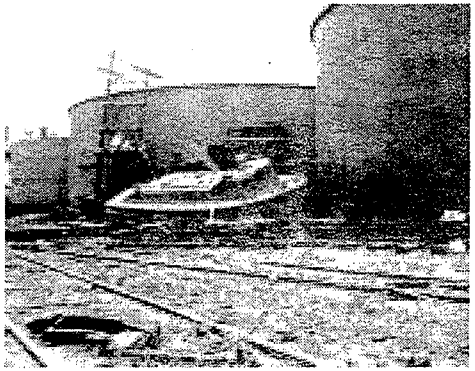
Principle 1 provides background information on local tsunami risk studies and hazard scenarios. In such studies, it is important to include information about infrastructure and critical facilities and to identify who is responsible for their location, design, construction, operation, and maintenance. This work includes the following:

- Define the tsunami hazard (see Principle 1) and describe it by intensity (expected effects) and probability of occurrence.
- Inventory and gather data about infrastructure elements and critical facilities in the potential damage area and describe why their functions make tsunami resistance an important issue for the community and what makes each facility vulnerable to damage from tsunami forces.
- Identify the responsible organizations and include their representatives in the mitigation process.

3) Adopt Comprehensive Risk Management Policies

Communities should adopt policies to manage the tsunami risk and integrate them into coastal management programs, land use plans, floodplain zoning, capital outlay plans, building regulation programs, and other procedures used to control the use and safety of facilities near the shoreline.

Essential service facilities should be operational following a hazard event. This concept already is contained in the Uniform Building Code (UBC) and could be adapted for tsunami hazards. The UBC requires the use of enhanced seismic and wind forces for design, and enhanced structural inspection during construction of essential service facilities. To ensure stronger structures, the UBC uses



A boat washed up over 400 feet onshore from the wharf by the 1946 tsunami in Hilo, Hawaii. Credit: Pacific Tsunami Museum

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Examples of infrastructure and critical facilities

INFRASTRUCTURE

Transportation Systems

- Roads, highways, bridges, parking lots and structures, and traffic control systems
- Railroads track beds, bridges, and rail and switching yards for freight and passengers
- Transit systems (rail, trolley, tram, and motor coach), storage and maintenance facilities, power systems and substations, control systems, bridges, tunnels, and tubes
- Airports and control towers
- Maritime ports, and maritime traffic control systems, marine terminals, loading/unloading facilities, storage facilities (including tank farms), docks, and ship moorings, piers, seawalls, and bulkheads

Utility Systems

- Electrical generation, transmission, substations, and distribution systems
- Natural gas production, processing, storage, transmission, pump, and distribution systems
- Land line communication systems: switching stations, trunk lines, and data lines

(cont.)

an "importance factor" to increase the force levels by 15 to 50 percent over those calculated for other occupancy categories.

4) Adopt a Comprehensive Infrastructure and Critical Facility Plan

Communities should revise or adopt measures that deal with existing and new infrastructure, critical facilities, and waterfront-dependent uses in relation to tsunami hazards. These comprehensive infrastructure and critical facility plans should define performance objectives for the various types of existing and planned facilities in the community. Strategies should include relocating or, if possible, strengthening existing infrastructure and critical facilities against tsunami forces. They should also include providing redundant facilities and emergency response measures to lessen the impact of losing infrastructure and critical facilities that remain at risk.

Proposals for new critical facilities and infrastructure located in tsunami hazard areas should be considered carefully to determine whether the performance expected is acceptable once feasible design measures are implemented. Proposals for new infrastructure should be evaluated in terms of the increased risk because of induced growth. For example, construction of new buildings and facilities may be facilitated by the provision of new water or wastewater collection services in the hazard area.

Existing infrastructure and critical facilities are particularly problematic. It is difficult and expensive to improve the tsunami performance of existing facilities and infrastructure, and relocation is usually impractical, especially in the short term. However, understanding the risk to these existing facilities and anticipating the consequences of tsunami events can lead to long-term risk-reducing strategies (see Principle 5 for a more detailed discussion of issues related to existing buildings).

Because of the varied nature and differing importance of infrastructure systems and critical facilities, an effort must be made to rank their relative importance to the community and to establish

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

performance objectives to help guide mitigation actions. This work includes the following:

- Determine appropriate performance levels (i.e., acceptable damage condition for a given tsunami intensity and probability). See Principle 4 for a discussion of performance levels.
- Determine how each existing system and facility has addressed tsunami and earthquake mitigation plus any important site hazards, such as potential landslides or soil failures.
- Establish a scale of relative importance to help focus mitigation efforts (e.g., preventing losses of the potable water systems may be more important than preventing losses of the wastewater system).
- Set acceptable outage intervals for each element (e.g., the community hospital must be minimally functional within one hour of the event, but a major street could be bypassed for two weeks).
- For new infrastructure and critical facilities, determine appropriate performance levels and whether their use is dependent on a waterfront location.
- For existing infrastructure and critical facilities, determine which mitigation options or combination of options can reduce the risk and whether the remaining risk would be acceptable.

Specific Infrastructure and Critical Facility Location and Design Strategies to Reduce Tsunami Risk

Strategy 1: Locate New Infrastructure and Critical Facilities Outside the Tsunami Hazard Area or Design to Resist Tsunami Forces

- Examine plans for infrastructure and critical facilities to see if other, equally efficient alternative locations, alignments, and routes can be used. Most critical facilities need not be located in a tsunami hazard area to serve their intended purpose. Some essential facilities may need to be located in a tsunami hazard area because alternative locations will not serve the day-to-day needs of the community.
- Reserve sites for infrastructure and critical facilities either outside the tsunami hazard area or in areas where the risk can be reduced through feasible measures.
- Prohibit new critical facilities in tsunami hazard areas unless: 1) they are waterfront dependent and the design can mitigate the vulnerability to such an extent that the resulting facility will perform as needed; 2) risk is reduced through

Examples of infrastructure and critical facilities (cont.)

- Cellular systems, switching stations, antenna, and towers
- Cable systems for television, radio, and data
- Satellite systems for television and data
- Potable water systems: wells, water supply sources, storage, pumps, and treatment and distribution systems
- Sewerage collection, mains, pumps, treatment facilities, and outfalls
- Pipelines that transport oil, fuels, and other petroleum products
- Storm water runoff facilities, drainage, and pipelines

CRITICAL FACILITIES

Essential Services

- Police stations
- Firehouses
- Hospitals with surgery, acute care, or emergency rooms
- Emergency operations and communications facilities and equipment
- Garages and shelters for emergency vehicles and aircraft

(cont.)

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Examples of infrastructure and critical facilities (cont.)

- Standby power-generating equipment for essential services
- Tanks or other structures containing water or other fire-suppression material or equipment required to protect essential, hazardous, or special occupancy facilities
- Permanent lifeguard stations

Special Occupancy Structures

- Schools
- Universities and colleges
- Residential treatment centers and nursing and convalescent homes
- Retirement communities
- Large-occupancy structures
- Power-generating stations and other utility facilities needed for continuous operations

Hazardous Facilities

- Fuel docks and storage
- Spent nuclear fuel storage
- Chemical storage facilities
- Rail tank cars and trucks with chemicals
- Munitions storage, loading docks, and harbors

mitigation and emergency planning measures; or 3) the need for the facility outweighs the consequences of its loss during a tsunami (e.g., a small hospital in a remote, tsunami-prone area may be justified because it needs to be close to the population for routine emergencies).

- Prohibit infrastructure improvements that will encourage construction of other facilities that cannot withstand the tsunami hazard.
- Consider the impact of new infrastructure on hazard intensity and distribution. For example, does it change drainage patterns, increase exposure to inundation, or channel currents in a way that will increase the hazard?
- Provide redundant facilities and infrastructure outside tsunami hazard areas where elements and facilities must serve high-hazard areas.
- Employ design professionals qualified in coastal, structural, and geotechnical engineering on infrastructure and critical facility projects in high-hazard areas. Communities should identify proposed projects that should involve specially qualified and licensed professionals, see that the owning organizations secure the specialized assistance as early as possible in the project planning, and locate both local and distant sources of qualified assistance that can be contacted when needed.
- Where it is impractical to locate infrastructure and critical facilities outside tsunami hazard areas, ensure that adequate mechanisms exist to isolate the damaged area, such as shutoff valves, detours, and others.

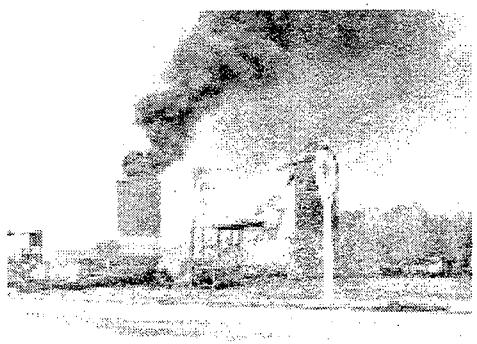
Strategy 2: Protect or Relocate Existing Infrastructure and Critical Facilities

- Do not allow expansion or renovation of existing facilities in tsunami hazard areas without requiring measures to reduce the risk.
- Construct barriers (reinforced walls and columns) to protect against impact forces and scour.
- Elevate existing facilities above the inundation elevation.
- Relocate portions of at-risk facilities.
- Take advantage of the eventual obsolescence of existing infrastructure and critical facilities as an opportunity to phase out the facility, relocate the facility, or incorporate design standards that will allow for acceptable performance following a tsunami.

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Strategy 3: Plan for Emergencies and Recovery

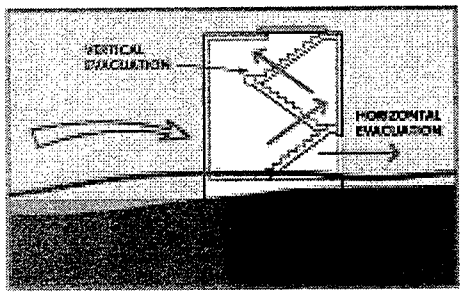
- Prepare emergency plans to cope with the emergency situation and expedite recovery.
- When waterfront-dependent infrastructure and critical facilities cannot be newly designed or retrofitted to withstand tsunami forces, they should be considered expendable and planning should be undertaken for evacuation, emergency response, recovery, and replacement facilities. It is important to remember that in a tsunami an expendable building may turn into debris that can batter people and non-expendable structures.



Petroleum tank on fire due to damage from the 1964 tsunami on Highway 101 near Crescent City, California. Credit: Del Norte Historical Society

P•7

Principle 7: Plan for evacuation



Vertical and horizontal evacuation

The primary strategy for saving lives immediately before tsunami waves arrive is to evacuate people from the hazard zone. Two methods are generally available:

- horizontal evacuation—moving people to more distant locations or higher ground
- vertical evacuation—moving people to higher floors in buildings

Horizontal evacuation and other emergency response measures are outside the scope of these guidelines and have been addressed in other publications (see Resources and Bibliography at the end of the guidelines). Vertical evacuation, however, is addressed in these guidelines since it is linked to issues of land use, siting, and building design and construction.

The Role of Vertical Evacuation in Reducing Tsunami Losses

Evacuating people can save lives and reduce injuries, but it will have little, if any, effect on reducing property and economic losses. In coastal areas where building and population densities are high, where roads, bridges, and other horizontal evacuation methods are limited, or where warning time may be insufficient, vertical evacuation may be needed as an alternative or supplement to horizontal evacuation. Land use planning, site planning, and building design discussed in the previous principles play an important role in a community's ability to rely, at least partially, on vertical evacuation to protect people.

Process for Implementing a Vertical Evacuation Strategy

1) Inventory Existing Buildings

The building stock for vertical evacuation varies greatly across communities. Thus, it is critical that a community inventory and assess buildings that could serve as vertical evacuation shelters. This may be difficult because important information about existing buildings, such as drawings and calculations, may not be available. Professional engineers play a key role in evaluating the capacity of structures to

Principle 7: Plan for evacuation

resist expected forces, and their reports often lead to rehabilitation and retrofit work designed to strengthen the buildings. This topic is discussed in more detail under Principle 5.

2) Ensure Adequate Standards Apply to New Buildings

New buildings to be designated as vertical evacuation shelters must have sufficient structural integrity to resist expected tsunami forces and earthquake groundshaking for tsunamis originating locally. Building codes and other applicable standards should ensure the tsunami and earthquake resistance of new buildings. These standards should go beyond the minimum life safety requirement of most locally-adopted codes.

Communities and building owners should also secure the assistance of qualified professionals in the fields of geotechnical, coastal, and structural engineering. Further information about building siting and design can be found under Principles 3, 4, 5, and 6.

3) Designate Emergency Services Personnel to Lead the Program

Vertical evacuation, while dependent on structures for its success, is primarily an emergency preparedness and response measure. It is important, therefore, that those community officials responsible for planning and managing emergency programs and operations take lead responsibility for vertical evacuation planning. In addition, it is extremely important to involve building owners and tenants in the process of establishing a vertical evacuation program.

4) Resolve Related Issues

There are several other issues that are important to vertical evacuation. These vary among communities and states, but include emergency preparedness requirements, standards of care for evacuees, access to designated shelters, and liability of public agencies and building owners.

Principle 7: Plan for evacuation



Tsunami evacuation route sign in Crescent City, California. Credit: FEMA

Specific Vertical Evacuation Plan Strategies to Reduce Tsunami Exposure for People

Strategy 1: Identify Specific Buildings to Serve as Vertical Shelters

Some existing buildings can serve as vertical shelters and newer ones can be located, designed, and constructed with that use in mind. Local building officials and consulting engineers can help inventory the community's stock of candidate buildings, evaluate the buildings' tsunami- and earthquake-resistant capabilities, and establish criteria and standards for rehabilitation or new construction that meet the expected hazard forces so the buildings will be able to serve as shelters.

Factors to be considered in determining a building's suitability include size, number of stories, access, contents, and available services. Only those buildings judged able to withstand the potential tsunami and earthquake forces and that meet other occupancy criteria should be designated as shelters. For example, if expected tsunami wave heights will not exceed one story (about 10 feet), then open-floor designs can be used to allow the waves to pass through with minimal impact on the building. Further information about evaluating the tsunami resistance of existing buildings is discussed under Principle 5.

Strategy 2: Work Out Agreements and Procedures with Building Owners

To a large extent, vertical evacuation shelters will be designated in privately owned buildings. For a program to be effective, therefore, appropriate agreements should be negotiated with the owners, and the owners or their representatives should be involved in the creation and maintenance of the program. While they will vary among communities and states, issues related to notification, standards of care, compensation, duration of occupancy, security, and liability will be important to the owners.

Strategy 3: Ensure Procedures Exist to Receive and Disseminate Warnings

It is very important that tsunami-vulnerable communities have adequate procedures and systems for notification by official warnings so appropriate actions can be taken, sometimes many hours in

Principle 7: Plan for evacuation

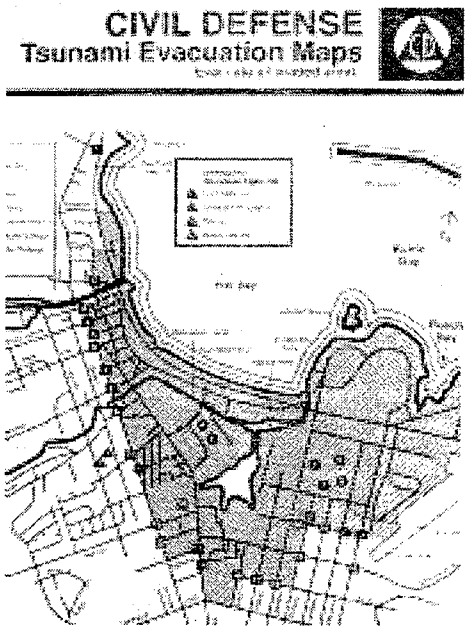
advance for distant tsunamis. Local tsunamis pose special problems because insufficient time might preclude official warnings. Some communities are advising and training their residents and visitors to evacuate immediately whenever earthquake shaking is felt. If no tsunami warning is issued, people can return after a short time.

Strategy 4: Implement Effective Information and Education Programs

Communities can use brochures, single-page instructions, periodic warning system tests, electronic and print media information, signs, and emergency response exercises to maintain awareness and instill effective response behavior. Some of this information will be directed towards specialized institutions, such as schools, hospitals, and convalescent-care facilities, and non-English speaking community members. Because of seasonal tourism in many coastal communities, some information is designed especially for tourists. Depending on the community's needs, it is important that information and education efforts be routine, comprehensive, and tailored for special facilities and populations.

Strategy 5: Maintain the Program Over the Long Term

Tsunamis are rare events, but their impacts on coastal communities can be devastating. It is a challenge to maintain emergency preparedness programs and procedures when the threat is perceived as remote. It is, therefore, important that vertical evacuation measures be integrated into community response plans and that they be reviewed and revised regularly. Since cooperation is essential, these reviews should include building owners and others involved in the program. Periodic simulations are a valuable learning exercise, and regular informational and instructional materials should be provided to those occupying potential tsunami damage areas.



Tsunami evacuation map from the civil defense section of the Hilo, Hawaii, telephone book

Principle 7: Case Study

Case Study: Tsunami Warning Programs

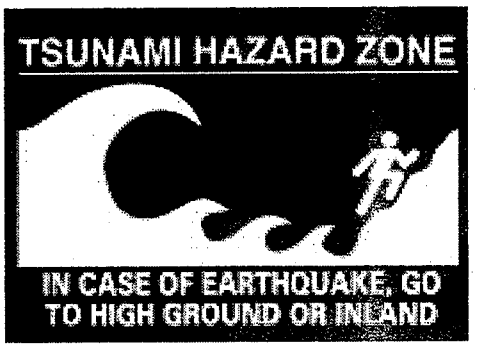
The following is a description of tsunami warning programs. This topic is not directly related to vertical evacuation, but provides helpful background information.

As part of an international cooperative effort to save lives and protect property, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service operates two tsunami warning centers. The West Coast and Alaska Tsunami Warning Center (WCATWC) in Palmer, Alaska, serves as the regional tsunami warning center for Alaska, British Columbia, Washington, Oregon, and California.

The Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the regional tsunami warning center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat. This international warning effort became a formal arrangement in 1965 when PTWC assumed the international warning responsibilities of the Pacific Tsunami Warning System (PTWS). The PTWS is composed of 26 international member states that are organized as the International Coordination Group for the Tsunami Warning System in the Pacific.

The two tsunami warning centers coordinate the information being disseminated. The objective of the tsunami warning centers is to detect, locate, and determine the magnitude of potentially tsunamigenic earthquakes. Earthquake information is provided by seismic stations. If the location and magnitude of an earthquake meet the known criteria for generation of a tsunami, a tsunami warning is issued to warn of an imminent tsunami hazard. The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours. A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period.

continued on next page



Tsunami hazard zone logo

Principle 7: Case Study

Case Study: Tsunami Warning Programs, cont.

If a significant tsunami is detected by sea-level monitoring instrumentation, the tsunami warning is extended to the entire Pacific Basin. Sea-level (or tidal) information is provided by NOAA's National Ocean Service, PTWC, WCATWC, university monitoring networks, and other participating nations of the PTWS.

Tsunami watch, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods:

- Tsunami watch, warning, and information bulletins issued by PTWC and WCATWC are disseminated to local, state, national, and international users as well as the media. These users, in turn, disseminate the tsunami information to the public, generally over commercial radio and television channels.
- The NOAA Weather Radio System, based on a large number of VHF transmitter sites, provides direct broadcast of tsunami information to the public.
- The U.S. Coast Guard also broadcasts urgent marine warnings and related tsunami information to coastal users equipped with medium frequency (MF) and very-high-frequency (VHF) marine radios.
- Local authorities and emergency managers are responsible for formulating and executing evacuation plans for areas under a tsunami warning. The public should stay tuned to the local media for evacuation orders should a tsunami warning be issued. And, the public should not return to low-lying areas until the tsunami threat has passed and the local authorities announce the "all clear."

GLOSSARY

Amplitude:
The tsunami's rise above or drop below the ambient water level as read on a tide gauge.

Bore:
Traveling wave with an abrupt vertical front or wall of water. Under certain conditions, the leading edge of a tsunami wave may form a bore as it approaches and runs onshore. A bore may also be formed when a tsunami wave enters a river channel, and may travel upstream penetrating to a greater distance inland than the general inundation.

Harbor Resonance:
The continued reflection and interference of waves from the edge of a harbor or narrow bay. This interference can cause amplification of the wave heights and extend the duration of wave activity from a tsunami.

Horizontal Inundation Distance:
The distance that a tsunami wave penetrates onto the shore. Measured horizontally from the mean sea level position of the water's edge, it is usually measured as the maximum distance for a particular segment of the coast.

Inundation:
The depth, relative to a stated reference level, to which a particular location is covered by water.

Inundation Area:
An area that is flooded with water.

Inundation Line (limit):
The inland limit of wetting, measured horizontally from the edge of the coast, defined by mean sea level.

Local/Regional Tsunami:
Source of the tsunami is within 1000 km of the area of interest. Local or near-field tsunami has a very short travel time (30 minutes or less), mid-field or regional tsunami waves have times on the order of 30 minutes to 2 hours. Note: "local" tsunami is sometimes used to refer to a tsunami of landslide origin.

Period:
The length of time between two successive peaks or troughs. May vary due to complex interference of waves. Tsunami periods generally range from 5 to 60 minutes.

Run-up:
Maximum height of the water onshore observed above a reference sea level. Usually measured at the horizontal inundation limit.

Seiche:
An oscillating wave in a partially or fully enclosed body of water. May be initiated by long period seismic waves, wind and water waves, or a tsunami.

Tidal Wave:
Common term for tsunami used in older literature, historical descriptions, and popular accounts. Tides, caused by the gravitational attractions of the sun and moon, may increase or decrease the impact of a tsunami, but have nothing to do with their generation or propagation. However, most tsunamis (initially) give the appearance of a fast-rising or fast-ebbing tide as they approach shore, and only rarely appear as a near-vertical wall of water.

Travel Time:
Time (usually measured in hours and tenths of hours) that it took the tsunami to travel from the source to a particular location.

Tsunami:
A Japanese term derived from the characters "tsu" meaning harbor and "nami" meaning wave. Now generally accepted by the international scientific community to describe a series of traveling waves in water produced by the displacement of the sea floor associated with submarine earthquakes, volcanic eruptions, or landslides.

RESOURCES

RESOURCES FOR LOCAL GOVERNMENT OFFICIALS AND THE PUBLIC

Compiled by Lee Walkling, Library Information Specialist, Washington Department of Natural Resources, Division of Geology and Earth Resources

BOOKS

American Institute of Professional Geologists, 1993. *The Citizens' Guide to Geologic Hazards—A Guide to Understanding Geologic Hazards, Including Asbestos, Radon, Swelling Soils, Earthquakes, Volcanoes, Landslides, Subsidence, Floods, and Coastal Hazards.* Arvada, CO: American Institute of Professional Geologists. (Good overview and easy-to-understand explanations)

Myles, Douglas, 1985. *The Great Waves.* New York: McGraw-Hill Book Company. (For the general public)

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Atwater, Brian F.; Marco V. Cisternas; Joanne Bourgeois; Walter C. Dudley; James W. Hendley, II; Peter H. Stauffer, compilers, 1999. *Surviving a Tsunami—Lessons from Chile, Hawaii, and Japan.* U.S. Geological Survey Circular 1187.

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U.S. Federal Emergency Management Agency, 1998. *Property Acquisition Handbook for Local Communities.* 3 vol. poster (FEMA 317). Washington, D.C.: U.S. Federal Emergency Management Agency. (For more information: http://www.fema.gov/mit/handbook/)

U.S. Federal Emergency Management Agency, 2000. *Coastal Construction Manual—Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas.* 3rd. ed., 3 vol. (FEMA 55) Washington, D.C.: U.S. Federal Emergency Management Agency. (For more information: http://www.fema.gov/MIT/bpat/bpn0600e.htm)

PERIODICALS

Natural Hazards Observer (print and online versions) (http://www.colorado.edu/IBS/hazards/o/o.html)

The bi-monthly newsletter of the Natural Hazards Center. It covers current disaster issues; new international, national, and local disaster management, mitigation, and education programs; hazards research; political and policy developments; new information sources; upcoming conferences; and recent publications.

TsuInfo Alert Newsletter

The bi-monthly newsletter of the National Tsunami Hazards Mitigation Program is distributed to approximately 250 emergency managers of the five Pacific coastal states. Back issues are online: http://www.wa.gov/dnr/htdocs/ger/tsuinfo/index.html

RESOURCES

WEBSITES

http://www.geophys.washington.edu/tsunami/intro.html
University of Washington Geophysics Program - many links to other tsunami sites.

http://www.fema.gov/library/tsunamif.htm
FEMA tsunami fact sheet and links.

http://www.pmel.noaa.gov/tsunami/
NOAA/PMEL Web site, with links to inundation mapping, modeling, events, forecasting and the National Tsunami Hazards Mitigation Program sites.

http://www.pmel.noaa.gov/tsunami-hazard/links.html
Important links to major tsunami sites.

http://www.redcross.org/disaster/safety/guide/tsunami.html
Red Cross tsunami site, with overview, discussion of warning systems, and good preparedness information.

http://www.geocities.com/CapeCanaveral/Lab/1029/
The Tsunami Page of Dr. George P.C. (Pararas-Carayannis)
Just about everything you'd need to know about tsunamis!

http://www.fema.gov/mit/handbook
Property Acquisition Handbook for Local Communities (FEMA 317).

VIDEOS

Forum: Earthquakes and Tsunamis (2 hrs.)
CVTV-23, Vancouver, WA (January 24, 2000)
Two lectures: Brian Atwater describes the detective work and sources of information about the January 1700 Cascadia earthquake and tsunami; Walter C. Dudley talks about Hawaiian tsunamis and the development of warning systems.

Tsunami: Killer Wave, Born of Fire (10 min.)
NOAA/PMEL.
Features tsunami destruction and fires on Okushiri Island, Japan; good graphics, explanations, and safety information. Narrated by Dr. Eddie Bernard (with Japanese subtitles).

Waves of Destruction (60 min.)
WNET Video Distribution
An episode of the "Savage Earth" series. Tsunamis around the Pacific Rim.

Disasters Are Preventable (22 min.)
USAID
Ways to reduce losses from various kinds of disasters through preparedness and prevention.

Tsunami: Surviving the Killer Waves (13 min.)
DOGAMI
Two versions, one with breaks inserted for discussion time.

Raging Planet; Tidal Wave (50 min.)
Produced for the Discovery Channel in 1997, this video shows a Japanese city that builds walls against tsunamis, talks with scientists about tsunami prediction, and has incredible survival stories.

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Looking west toward Pillar Point *K. Ridolfi*

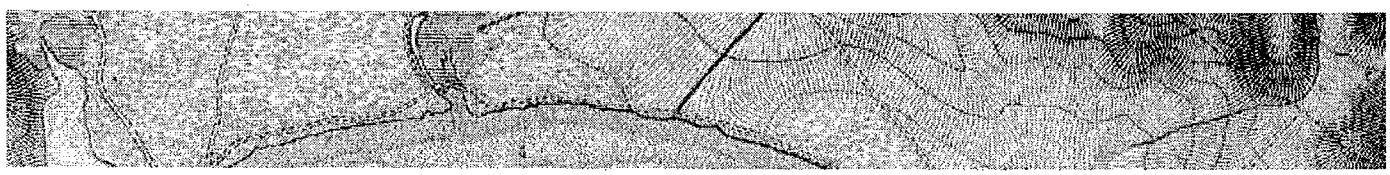
AN INTRODUCTION TO THE *HISTORICAL ECOLOGY* OF THE FITZGERALD MARINE RESERVE CCA

A tool for developing an action plan for the Critical Coastal Areas program

Scattered throughout local and regional archives, *historical information represents a valuable and often untapped resource for watershed management and coastal protection. Can an understanding of the historical landscape help us guide future landscape modifications? Can this understanding help re-establish native habitats and ecosystem function? How did natural and cultural processes shape the historic ecosystems that still persists as fragments in the current landscape?*

This publication is intended as an introduction to how historical ecology can help local residents and resource managers understand current conditions and develop strategies for environmental recovery. The area encompassed by the Fitzgerald Marine Reserve Critical Coastal Area (CCA) has experienced substantial physical and ecological changes due to active coastal processes and the history of agricultural and urban development. Understanding this history can help identify opportunities to restore natural watershed function within the contemporary landscape, which in turn can help control pollution sources. This document highlights areas of interest for potential restoration, focusing on three topics: salt marshes, stream networks, and freshwater wetlands. These opportunity areas will provide information for the stakeholders of the Fitzgerald Marine Reserve participating in the CCA Program pilot study to identify and prioritize actions that could improve watershed health. The CCA Program seeks to improve water quality along the California coast through the implementation of management measures to reduce the effects of diffuse sources of pollution, including urban and agricultural runoff.

For more information on the CCA program, please visit http://www.coastal.ca.gov/nps/cca-nps.html.



US Coast Survey hydrographic chart courtesy NOAA

Authors *Alison Whipple and Robin Grossinger* • ***Design and layout*** *Ruth Askevold and Alison Whipple*
Thanks to *Kat Ridolfi, Chuck Striplen, Erin Beller, and Micha Salomon*

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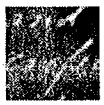
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May 2008

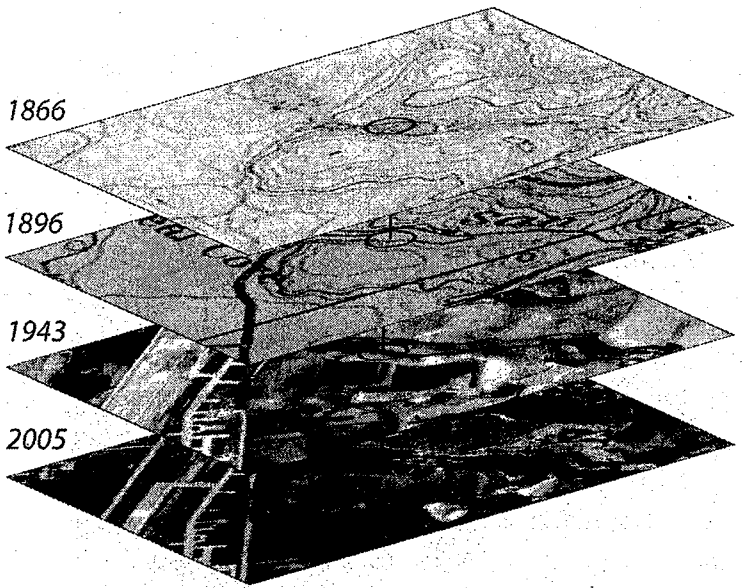
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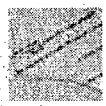


Building a HISTORICAL ECOLOGY Project



DATA COLLECTION • Research begins with the acquisition of historical materials from a broad range of institutions, including local museums and historical societies, city and county archives, and regional libraries. Journals, diaries, and newspaper articles about the landscape and notable environmental features document historical conditions. Early maps, surveys, and aerial photography provide the locations of historical features, such as streams, wetlands, and plant communities, as well as remaining property boundaries and roads that are valuable links to the contemporary landscape. Other important sources include landscape photography, sketches, and paintings.





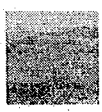
DATA COMPILATION • Sources are drawn together for synthesis and analysis along the themes of historical vegetation types, channel geometry, seasonality, and land use. We georeference early maps and aerial photography in a geographic information system (GIS), which allows historical evidence to be compared to modern conditions. We also extract and organize pertinent quotes from early land surveys and narrative sources and, where possible, place them on maps of the past and present. This process of comparing multiple, independent sources of historical and modern information facilitates a detailed and accurate depiction of environmental change.



SYNTHESIS AND ANALYSIS • We rely heavily on GIS to synthesize the data into layers that represent historical landscape characteristics. Mapped features may include channels, perennial and seasonal wetlands, coastal features, woodlands and savanna, and other habitats — each coded independently with their supporting sources and relative certainty level. A variety of methods are used to compare past and present landscapes, describing changes in habitat form and distribution. These depictions of habitat change are used by ecologists and other environmental scientists to describe changes in ecological functions, such as wildlife support. As a reliable map of the pre-modification landscape is developed, it begins to reveal the relationships between native habitats and physical gradients such as topography, salinity, and hydrology, providing a basis for identifying adaptive restoration and management strategies for the contemporary landscape.



REPORTS, GRAPHICS, AND PRESENTATIONS • The analysis is brought together into broadly accessible tools, including illustrated reports, websites (such as wetlandtracker.org), and maps. These present trends in habitat types and extent, discuss conceptual models and areas of interest for future environmental improvements, and provide direct access to many of the most significant historical data sources.

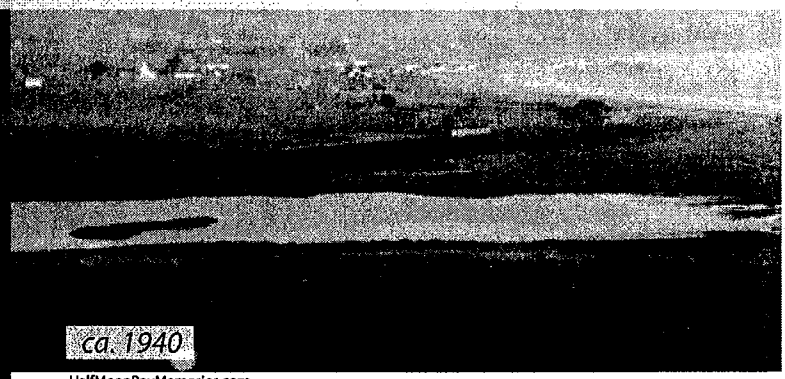


APPLICATIONS • Understanding the historical landscape and how it has changed over time can help address many of the challenges associated with managing and planning for the future of local watersheds. Historical ecology can help set priorities for restoring natural functions to local creeks, identify natural ways to reduce flood hazards, and reveal previously unrecognized conservation opportunities. The historical analysis often reveals ways to restore native habitats within our developed landscape for recreational benefits as well as wildlife conservation. Historical ecology can also reveal management constraints resulting from historical landscape changes, providing a more realistic basis for planning the future.

1 FITZGERALD MARINE RESERVE CCA
SALT MARSHES

These pages show a preliminary investigation of the extent and character of the salt marshes that once existed at creek mouths along the Reserve. Pillar Point Marsh, the largest of the salt marshes, persists today and is home to threatened and endangered species such as the California red-legged frog (Rana aurora draytonii) *and the Western snowy plover* (Charadrius alexandrinus nivosus). *Early cartography and surveys reveal that a similar system existed at the base of Denniston Creek. An important cartographic source, United States Coast Survey (USCS) topographic maps ("T-sheets," described below) provides an initial view of the historic marshes at Pillar Point and Denniston Creeks as well as hydrologic connections between upland and lowland systems. These perspectives can help establish a baseline from which to assess the impacts of modifications such as groundwater pumping, sedimentation, and increased drainage from urban areas, all of which affect water quality.*

Pillar Point Marsh (shown below ca. 1940 and at right in 2005), persists today as a unique system within the Fitzgerald Marine Reserve CCA.

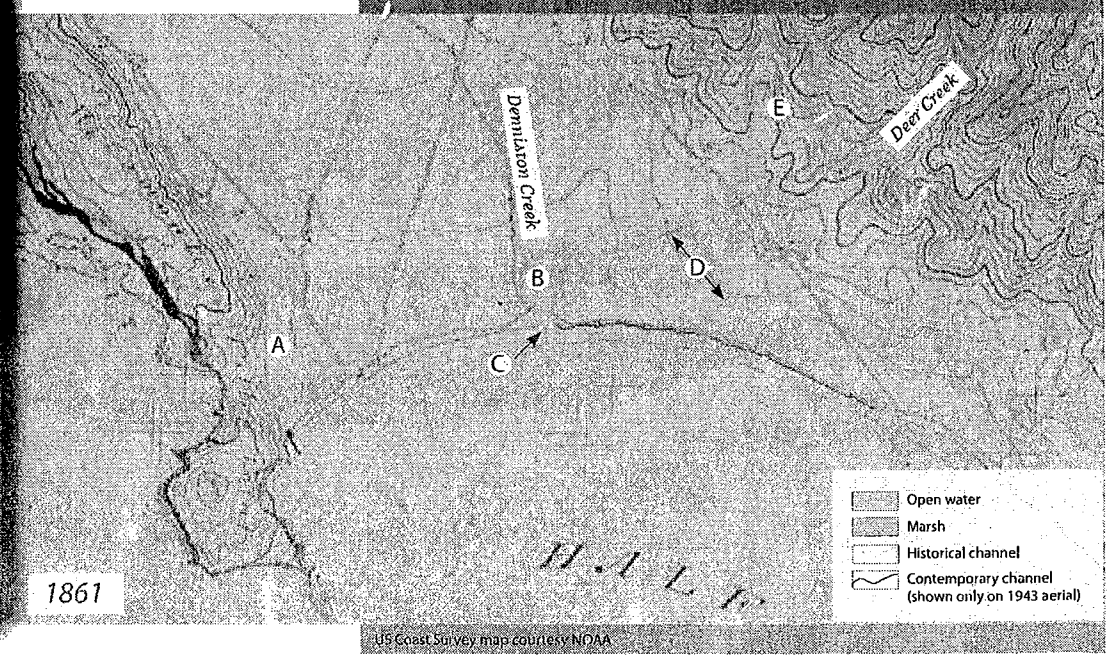


HalfMoonBayMemories.com

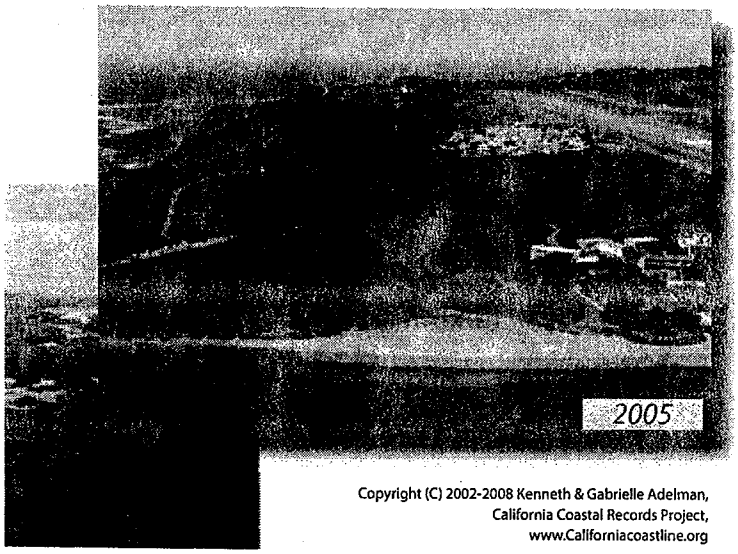
The 1861 USCS T-sheet (at right), which covers the Pillar Point area, depicts marsh complexes and channel networks along the coastline (Johnston 1861). Initiated in 1807 by the U.S. government, the Coast Survey maps provide an early and detailed cartographic depiction of the coastal landscape. The unprecedented use of geodetic surveying techniques - employing a common reference, or datum, to which all points are tied - produced remarkably accurate maps for the time period. Despite the absence of a standardized legend, T-sheets show hydrologic patterns and the distribution of coastal ecosystem types, which can be interpreted through a standard methodology (Grossinger and Askevold 2005).

In the comparison below, the 1861 **Pillar Point Marsh** complex (A) contains more open water (approximately 10 acres) and a longer adjacent marsh than that shown in 1943 aerial photography (with approximately 4 acres of open water). In 1861, only the southernmost portion shows any emergent vegetation, suggesting a perennial water body. The open water transitions to emergent marsh (horizontal lines) approximately at the historic dam where West Point Ave is today. US General Land Office (GLO) survey data adds another layer of information to help confirm the general character and location of the marshes and creek mouths. Surveyor C. C. Tracy (June, 1862) noted entering and leaving the "marsh" north of West Point Ave and commented on "wet, good grass" indicating a more continuous marsh complex than today.

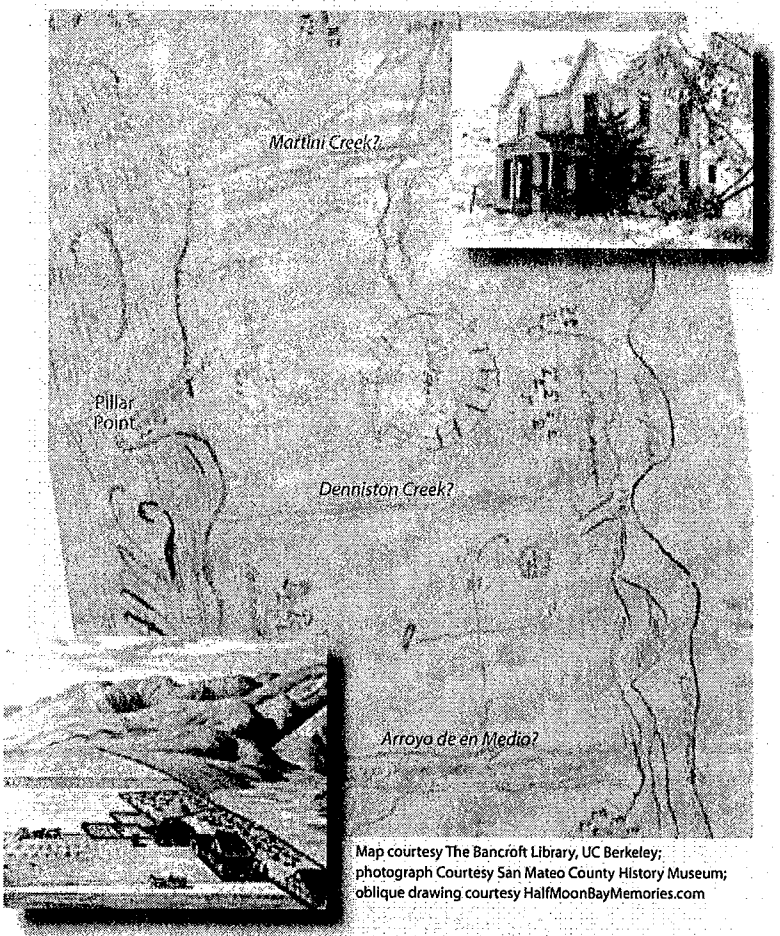
The 1861 T-sheet also shows a wetland system at the **mouth of Denniston Creek** (B) (interpretation aided by 1863 USCS hydrographic map shown on p.1); the presence of which is supported by the "level marsh" noted by Tracy. The subtidal channel



US Coast Survey map courtesy NOAA



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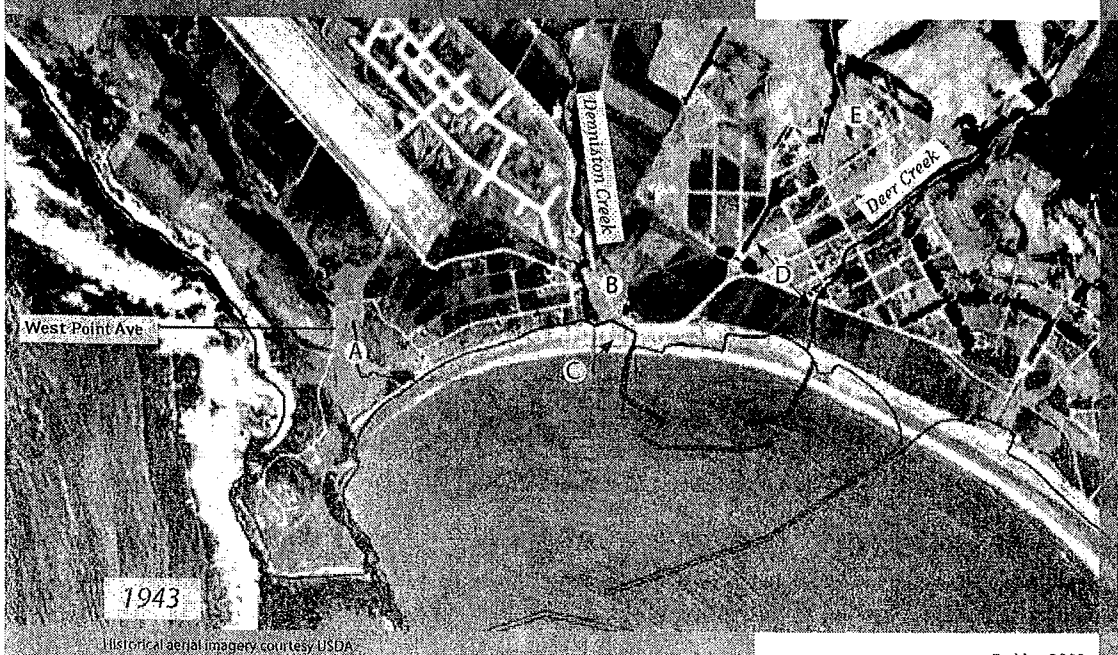


Map courtesy The Bancroft Library, UC Berkeley;
photograph Courtesy San Mateo County History Museum;
oblique drawing courtesy HalfMoonBayMemories.com

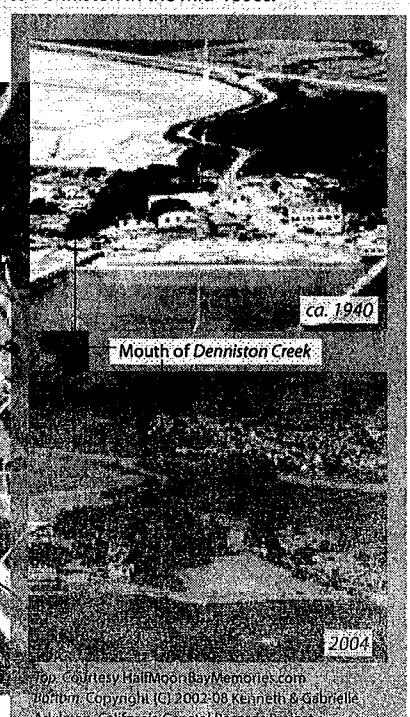
The 1837 diseño map above of the **Rancho Corral de Tierra** land grant uses natural features to locate the boundaries of the rancho. The "arroyos" (creeks) and "lomarias" (hills) formed the "earthen corral" (a constructed corral is also shown) after which the grant was named. The map likely shows Martini Creek to the north, and Denniston Creek in the middle, close to Pillar Point. Francisco Guerrero received this grant from the Mexican government in 1839. The lithograph and photograph above shows his son Victor's homestead, which became the home of James Denniston in the mid-1800s.

(C) drawn suggests that the marsh system may have been more consistently open to the ocean than Pillar Point Marsh. The 1943 aerials show the creek in roughly the same location as the T-sheet channel, but the marsh complex at the mouth of Denniston Creek appears to be largely absent. The inset oblique photographs show the mouth of Denniston Creek at the approximate time of the 1943 aerials in comparison to today.

Interestingly, the T-sheet already shows hydrologic modifications to the Denniston Creek watershed. A ditch (D) originates from a freshwater marsh (F) and connects to the Denniston Creek marsh; another connects to Deer Creek. This perhaps explains the drained appearance of the freshwater marsh in the 1943 aerial photography, which has since been replaced by dense vegetation. These ditches are early representations of the common trend toward increasing drainage density by connecting creeks that would have otherwise spread into marshes or alluvial fans (see pgs. 6-7).



Historical aerial imagery courtesy USDA

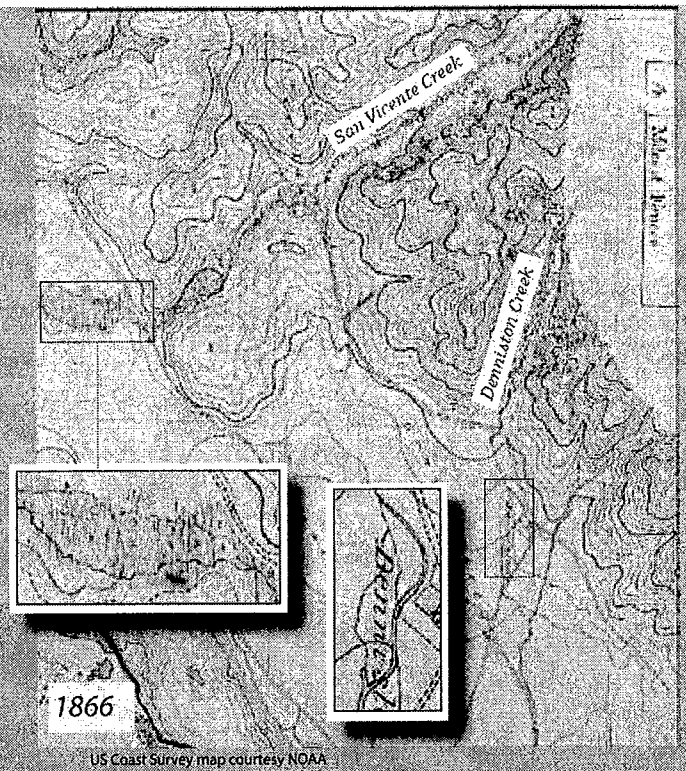


Top: Courtesy HalfMoonBayMemories.com
Bottom: Copyright (C) 2002-08 Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org

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Stream Networks

The lowland streams have experienced a long history of change; first with ranching and agriculture, and later with the development of the communities of El Granada, Princeton-by-the-sea, Moss Beach, and Montara. Altered hydrographs and sediment input can impact stream characteristics such as width and depth, which in turn affect riparian vegetation. Map and narrative sources like those shown here can help build an understanding of historic stream network characteristics and inform interpretation of the current hydrologic regime. This, in turn, can be used to resolve sedimentation and erosion issues and help re-establish native species such as steelhead trout (Oncorhynchus mykiss).



US Coast Survey map courtesy NOAA

The images above and to the right illustrate hydrologic change over time: wetland complexes and multi-thread channels (1866), and discontinuous drainage networks (1896) shift to a highly modified system in1943.

For streams like San Vicente Creek and Denniston Creek which appear to have had sufficient flow to form distinct channels via the ocean (see quote below left), **complex, multi-thread reaches** are indicated in the 1866 T-sheet in the locations highlighted above. This area in white box above on Denniston Creek was once known as "Three Bridges," supporting the evidence of multiple channels (Cloud 1928). The San Vicente Creek reach is slightly different in that it is associated with a freshwater marsh complex (see p. 6).



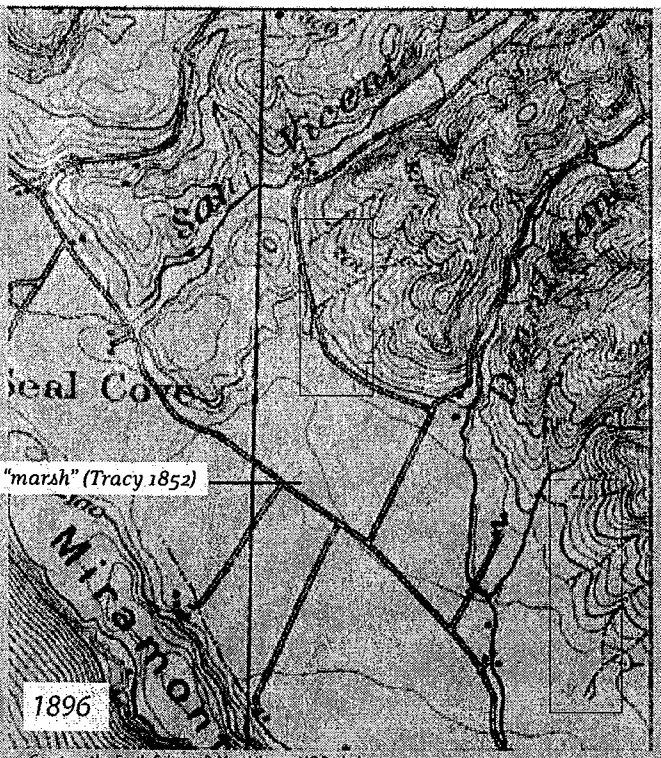
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The example here shows information that can be used in comparison to contemporary stream channel widths. The red lines imposed on the modern imagery to the right point to locations of known creek width, as recorded by an 1859 survey.

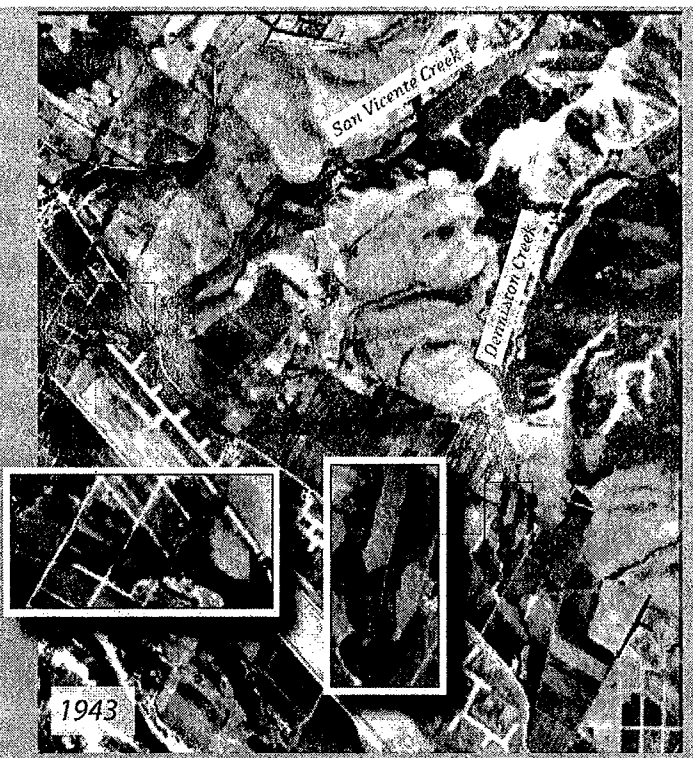
WE BROKE CAMP AND WENT ALONG THE SHORE UNTIL, leaving the point with island rocks [Pillar Point] to the west of us, we passed over some knolls and across [several small] hollows with [rather] deep gulches full of water, at which we were delayed by [having to] throw small bridges over them [for the pack-train to cross on].

- COSTANSO 1769 in Stanger and Brown 1969





Courtesy the Earth Science & Map Library, UC Berkeley



Aerial imagery courtesy USDA

The 1896 USGS map suggests a more **discontinuous drainage network** on some of the smaller local streams prior to hydrologic modifications which is a commonly recognized pattern among California's historic streams. Small intermittent creeks fanned across alluvial fans emerging from the steep Montara Mountains lacked the energy to form well defined channels as they encountered the relatively flat alluvial fans of the larger creeks. Instead, the channels dissipated like those shown in this 1896 USGS map. These networks were often associated with downstream wetlands. Although not depicted on the maps examined here, GLO surveyor C.C. Tracy reported entering and leaving a "marsh" along this line close to where Highway 1 is now.

The 1943 aerial photography overlain by contemporary stream mapping shows a **highly modified drainage network**. While remnants of Denniston Creek's multiple channels persist, San Vicente is a clear single channel system. The airport's construction resulted in significant hydromodifications of the Denniston Creek and Pillar Point drainage networks, where water historically drained toward Pillar Point marsh is now diverted more toward Denniston Creek through culverts. Such modifications can also have the effect of connecting the small discontinuous creeks, like those shown in the 1896 map, to larger stream channels.

GLO field notes from William J. Lewis, 1859

"Mouth of creek 50 links [10 m] wide, comes from southeast."

"Creek, 10 links, wide, course N86W."

"Creek, 20 links wide, course, S60W."

"Small spring, 5 links wide, course S.W."

"Creek, 25 links wide, course, S61W"

"Deep gulch 180 links [36 m] wide comes from N55E"

"Creek 1 chain wide, comes from S59E"

The figure at left shows stream widths at various locations on San Vicente, Dean, and Montara Creeks, recorded by General Land Office (GLO) surveyor William J. Lewis. The GLO Public Land Survey established the 6-mile square townships we are familiar with today across the western U.S. and confirmed land grant boundaries. The GLO reached Half Moon Bay in the 1850s. The surveys contain valuable ecological information: surveyors noted up to four "bearing" trees (marked trees with azimuth and distance to identify the location of survey lines) at every mile and half-mile point (notably no trees were found in the Fitzgerald CCA), described distinctive features along their survey lines, such as creeks (including width information which is shown here), lakes, marshes, or areas of thick brush, and commented on general soils and land characteristics.

3

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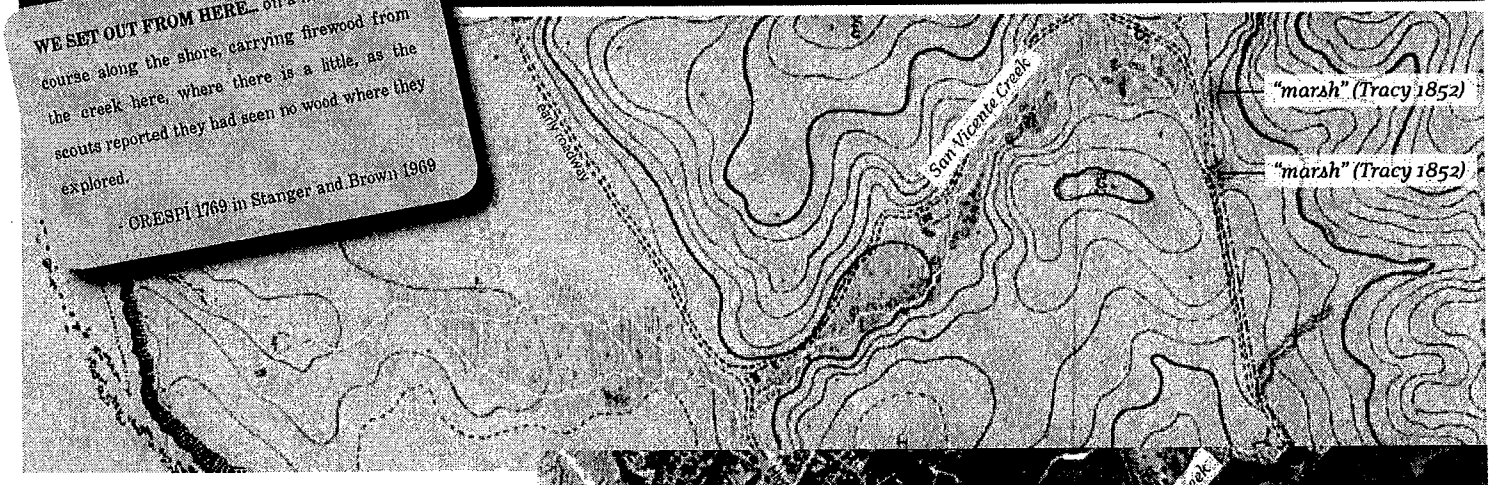
Freshwater Wetlands

Historical sources point to possible opportunities for the restoration of once extensive freshwater wetlands and willow riparian forests along San Vicente and Montara creeks. Aided by further research, understanding the extent and character of these freshwater wetlands could inform efforts to improve water quality and reduce flood peaks. Also, species diversity within the area could be potentially supported through the re-introduction of these sensitive plant communities that are under-respresented in the contemporary landscape.



WE SET OUT FROM HERE... on a northwesterly course along the shore, carrying firewood from the creek here, where there is a little, as the scouts reported they had seen no wood where they explored.

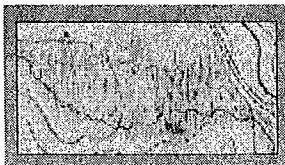
- ORESPI 1769 in Stanger and Brown 1969





Above, US Coast Survey map courtesy NOAA; imagery below courtesy USDA NAIP 2005

The image from the 1866 USCS T-sheet shown above depicts **freshwater marsh (light green) merging into a willow riparian forest (dark green)** along San Vicente Creek's braided reaches on the flat alluvial fan at the base of the Montara hills. The map suggests both a broader and more open (covered with herbaceous vegetation) wetland environment than the riparian reaches found along San Vicente Creek today. GLO surveyor C. C. Tracy (1852) also noted marshes (see above) along his survey line that crossed the creek and passed close to where reservoirs sit today. A similar progression of marsh to willow riparian forest is suggested along Montara Creek upstream of Harte St. (not shown). Considering the water quality and flood control benefits of wetland and marsh complexes, areas where open space still exists next to stream channels may be important sites to consider for recovering elements of the historical systems. Areas along the San Vicente and Montara creeks may contain restoration and conservation opportunities for freshwater marshes and wet meadows.



In summary, *historical ecology provides a tool for developing action plans for Critical Coastal Areas. Historical ecology research provides both technical information and an educational perspective that can help us recognize and respond to environmental change. While this preview shows some of the types of analysis that could be useful for the Fitzgerald Marine Reserve CCA, much more historical information about the local landscape is available and remains to be compiled. For more information about historical ecology methods and resources, please go to www.sfei.org/HEP.*

THE IMPACTS OF SEA-LEVEL RISE ON THE CALIFORNIA COAST

A Paper From:
California Climate Change Center

Prepared By:
Matthew Heberger, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore of the Pacific Institute

DISCLAIMER

This paper was prepared as the result of work funded by the California Energy Commission, the California Environmental Protection Agency, Metropolitan Transportation Commission, California Department of Transportation, and the California Ocean Protection Council (collectively "the funding agencies"). It does not necessarily represent the views of the funding agencies, their respective officers, agents and employees, or the State of California. The funding agencies, the State of California, and their respective officers, employees, agents, contractors, and subcontractors make no warrant, express or implied, and assume no responsibility or liability for the results of any actions taken or other information developed based on this paper; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This paper is being made available for informational purposes only and has not been approved or disapproved by the funding agencies, nor have the funding agencies passed upon the accuracy, currency, completeness, or adequacy of the information in this paper. Users of this paper agree by their use to hold blameless each of the funding agencies for any liability associated with its use in any form. This work shall not be used to assess actual coastal hazards, insurance requirements or property values, and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

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Arnold Schwarzenegger, *Governor*

FINAL PAPER

May 2009
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Many individuals, organizations, and agencies helped make this work possible by providing data, information, and input and review of the final report. We owe thanks to Will Travis, director of the Bay Conservation and Development Commission, for initiating the study and suggesting our involvement and to staff members Leslie Lacko, Tim Doherty, Adam Parris, and Steve Goldbeck, who worked closely with us as we prepared this report.

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Special thanks to the staff at the National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center, Kirk Waters and Keil Schmid, for helping us obtain several gigabytes of LIDAR data. Abby Sallenger at the United States Geological Survey gave additional advice and insights about the Coastal Change program's LIDAR data. Thanks to Mark Sanchez, geographic information system (GIS) wizard at the State of Oregon, for help in figuring out how to handle all those gigabytes!

Brian Fulfrost at the University of California (UC) Santa Cruz, now at DCE Planning, helped us locate several helpful GIS datasets. We thank Robert Colley, GIS Manager for Santa Clara County, for providing data and for recognizing that the free and open sharing of public data is so valuable to researchers and the public. Ray McDowell, GIS Data Coordinator at the California Resources Agency, helped locate and obtain still more GIS data. At the Federal Emergency Management Agency (FEMA), Eric Simmons and Ray Lenaburg engaged us in helpful discussion and gave pointers to the spatial data from recent FEMA mapping studies.

Staff at California's Resources Agency engaged us in a number of insightful and provocative discussions. Thanks to Sam Schuchat, Brian Baird, Tony Brunello, John Ellison, and Abe Doherty. Special thanks to Christine Blackburn at the Ocean Protection Council (OPC) for

seeing the importance of this issue to the entire state, for helping to coordinate OPC's participation in the project, and for many valuable conversations.

Johanna Fenton, formerly head of the Earthquake and Tsunami Program in the Governor's Office of Emergency Services, provided early guidance and advice. Leslie Ewing, Mark Johnsson, and Greg Benoit of the California Coastal Commission provided data or suggestions. We were especially thankful to discover the excellent work of Jennifer Dare, a NOAA Coastal fellow, who compiled the Coastal Armoring Database.

Thanks to Philip Pang in the South Pacific Division of the U.S. Army Corps of Engineers for his work estimating levee construction costs. Thanks to Jos Dijkman, flood management engineer at Deltares/Delft Hydraulics in the Netherlands, for a great deal of detailed information on the construction of dikes and flood defenses. Walt Crampton, principal engineer at TerraCosta Consulting Group, also provided seawall construction costs for California.

We wish to thank ESRI. A grant to the Pacific Institute in 2007 through their Conservation Grants program allowed us to expand the range and sophistication of our analysis.

Special thanks go to the leader of the PIER Research Team, Guido Franco, not only for skillfully overseeing this complex set of studies, but also for a number of insightful comments and suggestions. Technical editor Susie Moser provided insightful comments on an early draft. Thanks to editor Mark Wilson for skill and patience in making all of this readable.

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Preface

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California's electricity and natural gas ratepayers. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts focus on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's PIER Program established the **California Climate Change Center** to document climate change research relevant to the states. This center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts and the efforts designed to reduce emissions.

The California Climate Change Center Report Series details ongoing center-sponsored research. As interim project results, the information contained in these reports may change; authors should be contacted for the most recent project results. By providing ready access to this timely research, the center seeks to inform the public and expand dissemination of climate change information, thereby leveraging collaborative efforts and increasing the benefits of this research to California's citizens, environment, and economy.

For more information on the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier/ or contract the Energy Commission at (916) 654-5164.

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Abstract

Over the past century, sea level has risen nearly eight inches along the California coast, and general circulation model scenarios suggest very substantial increases in sea level as a significant impact of climate change over the coming century. This study includes a detailed analysis of the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the coast. The sea-level rise scenario was developed by the State of California from medium to high greenhouse gas emissions scenarios from the Intergovernmental Panel on Climate Change (IPCC) but does not reflect the worst-case sea-level rise that could occur. We also evaluate the cost of building structural measures to reduce that risk. If development continues in the areas at risk, all of these estimates will rise. No matter what policies are implemented in the future, sea-level rise will inevitably change the character of the California coast.

We estimate that a 1.4 meter sea-level rise will put 480,000 people at risk of a 100-year flood event, given today's population. Among those affected are large numbers of low-income people and communities of color, which are especially vulnerable. Critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation, as are vast areas of wetlands and other natural ecosystems. In addition, the cost of replacing property at risk of coastal flooding under this sea-level rise scenario is estimated to be nearly $100 billion (in year 2000 dollars). A number of structural and non-structural policies and actions could be implemented to reduce these risks. For example, we estimate that protecting some vulnerable areas from flooding by building seawalls and levees will cost at least $14 billion (in year 2000 dollars), with added maintenance costs of another $1.4 billion per year. Continued development in vulnerable areas will put additional areas at risk and raise protection costs.

Large sections of the Pacific coast are not vulnerable to flooding, but are highly susceptible to erosion. We estimate that a 1.4 meter sea-level rise will accelerate erosion, resulting in a loss of 41 square miles (over 26,000 acres) of California's coast by 2100. A total of 14,000 people currently live in the area at risk of future erosion. Additionally, significant transportation-related infrastructure and property are vulnerable to erosion. Statewide flood risk exceeds erosion risk, but in some counties and localities, coastal erosion poses a greater risk. This report also provides a comprehensive set of recommendations and strategies for adapting to sea-level rise.

Keywords: sea-level rise, coastal impacts, climate change, California, San Francisco Bay, flood, erosion, climate adaptation, climate impacts, levees, seawalls, greenhouse effect

1.0 Introduction

California's coastline, which includes more than 2,000 miles of open coast and enclosed bays, is vulnerable to a range of natural hazards, including storms, extreme high tides, and rising sea levels resulting from global climate change. Development along California's coast is extensive. In 2000, 26 million Californians lived in coastal counties, and by 2003, this number had grown to nearly 31 million (U.S. Census Bureau 2000; NOAA 2004). Indeed, six of the ten fastest growing coastal counties in the United States between 1980 and 2003 were in California (NOAA 2004). Major transportation corridors and other critical infrastructure are found along the California coast, including oil, natural gas, and nuclear energy facilities, as well as major ports, harbors, and water and wastewater plants. The California coast is also an extraordinary cultural and ecological resource and offers extensive tourism and recreational opportunities.

Flooding and erosion already pose a threat to communities along the California coast and there is compelling evidence that these risks will increase in the future. Based on a set of climate scenarios prepared for the California Energy Commission's Public Interest Energy Research (PIER) Climate Change Research Program, Cayan et al. (2009) project that, under medium to medium-high emissions scenarios, mean sea level along the California coast will rise from 1.0 to 1.4 meters (m) by the year 2100.[1] Rising seas put new areas at risk of flooding and increase the likelihood and intensity of floods in areas that are already at risk. In areas where the coast erodes easily, sea-level rise will likely accelerate shoreline recession due to erosion. Erosion of some barrier dunes may expose previously protected areas to flooding.

National studies on the economic cost of sea-level rise suggest that while adapting to climate change will be expensive, so are the costs of doing nothing, as substantial investments are already at risk and vulnerable.[2] Because the economic costs of flooding are highly site-specific, regional analyses are critical for guiding land-use decisions and evaluating adaptive strategies.

The Pacific Institute published one of the earliest comprehensive regional assessments of sea-level rise (Gleick and Maurer 1990), concluding that a one-meter sea-level rise would threaten existing commercial, residential, and industrial structures around San Francisco Bay valued at $48 billion (in year 1990 dollars). Building or strengthening levees and seawalls simply to protect existing high-value development was estimated to require an immediate capital investment of approximately $1 billion (in year 1990 dollars) and would require an additional $100 million per year in ongoing maintenance.[3] The report also noted that substantial areas of the San Francisco Bay, especially wetlands and marshes, could not be protected and would likely be damaged or lost.

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[1] It is important to note that most climate models fail to include ice-melt contributions from the Greenland and Antarctic ice sheets, and as a result, the potential increase in mean sea level may be much higher.

[2] See, for example, Titus et al. (1992) and Yohe et al. (1996).

[3] This estimate does not include the cost of protecting and restoring wetlands, groundwater aquifers, etc.

This assessment updates and expands our 1990 analysis using more comprehensive data, new climate scenarios, and modern computerized analytical tools. We made extensive use of geographic information system (GIS) software and updated sea-level rise scenarios from the Scripps Institution of Oceanography to estimate the population, infrastructure, ecosystems, and property at risk. We also estimate some of the cost of armoring the coast, one potential adaptation strategy to reduce that risk. This work is part of a larger set of research projects by the California Climate Action Team to understand the impacts of climate change to Californians, funded by the California Energy Commission's Public Interest Energy Research (PIER) program. The Pacific Institute also received significant financial support from two other state agencies: the Ocean Protection Council and the Metropolitan Transportation Commission, part of the Department of Transportation.

1.1. Key Findings

Over the past century, sea level has risen nearly eight inches along the California coast, and general circulation model scenarios suggest very substantial increases in sea level as a significant impact of climate change over the coming century. This study includes a detailed analysis of the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the coast, and the cost of building structural measures to reduce that risk. We find the following:

- Under medium to medium-high greenhouse-gas emissions scenarios, mean sea level along the California coast is projected to rise from 1.0 to 1.4 meters (m) by the year 2100. Maps for the entire coast of California demonstrating the extent of the areas at risk are posted at www.pacinst.org/reports/sea_level_rise.[4]

- A 1.4 meter sea-level rise will put 480,000 people at risk of a 100-year flood event, given today's population. Populations in San Mateo and Orange Counties are especially vulnerable. In each, an estimated 110,000 people are at risk. Large numbers of residents (66,000) in Alameda County are also at risk.

- A demographic analysis identified large numbers of people at risk with heightened vulnerability, including low-income households and communities of color. Additionally, adapting to sea-level rise will require tremendous financial investment. Given the high cost and the likelihood that individuals, the State, and local agencies will not protect everything, adaptation raises additional environmental justice concerns.

- A wide range of critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation in a 100-year flood event. This infrastructure at risk includes:

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[4] These maps are not the result of detailed site studies and were created to quantify risk over a large geographic area. They should not be used to assess actual coastal hazards, insurance requirements or property values, and specifically shall not be used in lieu of Flood insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA). Local governments or regional planning agencies should conduct detailed studies to better understand the potential impacts of sea-level rise in their communities.

- nearly 140 schools;
- 34 police and fire stations;
- 55 healthcare facilities;
- more than 330 U.S. Environmental Protection Agency (U.S. EPA)-regulated hazardous waste facilities or sites, with large numbers in Alameda, Santa Clara, San Mateo, and Los Angeles counties;
- an estimated 3,500 miles of roads and highways and 280 miles of railways;
- 30 coastal power plants, with a combined capacity of more than 10,000 megawatts;
- 28 wastewater treatment plants, 21 on the San Francisco Bay and 7 on the Pacific coast, with a combined capacity of 530 million gallons per day; and
- the San Francisco and Oakland airports.

- Vast areas of wetlands and other natural ecosystems are vulnerable to sea-level rise. An estimated 550 square miles, or 350,000 acres, of wetlands exist along the California coast, but additional work is needed to evaluate the extent to which these wetlands would be destroyed, degraded, or modified over time. A sea-level rise of 1.4 m would flood approximately 150 square miles of land immediately adjacent to current wetlands, potentially creating new wetland habitat if those lands are protected from further development.
- We estimate that nearly $100 billion (in year 2000 dollars) worth of property, measured as the current replacement value of buildings and contents, is at risk of flooding from a 100-year event with a 1.4 m sea-level rise if no adaptation actions are taken. An overwhelming two-thirds of that property is concentrated on San Francisco Bay. The majority of this property is residential.
- Coastal armoring is one potential adaptation strategy. Approximately 1,100 miles of new or modified coastal protection structures are needed on the Pacific Coast and San Francisco Bay to protect against coastal flooding. The total cost of building new or upgrading existing structures is estimated at about $14 billion (in year 2000 dollars). We estimate that operating and maintaining the protection structures would cost approximately 10% of the initial capital investment, or around another $1.4 billion per year (in year 2000 dollars).
- Large sections of the Pacific coast are not vulnerable to flooding, but are highly susceptible to erosion. We estimate that a 1.4 m sea-level rise will accelerate erosion, resulting in a loss of 41 square miles of California's coast by 2100. A total of 14,000 people live in areas at risk of erosion. In addition, significant transportation-related infrastructure and property are also at risk. Throughout most of the state, flood risk exceeds erosion risk, but in some counties, coastal erosion poses a greater risk.

- Continued development in vulnerable areas will put additional areas at risk and raise protection costs.

2.0 Methods

Numerous studies have attempted to quantify the cost of sea-level rise and have been based primarily on a framework developed in Yohe (1989) and refined in Yohe et al. (1996) and Yohe and Schlesinger (1998). That framework employs a cost-benefit model to evaluate the property at risk and the cost of protecting or abandoning that property. Property is protected if the value of the property exceeds the protection cost at the time of inundation, and the protection cost is equal to the construction cost of the protective structure. If the value of the property does not exceed the cost of protection, then the property is abandoned, with the cost equal to the value of the land and structure at the time of inundation. The total economic cost is then the sum of the protection cost plus the value of the lost property.

To determine the value of lost property, the Yohe approach considers land and structure values separately. In most locations, coastal land commands a premium price, with the price declining as one moves inland. With inundation, the Yohe method assumes that land values will simply migrate inland, and thus, the economic value of lost land is equal to the economic value of interior land. The value of structures is calculated under two conditions: with and without foresight. With perfect foresight, the economic value of structures is assumed to depreciate over time as the "impending inundation and abandonment become known" (Yohe and Schlesinger 1998), approaching $0 at the time of inundation. Without foresight, the structure value does not depreciate.

Despite its wide application, the Yohe method has a number of limitations, many of which are discussed in Hanemann (2008):

- First, it ignores any transfers among property owners and looks only at the net social cost. In reality, there will be winners (those who had inland property that is now closer to the coast and thus more valuable) and losers (those who have lost their property), and the gross social cost "could be enormous" (Yohe et al. 1996).
- Second, it assumes that coastal protection will be constructed just in time to avoid damage from flooding. This is unlikely. If coastal protection is constructed too late, then the property would incur some damage, thereby increasing the cost. If constructed too early, then the discounted net present value of the cost of building the structure would be higher (Hanemann 2008).
- Third, it only examines changes in mean sea level (eustatic change), thereby ignoring damage from storm surge and extreme events.
- Fourth, by focusing on property values, it ignores other potentially expensive costs. For example, the flooding of transportation infrastructure essential for moving people or goods, e.g., highways and ports, could cause major interruptions to the local economy. Flooding also causes impacts on the health and well-being of the affected individuals and environmental damage, including erosion, oils spills, and discharge of pollution

from coastal industry (Hanemann 2008). Over the long-term, flooding can lead to the loss of wetlands.

- Fifth, prioritization of protection based on property value may directly undermine an environmental justice framework for protection.

This study used a different approach to estimate the economic impact of sea-level rise. We adopted the scenarios developed for the PIER studies and mapped the extent of inundation from a 100-year flood event that is likely to occur with rising sea levels. We also identified areas at increased risk from erosion as a result of rising seas. The inundation and erosion geodata were overlaid with other geospatial data using GIS to produce quantitative estimates of the population, infrastructure, and replacement value of property at risk from sea-level rise, as well as the impacts on harder-to-quantify coastal ecosystems. We also produced an initial estimate of the cost of adaptation measures, specifically building seawalls and levees in high-valued coastal zones to protect against future flooding. Greater detail on the methods is provided below.

2.1. Study Area

The study area spans approximately 1,100 miles of California's Pacific coast and 1,000 miles of shoreline along the perimeter of the San Francisco Bay. The San Francisco Bay study area extends from the Golden Gate in the west to Pittsburg, California, in the east and San Jose in the south. The eastern boundary of the San Francisco Bay study was set according to where United States Geological Survey (USGS) researchers were able to extract reliable flood elevations from the Bay hydrodynamic model. We provide estimates for a number of scenarios for San Francisco Bay due to the ready availability of high-resolution geographic data provided by the USGS.

The study area of the erosion analysis extended from Santa Barbara to the Oregon border, covering about 930 miles (1,450 kilometers, km). Much of the Southern California coast was excluded from the erosion analysis due to myriad ongoing initiatives focused on climate change and hazards mapping.

2.2. Sea-Level Rise Projections

2.2.1. Mean Water Levels and Extreme Events

Sea levels are constantly in flux, subject to the influence of astronomical forces from the sun, moon, and earth, as well as meteorological effects like El Niño. A worldwide network of more than 1,750 tidal gages continuously collects data on water levels relative to a nearby geodetic reference, and new satellite-based sensors are extending measurements. Tide gage data indicate that the global mean sea level is rising. Water level measurements from the San Francisco gage (CA Station ID: 9414290), shown in Figure 1, indicate that mean sea level rose by an average of

2.01 millimeters (mm) per year from 1897 to 2006, equivalent to a change of eight inches in the last century.[5]

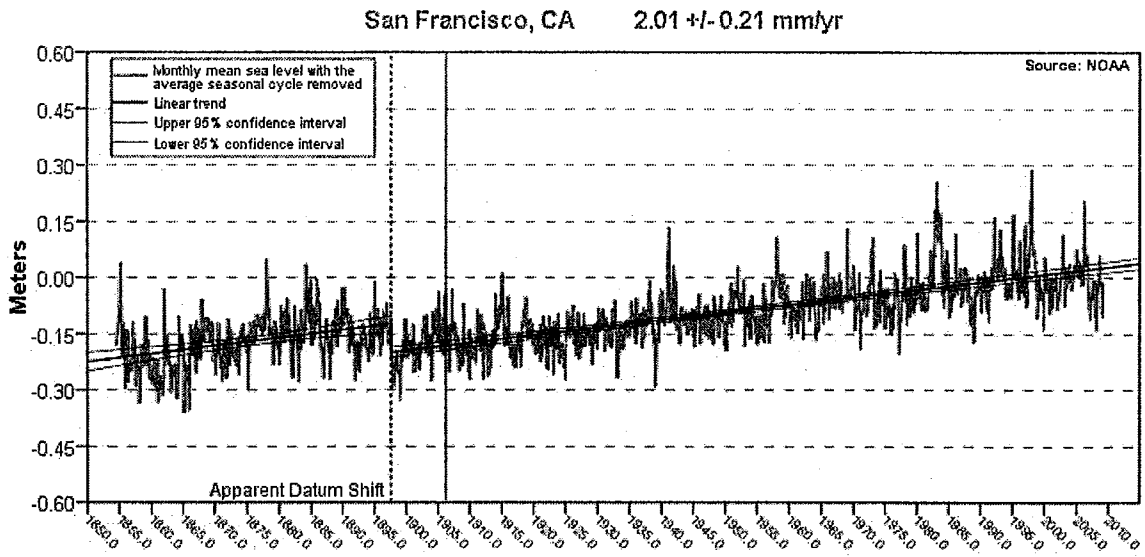


Figure 1. Trend in monthly mean sea level at the San Francisco tide station from 1854–2006

Source: NOAA Sea Levels Online, http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9414290

Sea levels are expected to continue to rise, and the rate of increase will likely accelerate. In order to evaluate climate change impacts, the Intergovernmental Panel on Climate Change (IPCC) developed future emission scenarios that differ based on assumptions about economic development, population, regulation, and technology (see Box 1 for a description of the scenarios). Based on these scenarios, mean sea level was projected to rise by 0.2 m to 0.6 m by 2100, relative to a baseline of 1980–1999, in response to changes in oceanic temperature and the exchange of water between oceans and land-based reservoirs, such as glaciers and ice sheets (Meehl et al. 2007).

More recent research by leading climate scientists, which includes more accurate sea-level measurements by satellites, indicates that sea-level rise from 1993–2006 has outpaced the IPCC projections (Rahmstorf et al. 2007). The authors suggest that the climate system, particularly sea levels, may be responding to climate changes more quickly than the models predict. Additionally, most climate models fail to include ice-melt contributions from the Greenland and Antarctic ice sheets and may underestimate the change in volume of the world's oceans.

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[5] The solid vertical line shows the earthquake of 1906. NOAA researchers fit separate trendlines before and after an apparent datum shift (vertical movement of the land surface) that occurred in 1897, disrupting consistent measurements.

To address these new factors, the PIER projects used sea-level rise forecasts developed by a team at the Scripps Institution of Oceanography led by Dr. Dan Cayan. Using a methodology developed by Rahmstorf (2007), Cayan et al. (2009) produced global sea-level estimates based on projected surface air temperatures from global climate simulations for both the IPCC A2 and B1 scenarios using the output from six global climate models: the National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM); the National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluids Dynamics Laboratory (GFDL) version 2.1; the NCAR Community Climate System Model (CCSM); the Max Planck Institute ECHAM3; the MIROC 3.2 medium-resolution model from the Center for Climate System Research of the University of Tokyo and collaborators; and the French Centre National de Recherches Météorologiques (CNRM) models.

Box 1: IPCC Climate Change Scenarios

The impacts of climate change will ultimately depend on future greenhouse gas concentrations. Future greenhouse gas emissions remain uncertain and are influenced by a variety of demographic, socio-economic, and technological factors. Scenarios can be a useful tool for examining how changes in these driving factors affect greenhouse gas concentrations. These scenarios can be useful for evaluating impacts associated with climate change as well as assessing adaptation and mitigation activities. The Special Report on Emissions Scenarios (SRES) outlines four storylines that differ according to demographics, social, economic, environmental, and technological factors and lead to different levels of greenhouse gas emissions. Each storyline has a number of different scenarios, referred to as a family. A total of 40 scenarios have been developed.

The four storylines are described below:

The **A1** storyline is characterized by "a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income" (IPCC 2000). The A1 family is further divided into three subgroups that are differentiated according to energy source: fossil intensive (**A1FI**), non-fossil sources (**A1T**), and a mix of fossil and non-fossil sources (**A1B**).

The **A2** storyline is characterized by "self-reliance and preservation of local identities" (IPCC 2000). Population is expected to continuously increase, but economic growth and technological development are expected to be slow.

The **B1** storyline has the same population projections as the A1 storyline but "rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies" (IPCC 2000).

The **B2** storyline is characterized by "a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines" (IPCC 2000).

Additionally, Cayan et al. (2009) modified the sea-level rise estimates to account for water trapped in dams and reservoirs that artificially reduced runoff into the oceans (Chao et al. 2008). Absolute sea-level rise along the California coast was assumed to be the same as the global estimate. Based on these methods, Cayan et al. (2009) estimate an overall projected rise in mean sea level along the California coast for the B1 and A2 scenarios of 1.0 m and 1.4 m, respectively, by 2100 (Figure 2). The more severe A1FI scenario, which assumes a continued high level use of fossil fuels, was not used in this analysis, but is shown for comparative purposes.

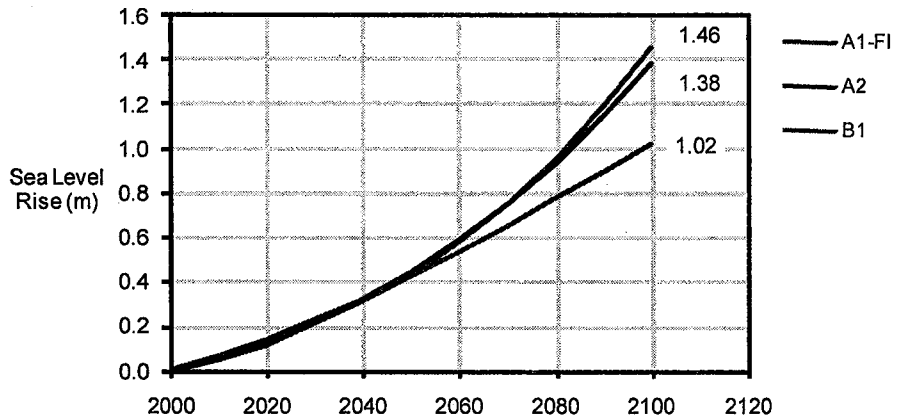


Figure 2. Scenarios of sea-level rise to 2100
Source: Dan Cayan, Scripps Institution of Oceanography, NCAR CCSM3 simulations, Rahmstorf method.

The majority of studies on climate change have emphasized changes in average conditions, yet the greatest socio-economic impacts tend to occur as a result of extreme events. Coastal flooding is often caused by storm surges, which are caused by high winds and pressure differentials associated with storms. Along the California coast, wave-induced storm surge can exceed 1.5 m (Cayan et al. 2006), flooding low-lying areas and eroding coastal bluffs. Increases in mean sea level are expected to increase the frequency and intensity of these extreme events. Although this study does not explicitly account for changes in storm surge, we do account for higher flood elevations associated with extreme events, as described below in Section 2.3.

2.3. Expected Risk to the Coast

2.3.1. Coastal Inundation Risk

Sea-level rise increases the risk of flooding in low-lying areas. For this study, we considered coastal flood risks only, e.g., flooding caused by rising seas along the Pacific Ocean and San Francisco Bay. Higher sea levels, however, can also worsen flooding in nearby rivers as higher water surface elevations at the downstream end of a river causes water to back up and increase upstream flooding. These impacts are not evaluated here.

For the California coast, we used GIS to produce maps of the areas at risk of inundation from a 1.4 m sea-level rise. For the San Francisco Bay, we produced maps of the areas at risk of inundation under three different sea-level rise scenarios: 0.5 m, 1.0 m, and 1.4 m. Below, we describe the methods used to determine the areas at risk of flooding along the Pacific coast and in the San Francisco Bay. Erosion is discussed in Section 2.3.2.

Pacific Coast

A flood is often described by its recurrence interval, which is the period of time between floods of a particular intensity that is based on historic conditions for a given area. The terminology used to describe the recurrence interval, however, can be misleading and is often misinterpreted. A "100-year flood" does not refer to a flood level that occurs every 100 years. Rather, it refers to a flood that has a 1/100, or 1%, chance of occurring in any year. Thus, over a typical 30-year mortgage period, a 100-year flood has a 1-in-4 chance of occurring (see Box 2).

For the Pacific coast, we approximate the potential future flood impact by adding projected sea-level rise estimates to water levels associated with a 100-year flood event; that is, current flood elevations for the 100-year flood are increased by 1.4 meters, the projected increase in sea level by 2100 under the A2 scenario (Figure 3).

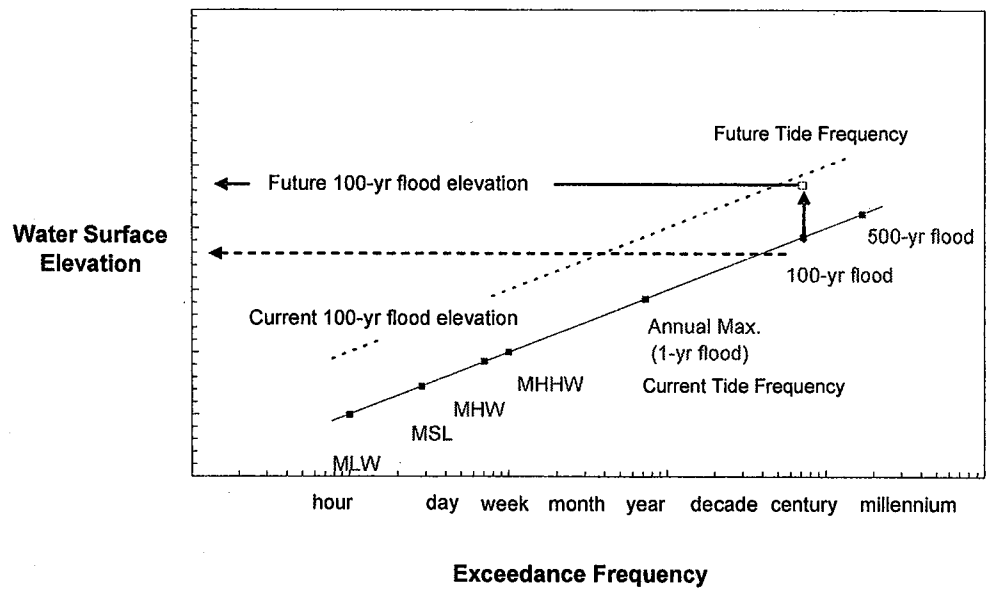


Figure 3. Determining future flood elevations

Note: The solid line represents the current tide frequency. The dotted line represents the future flood frequency. As can be seen, an increase in water surface elevation increases the frequency and intensity of flood events. For example, a 100-year flood event could become an annual flood event. The flood frequency estimates shown are for demonstration purposes only and are not based on actual data. See the Glossary for definitions of the abbreviations MLW, MSL, MHW, and MHHW.

This approach assumes that all tide datums, e.g., mean high tide and flood elevations, will increase by the same amount as mean sea level. There is some evidence that this assumption may not always hold true. Flick et al. (1999) found that in San Francisco, mean higher high water (MHHW) was increasing at a rate of 258 mm per century, while the mean sea level

increased at a lower rate of 217 mm per century (Figure 4). Thus, while the overall trend is one of rising seas, the intertidal range, i.e., the difference between MHHW and mean lower low water (MLLW), also seems to be widening. In addition, an increase in storminess due to climate change might cause more frequent storm surges and an increase in the frequency of high water events, although there is not yet consensus among climate scientists on changes in storm intensity or frequency, and such changes are not included here explicitly.

Box 2: Estimating Flood Risk

What are the chances that a 100-year flood will occur during a 30-year period?

To make this determination, we must apply basic probability theory. Flooding is a random event, i.e., the odds of it occurring in any year are independent of past conditions. Thus the odds of a storm not occurring over a 30-year period can be calculated using the following methodology.

If an event has an X percent chance of occurring in a given year, then the odds that the event will **not** occur in a given year are

$$1-X$$

The odds that an event will not occur in two successive years is

$$(1-X)(1-X) = (1-X)^2$$

And the odds of an event not occurring over y number of years is

$$(1-X)^y$$

Let's now calculate the odds that a 100-year flood event will not occur over 30 years.

In this case,

$$X = 1/100 = 0.01 \text{ and } y = 30$$

$$(1-X)^y = (1-0.01)^{30} = 0.74$$

Thus there is a 74% change that a 100-year storm will not occur over a 30-year period; and a 26%, or approximately a 1 in 4 chance that it will occur.

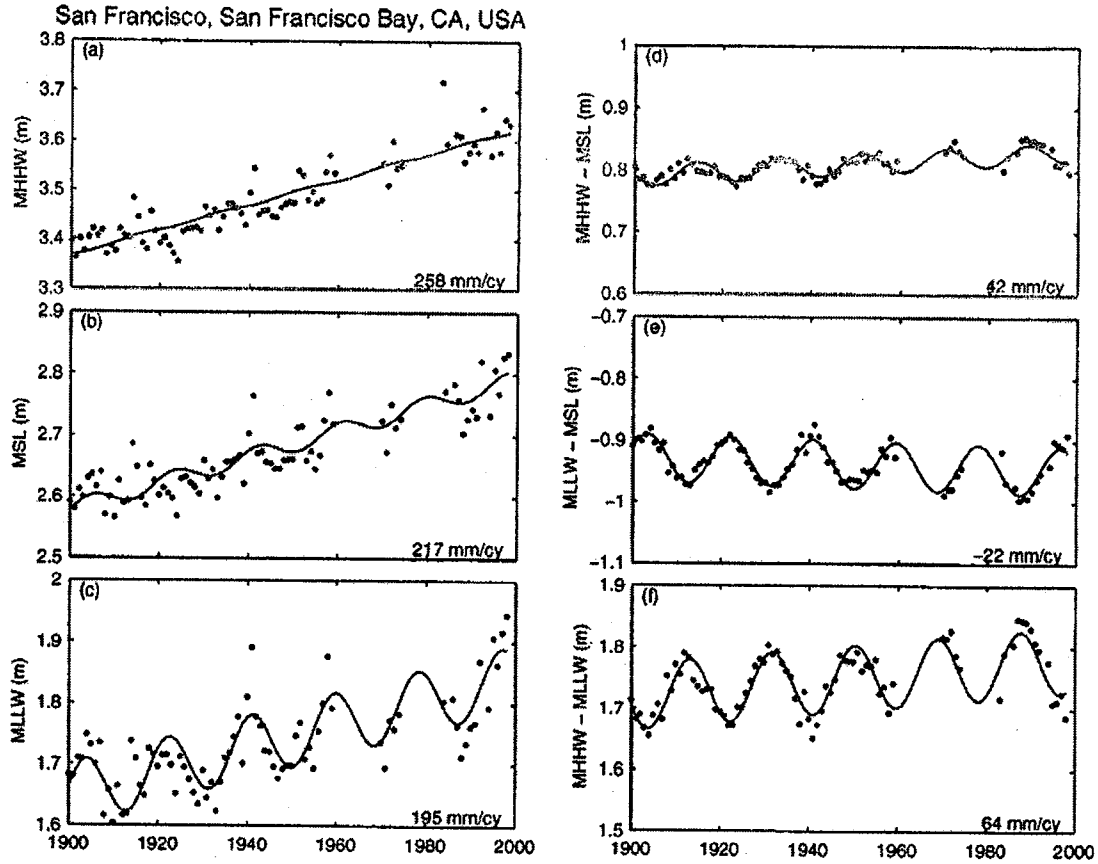


Figure 4. Rates of change of tidal datums, San Francisco from 1900–2000
Source: Flick et al. 1999

Existing flood levels were based on estimates of the 100-year flood elevation (also called the *base flood elevation* or BFE) from Flood Insurance Studies published by the Federal Emergency Management Agency (FEMA). The FEMA BFEs, however, only cover a part of the coast. We contracted with Philip Williams and Associates (PWA) to provide estimates of BFEs where none exist. Their work consisted of the following:

1. Compiled available coastal flood BFEs published by FEMA for the California coast.
2. Estimated BFEs where FEMA estimates are not available using professional judgment.
3. Converted elevations to the North American Vertical Datum of 1988 (NAVD88).
4. Adjusted elevations to nearest half foot based on observed sea-level rise to present day.

Further information on the methods used by PWA is available in a separate technical memorandum (Battalio et al. 2008).

We used automated mapping methods in GIS to delineate areas inundated by the current and future flood elevations. The key inputs to this analysis are digital elevation models (DEMs), gridded datasets that contain values representing elevations of the Earth's surface. We used the most accurate, high-resolution terrain data available. NOAA's Coastal Service Center assisted

us in processing and obtaining each of these data sets. The elevation datasets used for this project are summarized in Table 1.

For much of the Central and Northern California coast, high-accuracy Light Detection and Ranging (LIDAR) data were available from Airborne LIDAR Assessment of Coastal Erosion (ALACE) project, a partnership between NOAA, the National Aeronautics and Space Administration (NASA), and USGS. The ALACE project emphasized shoreline change, and so the data were available for a relatively narrow swath of the coast. The coverage did not always extend inland far enough to fully map the coastal floodplain. In addition, there were several gaps in coverage along the entire coast.

We supplemented the LIDAR data, filling in gaps in coverage with topographic information from the USGS National Elevation dataset. Although these data are at a lower resolution and accuracy, they allowed us to map the entire coast. For portions of the Southern California coast, Interferometric Synthetic Aperture Radar (IFSAR) data were available from NOAA. The IFSAR data are of coarser resolution than the LIDAR data described above (i.e., they are 3-meter pixel resolution compared to 2-meter resolution), and they have less vertical accuracy (i.e., ±2.2 m compared to ±0.07 m for the LIDAR data).

Table 1. Elevation datasets used for mapping coastal flood risks

Dataset	National Elevation Dataset	ALACE 1998	ALACE 2002	So. Cal. IFSAR
Source/Mission	USGS	NASA, NOAA, USGS	NASA, NOAA, USGS	NOAA
Geographic Coverage	National	Stinson Beach to Santa Barbara	Northern border of California to Stinson Beach	Santa Barbara to Mexican border
Data Collection Method	Various	LIDAR	LIDAR	IFSAR
Resolution	10 m	3 m	2 m	3 m
Year Collected	Various	1998	2002	2003
Stated Vertical Accuracy	± 7.5 m	± 0.07 m	± 0.07 m	± 2.2 m

GIS raster math tools were used to compare the elevation of land surfaces with the adjacent flood elevation to determine the extent of flooding. Because of the large file sizes, and the large area being studied, we worked with the terrain datasets in over 600 tiles. Pacific Institute researchers wrote scripts to automate the processing steps on each of these tiles. The resulting inundation grids were boundary-smoothed and small isolated ponds and islands were removed. The raster datasets were then converted to vector polygons and merged so they could be used in the social and economic analyses. A separate technical memorandum is available at www.pacinst.org/reports/sea_level_rise that describes the GIS flood delineation methodology in greater detail.

San Francisco Bay

While our study looks at the entire California coastline, we also produced more detailed estimates of coastal flood risk in San Francisco Bay. In total, we estimated impacts along approximately 1,100 miles of Pacific Coast from Oregon to Mexico, and an additional 1,000 miles inside of San Francisco Bay. Inundation maps generated from the climate scenarios were provided to the Pacific Institute by Dr. Noah Knowles of the United States Geological Survey (Knowles 2008). These estimates are described in Knowles 2009.

To estimate inundated areas in the Bay, "the highest resolution elevation data available were assembled from various sources and mosaicked to cover the land surfaces of the San Francisco Bay region. Next, to quantify high water levels throughout the Bay, a hydrodynamic model of the San Francisco Estuary was driven by a projection of hourly water levels at the Presidio. This projection was based on a combination of climate model outputs and empirical models and incorporates astronomical, storm surge, El Niño, and long-term sea level rise influences" (Knowles 2009). The Bay computer model simulates the water surface elevation for each hour from 2000–2009. Inputs to the model include both upstream inflows and downstream water surface elevations (Figure 5).

Dr. Knowles performed statistical analyses on the Bay model output to determine flood quantiles for various years and provided outputs in the form of GIS raster files to the Pacific Institute. These files were provided for five flood recurrence intervals (Table 2) for each of four years between 2000 and 2099, for a total of 20 files. Based on this information, we estimated risks due to inundation with a 0.5 m, 1.0 m, and 1.4 m sea-level rise, which for the A2 scenario correspond to 2050, 2081, and 2099, respectively.

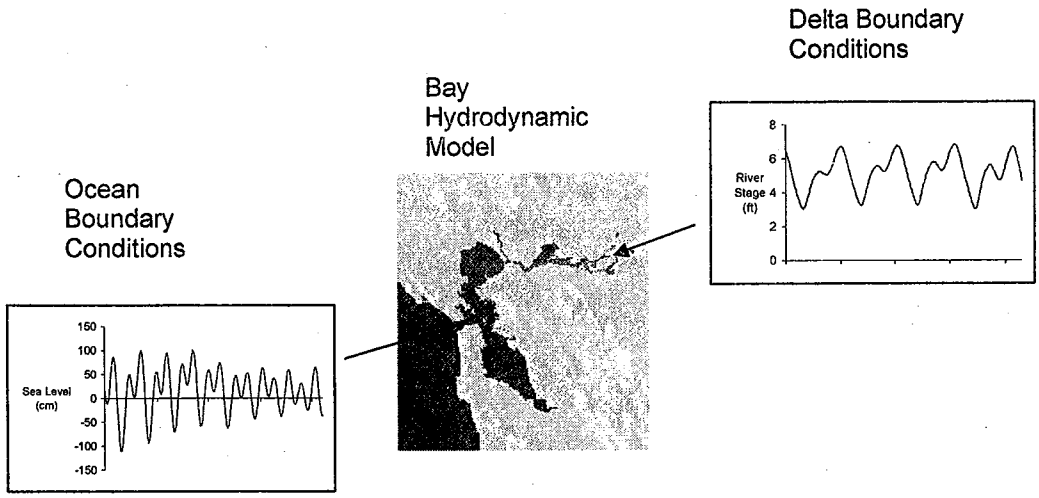


Figure 5. Simple schematic of USGS San Francisco Bay hydrodynamic model

It is important to note that we report results based on the vertical rise in sea level rather than a particular year in which the rise is projected to occur. As shown in Table 3, the year in which a 0.5 m sea-level rise is projected to occur under the A2 and B1 scenarios differs by only three years. Additionally, sea-level rise estimates are continuously updated as climate science advances and greenhouse gas emissions change over time. Indeed, carbon dioxide emissions in 2005 and 2006 were well above even the highest future emissions scenario, as shown in Figure 6 (Raupach et al. 2007). Because the results of this analysis are driven by sea levels and are not directly tied to any set of scenarios, the results of this study will be relevant even when climate projections change.

Table 2. Recurrence intervals of inundation estimates

Flood Interval	Annual probability
1-year	1
10-year	0.1
50-year	0.02
100-year	0.01
500-year	0.002

Table 3. Year and estimated mean sea-level for inundation estimates under the A2 and B1 scenarios

Mean Sea-Level Rise (m)	Year Reached	
	A2	B1
0	2000	2000
0.5	2054	2057
1.0	2083	2098
1.4	2100	2125

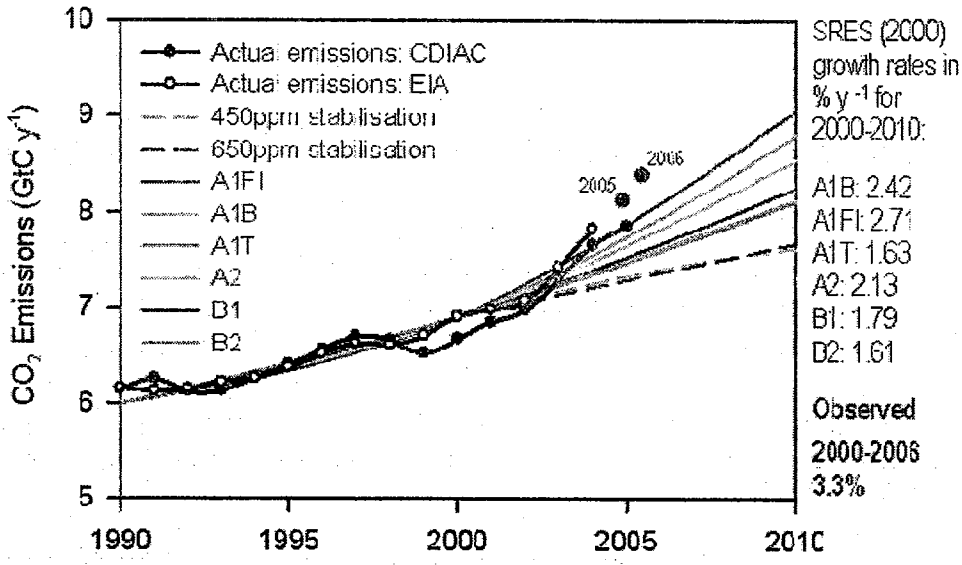


Figure 6. Historical and projected carbon dioxide emissions scenarios, 1990–2010

Note that actual emissions for 2004–2006 exceed the highest IPCC scenarios.

Source: Raupach et al. 2007

2.3.2. Erosion Risk

Large sections of the Pacific coast, especially those with rocky headlands or sea cliffs, are not vulnerable to flooding, but are highly susceptible to erosion. In areas where the coast erodes easily, higher sea levels are likely to accelerate shoreline erosion due to increased wave attack. In addition, erosion of some sand spits and dunes may expose previously protected areas to flooding.

The amount of erosion can be estimated by several methods. The most widely applied method of predicting shoreline recession based on a sea-level rise was developed by Bruun in 1962. This is based on the concept that the depth of water near the coast remains constant with sea-level rise, that the basic beach profile will remain the same, and that there is a well-defined offshore limit of sediment transport. The sediment required to maintain the beach profile through water-level changes is derived from erosion of the shore material. Based on this, an approximate estimate of the shoreline recession due to readjustment of the beach profile to an equilibrium state is 1.0-to-1.5 meters of shore recession per centimeter of sea-level rise.

Although once widely used, the Bruun rule has been largely abandoned because it makes several assumptions that may not be accurate (Pilkey and Cooper 2004). The formulation is based on a two-dimensional concept, while the sediment transport along a shoreline is a three-dimensional process. The Bruun rule assumes a shoreline profile in equilibrium, which is difficult to confirm at any site. Another problem is that this approach always predicts shoreline recession with offshore sediment transport as sea-level rises, yet there are several cases where shorelines have accreted as a result of sea-level rise due to the movement of sand onshore from offshore deposits. Depending on local sources and sinks of sediment, wave climate, topography, and other conditions governing sediment transport mechanisms, the predictions of shoreline

recession obtained using the Bruun rule can significantly over- or underestimate the future recession. More specific methods are needed for particular sites, and should be conducted to better evaluate the impact of sea-level rise on a given region.

A team of scientists and engineers at Philip Williams and Associates (PWA) developed an alternative approach to evaluate erosion risk. They evaluated potential future erosion by examining changes to a time series of total-water level (TWL) elevations. TWL is a water elevation determined by the sum of mean sea level, tides, waves and wave run-up, other storm components (including surge), and El Niño (Ruggiero et al. 1996; Ruggiero et al. 2001). Studies suggest that erosion will accelerate as sea levels rise and the coast is exposed to higher waves. Higher water levels result in greater wave energy being dissipated higher up on the shoreline and directly onto the face of cliffs and dunes. The exceedance of TWL above the elevation of the toe junction has been related to erosion (Sallenger et al. 2002; Ruggiero et al. 2001; Hampton and Griggs 2004; FEMA 2005).

To generate the TWL predictions, PWA used a 100-year time series of "measured tides" and deepwater waves from Dr. Dan Cayan and colleagues at Scripps (Cayan et al. 2009). The deepwater wave heights were transformed to 140 near-shore locations by the Coastal Data Information Program to account for differences in wave exposure and shoreline orientation. Finally wave run-up was calculated using the relationship between wave height, wave period, and beach slope (Stockdon et al. 2006). The combination of sea levels and wave run-up were evaluated over time to estimate future elevations of TWL, which were then intersected with the land elevations along 4,100 segments of the coast.

California's coastline is geologically and morphologically complex and each major geologic unit will exhibit differential response to rising sea levels. PWA classified the shoreline based on geologic formations and type, such as sea cliffs and dunes. For each type of coast, slightly different methods were used to project the response to rising seas. For sea cliffs, which accounted for 720 miles of the study area, erosion was estimated based on an acceleration of the historic erosion rate and a percent increase in TWL exceeding the elevation of the toe of the sea cliffs. The historic sea cliff erosion data were obtained from the USGS National Shoreline Change Assessment (Hapke and Reid 2007). The data were averaged by geologic unit with an additional factor of safety (two standard deviations) included to account for subtle changes in geology along the coast.

For the dune classified shorelines, which covered about 170 miles of the study area, erosion rates were based on the following information:

- Recession based on changes in TWL from sea level-rise.
- Historic shoreline change trends from the USGS National Shoreline Change Assessment (Hapke et al. 2006).
- The impact of a "100-year storm event" extracted from the TWL time series and estimated using a storm-response geometric model of dune erosion (Komar et al. 1999).

Based on this approach, PWA developed digital GIS shapefiles representing future coastal erosion hazard zones for cliff-backed and dune-backed coastal areas for 2025, 2050, and 2100 under a low (1.0 m) and a high (1.4 m) sea-level rise scenario. For this analysis, we evaluate the socio-economic impacts of erosion under the 1.4 m sea-level rise scenario for 2100. Note that for erosion, the year is important because it includes a background erosion rate plus accelerated erosion rates resulting from sea-level rise.

The study area of the erosion analysis extended from Santa Barbara to the Oregon border, covering about 930 miles (1,450 km). Much of the Southern California coast was excluded due to the myriad of ongoing initiatives focused on climate change and hazards mapping. Due to insufficient data, however, PWA was only able to include 80% of the 930 mile study area (see Section 2.4 for additional discussion of the limitations).

The erosion analysis represents a first-order evaluation of coastal hazards based on currently available projections of water levels and wave conditions and interpretations of sea-level rise, shoreline change rates, and geomorphic conditions. Available methods and data are not sufficient to model coastal erosion with high confidence. While the methodology used to develop the hazard zones was kept relatively simple and modular to facilitate understanding and future application with minimal effort, it represents one of the most comprehensive erosion hazard assessments under conditions of climate change ever completed for the California coast. For additional information, see PWA (2008).

2.3.3. Limitations of the Analysis

Researchers at Scripps Institution of Oceanography and USGS performed hydrographic modeling of the San Francisco Bay Estuary to determine the flood elevations under climate change scenarios. All models are subject to errors and inaccuracies. It was not possible to directly calibrate or verify a model that predicts flood frequencies. We performed an independent evaluation of USGS-predicted San Francisco Bay flood elevations and found that the model estimates of the 100-year water surface elevation for the year 2000 were generally similar to flood elevations predicted by the U.S. Army Corps of Engineers (USACE 1984a). We compared all 52 points on the San Francisco Bay shoreline shown on the 1984 Corps maps and found that 75% of the flood elevations were within 0.25 feet of those predicted by USGS. Most of the new estimates were slightly lower than the heights estimated by the Corps, as shown in Figure 7.

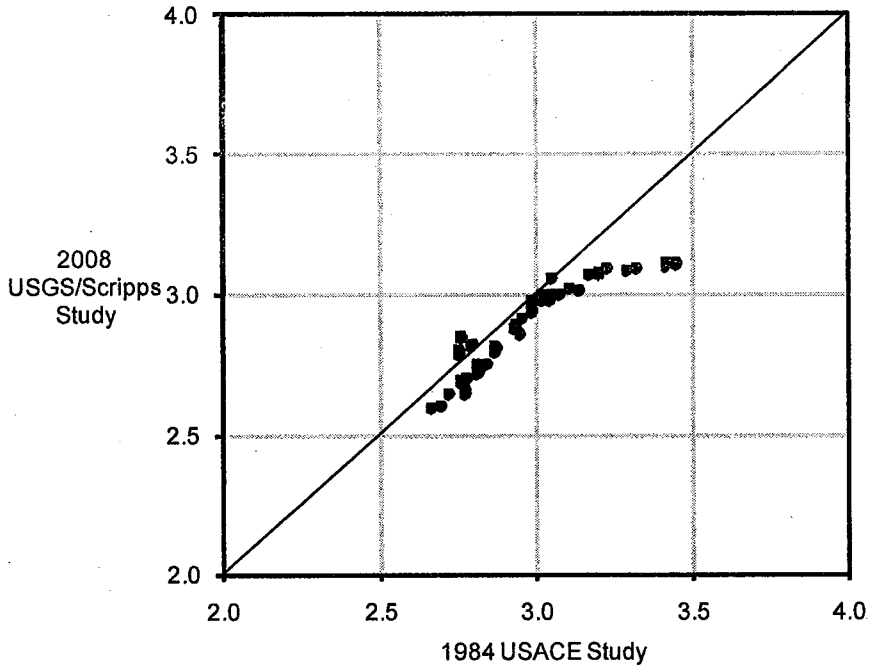


Figure 7. Comparison of 100-year flood elevations (in meters NAVD88)

The location of the shoreline is inexact and probably subjective. Knowles used a "mask" of open water as a filter, so as to report only land areas that are flooded. However, the shoreline is constantly in flux and difficult to map precisely. Further, there are errors and inaccuracies in the terrain data. The digital terrain model creates a smoothed or average surface from the raw elevation data, and it does not accurately depict breaks in elevation that occur at a vertical wall such as a cliff or a curb.

Another limitation is that the automatic, computerized method classifies flooding by depth only. The algorithm using depth alone to determine flooding does not factor in the presence of a flow pathway. In some cases, the high ground may be a levee specifically designed to protect adjacent low-lying areas. In other locations, there are simply depressions, but they are not really at risk because there is no path for seawater to flow into them. This means low-lying objects or features such as ditches, stormwater detention basins, subway tunnels, and empty swimming pools are filled in inappropriately at times, as shown in Figure 8.

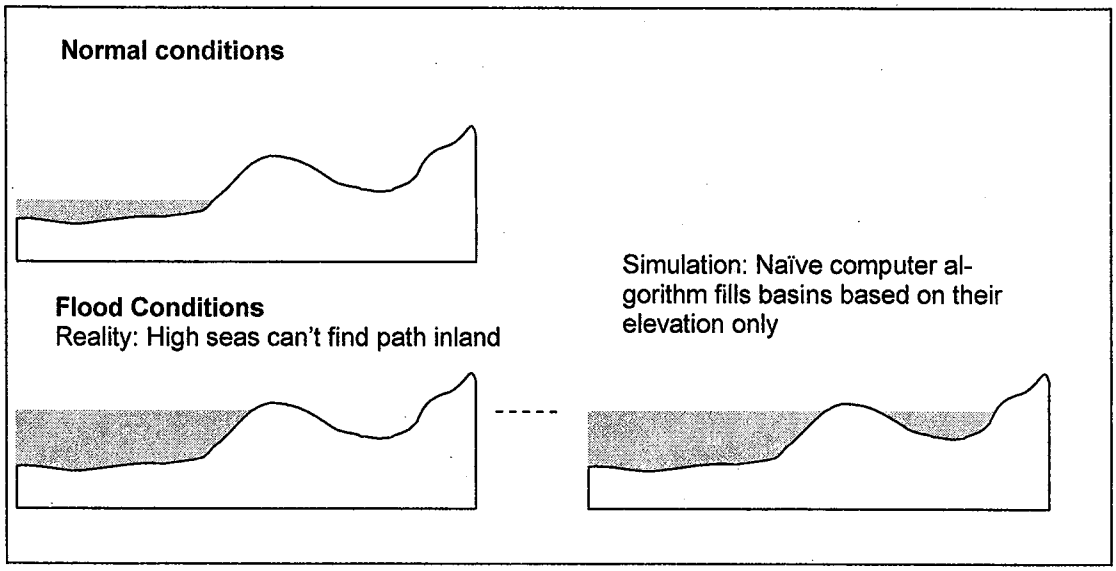


Figure 8. Limitations of the computer's ability to accurately map coastal flooding in areas protected by seawalls or levees or natural barriers

The study area for the erosion analysis was constrained by data availability. The erosion analysis covered only the 11 counties north of Santa Barbara County. Furthermore, data limitations limited the analysis to only 81% of the coast in the 11 counties (Table 4). The three counties with the least coverage include Humboldt County, Monterey, and Santa Barbara. Humboldt County included the Kings Range and the Lost Coast, public lands with no development. The Monterey County analysis was limited along the Big Sur coast where high levels of erosion currently affect the major transportation corridor of Highway 1 and are expected to continue. In Santa Barbara, missing data along the region between Pt. Conception and Goleta and the ending of the erosion analysis south of Santa Barbara harbor explain the missing erosion analysis. As a result, the vulnerability assessments underestimate the actual economic impact from erosion. Note that the flood analysis covered the entire Pacific coast of California and results for the erosion analysis were not adjusted to account for missing segments of the coast.

Table 4. Miles and fraction of coastline studied for the erosion hazard study, by county

County	Studied	Total	% Studied
Del Norte	42.7	49.7	86
Humboldt	72.9	123.3	59
Marin	69.5	75.2	93
Mendocino	145.5	151.4	96
Monterey	94.4	132.0	71
San Francisco	7.5	8.8	85
San Luis Obispo	77.0	102.6	75
San Mateo	57.8	59.6	97
Santa Barbara	84.4	116.5	72
Santa Cruz	46.0	46.0	100
Sonoma	63.0	68.9	91
Total	**760.7**	**934.1**	**81**

2.4. Resources Threatened by Sea-Level Rise

In any given area, rising seas pose a threat to many different types of resources. Among the vulnerable coastal systems are transportation facilities such as roadways, airports, bridges, and mass transit systems; electric utility systems and power plants; stormwater systems and wastewater treatment plants and outfalls; groundwater aquifers; wetlands and fisheries; and many other human and natural systems from homes to schools, hospitals, and industry. Any impacts on resources within the affected area may lead to secondary impacts elsewhere. Determining the types of resources threatened by sea-level rise is a crucial step toward choosing an appropriate level of response and method of protection.

2.4.1. Population

Sea-level rise and increased coastal flooding will lead to disruption due to evacuations, displacement from destruction of homes and property, and possibly the loss of lives. To determine populations at risk if no adaptation actions are taken, we overlay the inundation and erosion hazard maps with year 2000 census block data. We use current population data aggregated by census block, the highest resolution available for California. We make an assumption common in regional GIS analyses that the population is distributed evenly within a block's boundaries. So if our mapping shows that 50% of a 500-person census block is inundated by a flood, we estimate that 250 people are at risk. This method may underestimate (where the houses are clustered on the coast) or overestimate (when the houses are set back from the coast) the actual risk.

While disasters do not discriminate, the existing societal and environmental conditions before, during, and after a disaster produce differences in vulnerability among groups within the population affected.

It is critical to understand that our estimates of populations at risk are based on current population data, not a projection of populations that might be at risk in the future. If no policies are put in place to limit new exposure in areas at risk of rising seas, our estimates will be low—perhaps substantially low. If, however, policymakers are proactive about reducing coastal risks in coming decades, the levels of risk could be substantially reduced.

We also evaluate potential environmental justice impacts of sea-level rise.[6] As seen during Hurricane Katrina, flooding and other natural disasters often do the greatest harm to low-income communities and communities of color. Hurricane Audrey, for example, struck the coast of Louisiana in 1957 and had a death rate of 38 per thousand among whites and 322 per thousand among blacks (Bates et al. 1963, cited in Pastor et al. 2006). A study of all U.S. disasters between 1970 and 1980 found that white households had $2,370 less of a financial burden following a disaster than other racial groups (Rossi et al. 1983). One year after Hurricane Katrina, the black population of New Orleans had decreased 57% while the white population had fallen 36% (Frey 2007). Racial disparities are mirrored in economic disparities where low-income communities have shouldered a disproportionate burden of harm resulting from disasters: reports following Hurricanes Hugo and Katrina pointed to a range of problems related to the "invisibility" of low-income communities before the disasters (Pastor et al. 2006).

The uneven distribution of the harms of natural disasters highlights the same racial and economic inequities present in the distribution of other environmental risks and benefits, which in the 1980s catalyzed affected communities to develop the framework of "environmental justice." This framework was ultimately affirmed by the United States Environmental Protection Agency (U.S. EPA) in its 1992 creation of what is now called the Office of Environmental Justice, which holds that

> "no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal environmental programs" (U.S. EPA).

Presidential Order 12898 of 1994 expanded the application of environmental justice principles in its decree that "each Federal agency shall make achieving environmental justice part of its mission" (Presidential Executive Order 12898).

We use the environmental justice framework in two analyses that are relevant to understanding the full costs of sea-level rise in California. The first is a simple analysis looking for potential inequities in who is likely to be directly exposed to sea-level rise, within the geographic units at which relevant political decisions are made. In this case these geographic units include the state of California as a whole and each county affected by sea-level rise. We urge further studies looking at possible inequities at different spatial scales, e.g., within cities, neighborhoods, and metropolitan regions. Our second environmental justice analysis focuses on the factors of

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[6] Here, we evaluate the environmental justice impacts of flooding but not erosion. Additional analysis should examine erosion as well.

vulnerability and the differential vulnerability to the impacts of sea-level rise of people from different demographic groups.

A third analysis, which is beyond the scope of this study, should focus on potential inequities in the distribution of the resources invested to protect and adapt to sea-level rise. Here we focus on completing a part of the first and second analyses, and leave the third analysis for future studies.

Any analysis of populations affected by sea-level rise should include a broader discussion of vulnerability to these events. According to the IPCC, "Vulnerability to climate change is the degree to which these systems are susceptible to, and unable to cope with, adverse impacts" (Schneider et al. 2007). Vulnerability is a function of the magnitude of the impact, the sensitivity of the system to that impact, and the system's ability to adapt. Vulnerabilities, like lack of access to a vehicle or other means of transportation, are shaped by "intervening conditions" that are not tied to a specific hazard but will greatly determine the human impact of the disaster and the specific needs for preparedness, response, and recovery (Hewitt 1997).

Here, we report key population characteristics that increase vulnerability to the adverse impacts of flood events and disasters for low-income people and communities of color. We sort the types of vulnerabilities and key demographics correlated with increased vulnerability, according to the three phases of a disaster event: preconditions, disaster, and recovery and reconstruction (Hewitt 1997). Figure 9 offers a conceptual model of the relationship between demographics, vulnerabilities, and human impact. Our analysis is limited to two factors: the distribution of race and income. A more comprehensive analysis of the human impact of sea-level rise is needed for all vulnerable subgroups, including children, elderly, homeless, and incarcerated residents.

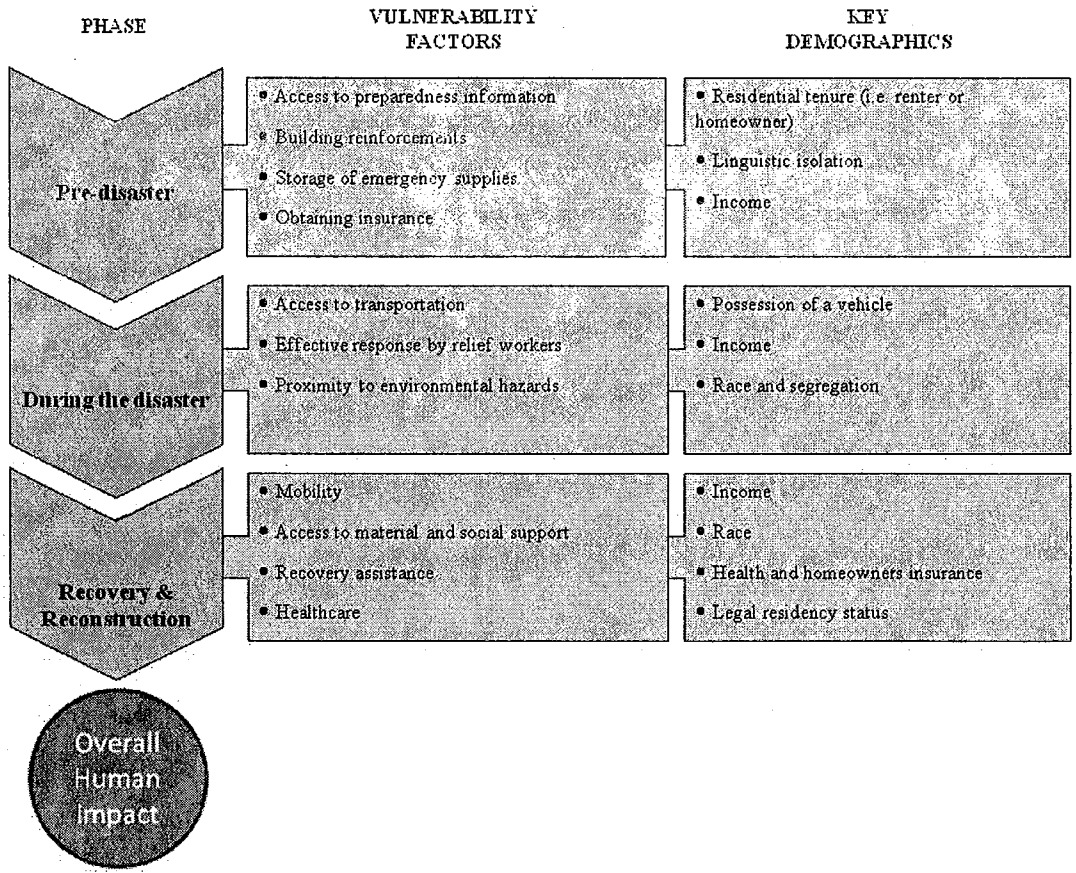


Figure 9. Relationship between demographics and vulnerabilities

2.4.2. Impacts on the Built Environment

Extensive development has occurred in areas already threatened by erosion and floods along the California coast. Residential homes along the California coast often draw a premium price as a result of their location. Some homes in coastal zones are protected by levees and revetments; many are not protected at all. Additionally, high-value commercial, industrial, and transportation facilities are also located along the coast. Such facilities make use of the waterfront for waste disposal, movement of goods or people, or commercial activities. Among the most common coastal facilities are airports, railroad tracks and terminals, highways, power plants, waste-disposal sites, waste-treatment plants, ports and docks, warehouses, salt ponds, and marinas. Existing forms of protection for these facilities vary greatly, from bulkheads and engineered seawalls to riprap and non-engineered levees. An increase in sea level will increase the severity of possible damages in threatened areas and will expand the size of flood and erosion zones.

Data on the replacement value of buildings and contents were taken from datasets supplied with the HAZUS model, which was developed for FEMA's Mitigation Division by the National Institute of Building Sciences. HAZUS was designed to help planners estimate the potential

losses from natural disasters such as earthquakes, floods, and hurricane winds. HAZUS uses a database called the "General Building Stock Inventory" that contains the value of buildings and contents based on data from a number of sources including the U.S. Census Bureau, Dun & Bradstreet (a business listing service), and the U.S. Department of Energy. HAZUS estimates direct economic losses based on the repair and replacement of damaged or destroyed buildings and their contents, and includes the following:

- Cost of repair and replacement of damaged and destroyed buildings
- Cost of damage to building contents
- Losses of building inventory (contents related to business activities)

Replacement values are provided for residential, commercial, industrial, agricultural, religious, governmental, and educational developments and are compiled at the census block level. See Section 14.2 of the HAZUS technical manual for additional detail (FEMA 2006). To determine the replacement value for the areas at risk, we overlay the inundation maps with year 2000 census block data. We assume that if 50% of an area is affected, then 50% of its assets are at risk. For inundation risks, we use replacement value, as described in more detail below, because flooding does not usually destroy property and land value completely. In contrast, erosion often completely destroys the property. As a result, replacement value is not appropriate for evaluating the economic cost of erosion and was not used for that part of the study. For the erosion analysis, we assume that the value of the average coastal property is about $1.4 million (Heinz Center 2000).

We compared replacement costs and the market value of homes at a few locations along the California coast and found that the replacement costs in HAZUS can substantially underestimate actual market values for residential properties. According to the HAZUS database, the median home replacement values range from $63,000 in Del Norte County to $135,000 in San Mateo County (Figure 10). In comparison, the median home price in California was $286,000 in November 2008. In Northern California, the median price was $307,000, and in the San Francisco Bay Area, the median price was $474,000. Of course, homes on the coast are usually much more expensive.

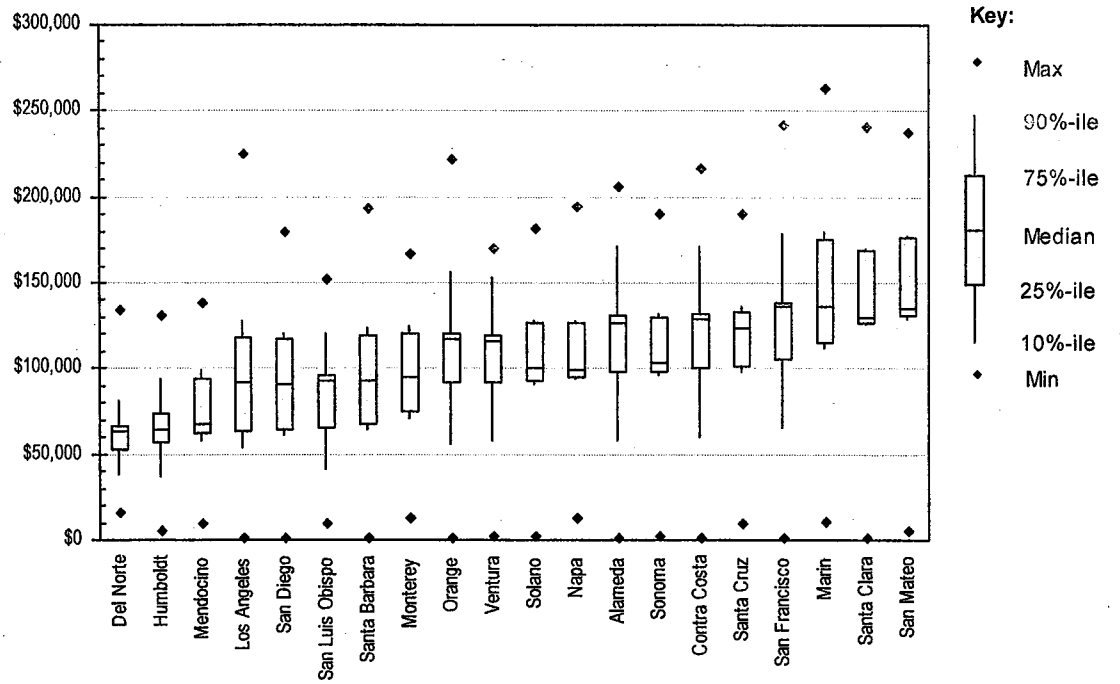


Figure 10. Distribution of census-block average replacement costs for single-family homes from HAZUS

The difference between the replacement value and the market value of a home is likely due to several factors. Home values are determined by more than the cost to build the house, including land value, neighborhood, school district, and dozens of other tangible and intangible factors. In addition, the HAZUS documentation warns that replacement value is based on national-average construction costs, which are much lower than construction costs in California. Future studies should include more detailed estimates of California construction costs.

Parcel data from each county assessor's office provide higher spatial resolution, but there are some significant limitations to using these data. First, we were unable to obtain complete coverage for all coastal counties. In some counties, parcel data have not been converted to a digital format, while others claimed that sharing these data was a threat to Homeland Security. Second, even where parcel boundary files are available, these must be linked to the value of the property. While obtaining a list of affected parcels is straightforward, most counties do not readily share their tax rolls or tables with assessed value. This information is part of the public record, and can legally be requested in person or by phone from a county assessor's office, but this approach is not feasible for a regional analysis where hundreds or thousands of parcels are affected. Third, even if assessed value were readily available to us, it often bears little relationship with the actual market value of a property. Finally, assessed value will not include any publicly owned buildings, so it would exclude many police and fire stations, government buildings, park buildings, schools, water treatment plants, and others.

Important transportation infrastructure is also at risk of flooding and erosion from projected increases in sea-level rise (Figure 11). We estimate the miles of roadways and railroads at risk by overlaying the GIS inundation and erosion hazard layers with transportation data from Tele Atlas. We note that because there are not elevations associated with the roadways, it is difficult to infer the extent to which the roadway is at risk from flooding. Additionally, the railroad data do not provide information on the number of tracks, e.g., single, double. We also do not provide estimates of the value of this infrastructure because adequate data are not available. Thus, the information on roads and railways is presented as miles of structures at risk rather than value, but it provides an indication of the areas at risk and those warranting additional analysis.

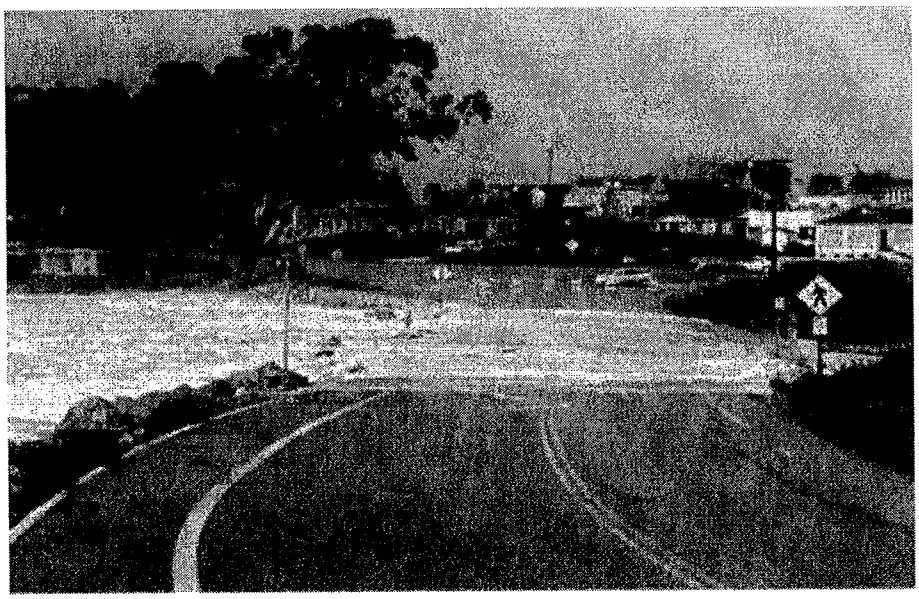


Figure 11. Flooding of a coastal road in Santa Cruz, California

Photo courtesy of David L. Revell

A number of other facilities along the coast are also at risk of flooding and erosion. We evaluate the sites and facilities at risk by overlaying the GIS inundation layer with the relevant spatial data. Data on the locations of schools and emergency facilities come from the HAZUS geographic database (FEMA 2006). Data on licensed healthcare facilities come from the California Office of Statewide Health Planning and Development (2006). Data on coastal power plants were provided by the California Energy Commission.

Data on U.S. EPA-monitored hazardous materials sites were from the U.S. EPA Geospatial Data Access Project 2008 and included Superfund sites, hazardous waste generators, facilities required to report emissions for the Toxics Release Inventory, facilities regulated under the National Pollutant Discharge Elimination System (NPDES), major dischargers of air pollutants with Title V permits, and brownfield properties.[7] The Pacific Institute developed a geographic database of wastewater treatment plants based on data in the U.S. EPA's Permit Compliance System (PCS) database, by interpreting aerial photos and by telephone and Internet research.

2.4.3. Natural Resources

Wetlands are among the Earth's most productive ecosystems. Once abundant across the United States, wetlands have been extensively drained and filled to make way for agricultural, industrial, commercial, and residential development. Pollution and invasive species threaten the health of the remaining areas. The U.S. EPA estimates that more than 220 million acres of wetlands existed in the lower 48 states in the 1600s. By 2000, only 100 million acres of wetlands remained (U.S. EPA 2001). In some parts of the United States, wetland loss was even more severe. In California, for example, more than 90% of the historic wetlands have been lost to development. Growing recognition of their importance and concern about their rapid decline has prompted wetland restoration efforts across the United States, including the San Francisco Bay. A recent U.S. Fish and Wildlife Service report suggests that the net wetland acreage actually increased between 1998 and 2004 for the first time as a result of restoration efforts and the construction of engineered wetlands (Dahl 2006).

While legislation has helped to protect wetlands from further destruction, rising seas threaten to substantially modify or destroy remaining wetland habitat. Most coastal wetlands in the United States are within one tidal range of mean sea level (Titus 1988), i.e., between mean high tide and mean low tide. Thus, as noted by Titus (1988), if sea levels rose by one tidal range overnight, "then all of the existing wetlands in an area would drown." Rising seas, however, may also inundate land that is now dry, thereby creating new wetlands. Wetlands may also be able to adapt to rising water levels over time by trapping sediment or building on the peat the sediment creates, a process referred to as vertical accretion. These compensatory mechanisms may be hindered by coastal development that limits wetland migration or rates of sea-level rise that exceed natural accretion rates.

Spatial Extent of Wetlands

In this analysis, we use GIS data from the National Wetlands Inventory (NWI) to determine the current spatial extent of wetlands along the California coast and the San Francisco Bay. While there is currently no single source that contains the boundaries of all existing wetlands, the NWI is the best dataset available. It is important to note that all datasets likely underestimate the actual wetland area. Wetland delineation is a time- and labor-intensive task requiring extensive field work by experts; vast areas have never been subject to detailed study.

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[7] A *brownfield* is an abandoned industrial site available for redevelopment, often with environmental contamination.

The NWI does not make a clear distinction between coastal and upland wetlands. The datasets are distributed in tiles, with each tile containing a mix of marine, estuarine, and freshwater wetlands. We used a simple rule-based approach to decide which wetlands are coastal, or "coast-dependent"" we assume that coastal wetlands are generally limited to within 100 feet (horizontally) of the mean higher-high water line (Figure 12).

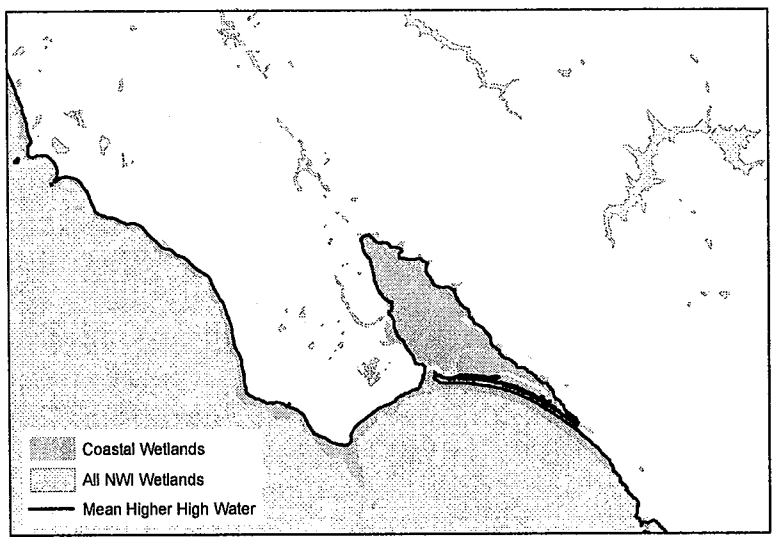


Figure 12. National Wetlands Inventory wetlands classified as "coastal" are below or adjacent to the MHHW line

Economic Value of Wetlands

Wetlands are highly diverse ecosystems that provide a variety of goods and services, including flood protection, water purification, wildlife habitat, recreational opportunities, and carbon sequestration. While there are rarely any direct market values for services provided by wetlands, such as biodiversity and flood control, there is a growing recognition that these services have real economic values and should be included in decision-making processes.

Methods for estimating the economic value of an ecosystem, including wetlands, can be done in one of three ways: direct, indirect, and proxy (Table 5). Each of these methods has strengths and weaknesses; each fails to fully capture the value of ecosystems. The unacceptable alternative, however, is to assign an economic value of $0—clearly acknowledged to be wrong. To put it simply, "we don't protect what we don't value" (Myers and Reichert 1997).

In recent years, a number of studies have attempted to estimate the economic value of wetlands. Based on a literature review and some original calculations, Costanza et al. (1997) estimate that the value of tidal marshes is around $5,700 per acre per year (in year 2007 dollars). In a meta-analysis of 39 wetland valuation studies, Woodward and Wui (2001) found that wetland values varied considerably according to the methods used, the type and location of wetlands evaluated, and the study characteristics. While the valuation method affected the value

obtained, the method was not the primary determinant of value. However, study quality was not a strong determinant either; weak studies yielded wetland values similar to strong studies, but with more error, suggesting that the quality of the study affects precision. The authors conclude: "From our analysis it is clear that the prediction of a wetland's value based on previous studies is, at best, an imprecise science. The need for site-specific studies remains" (Woodward and Wui 2001).

For this analysis, we estimate the economic value of wetlands in California using recent cost estimates for restoring wetlands. Numerous wetland restoration projects have been initiated in the San Francisco Bay, with the cost of restoring these tidal marshes ranging from $5,000 to $200,000 per acre (Hutzel 2008). The South Bay wetland restoration project, for example, is estimated to cost about $67,000 per acre (Hutzel 2008). We note that these estimates represent the public's willingness to pay for these ecosystems rather than their actual value, but without a more detailed site-specific analysis, the restoration costs are the best estimates available. We do not evaluate the ability of wetlands to adapt to these changes through vertical accretion or landward migration, but note that these processes could reduce damage to wetlands. We urge more detailed wetland valuation studies be conducted to improve these estimates.

Table 5. Approaches for estimating ecosystem values

Approaches	Description	Example	Weaknesses	Strengths
Direct	Surveys can be used to ascertain people's willingness to pay for benefits provided by the wetland or the level of compensation they would expect for the loss of those benefits. Such surveys measure the value of specific benefits.	A survey that asks users what they would be willing to pay to retain a recreational area.	This approach requires sophisticated survey design, analysis and interpretation.	This approach can measure relatively subtle changes in value and can also be used to calculate the value of non-use benefits.
Indirect	Economists use mathematical models to estimate wetland values based on the market demand for related goods and services.	Expenditures and the distance traveled by people visiting a wetland are used as indicators of the value of the wetland for recreational purposes. Similarly, real-estate price differences could be used to estimate the value of the wetland's aesthetic benefits.	This approach cannot measure non-use benefits (e.g., option or bequest benefits) or benefits that do not currently exist (e.g., the benefits of an enlarged wetland).	This approach is usually faster and less expensive, as it can be based on easily accessible data.
Proxy	The values of other goods and services are used to approximate the values of wetland benefits.	The replacement cost for a wetland benefit (e.g., water filtration), such as the cost of installing a buffer strip or building a water treatment plant, is used as a measure of the value of the benefit.	This approach may confuse costs and benefits. For example, using the cost of a water treatment plant estimates the cost rather than the value of water filtration, (i.e., people's willingness to pay for clean water).	This approach can be more quickly calculated, but the result is only a very rough estimate of value.

Source: Environment Canada 2001

Impact of Sea-Level Rise on Wetlands

Evaluating the impacts of sea-level rise on a particular coastal wetland area requires site-specific data on various physical and biological factors, as described above. While this information is clearly important for developing adaptation strategies, it is beyond the scope of this analysis. A simple method to estimate wetland loss is to compare wetland elevations to future tide elevations. If the areas are permanently inundated in the future, they will be converted to open

water and lose their value as wetland habitat. Data limitations, however, prevent us from performing even this simple analysis: the existing digital elevation models (DEMs) do not include data below the shoreline and the modeled mean lower low water mark, even with 1.4 m of sea-level rise, falls below this elevation. This means there are no data in the critical area where the boundary must be drawn. We recommend additional work in this area to create a DEM for the California coast that combines land surface elevations with accurate bathymetry to allow for more detailed study of potential wetland responses to sea-level rise. Given these data limitations, we evaluate the land cover *adjacent* to existing wetlands and the potential for these areas to support suitable wetland habitat. We note that this simplified analysis does not take into account erosion or accretion due to sediment movement, which is difficult to predict with any accuracy.

Wetlands exist in areas that are frequently, but not permanently, inundated. In *The Effects of Sea Level Rise on US Coastal Wetlands*, Park et al. (1989) assumed that all areas between mean lower water (MLW) and mean higher water springs (MHWS) are tidal wetlands (Figure 13). The MHWS is only a few centimeters from the mean higher high water (MHHW) datum, which is more readily calculated and tabulated in tide reports. We assume that wetlands will migrate to land areas that are below the future MHHW, which we estimate as current MHHW plus the projected 1.4 m sea-level rise.

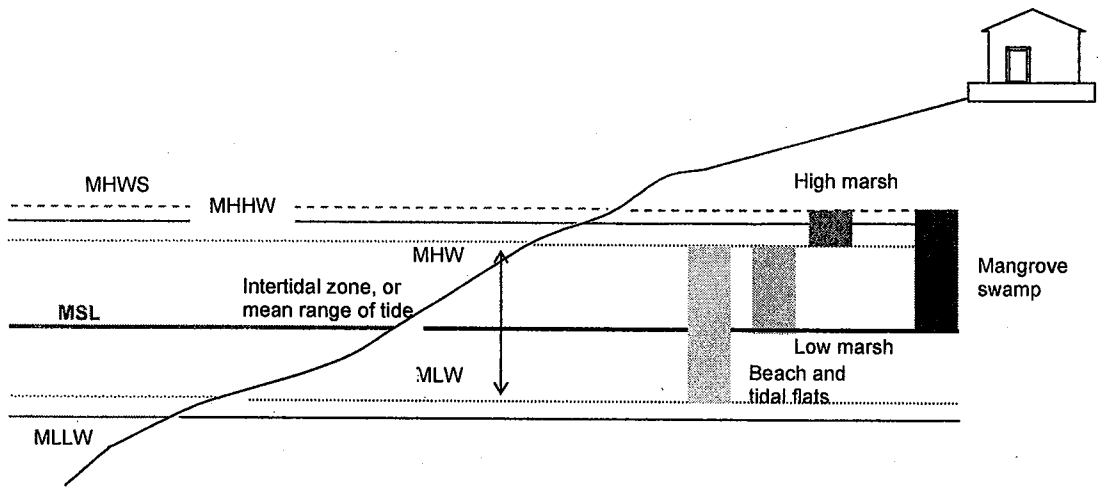


Figure 13. Assumed wetland area defined by the intertidal range

Adapted from Park et al. 1989.

The National Oceanic and Atmospheric Administration maintains tide stations along the California coast that provide measurements of MHHW. We interpolated the high-water elevation for the entire California Pacific coast using data from 12 long-term coastal tide gages. Each of these NOAA tide stations has been in continuous operation for over 25 years. The MHHW elevation for each of these stations is listed in Table 6. Using spatial interpolation tools

available in ArcGIS software, we developed a continuous grid or "surface" of MHHW elevations in year 2000.[8] To estimate MHHW elevations with a 1.4 m sea-level rise for the Pacific coast of California, we created a second surface by adding 1.4 m to each pixel in the year 2000 MHHW surface. The difference between the high water lines is the "wetland migration zone": the land into which wetlands must migrate to survive.

Table 6. Mean higher high water (MHHW) for long-term tide stations on California's Pacific coast

NOAA Station ID	Station Name	MHHW
9410170	San Diego, CA	1.61
9410230	La Jolla, CA	1.57
9410660	Los Angeles, CA	1.61
9410840	Santa Monica, CA	1.60
9411340	Santa Barbara, CA	1.61
9412110	Port San Luis, CA	1.60
9413450	Monterey, CA	1.67
9414290	San Francisco, CA	1.80
9415020	Point Reyes, CA	1.75
9416841	Arena Cove, CA	1.76
9418767	North Spit, CA	1.99
9419750	Crescent City, CA	1.98

Note: Elevations in meters above NAVD88 vertical datum. Tide datums calculated by NOAA for the 1983–2001 epoch.

Source: http://tidesandcurrents.noaa.gov/

We analyzed the land cover in the potential wetland migration zone using 2001 land cover data from NOAA's Coastal Change Analysis Program (C-CAP).[9] We rated each land cover type according to its suitability to support wetland habitat in the future. We assume that natural lands such as woodland, grassland, or shrub could provide suitable habitat for wetland plants and animals in the future when they are in the new intertidal zone and are intermittently wetted. Other land cover types may be viable for conversion to wetlands, but at a loss of some direct value to humans, e.g., farmland or parks. The third and final category represents built-up

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[8] In some areas of Southern California, however, the available digital terrain data were not sufficiently detailed to complete the analysis. The terrain data do not include points below an elevation of 1.5 m NAVD88, and we could not map the current MHHW inundation extent for the entire coast. We mapped about 49% of Santa Barbara County, 23% of Los Angeles County, and 65% of Orange County. The coverage was 100% in the other 11 counties on the Pacific coast.

[9] The C-CAP data layer classifies land cover based on an adapted version of the Anderson et al. (1976) classification scheme and is estimated to have an accuracy of 85% (NOAA Land Cover Analysis website www.csc.noaa.gov/crs/lca/ccap.html).

areas that will likely provide unsuitable habitat for wetlands in the future due to the presence of buildings and other paved areas.

2.4.4. Limitations

Our analysis also has limitations related to the economic valuation methodology. For the flood analysis, we estimate the economic cost of sea-level rise based on estimates of the replacement value of buildings and their contents. We do not include estimates of the property or land value, which are much higher and should be included if inundation is permanent or leads the abandonment of property. Replacement values are also not appropriate for estimating the cost of erosion because it typically results in the total loss of property and land. We make a rough estimate of land values along the coast but note that additional study is needed.

Flooding and erosion can cause serious economic and social disruptions that are not captured in estimates of the buildings and infrastructure. For example, flooding events can cause deaths and injuries. Flooding or erosion of a major highway can prevent people from getting to work. Thus, estimating the replacement value and even some wetland values substantially underestimates the total cost of flood impacts and as a result, our findings should be considered conservative. A more detailed analysis would include transportation risks, lost work days, health issues, impacts on migratory bird habitat, and others.

We also do not factor in any expected changes in population density or the level of development in the regions at risk over the next century: these are largely unknown and will be determined by future policies. If policies are put in place to reduce development in regions of future flooding, society could over time reduce the risks. While limiting coastal development (an institutional adaptation) is likely the most effective way to reduce risk, this approach can also incur costs. Development permits designed to provide flexibility for future generations to address sea-level rise (e.g., development permits that allow development but stipulate that the area reverts to nature if seas rise a specified amount) may reduce today's cost. Conversely, if current development in coastal areas continues unchecked, a far larger population and far more infrastructure will be vulnerable than at present. We make no estimates of these changes, but future research could look at different scenarios for growth and coastal development and integrate them into the assessment tools developed here.

2.5. Determine the Protective Responses Appropriate for the Region

Each of the resources and facilities described in Section 2.4 can be protected by some combination of structural and non-structural measures. Some of the possible structural measures include building or improving coastal defenses such as dikes and dunes, seawalls, bulkheads, and other structures. Non-structural measures include abandoning property and land and moving to less threatened areas and beach nourishment. Perhaps the most effective non-structural response is to prohibit development in regions likely to be threatened in the future. This choice, however, requires the most forethought and planning. Below, we describe some of the structural measures and their associated costs.

2.5.1. Structural Coastal Protection Measures

Beach Nourishment

The addition of beach sand to a shoreline has been used to construct beaches where none had previously existed and to replenish eroded sand. As a response to the expected increase in erosion due to sea-level rise, the purpose of beach nourishment is to restore the width of an eroding beach on a temporary basis, although nourishment can also provide long-term restoration in certain types of areas. The rate at which the replenished beach erodes is a function of wave action, the uniformity of placement of the sand, and the grain size (U.S. Army Corps of Engineers 1984b). The sand used for a beach nourishment project usually comes from offshore dredging and pumping to the desired site; less frequently material is imported from an off-site location. The cost of the material can vary greatly depending on its origin and associated transportation costs.

Groins

One type of structure designed to lessen the impact of coastal processes on a shoreline is a groin —a structure oriented perpendicular to the shore that serves to reduce the flow of sediment along a shore (the local littoral drift rate). Sand collects on the updrift side of the groin until it is filled to capacity, when longshore drift is allowed to pass. Groins are often used in fields (sets of more than one groin) to protect a long section of coastline. The shoreline immediately downfield of the groin field, however, is often subjected to accelerated erosion, especially when the groins are not filled with sand during construction (National Research Council 1987).

Sea-level rise can affect a groin by reducing its effectiveness due to "flanking" or "submergence." A groin typically extends landward to the dune line, and the dune line may retreat due to sea-level rise, leaving the groin susceptible to flanking during high or storm tides, allowing sand to bypass the groin. Submergence of the groin can lead to overtopping by the longshore current, further decreasing the structures' efficiency at stabilizing the area (National Research Council 1987).

Seawalls, Bulkheads, and Revetments

There are three principal forms of vertical shoreline walls used to protect upland areas from storm surges and high tides: seawalls, bulkheads, and revetments. The differences between seawalls, bulkheads, and revetments are in their protective function. Seawalls are designed to resist the forces of storm waves; bulkheads are to retain the fill; and revetments are to protect the shoreline against the erosion associated with light waves (U.S. Army Corps of Engineers 1984b). These structures tend to fix the position of the coast. While this strategy may protect upland development, there are two kinds of adverse consequences of these types of structures. *Placement loss* refers to the loss of beach due to the footprint of the structure. For seawalls this is not as great as a revetment, which is usually built at a 2:1 (horizontal:vertical) slope. The other impact of these structures is called *passive erosion*. As sea level rises, and the structure fixes the position of the shoreline, the beach in front of the structures can be "drowned," resulting in a loss of recreation opportunities and habitat (Griggs 2005).

Breakwaters

Offshore breakwaters are above-water structures parallel to the shore that reduce both wave heights at the shoreline and littoral drift. Sea-level rise will reduce the protective capacities of breakwaters in two ways: rising water levels will effectively move the shoreline farther from the breakwater, increasing the ability of the waves to diffract behind the structure and reducing the sheltering and efficacy of the device; and the increased frequency of overtopping will diminish the ability of the breakwater to reduce the wave energy in the sheltered region (National Research Council 1987).

Dikes and Levees

Dikes or levees are embankments to protect low-lying land. A sea-level rise can result in reduced stability and increased overtopping of existing levees. New levees may be constructed to protect developed areas (National Research Council 1987). Whether existing levees can be modified for a rise in sea level depends on the availability of material for raising the levee, the suitability of the foundation material to support the additional weight of the material, the stability of the levee with the increased water level, and the accessibility of additional area for widening the base of the levee. Considerations for new levees also include issues such as land condemnation and interference of the levee with navigation (National Research Council 1987).

Raise Existing Structures (Roadways, Railroads, and Other Structures)

In some regions, building levees or seawalls to protect a small number of structures may not be cost effective. In these instances, raising the structures may be a better alternative. Roadways, railroads, and other structures may be raised so as to avoid damage from flooding. Over time, for example, we think it likely that important economic assets such as airports, transmission lines, or roadways will be raised rather than protected with levees or seawalls.

2.5.2. Cost of Structural Protection Measures

The cost of flood defenses is site-specific and little reliable information is available to generalize these costs. Gleick and Maurer (1990) developed cost estimates for building new coastal protection structures and raising existing ones, as well as raising roadways, railroads, and individual structures. We update these costs for this analysis based on a literature review (Table 7). Costs are converted to year 2000 dollars. Given the site specificity of construction costs, we relied on cost information from California where possible.

Data suggest that a new levee between 10 and 20 feet in height with a waterside slope of 3:1 would cost about $1,500 per linear foot (in year 2000 dollars). This represents a 320% increase over the 1990 estimate, much higher than the rate of inflation. The increase is likely due to large increases in construction and material costs in recent years. We estimate that raising existing levees would cost about $530 per linear foot (in year 2000 dollars). Seawalls, while providing significant protection, are among the most expensive option, estimated at about $5,300 per linear foot (in year 2000 dollars).

Table 7. Costs (in year 2000 dollars) for building new levees, raising existing levees, and building new seawalls

	Cost ($ per linear foot)	Location	Sources
New Levee	$725–$2,228	San Francisco, CA	Pang (2008)
Average New Levee	**$1,500**		
Raise Levee	$319	Central Valley, CA	Mount and Twiss (2005)
	$223–$1,085	San Francisco, CA	Moffatt and Nichol Engineers (2005)
	$278–$944	Central Valley, CA	Mount and Twiss (2005)
Average Levee Upgrade	**$530**		
New Seawall	$1,292	New England	Kanak (2008)
	$3,828	Southern California	Gustaitis (2002)
	$2,646–$6,173	Northern California	Stamski (2005)
	$5,654–$8,078	Philadelphia	PennPraxis (2008)
	$4,847	California	Crampton (2008)
Average New Seawall	**$5,300**		

Note: All costs are shown in year 2000 dollars. Costs shown for a new levee are based on a U.S. Army Corps of Engineers cost-estimation model, for a levee between 10 and 20 feet in height with a waterside slope of 3:1 and built using local materials.

In addition to the construction costs of the various structures described above, maintenance costs are often significant. In general, the greater the engineering employed in the construction of a shore protection scheme, the lower the proportion of maintenance costs. The maintenance cost of engineered riprap-revetment, for example, can amount to 2%–4% of the construction cost per year over the life of the project. This can be compared with the maintenance cost for a non-engineered revetment of 5%–15% of the construction cost per year (Fulton-Bennett and Griggs 1986). Average maintenance costs for levees are about 10% per year of the costs of construction. The estimated maintenance costs for seawalls run from 1%–4% per year, reflecting the higher level of engineering that goes into their construction. Because the majority of structures in our study are levees, we assume here an annual operation and maintenance cost equal to 10% of the capital cost of construction.

Levees, seawalls, and other structural methods have a number of environmental and social costs that are not reflected in the cost estimates shown in Table 7. Armoring the coast prevents natural movement and migration of the beach and associated ecosystems. In some areas, beaches may disappear completely, as shown in Figure 14. Structural measures can also increase vulnerability by encouraging development in flood-prone areas and giving those who live behind the structure a false sense of security. According to the United Nations,

"protective works have a tendency to increase the level of development in floodprone areas, as the assumption is made that it is now safe to build and invest in areas that are protected. However, it must be recognized that at some point in the future the design event will likely be exceeded and catastrophic damages will result" (United Nations 2004).

In addition, structural measures require regular maintenance, a task that is often overlooked due to budgetary constraints. Failure to maintain protective structures can lead to structural failures and catastrophic damage.

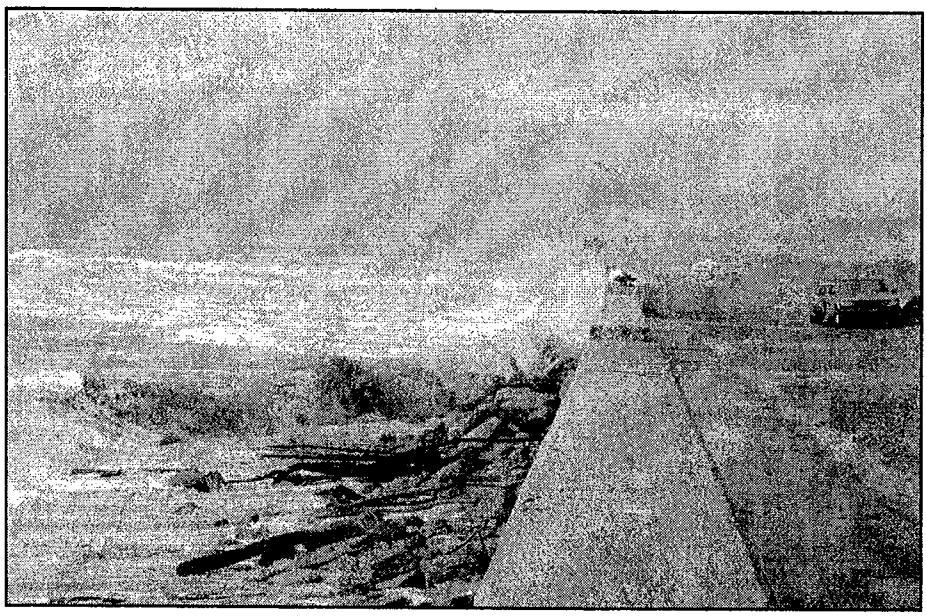


Figure 14. An example of coastal armoring leading to the disappearance of beach
Source: David L. Revell

2.5.3. Estimating Needed Coastal Defenses

Details about what level of protection to choose are a function of the perception of the value of the threatened property, the cost of alternative measures, and political and societal factors. In this analysis, we evaluate one scenario: the cost associated with raising the height of existing structures to maintain current flood protection levels and building new structures to protect some development that will be at risk of flooding with a 1.4 m sea-level rise. We do not evaluate coastal protection costs for erosion and urge additional studies on this topic.

In order to determine the cost of protecting development along the San Francisco Bay and California coast, we first needed to determine the location and type of existing coastal protection structures. Unfortunately, neither the U.S. Army Corps of Engineers nor any other agency maintains a comprehensive database with this information. The California Coastal Commission, however, recently compiled spatial data on the location and type of protective structure along the Pacific coast, e.g., groins, revetments, levees, and seawalls. Similar data were not available for the San Francisco Bay. Digital Flood Insurance Maps (DFIRMs) that showed

the presence of protective structures in the San Francisco Bay, however, were available in some areas. We supplemented the DFIRMS with a visual assessment of aerial imagery of the region. Because the DFIRMs do not distinguish between the types of structure, we assumed that seawalls were located around high-density, highly valued areas and levees were located around all other areas.

Geospatial data on the existing coastal protection structures were overlaid with the inundation maps to determine where existing structures needed to be raised and new structures built. To make this determination, we made the following assumptions:

- Existing coastal protection structures are strengthened and raised by 1.4 m with no change in the type of protection, e.g., levees are raised but are not replaced by a seawall.
- New coastal protection structures are needed wherever built structures are at risk of flooding. Agricultural land was not protected, unless a levee already existed.
- Seawalls are used in areas along the Pacific coast that are currently not protected but will need protection in the future and in areas where space limitations due to development prohibit the construction of new levees.
- Levees are used within enclosed areas, like the San Francisco Bay, that are currently not protected but will need protection in the future. These bays are protected from wave action, and we assume that levees will provide sufficient protection.

3.0 Results

Here we report on the results of our analyses for San Francisco Bay and the Pacific coast. In particular, we report on the population, infrastructure, and property at risk from sea-level rise, as well as the impacts on harder-to-quantify coastal ecosystems. We also provide an estimate of the economic costs of building coastal protections of different types to protect lives and property from flooding. All economic values are reported in year 2000 dollars. Results are reported separately for the flood and erosion risks.

3.1. Flood-Related Risks

In this analysis, we use the 100-year flood levels to evaluate the vulnerability to inundation. The 100-year flood is used as a standard for planning, insurance, and environmental regulations. It is important to note that people, infrastructure, and property are already located in areas vulnerable to flooding from a 100-year event. Sea-level rise will cause more frequent and more damaging floods to those already at risk and will increase the size of the coastal floodplain, placing new areas at risk where there were none before. In Figure 15, for example, those areas shown in light blue are currently vulnerable to a 100-year flood event in the Santa Cruz area. With a 1.4 m sea-level rise, additional areas (shown in dark blue) will be at risk. Thus, the damage attributed to a 1.4 m sea-level rise is equal to the area currently vulnerable to a 100-year flood event (but now protected by levees, seawalls, etc.) plus new inundated areas, i.e., the areas shown in light blue and dark blue in Figure 15.

A series of maps for the entire coast of California demonstrating the extent of the areas at risk are posted at www.pacinst.org/reports/sea_level_rise. It should be noted again that these maps are not the result of detailed site studies, and were created to quantify risk over a large geographic area. **These maps should not be used to assess actual coastal hazards, insurance requirements or property values, and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).** Local governments or regional planning agencies should conduct detailed studies to better understand the potential impacts of sea-level rise in their communities.



Coastal Flood Risk Area

Current Base Flood
(approximate 100-year flood extent)

Sea Level Rise Scenario
Base Flood + 1.4 meters (55 inches)

Figure 15. Estimated current and future 100-year coastal flood risk areas around Santa Cruz

3.1.1. Population at Risk

Major population centers are located all along California's coast. Nearly 26 million people lived in coastal counties in 2000. Of these, 74% lived along the Pacific coast and the remaining 26% lived along the San Francisco Bay. An estimated 260,000 people, or 1% of the population in

California's coastal counties, live in areas that are currently vulnerable to a 100-year flood event. As discussed in Section 2.3.3, the inundated area does not adequately take into account existing flood barriers. It is likely that most existing coastal protection structures are sufficient to protect people living in these areas against the present-day flood risk. Most existing defenses, however, will not be adequate to protect inhabitants following significant sea-level rise.

As sea levels rise, the area and the number of people vulnerable to flooding will also rise. Rising sea levels will overwhelm the existing protection structures, putting the 260,000 people currently living in vulnerable areas at increased risk. In total, we estimate that a 1.4 m sea-level rise will put around 480,000 people (nearly half a million) at risk from a 100-year flood event (Figure 16). Continued development in these regions could put additional people at risk.

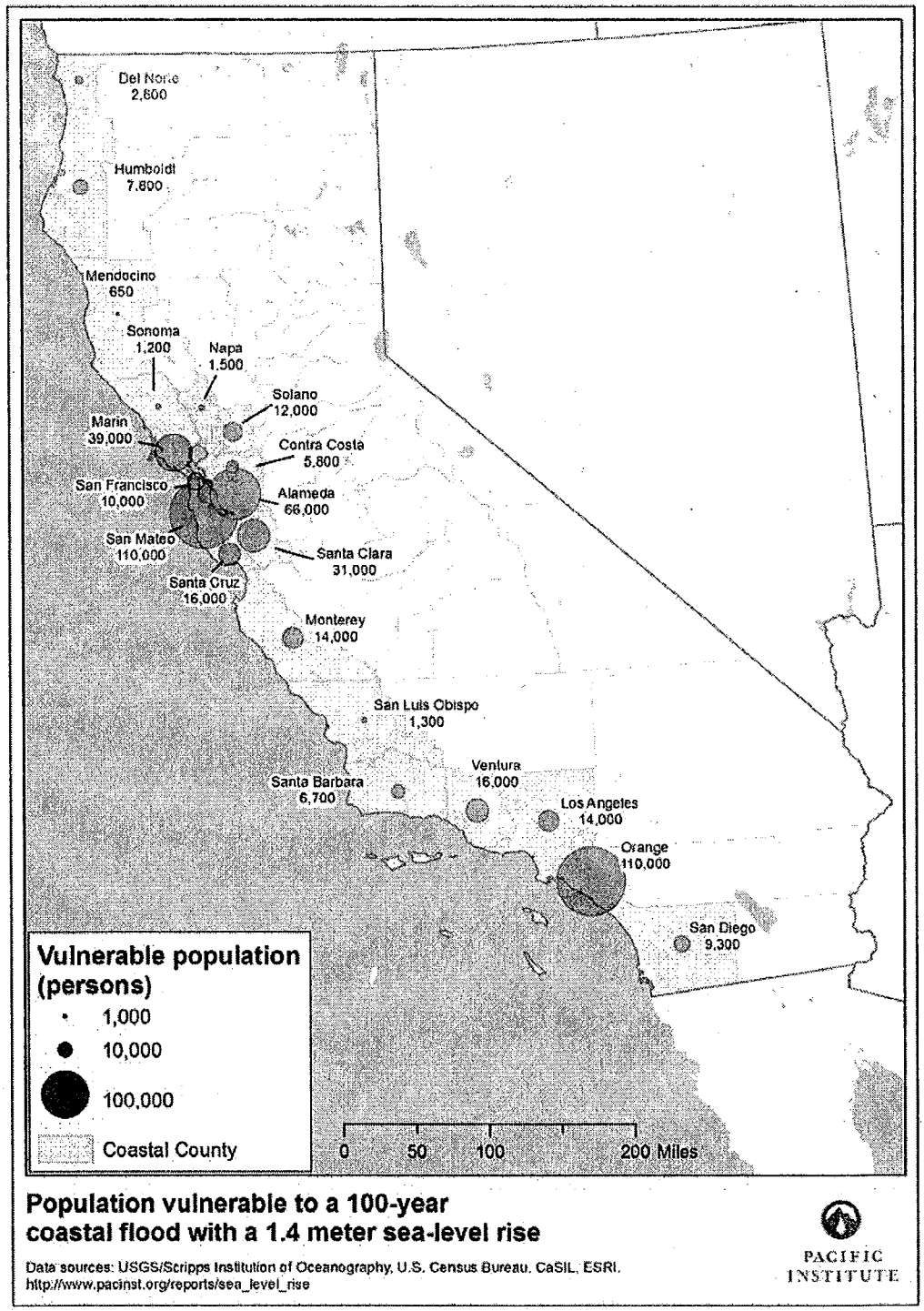


Figure 16. Population vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise, by county

Table 8 shows the population vulnerable to a 100-year flood event along the Pacific coast by county. In 2000, an estimated 130,000 people lived in areas vulnerable to a 100-year flood event. A 1.4 m sea-level rise will increase the number of people vulnerable to a 100-year flood event to 210,000. Half of these residents live in Orange County, although significant numbers of people are also at risk in Los Angeles, Monterey, San Mateo, Santa Cruz, and Ventura Counties.

Table 8. Population vulnerable to a 100-year flood along the Pacific coast, by county

County	Current Risk	Risk with 1.4 m sea-level rise	Percent increase
Del Norte	1,800	2,600	47%
Humboldt	3,700	7,800	110%
Los Angeles	3,700	14,000	270%
Marin	530	630	20%
Mendocino	530	650	22%
Monterey	11,000	14,000	36%
Orange	72,000	110,000	55%
San Diego	3,000	9,300	210%
San Francisco	4,800	6,500	35%
San Luis Obispo	670	1,300	98%
San Mateo	4,700	5,900	24%
Santa Barbara	3,400	6,700	94%
Santa Cruz	11,000	16,000	49%
Sonoma	580	700	21%
Ventura	7,300	16,000	120%
Total	**130,000**	**210,000**	**67%**

Note: Counties with borders on the Pacific coast and the San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected. Numbers may not add up due to rounding.

In San Francisco Bay, the population vulnerable to flooding is even greater. Table 9 shows the population vulnerable to a 100-year flood event in 2000 and with a 0.5 m, 1.0 m, and 1.4 m sea-level rise. In 2000, an estimated 140,000 people lived in areas at risk from a 100-year flood event. An increase in sea levels of 0.5 m has only a modest effect on the number of people at risk. With a 1.4 m increase in sea levels, however, the number of people at risk of a 100-year flood event nearly doubles to 270,000. Populations in San Mateo County are especially vulnerable, accounting for about 40% of those at risk with a 1.4 m sea-level rise. Large numbers of residents in Alameda, Marin, and Santa Clara counties are also at risk.

Table 9. Population vulnerable to a 100-year flood along the San Francisco Bay, by county

County	Current risk	Risk with sea-level rise			Percent increase (with 1.4 m rise)
		0.5 m	1.0 m	1.4 m	
Alameda	12,000	22,000	43,000	66,000	+ 470%
Contra Costa	840	1,600	3,400	5,800	+ 590%
Marin	25,000	29,000	34,000	39,000	+ 55%
Napa	760	830	970	1,500	+ 99%
San Francisco	190	600	1,600	3,800	+ 1900%
San Mateo	80,000	88,000	99,000	110,000	+ 34%
Santa Clara	13,000	17,000	24,000	31,000	+ 140%
Solano	3,700	5,500	8,800	12,000	+ 230%
Sonoma	250	300	420	540	+ 110%
Total	**140,000**	**160,000**	**220,000**	**270,000**	**+ 98%**

Note: Counties with borders on the Pacific coast and the San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected. Numbers may not add up due to rounding.

Workplaces as well as residences will be vulnerable. We estimate that statewide, the number of employees in the hazard area will increase from 190,000 at present to 410,000. In this group, 80% are employed in commercial settings, and 20% in the industrial sector. Of those affected, 80% are in areas vulnerable to flooding from San Francisco Bay, with the other 20% along the Pacific coast.

Environmental Justice Concerns

The analysis of the potential environmental justice impacts of sea-level rise considers the population within the areas at risk and their vulnerability to the potential adverse impacts. There is little difference between the overall racial and income demographics of Californians affected by a 1.4 m sea-level rise and those of the state as a whole. However, we do find some important differences between the racial and income demographics of those affected and those of the total population of each county.

Table 10 and Figure 17 show a simplified racial breakdown of the flood-affected population and the population of the counties as a whole. Sea-level rise induced flooding may disproportionately affect whites in the majority of counties along the California coast. In Los Angeles County, for example, 72% of those affected are white, while only 31% of the population in the county is white. Conversely, along the San Francisco Bay, however, communities of color are disproportionately impacted by sea-level rise. In total, communities of color are disproportionately impacted in 10 of the 20 counties studied. The greater proportion of people of color in areas affected by a 1.4-meter sea-level rise highlights the need for these counties to take concerted efforts to understand and mitigate potential environmental injustice.

The results presented above highlight the importance of conducting socio-economic analyses and comparisons at various geographic scales. It is significant to note that these numbers only reflect exposure to the hazard. In the next section, we also evaluate other vulnerability factors, such as access to transportation and ability to speak English.

Table 10. Total county population and population vulnerable to a 100-year flood with a 1.4-meter sea-level rise along the Pacific coast, by race

County	White		Asian, Black, Latino, Native American, or Other Race	
	Affected population (%)	County population (%)	Affected population (%)	County population (%)
Alameda	35	41	60	55
Contra Costa	28	58	69	39
Del Norte	75	70	21	26
Humboldt	82	82	15	15
Los Angeles	72	31	26	67
Marin	59	79	38	19
Mendocino	74	75	23	22
Monterey	29	40	69	57
Napa	63	69	35	29
Orange	80	51	18	46
San Diego	73	55	25	42
San Francisco	51	44	46	53
San Luis Obispo	85	76	13	22
San Mateo	46	50	51	47
Santa Barbara	68	57	30	41
Santa Clara	49	44	47	53
Santa Cruz	43	66	54	32
Solano	38	49	58	46
Sonoma	70	75	28	23
Ventura	56	57	41	41
All coastal counties	56	44	41	53

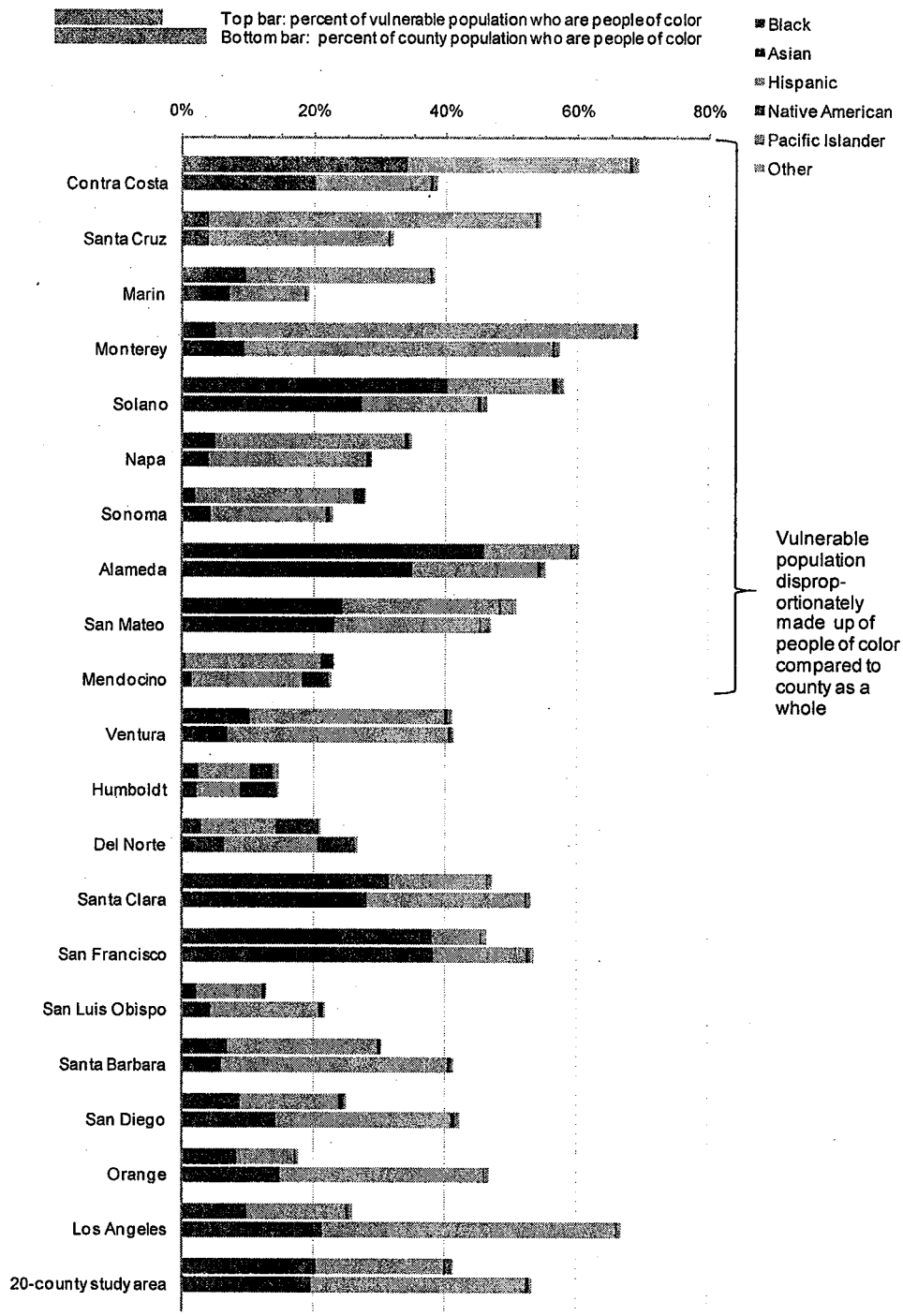


Figure 17. Total county population and population vulnerable to a 100-year flood with a 1.4 meter sea-level rise along the Pacific coast, by race

Note: The lower bar shows the percentage of the county's population that is classified as people of color, and the top bar shows the percentage of the population at risk of a 100-year flood with a 1.4 m sea-level rise that is classified as people of color. A county for which the top bar is longer indicates that there is a disproportionate impact on communities of color.

Preconditions

The period preceding a disaster is the key phase for taking action to reduce vulnerabilities and proactively prevent harm. For example, reinforcing residential buildings, obtaining insurance, and storing emergency supplies can reduce injury and loss. Studies show that those who are the most vulnerable are the least likely to adopt these preventive measures. Below, we evaluate key demographic factors affecting vulnerability during the pre-disaster phase, including residential tenure (renter or homeowner), income, and linguistic isolation.

Preventive measures such as reinforcing buildings and buying insurance are adopted at lower rates by people with low income levels (Bolin and Bolton 1986; Blanchard-Boehm 1997). In California, 31% of households earn less than 150% of the federal poverty threshold ($30,000). Low-income households make up 29% of the 20-county study area, slightly less than the statewide total (Figure 18).

An estimated 56,000 people along the Pacific coast, or about 27% of those vulnerable to a 100-year flood with a 1.4 m sea-level rise, earn less than $30,000. Likewise, an estimated 51,000 people along the San Francisco Bay, or about 19% of the affected population, earn less than $30,000 (Table 11). Income demographics vary markedly among the vulnerable populations and counties in this study (Figure 18). Our analysis indicates that there is a disproportionate impact on low-income households in 13 of the 20 coastal counties. These households are less likely than their counterparts to be able to afford emergency preparedness materials, buy insurance policies, and obtain needed building reinforcements.

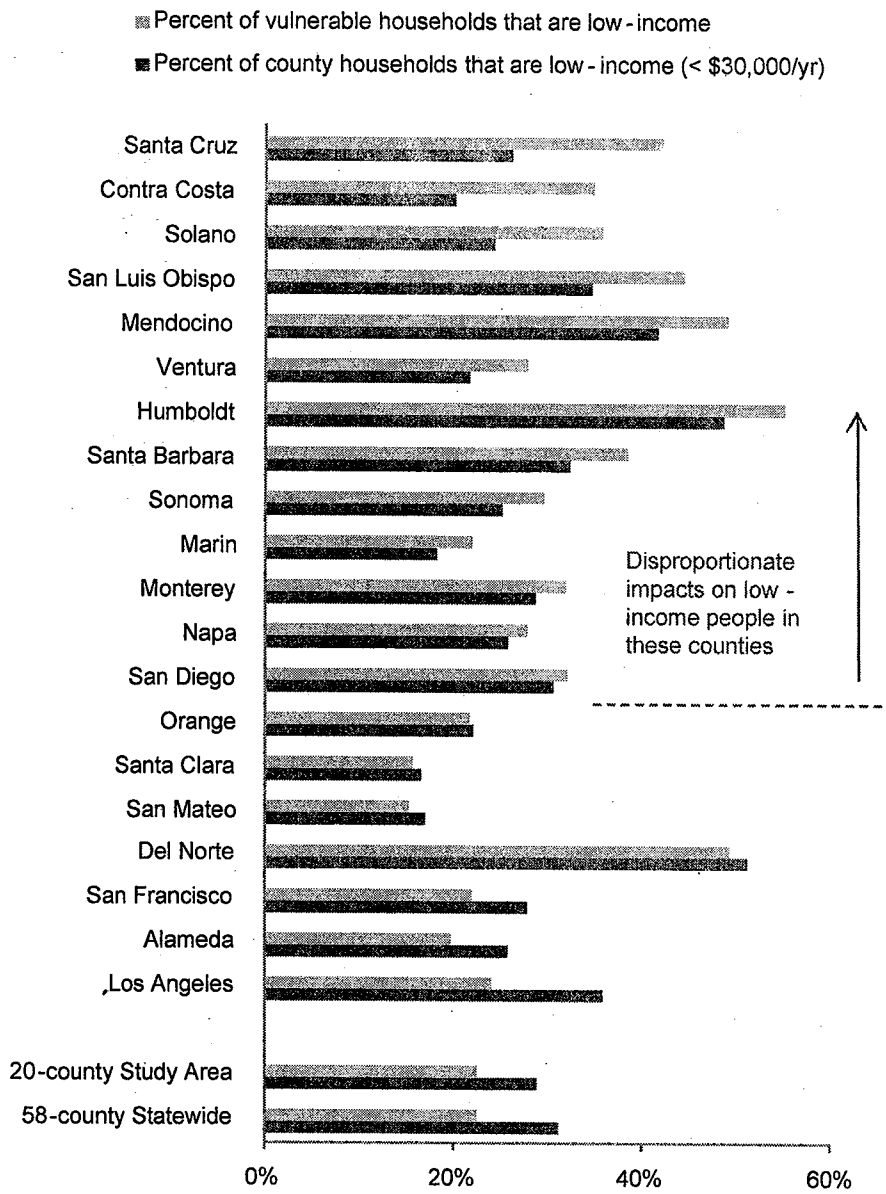


Figure 18. Percentages of low-income households among the population vulnerable to a 100-year flood with a 1.4 m sea-level rise compared with the county total

Note: The lower bar shows the percentage of low-income households in the county, and the top bar shows the percentage of low-income households within the population at risk of a 100-year flood with a 1.4 m sea-level rise. A county for which the top bar is longer indicates that there is a disproportionate impact on low-income households.

Table 11. Key demographics of populations vulnerable to a 100-year flood event with a 1.4 m sea-level rise

	Pacific Coast		San Francisco Bay	
	Number in 100-year flood zone	Percent of total in flood zone	Number in 100-year flood zone	Percent of total in flood zone
Households				
Linguistically isolated	4,700	4%	9,700	9%
With no vehicle	7,600	7%	8,200	7%
Who rent (not own) their home	45,000	43%	47,000	41%
People				
Earn less than 150% the federal poverty threshold ($30,000)	56,000	27%	51,000	19%
People of color	60,000	29%	148,000	55%

Data source: U.S. Census Bureau 2000

Renters are also less likely to reinforce buildings and buy insurance because the decision to make major improvements and financial gains typically lies with the property owner. Of those vulnerable to a 100-year flood event with a 1.4 m sea-level rise, about 45,000 households along the Pacific coast and 47,000 households along the San Francisco Bay rent their homes. These households comprise 43% and 41%, respectively, of the homes within the areas at risk.

Language ability is also an important factor in assessing vulnerability (Wang and Yasui 2008). Earthquake preparedness materials following the 1987 Whittier-Narrows earthquake in California, for example, were available only in English, despite other language needs of the victims (Tierney 1993, cited in Pastor et al. 2006). Additionally, emergency response crews may be unable to communicate with non-English speakers. A recent study of 148 emergency preparedness and public health entities found that only 72% provided links on their website to translated materials, and only 14% offered courses for service providers that addressed potential language issues and cultural competence (Andrulis et al. 2008). Among the population at risk from a 100-year flood event with a 1.4 m sea-level rise, 9,700 households along the San Francisco Bay and 4,700 households along the Pacific coast are "linguistically isolated," meaning no one over age 14 speaks English well (Table 11). These 14,000 households are the most likely to need preparedness materials and outreach strategies suitable for non-English speakers of various backgrounds.

Even among those for whom language is not a barrier, cultural factors can influence the effectiveness of preparedness outreach. Numerous studies show that black and Latino communities prefer neighborhood meetings as a way of receiving information about hazards (Blanchard-Boehm 1997; Perry and Mushkatel 1986; Phillips and Ephraim 1992, cited in Pastor et al. 2006). The historic role of African-American churches in providing disaster planning and

response provides a unique asset and partner to public efforts in these communities (Trader-Leigh 2008).

The representation of low-income and people of color in the groups with heightened vulnerabilities during the pre-disaster phase are higher than these communities' representation in the overall population. In 2000, 65% of white Californian heads of households were homeowners, while 55% of Asian, 46% of Native American, 44% of Latino, and 39% of black heads of household owned their home (U.S. Census Bureau 2000). Eighty-one percent (81%) of Californians who cannot speak English "well" or "well at all" are people of color, while people of color are 31% of the California population (U.S. Census Bureau 2000). Additionally, people of color tend to earn less than white wage earners. The median household income of black, Latino, and Native households in California was $15,000 less than white and Asian households (U.S. Census Bureau 2000). These factors raise vulnerability to a disaster and increase the likelihood that communities of color and low-income Californians will share a disproportionate burden of harm.

During a disaster

The ability to remain safe and/or evacuate high-risk areas during a flood event is shaped by factors such as quality of residential structures, access to transportation, availability of emergency supplies, effective service by emergency responders, and exposure to environmental hazards. Key demographics associated with these vulnerabilities are income, possession of a vehicle, race, and proximity to environmental hazards that compound health risk, such as toxic waste facilities.

Low-income communities have been unable to evacuate during disasters like Hurricane Andrew due to lack of financial means to buy supplies or transportation (Morrow and Enarson 1996). In a survey after Hurricane Katrina, 55% of respondents who did not evacuate said one of the main reasons was that they did not have a car or other means of transportation (Brodie et al. 2006). Our study shows that nearly 16,000 households in areas vulnerable to a 100-year flood event with a 1.4 m sea-level rise do not have a vehicle (Table 11). Half of these households are located along the San Francisco Bay and the remaining half along the Pacific coast. These households will be more vulnerable to the adverse effects of sea-level rise due to their increased chance of lacking the transportation means necessary to evacuate.

Race has been an important factor influencing the effectiveness of past emergency response efforts. Perceptions of emergency response workers toward neighborhoods that are predominantly people of color can increase the vulnerability of these communities. In a recent report, the International Federation of Red Cross and Red Crescent Societies (IFRCC) found that "stereotypical views of a specific group can overwhelm the scientific methods employed to prioritize the order of relief works, even if some of those involved are professionally trained, such as disaster managers and relief workers" (Klynman 2007). Along the Pacific coast, we estimate that 60,000 Asian, black, and Latino residents live in areas vulnerable to a 100-year flood event with a 1.4 m sea-level rise. The numbers are even higher along the San Francisco Bay, where an estimated 150,000 Asian, black, and Latino residents live in vulnerable areas. The

areas with the highest concentrations of people of color are more likely to be subject to problems with stereotypes that may result in less effective emergency services.

Section 3.1.3, below, describes the number of U.S. EPA-regulated facilities that are at risk of flooding. These facilities contain a range of toxic chemicals that result in increased risk during a flood event due to the possibility that environmental hazards could be released and nearby residents exposed. In California as a whole, the population living within 3 kilometers (1.8 miles) of a commercial hazardous waste facility is disproportionately (81%) people of color compared to communities without such facilities (51% people of color) (Bullard et al. 2007). The same national study concluded that "race continues to be an independent predictor of where hazardous wastes are located, and it is a stronger predictor than income, education, and other socioeconomic indicators" (Bullard et al. 2007). The combination of higher concentrations of environmental hazards and higher rates of demographic characteristics that increase vulnerability has been termed "double jeopardy" by the Institute of Medicine (1999).

This disproportionate representation of people of color living near hazardous waste facilities is coupled with an overrepresentation among households with no vehicle. While black and Latino households comprised 7% and 22% of California's households in 2000, respectively, they comprised 13% and 32% of the households with no vehicle (U.S. Census Bureau 2000), and, as noted above, people of color are also over-represented among low-income Californians. Their higher rates of characteristics associated with vulnerabilities during the time of a disaster raise the possibility that communities of color and low-income people will be disproportionately affected.

Recovery and reconstruction

Following a flood event or other disaster, a range of conditions determines the victims' ability to recover and reconstruct their homes and lives. Important vulnerability factors include the ability to move where opportunities arise, obtain insurance compensation for losses, and receive medical care and public services. The demographic characteristics of income, insurance coverage, legal residency status, and race affect the vulnerability of individuals living in potential flood areas.

White and upper middle-class groups have been found to receive more disaster recovery assistance than black and low-income groups (Bolin and Bolton 1986; Fothergill 2004). For example, following the 1995 flooding of New Orleans, low-income elderly women were one-third as likely as other elderly victims to receive FEMA low-interest loans (Childers 1999). Disaster recovery services have often targeted homeowners to the disadvantage of renters and residents of public housing (Pastor et al. 2006). Reconstruction efforts of the past have inadequately rebuilt housing suitable for low-income families. Four years after the Loma Prieta earthquake, half of the affected multifamily units remained uninhabitable (Comerio et al. 1994). Government agencies explicitly denied housing assistance to those who were homeless before the earthquake (Tierney 2007).

The loss of wealth to homeowners resulting from a disaster is greater for those whose home equity comprises a greater proportion of their wealth. This effect is particularly problematic for

black homeowners, whose home equity accounts for 20% more of their wealth than white homeowners (Oliver and Shapiro 1995; Gittleman and Wolff 2000).

Legal residency status influences recovery efforts as well. Undocumented residents fear that participating in recovery assistance programs will put them at risk of deportation (Subervi-Velez et al. 1992; Yelvington 1997). Data on the number of undocumented immigrants are elusive, but the Public Policy Institute of California (2008) estimates that 8% of Californians are undocumented. The number and distribution of undocumented immigrants in areas vulnerable to current and future flood events deserves further study.

Recovery for disaster victims suffering adverse health effects is dependent upon their access to health insurance. The uninsured get about half as much medical care as the insured, are less likely to receive preventive screening and care, and overall have worse health outcomes (Bovbjerg and Hadley 2007). Race is a predictor of rates of health insurance coverage in California: 34% of California Latinos did not have health insurance in 2005, while 22% of Native Californians, 18% of Asians, 15% of black Californians, and 13% of whites were not insured, according to the California Health Interview Survey (Brown et al. 2007).

The correlation of lower income and race, and the over-representation of communities of color among those without legal residency and without health insurance, increases these communities' vulnerability to the harms of sea-level rise even in the period following a disaster. The history of disparate treatment of people of color in recovery assistance services suggests another level of increased vulnerability.

Summary of Environmental Justice Concerns

The adverse impacts of sea-level rise on Californians will depend upon the population's vulnerabilities, which are heightened for certain demographic groups. Race and income cut across many of the key vulnerabilities, with low-income and communities of color overly represented in the most vulnerable segments of the population. Additionally, adapting to sea-level rise will require tremendous financial investment. Given the high cost and the likelihood that we will not protect everything, adaptation raises additional environmental justice concerns. Specifically, what we choose to protect and how we pay for it may have a disproportionate impact on low-income neighborhoods and communities of color. Decisions about how to use public funds can lead to inequitable distribution of costs and benefits, whether they are based on economics (protect the most valuable assets) or utility (protect the largest number of people). We urge, therefore, that policy makers planning responses to sea-level rise understand and address environmental justice concerns carefully and proactively.

3.1.2. Emergency and Healthcare Facilities at Risk

Table 12 shows the schools and emergency and healthcare facilities along the Pacific coast that are currently at risk from a 100-year flood event and that will be at risk with a 1.4 m sea-level rise. Numerous schools are vulnerable to flooding along the Pacific coast. In 2000, 30 schools were vulnerable to a 100-year flood event. With a 1.4 m sea-level rise, however, the number of schools at risk nearly doubles, rising to 56 schools. Emergency and healthcare facilities are also at risk.

Table 12. Schools and emergency and healthcare facilities along the Pacific coast that are at risk from a 100-year flood event in 2000 and with a 1.4 m sea-level rise

Facility	Current risk	Risk with 1.4 m sea-level rise
Schools	30	56
Healthcare facilities	5	13
Fire stations and training facilities	2	6
Police stations	4	8

Note: Healthcare facilities include clinics, long-term care facilities, hospitals, and home health agencies/hospices. Counties with borders on the Pacific coast and the San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

Table 13 shows the schools and emergency and healthcare facilities along San Francisco Bay that are currently at risk of a 100-year flood event and that will be at risk with a 0.5 m, 1.0 m, and 1.4 m sea-level rise. The risk for each of these facilities is greater than along the remainder of the Pacific coast. Schools in particular are at significant risk. In 2000, 35 schools were at risk of a 100-year flood event. With a 1.4 m sea-level rise, the number of schools at risk more than doubles, to 81. Significant numbers of healthcare facilities are also at risk. In 2000, there were 15 healthcare facilities at risk of a 100-year flood. With a 1.4 m sea-level rise, however, the number of healthcare facilities at risk rises to 42.

Table 13. Schools and emergency and healthcare facilities along San Francisco Bay that are at risk of a 100-year flood event in 2000 and with a 0.5 m, 1.0 m, and 1.4 m sea-level rise.

Facility	Current risk	Risk with sea-level rise		
		0.5 m	1.0 m	1.4 m
Schools	35	41	60	81
Healthcare facilities	15	19	29	42
Fire stations and training facilities	6	7	10	11
Police stations	5	6	8	9

Note: Healthcare facilities include clinics, long-term care facilities, hospitals, and home health agencies/hospices. Counties with borders on the Pacific coast and the San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

3.1.3. Hazardous Materials Sites

The presence of land or facilities containing hazardous materials in areas at risk of inundation increases the risk of exposure to toxic chemicals for nearby residents and ecosystems. For example, sediment samples in New Orleans taken one month after Hurricane Katrina found

excess levels of arsenic, lead, and the gasoline constituent benzene, all considered toxic pollutants by the U.S. EPA (Adams et al. 2007). Those living or working near these facilities may be affected by the potential release and spreading of contamination through floodwaters or through flood-related facility malfunctions.

We evaluated sites containing hazardous materials at risk of flooding along the Pacific coast and the San Francisco Bay. Here, we report on a range of sites monitored by the U.S. EPA, including Superfund sites; hazardous waste generators; facilities required to report emissions for the Toxics Release Inventory; facilities regulated under the National Pollutant Discharge Elimination System (NPDES); major dischargers of air pollutants with Title V permits; and brownfield properties. An estimated 130 U.S. EPA-regulated sites are currently vulnerable to a 100-year flood event (Table 14). Nearly 60% of these facilities are located in San Mateo and Santa Clara counties. Sea-level rise will put additional facilities, people, and the environment at risk. The number of facilities at risk increases by 250% with a 1.4 m sea-level rise, with more than 330 facilities at risk of a 100-year flood event. San Mateo, Alameda, and Santa Clara counties have the highest numbers of U.S. EPA-regulated sites within future flood areas.

Table 14. U.S. EPA-regulated sites within areas vulnerable to 100-year flood event in 2000 and with a 1.4 m sea-level rise

County	Sites currently at risk	Risk with 1.4 m sea-level rise
Alameda	6	63
Contra Costa	4	22
Del Norte	1	3
Humboldt	10	13
Los Angeles	13	26
Marin	1	6
Monterey	1	1
Napa	1	2
Orange	4	16
San Diego	-	13
San Francisco	-	4
San Luis Obispo	-	1
San Mateo	39	78
Santa Barbara	1	5
Santa Clara	41	53
Santa Cruz	5	6
Solano	2	5
Sonoma	-	2
Ventura	5	13
Total	**134**	**332**

Data Source: EPA Geospatial Data Access Project 2008
Note: Table combines risk for those counties along the San Francisco Bay and Pacific coast.

3.1.4. Infrastructure at Risk

Roads and Railways

California's transportation infrastructure is vulnerable to flooding under current conditions, and those risks will be greater in the future due to sea-level rise (Tables 15, 16, and 17 and Figures 19 and 20). Under current conditions, we estimate that 1,900 miles of roadway are at risk of a 100-year flood event. With a 1.4 m sea-level rise, 3,500 miles of roads will be at risk of flooding, nearly a doubling of current risk. Of the total, about 430 miles are highways (12% of the total mileage), while the remainder are neighborhood and local streets. About half of the roads at risk are around San Francisco Bay, and another half on the Pacific Coast.

Railways are also at risk. In 2000, 140 miles of railways were at risk of flooding. With a 1.4 m sea-level rise, the length of railways at risk doubles to 280 miles. About 60% of the vulnerable railway lines are in the San Francisco Bay area.

Table 15. Miles of roads and railways vulnerable to a 100-year flood in 2000 and with a 1.4 m sea-level rise along the Pacific coast, by county and type

County	Highways (miles)		Roads (miles)		Railways (miles)	
	Current risk	Risk with 1.4 m sea-level rise	Current risk	Risk with 1.4 m sea-level rise	Current Risk	Risk with 1.4 m sea-level rise
Del Norte	6.6	8.2	59	80	-	-
Humboldt	37	58	120	190	21	28
Los Angeles	14	31	42	140	5.6	14
Marin	1.2	4.1	22	27	-	-
Mendocino	5.6	7.9	28	41	2.7	4.0
Monterey	27	31	85	110	19	23
Orange	32	48	340	490	5.3	6.6
San Diego	0.62	8.0	12	57	3.0	9.8
San Francisco	0.20	0.37	17	22	-	-
San Luis Obispo	5.3	7.4	10	21	0.019	0.31
San Mateo	3.4	5.0	23	30	-	-
Santa Barbara	1.5	8.0	9.1	25	3.4	7.0
Santa Cruz	9.4	11	52	67	4.2	5.5
Sonoma	4.5	5.9	14	20	-	-
Ventura	2.4	11	69	150	3.7	10
Total	150	250	910	1,500	68	110

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected. Numbers may not add up due to rounding.

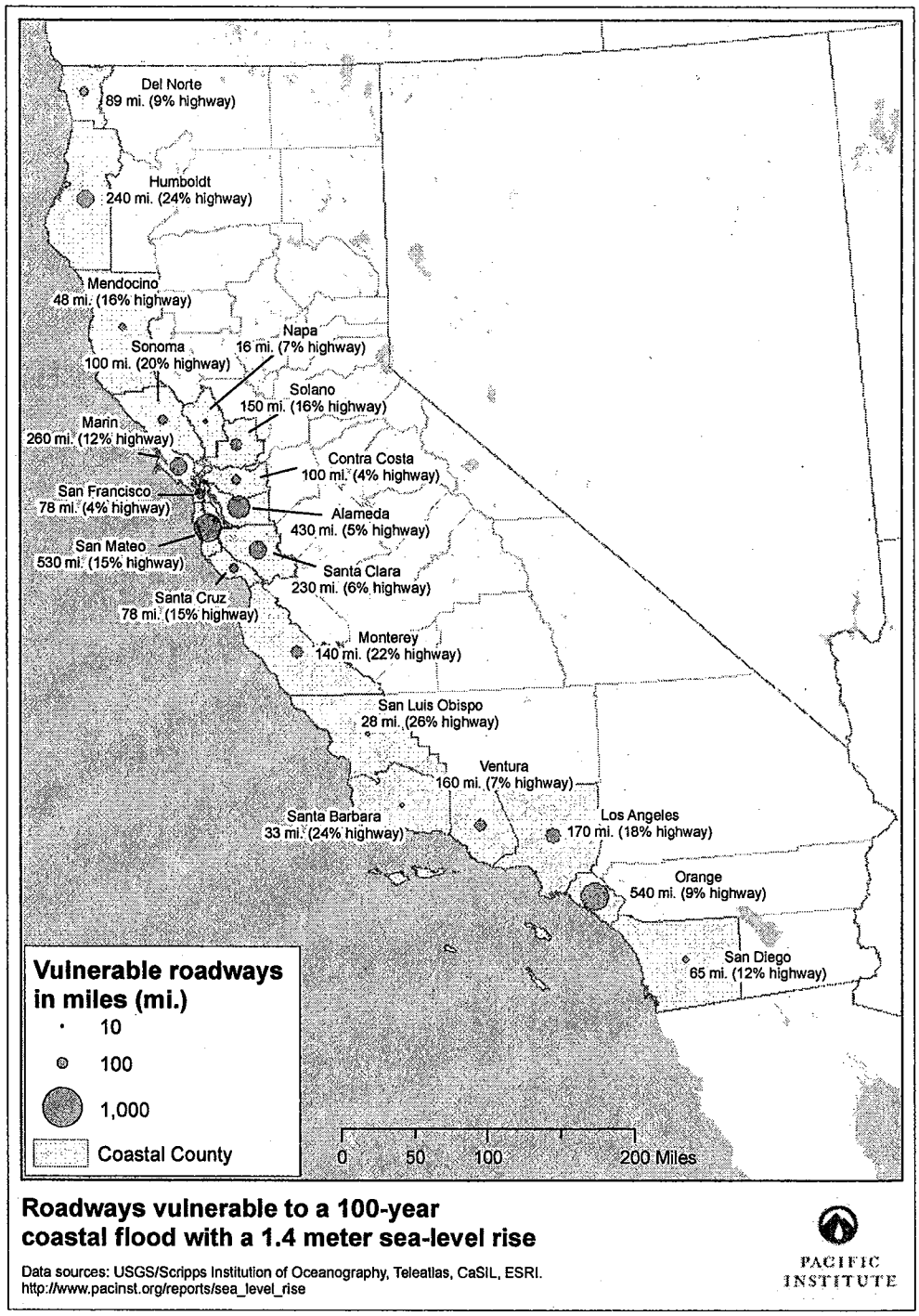


Figure 19. Roadways vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

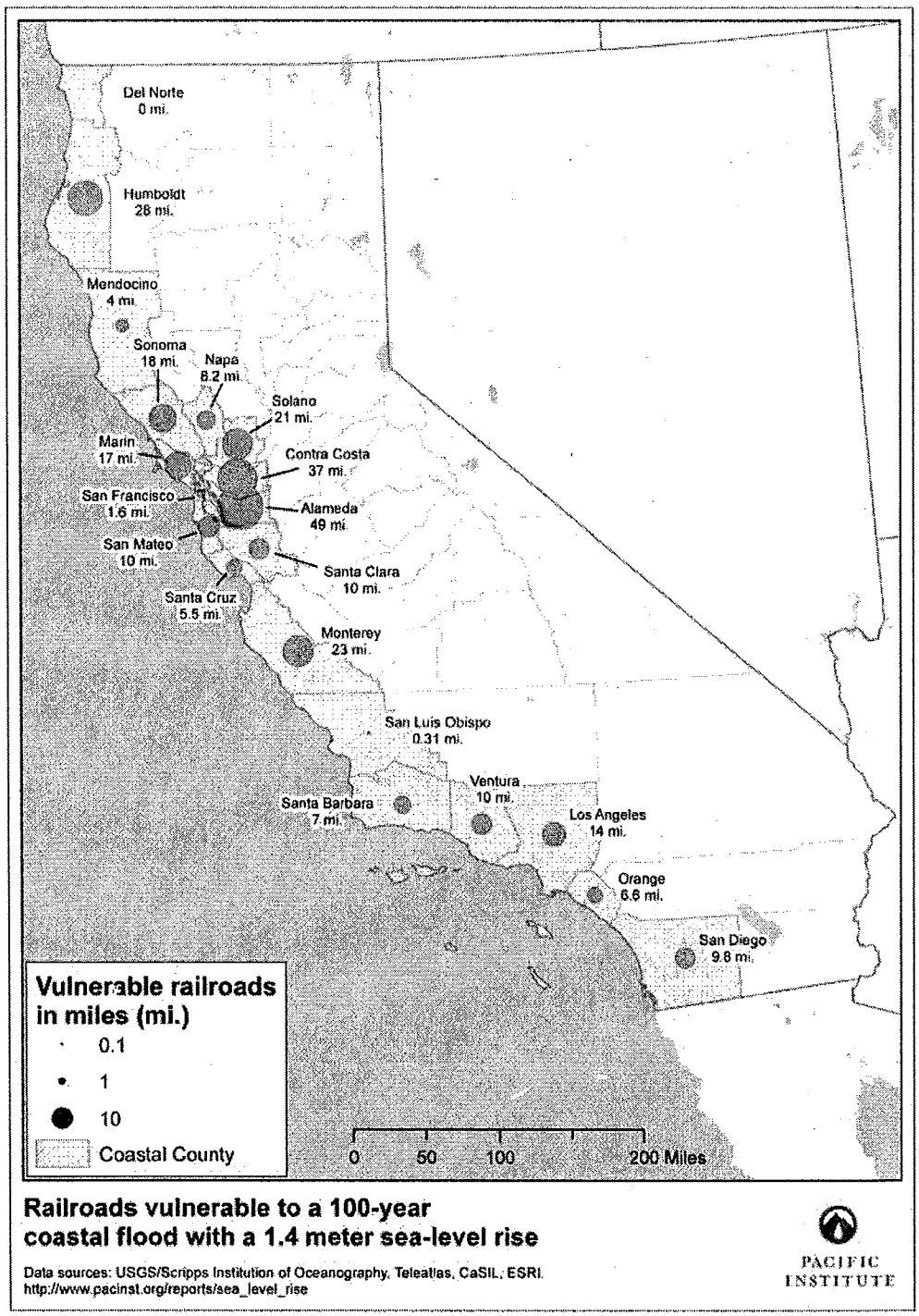


Figure 20. Railroads vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

Table 16. Miles of roads vulnerable to a 100-year flood along San Francisco Bay, by county and type

County	Current Risk		Risk with sea-level rise					
			0.5 m		1.0 m		1.4 m	
	Highways (miles)	Roads (miles)	Highways (miles)	Roads (miles)	Highways (miles)	Roads (miles)	Highways (miles)	Roads (miles)
Alameda	1.1	76	4.8	160	14	280	23	410
Contra Costa	2.4	20	2.7	42	3.4	67	4.5	96
Marin	16	110	20	150	24	180	28	200
Napa	0.70	7.0	0.70	9.0	0.80	11	1.2	15
San Francisco	0.30	3.4	0.60	11	1.5	29	3.1	53
San Mateo	27	300	49	360	66	390	72	420
Santa Clara	9.4	110	12	150	14	180	15	220
Solano	5.7	53	14	78	19	100	23	120
Sonoma	11	53	12	57	13	59	14	61
Total	**72**	**730**	**120**	**1,000**	**160**	**1,300**	**180**	**1,600**

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected. Numbers may not add up due to rounding.

Table 17. Miles of railways vulnerable to a 100-year flood along San Francisco Bay, by county

County	Current risk	Risk with sea-level rise			Percent increase (with 1.4 m rise)
		0.5 m	1.0 m	1.4 m	
Alameda	9.1	17	35	49	+ 81%
Contra Costa	10	17	25	37	+ 73%
Marin	12	15	16	17	+ 29%
Napa	6.0	7.0	7.9	8.2	+ 27%
San Francisco	0.26	0.56	0.91	1.6	+ 84%
San Mateo	3.7	5.2	7.8	10	+ 65%
Santa Clara	5.9	7.2	8.9	10	+ 43%
Solano	9.3	12	17	21	+ 56%
Sonoma	11	14	17	18	+ 39%
Total	**68**	**94**	**140**	**170**	**+ 61%**

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected. Numbers may not add up due to rounding.

We do not attempt to quantify the cost of flooding on roads and railways. In some cases, damages may be minor, resulting in temporary closures and modest repairs. As the frequency and intensity of flooding increases, however, closures may become longer and the cost of repair may rise. Eventually, roads and railways may need to be raised or rerouted. The cost of repairing, moving, or raising roads and railways is highly site-specific and dependent on the level of damage that is sustained.

Furthermore, flooding and closure of roads and railways can have significant impacts on the local, state, and national economy. Railways are particularly important for the conveyance of goods shipped to and from California ports. In addition, road closures can prevent people from getting to work, causing major economic disruptions. Additional research is needed to improve our understanding of specific transportation risks.

Power Plants

Figures 21, 22, and 23 show California's coastal power plants vulnerable to a 100-year flood event with a 1.4 m sea-level rise. In some cases, actual power generating infrastructure is at risk; in others, intake or other peripheral structures are vulnerable. Specific site assessments are needed for each coastal plant. In total, 30 coastal power plants, with a combined capacity of more than 10,000 megawatts (MW), are at risk from a 100-year flood with a 1.4 m sea-level rise. The capacities of the vulnerable power plants range from a relatively small 0.2 MW plant to one that is more than 2,000 MW. The majority of vulnerable plants are located in Southern California and along the San Francisco Bay.

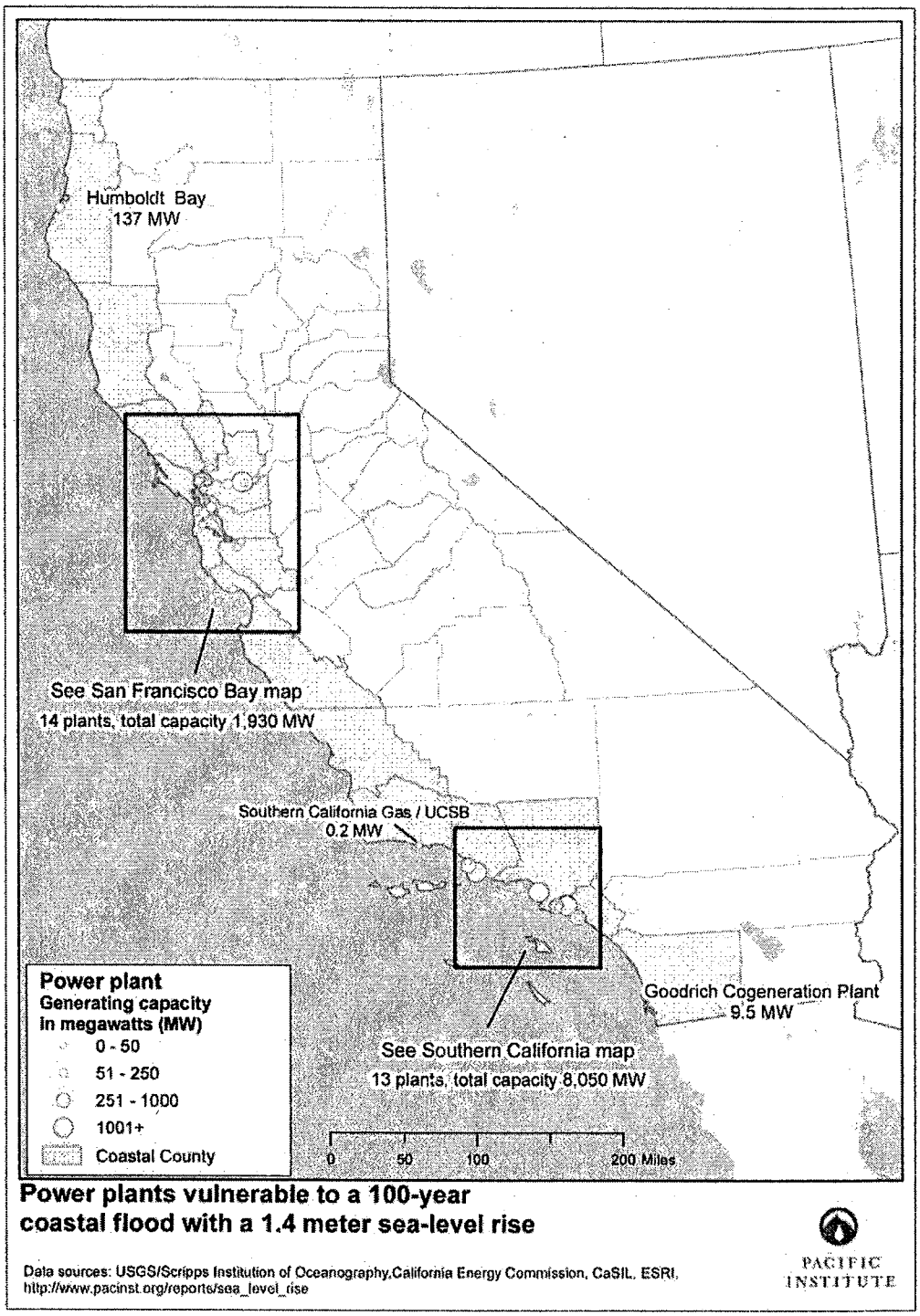


Figure 21. Power plants vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

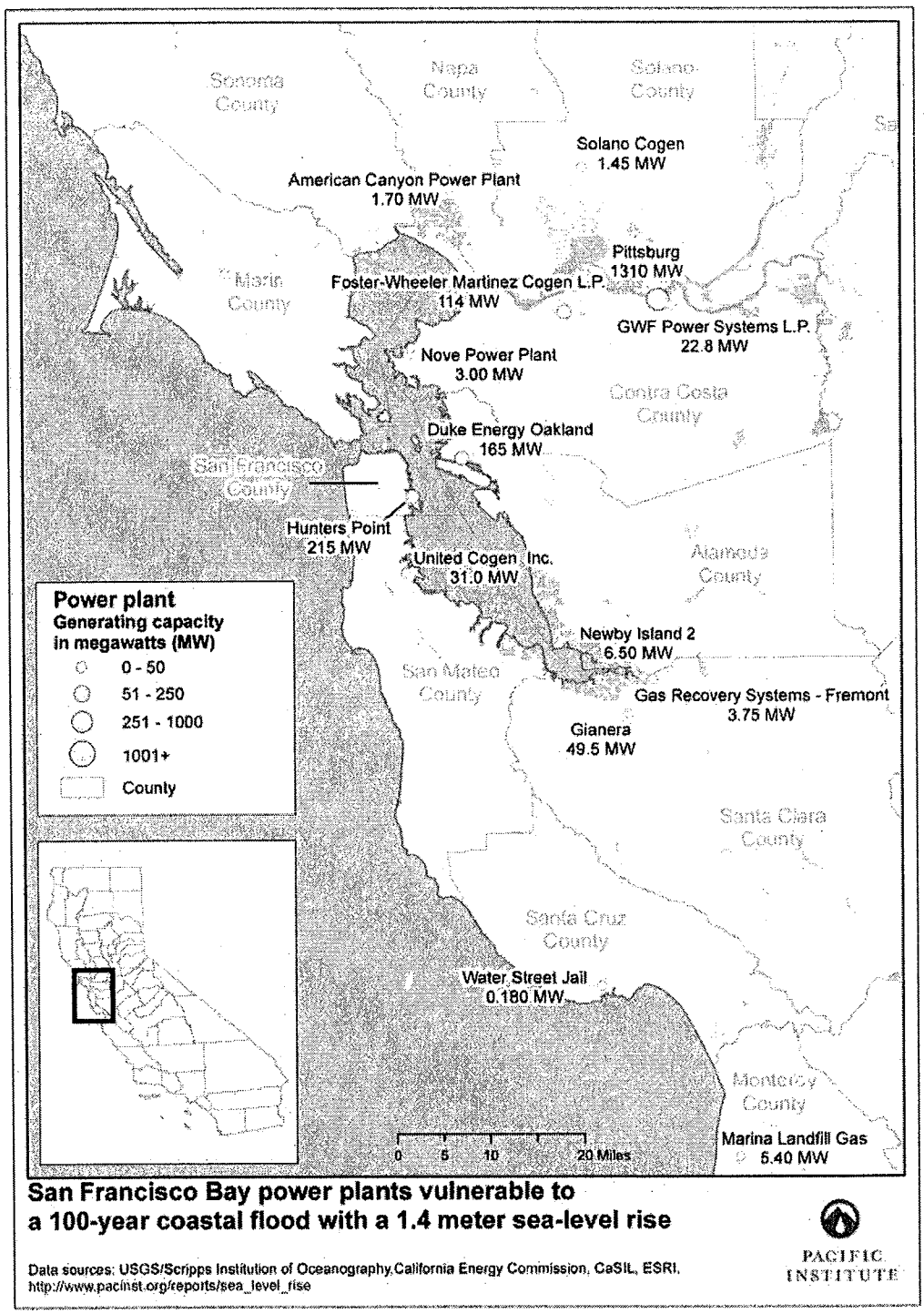


Figure 22. San Francisco Bay power plants vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

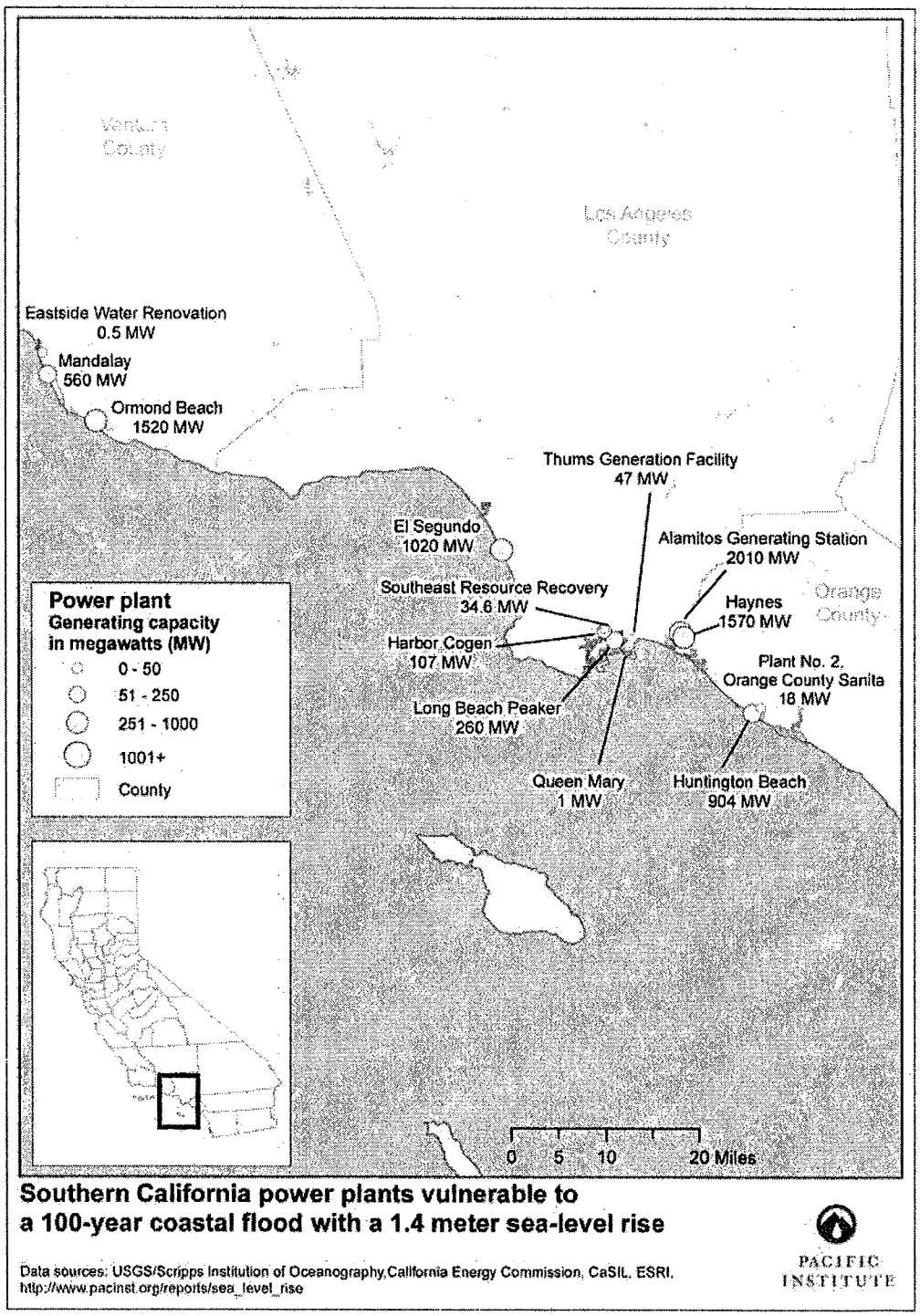


Figure 23. Southern California power plants vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

Wastewater Treatment Plants

Figures 24 and 25 show the wastewater treatment plants vulnerable to a 100-year flood event with a 1.4 m sea-level rise. We identified a total of 28 vulnerable wastewater treatment plants: 21 on the San Francisco Bay and 7 on the Pacific coast. The combined capacity of these plants is 530 million gallons per day (MGD). Inundation from floods could damage pumps and other equipment, and lead to untreated sewage discharges. Besides the flood risk to plants, higher water levels could interfere with discharge from outfalls sited on the coast. Cities and sanitation districts should begin to assess how higher water levels will affect plant operations and plan for future conditions.

Ports

Goods movement in California, and especially the San Francisco Bay Area, is critically important to the state's economy. A recent report by the Metropolitan Transportation Commission (MTC) stated that "over 37 percent of Bay Area economic output is in manufacturing, freight transportation, and warehouse and distribution businesses. Collectively, these goods-movement-dependent businesses spend approximately $6.6 billion on transportation services. The businesses providing these services also play a critical role as generators of jobs and economic activity in their own right" (MTC 2004).

Our assessment of future flood risk with sea-level rise shows significant flooding is possible at California's major ports in Oakland, Los Angeles, and Long Beach. These ports are central to the economy of California, the nation, and the world. The Port of Los Angeles-Long Beach, for example, handles 45%–50% of the containers shipped into the United States. Of these containers, 77% leave the state—half by train and half by truck (Christensen 2008).

Many port managers have already experienced how disasters can affect their operations. Following the Loma Prieta earthquake in 1989, for example, the Port of Oakland sustained damages that interrupted business for 18 months. These disruptions have economic implications for the nation and the world, as evident by a 2002 contract dispute that resulted in a work slowdown at West Coast ports and cost the U.S. economy an estimated $1 billion to $2 billion per day. Others speculated that Japan and China would lose several percentage points off their gross domestic product if the ports closed for longer than a week (Farris 2008).

In addition to directly affecting port operations, sea-level rise may cause other interruptions to goods movement at ports. Sea-level rise can reduce bridge clearance, thereby reducing the size of ships able to pass or restricting their movements to times of low tide. Higher seas may cause ships to sit higher in the water, possibly resulting in less efficient port operations (National Research Council 1987). These impacts are highly site specific, and somewhat speculative, requiring detailed local study. We also note the connection between possible direct impacts of sea-level rise on the ports themselves and possible flooding of transportation (rail and road) corridors to and from the ports.

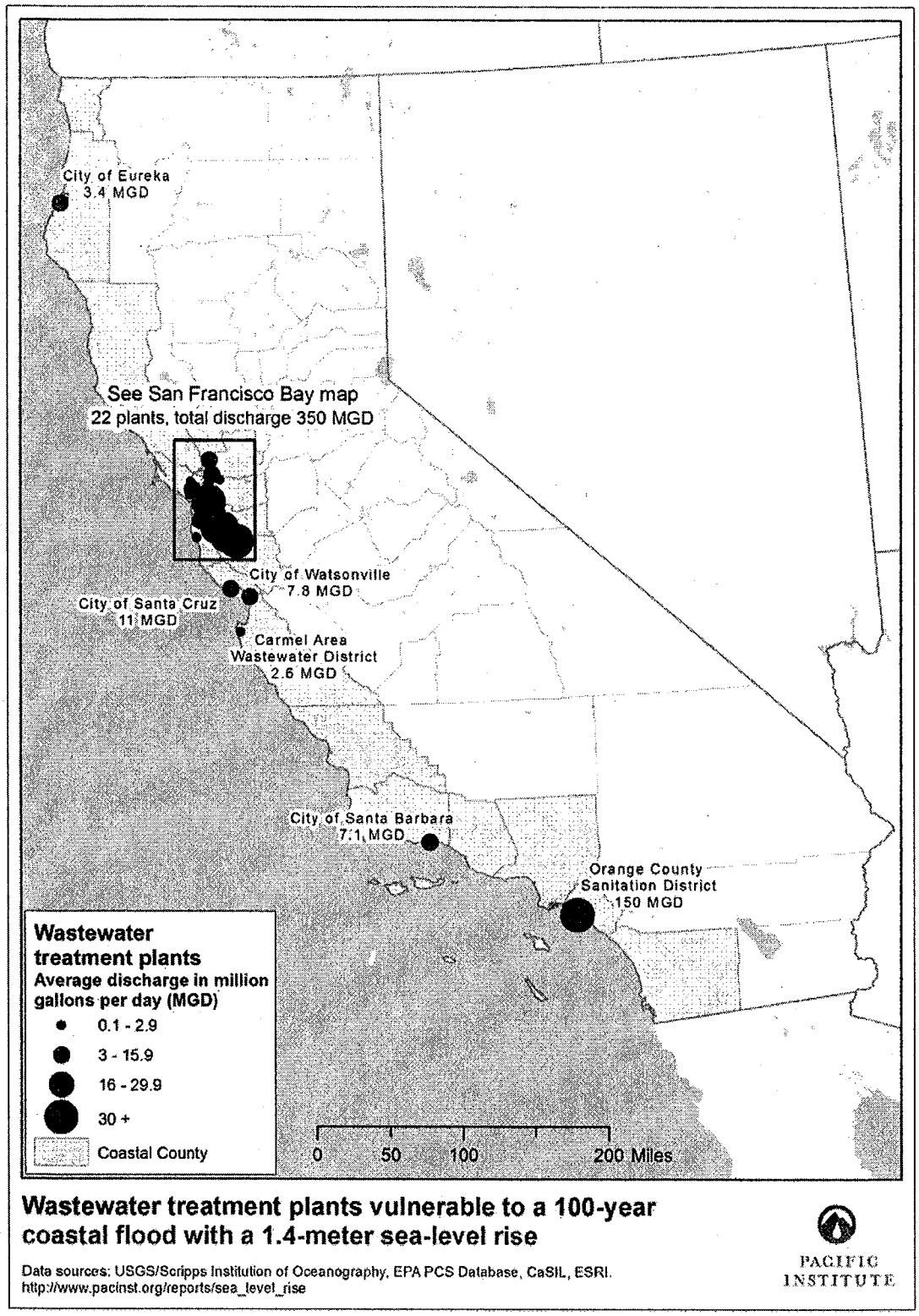


Figure 24. Wastewater treatment plants on the Pacific coast vulnerable to a 100-year flood with a 1.4 m sea-level rise

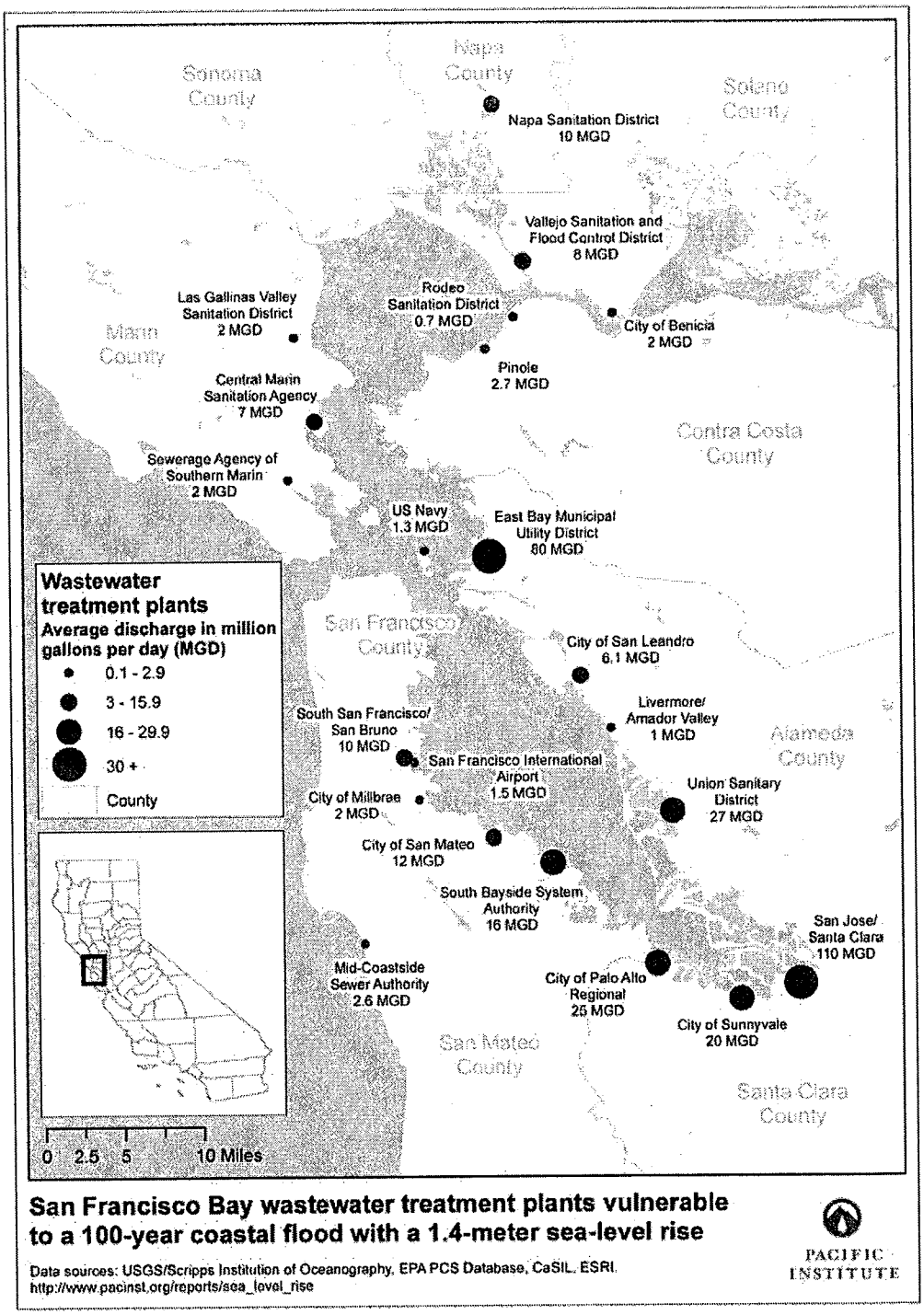


Figure 25. Wastewater treatment plants on the San Francisco Bay vulnerable to a 100-year flood with a 1.4 m sea-level rise

Airports

The San Francisco and Oakland airports are vulnerable to flooding with a 1.4-meter sea-level rise. Other major airports near the coast, such as the San Diego, San Jose, and Los Angeles airports, were not identified as vulnerable in our analysis.

The economic impact of a disruption in airport traffic in San Francisco and Oakland is potentially large, and it would have significant effects on the state and regional economy. In 2007, the Oakland International airport transported 15 million passengers and 647,000 metric tons of freight. Activity at the San Francisco International airport is even greater than in Oakland. The San Francisco International Airport is the nation's thirteenth busiest airport, transporting 36 million people in 2007 (Airports Council International 2007). It also plays a significant role in the movement of goods regionally and internationally. In 2007, the San Francisco airport handled 560,000 metric tons of freight. San Francisco Airport ranked twelfth among foreign trade freight gateways by value of shipments in 2005, handling $25 billion in exports and $32 billion in imports (Bureau of Transportation Statistics 2006), more than double that of the $23.7 billion handled by vessels at the Port of Oakland.

3.1.5. Wetlands

Today, there are approximately 350,000 acres, or 550 square miles, of coastal wetlands in California (Figure 26). Based on an approximated wetland value of $5,000 to $200,000 per acre, we estimate that California's coastal wetlands are worth from $1.8 billion to $70 billion. Large wetland areas are found in almost every county on the California coast (Table 18). The vast majority of coastal wetlands are in San Francisco Bay and the Sacramento-San Joaquin Delta.

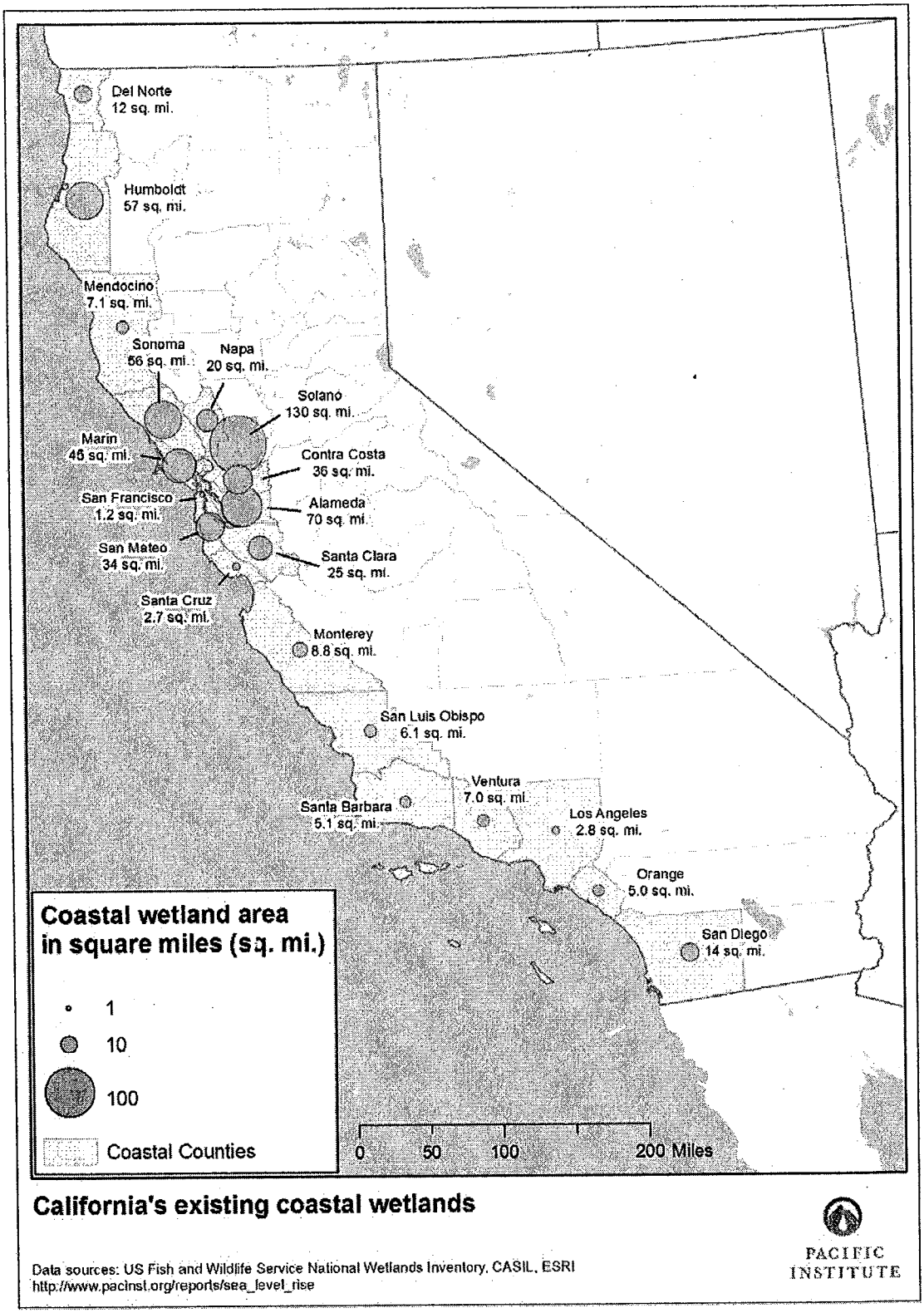


Figure 26. Existing coastal wetlands

There are also significant and important coastal wetlands in Northern California, especially in and around Humboldt and Eureka. Much of the Central California coast, from the Lost Coast in Mendocino County to Big Sur in Monterey, San Luis Obispo, and Santa Barbara counties, is dominated by rugged hills and cliffs plunging into the sea. In these areas, there are very few coastal wetlands. There are critically important wetlands that may be of small size, but that serve vital ecological functions—we understand that size is not the only measure of wetland value. We note that adequate wetland delineation has not been performed on vast areas of California and the actual wetland area may be larger.

Table 18. Existing California coastal wetland area by county

County	Area (square miles)	Area (acres)	Percent of state total
Alameda	70	45,000	13%
Contra Costa	36	23,000	6.5%
Del Norte	12	7,700	2.2%
Humboldt	57	37,000	10%
Los Angeles	2.8	1,800	0.5%
Marin	45	29,000	8.3%
Mendocino	7.1	4,500	1.3%
Monterey	8.8	5,600	1.6%
Napa	20	13,000	3.6%
Orange	5	3,200	0.9%
San Diego	14	8,900	2.5%
San Francisco	1.2	760	0.2%
San Luis Obispo	6.1	3,900	1.1%
San Mateo	34	22,000	6.2%
Santa Barbara	5.1	3,300	0.9%
Santa Clara	25	16,000	4.5%
Santa Cruz	2.7	1,700	0.5%
Solano	130	86,000	24%
Sonoma	56	36,000	10%
Ventura	7	4,500	1.3%
Total	**550**	**350,000**	**100%**

Note: Numbers may not add up due to independent rounding.

Evaluating the impacts of sea-level rise on a particular coastal wetland area requires site-specific data on various physical and biological factors. A simple method to estimate wetland loss is to compare wetland elevations to future tide elevations. Data limitations, however, prevent us from performing even this simple analysis, i.e., there are no data in the critical area where the boundary must be drawn. Given these data limitations, we evaluated the land cover *adjacent* to existing wetlands and the potential for these areas to support suitable wetland habitat. We note that this simplified analysis does not take into account erosion or accretion due to sediment movement, which is difficult to predict with any accuracy.

We estimate that wetlands require approximately 150 square miles of accommodation space, or land into which they must migrate to survive a sea-level rise of 1.4 m. Of this amount, 83 square miles, or 55%, would make viable wetland habitat (Table 19). These areas should be protected to ensure their viability as wetland habitat is maintained. Twenty-three square miles, or 15%, is land that is viable for wetland migration but at some loss of value, including parks, orchards, and agricultural land. The remaining 30% of the available accommodation space is unsuitable for wetland migration because it is built up; covered with roads, buildings, and pavement.

Table 19. Wetland migration frontier area classified by land cover type and conversion potential

Land cover type	Total frontier area (square miles)
Not viable for wetland migration	
High Intensity Developed	12
Medium Intensity Developed	12
Low Intensity Developed	21
Subtotal	**45**
Viable for wetland migration, but will cause property loss	
Developed Open Space	4.7
Pasture/Hay	11
Cultivated	7.0
Subtotal	**23**
Viable for wetland migration	
Evergreen Forest	0.28
Deciduous Forest	0.040
Mixed Forest	0.27
Scrub/Shrub	1.3
Grassland	16
Bare Land	0.89
Palustrine Scrub/Shrub Wetland	0.85
Palustrine Forested Wetland	0.47
Palustrine Emergent Wetland	4.7
Estuarine Scrub/Shrub Wetland	42
Estuarine Forested Wetland	2.4
Estuarine Emergent Wetland	0.11
Estuarine Aquatic Bed	0.046
Unconsolidated Shore	4.0
Water	10
Subtotal	**83**
Total	**150**

Note: Numbers may not add up due to rounding.

Figures 27, 28, 29, and 30 and Table 20 summarize the potential wetland migration area by county. Solano County has the largest wetland migration area, totaling 22 miles, and 85% of that area is currently viable wetland habitat. Of the potential 20 miles of wetland migration area in Humboldt County, only 39% is viable wetland habitat, although an additional 54% is viable but with some economic loss. San Francisco and Los Angeles Counties have only small potential wetland migration areas, in part because there are few wetlands in these counties. Unfortunately, those that do exist are at high risk because 70% and 60% of the potential wetland migration area in San Francisco and Los Angeles Counties, respectively, is not viable wetland habitat.

Table 20. Land area available for wetland migration, by county, in square miles, with percent of county total in italics

County	Wetland migration viable		Migration viable with loss of value		Migration not viable		Total	Percent of State Total
Alameda	8.5	*49%*	0.94	*5%*	8.1	*46%*	17	10%
Contra Costa	8.1	*72%*	0.68	*6%*	2.5	*22%*	11	6.7%
Del Norte	2.1	*81%*	0.39	*15%*	0.13	*5%*	2.6	1.6%
Humboldt	7.7	*39%*	11	*54%*	1.2	*6%*	20	12%
Los Angeles*	0.10	*35%*	0.012	*4%*	0.17	*60%*	0.28	0.17%
Marin	5.7	*54%*	0.29	*3%*	4.7	*44%*	11	6.3%
Mendocino	1.3	*93%*	0.035	*2%*	0.059	*4%*	1.4	0.8%
Monterey	4.1	*56%*	2.6	*36%*	0.60	*8%*	7.3	4.3%
Napa	2.9	*80%*	0.24	*6%*	0.51	*14%*	3.7	2.2%
Orange*	0.72	*22%*	0.20	*6%*	2.4	*72%*	3.3	2.0%
San Diego	3.7	*64%*	0.33	*6%*	1.7	*30%*	5.8	3.4%
San Francisco	0.20	*18%*	0.15	*13%*	0.80	*70%*	1.1	0.7%
San Luis Obispo	0.78	*69%*	0.081	*7%*	0.27	*24%*	1.1	0.7%
San Mateo	2.9	*20%*	0.54	*4%*	11	*76%*	15	8.7%
Santa Barbara*	0.87	*86%*	0.023	*2%*	0.12	*12%*	1.0	0.6%
Santa Clara	2.2	*29%*	0.81	*11%*	4.6	*60%*	7.6	4.5%
Santa Cruz	0.98	*40%*	1.1	*43%*	0.42	*17%*	2.5	1.5%
Solano	19	*85%*	0.87	*4%*	2.5	*11%*	22	13%
Sonoma	7.6	*87%*	0.53	*6%*	0.59	*7%*	8.8	5.2%
Ventura	**3.4**	*45%*	2.2	*29%*	2.0	*26%*	7.6	4.5%
Total	**83**	***55%***	**23**	***15%***	**45**	***30%***	**150**	**100%**

*Given data limitations, we mapped about 49% of Santa Barbara County, 23% of Los Angeles County, and 65% of Orange County. The coverage was 100% in the other 11 counties on the Pacific coast.

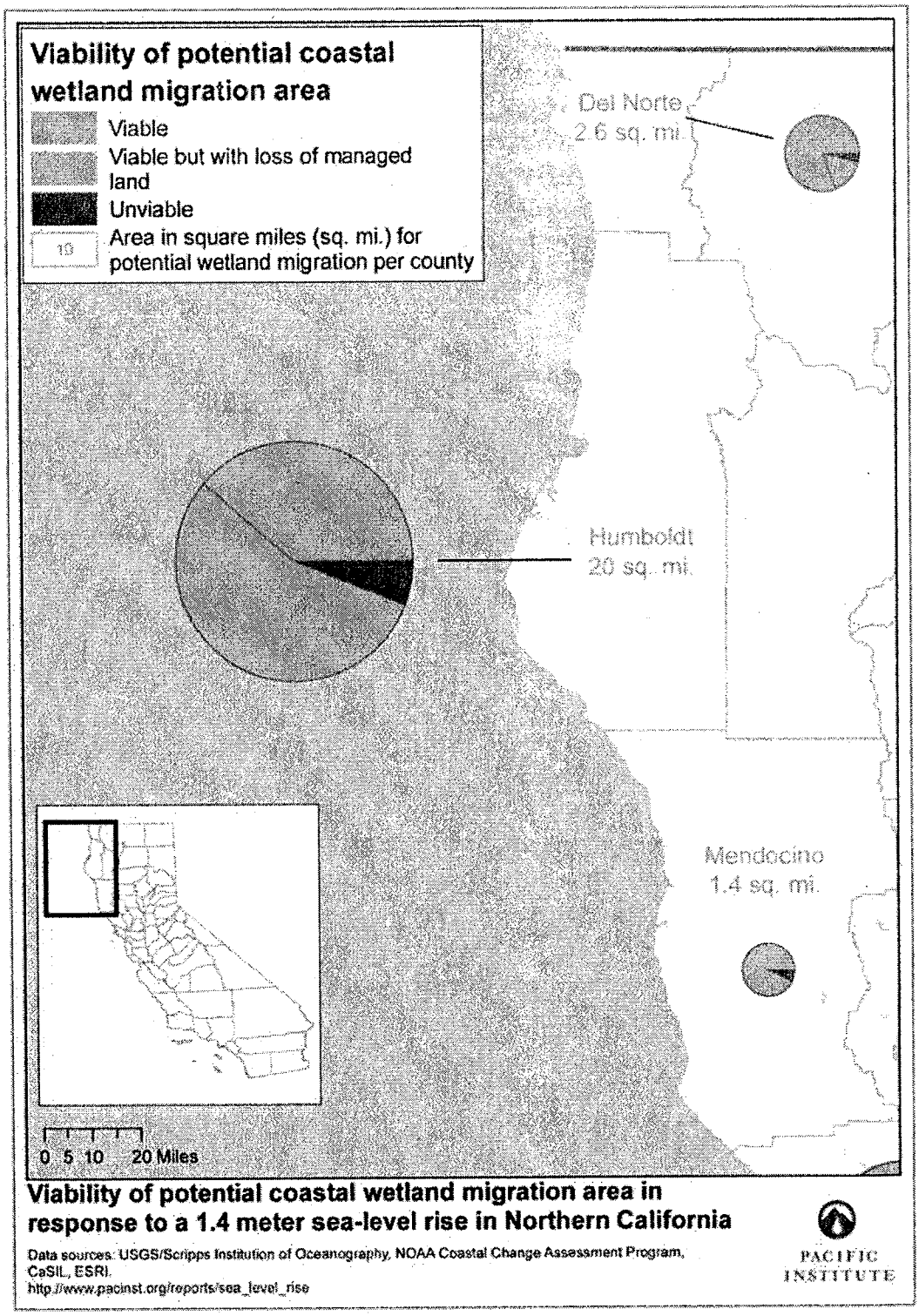


Figure 27. Viability of potential wetland migration area in response to a 1.4 m sea-level rise in Northern California

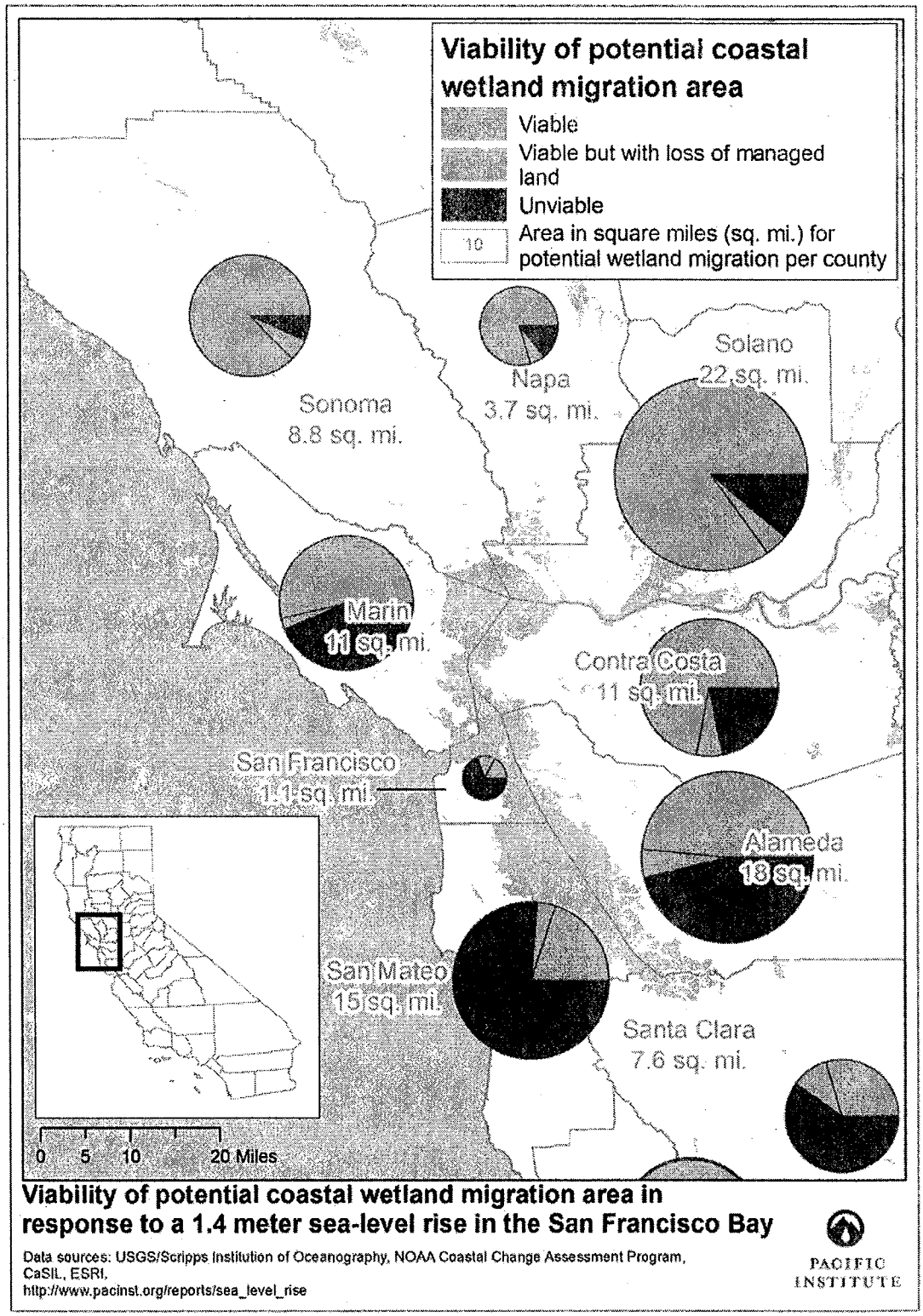


Figure 28. Viability of potential wetland migration area in response to a 1.4 m sea-level rise in the San Francisco Bay

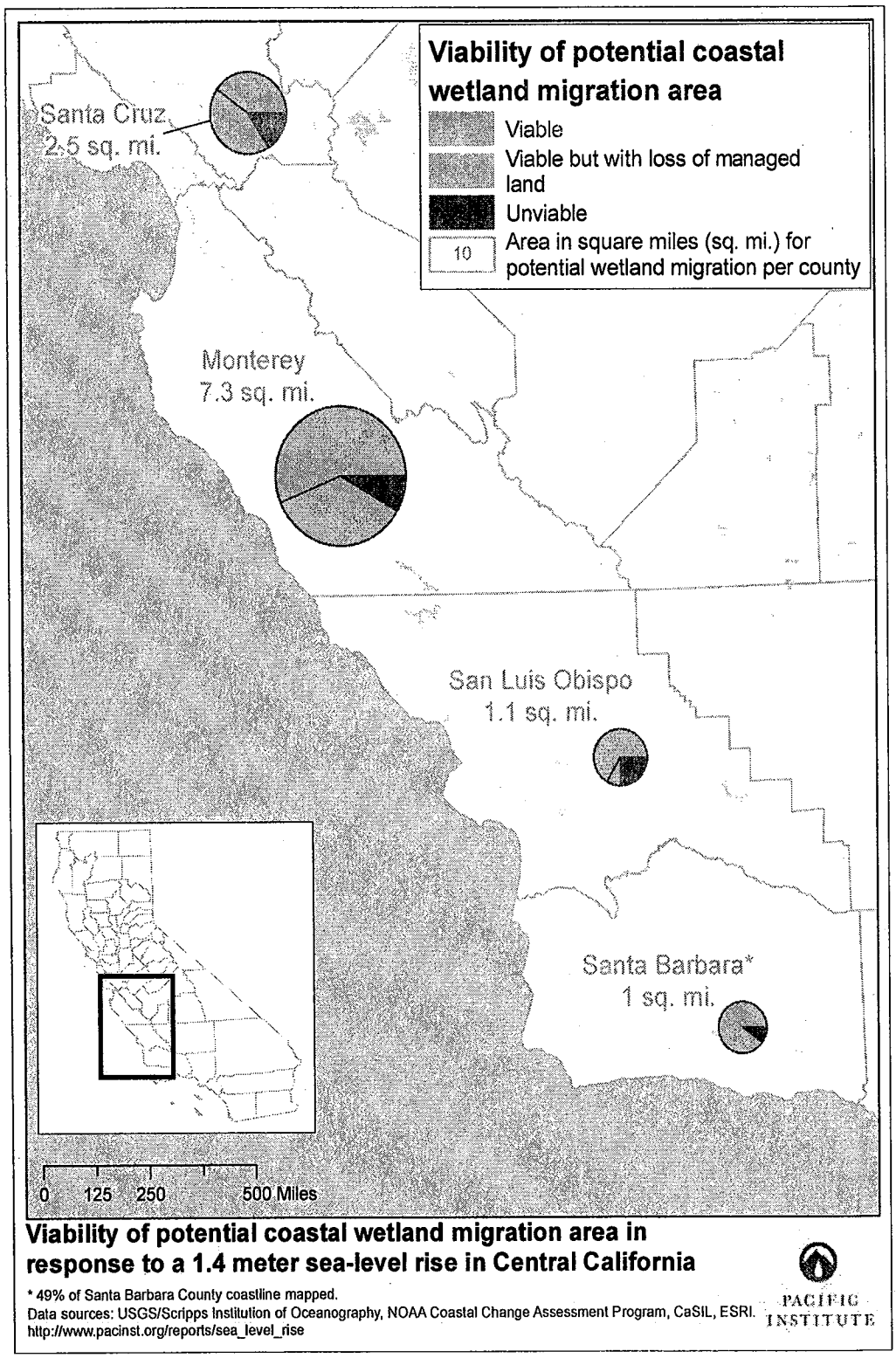


Figure 29. Viability of potential wetland migration area in response to a 1.4 m sea-level rise in Central California

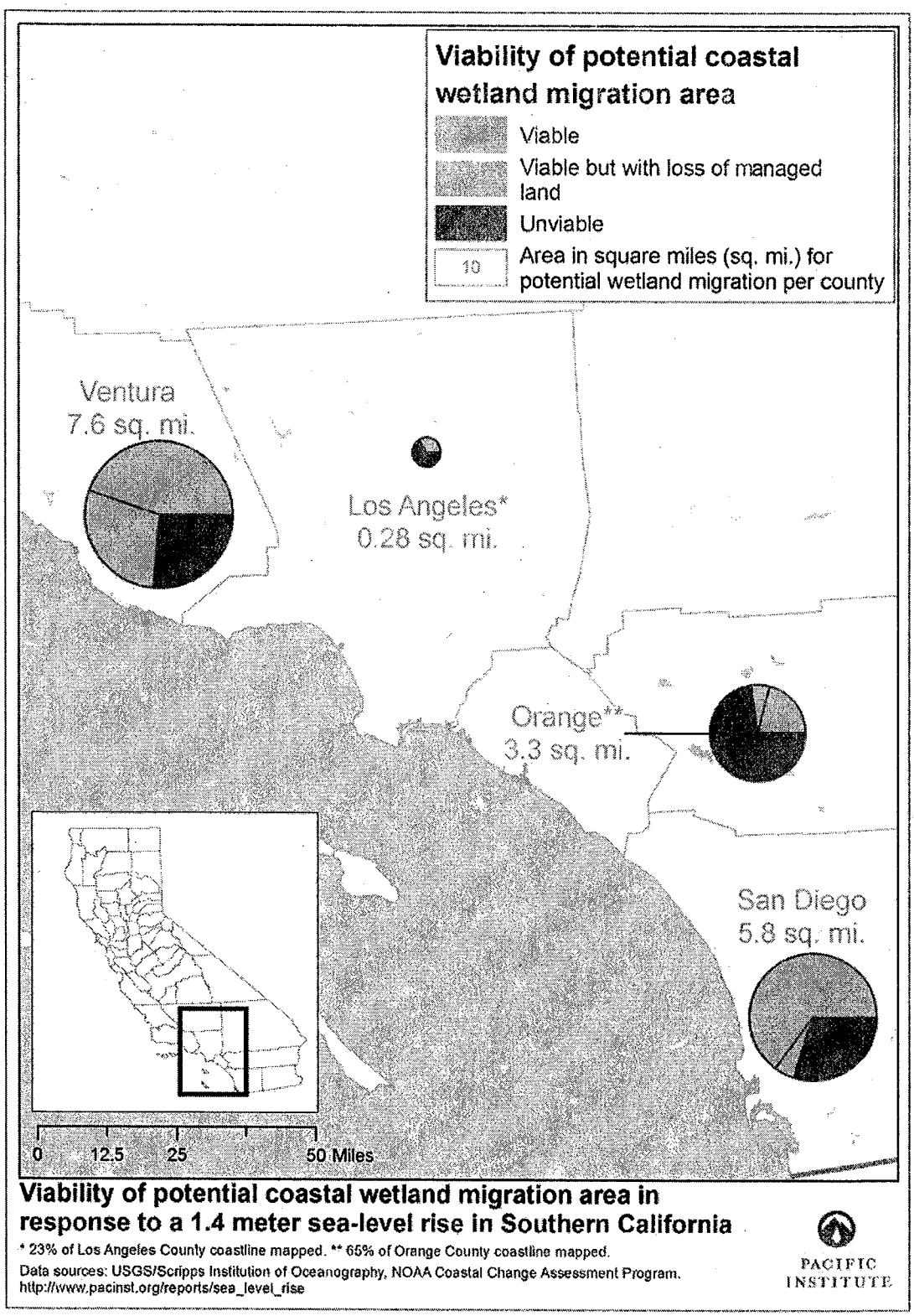


Figure 30. Viability of potential wetland migration area in response to a 1.4 m sea-level rise in Southern California

3.1.6. Property at Risk

Significant property is at risk of flooding from 100-year flood events as a result of a 1.4 m sea-level rise. In total, we estimate that the replacement value of this property totals nearly $100 billion (Figure 31). An overwhelming two-thirds of that property is concentrated on San Francisco Bay, indicating that this region is particularly vulnerable to impacts associated with sea-level rise due to extensive development on the margins of the Bay (Figure 32).

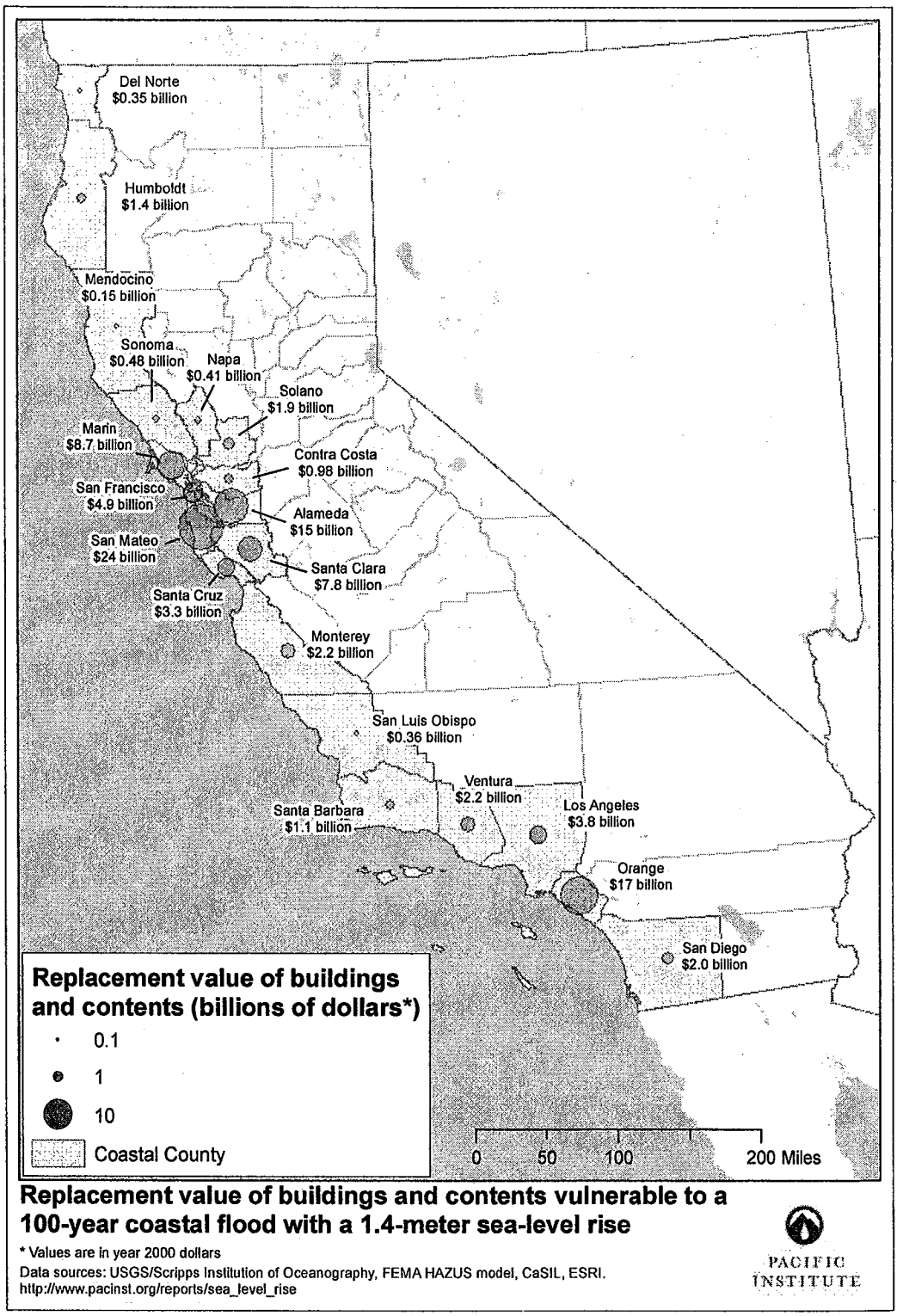


Figure 31. Replacement value of buildings and contents vulnerable to a 100-year coastal flood with a 1.4 m sea-level rise

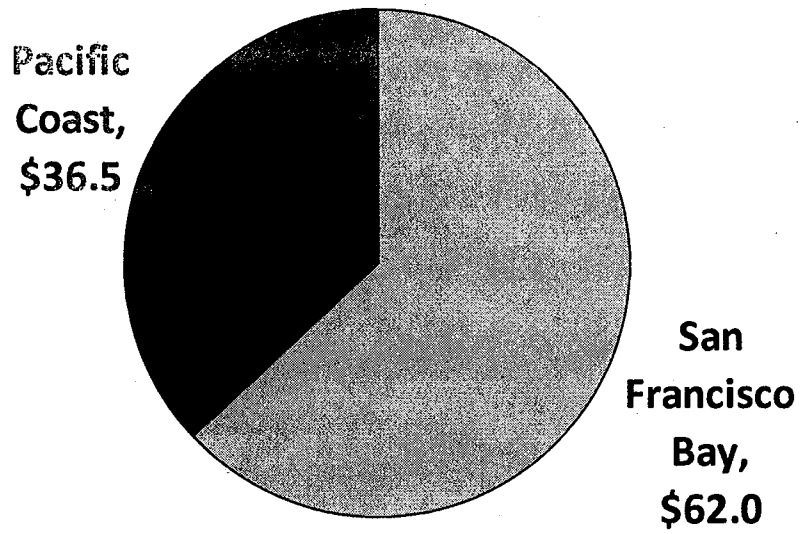


Figure 32. Replacement value (in billions of year 2000 dollars) of buildings and contents at risk of a 100-year flood event with a 1.4 m sea-level rise, by region

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

Pacific Coast

Within each region, vulnerability to sea-level rise is highly variable. Table 21 shows the replacement value of buildings and their contents at risk of a 100-year flood event with a 1.4 m sea-level rise for the Pacific coast by county. Property at risk during a 100-year flood increases from about $21 billion in 2000 to $37 billion (in year 2000 dollars) with a 1.4 m sea-level rise. About $17 billion of property, or about 50% of the total property at risk, is in Orange County. Los Angeles, Santa Cruz, Monterey, and Ventura Counties also have significant assets at risk, totaling in excess of $2 billion each.

Table 21. Replacement value of buildings and contents (millions of year 2000 dollars) at risk of a 100-year flood event along the Pacific coast, by county

County	Current risk	Risk with 1.4 m sea-level rise	Percent increase
Del Norte	240	350	+ 43%
Humboldt	680	1,400	+ 110%
Los Angeles	1,400	3,800	+ 180%
Marin	220	260	+ 16%
Mendocino	120	150	+ 22%
Monterey	1,700	2,200	+ 36%
Orange	11,000	17,000	+ 63%
San Diego	690	2,000	+ 190%
San Francisco	670	890	+ 33%
San Luis Obispo	220	360	+ 67%
San Mateo	730	910	+ 26%
Santa Barbara	460	1,100	+ 140%
Santa Cruz	2,400	3,300	+ 34%
Sonoma	170	200	+ 20%
Ventura	980	2,200	+ 120%
Total	**21,000**	**37,000**	**+ 71%**

Note: All values are shown in millions of year 2000 dollars. Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

All economic sectors are vulnerable to impacts associated with sea-level rise. Figure 33 shows the breakdown of the buildings and contents at risk of 100-year flood by major economic sector for the Pacific coast (specific sectors, such as transportation, are discussed in Section 3.2). More than 70% of the assets at risk are residential. The commercial sector, accounting for nearly 20% of the value at risk, will also likely encounter significant costs. Agriculture, education, religion, and government each account for about 1% of the assets at risk, thus, their exposure to risk is relatively small.

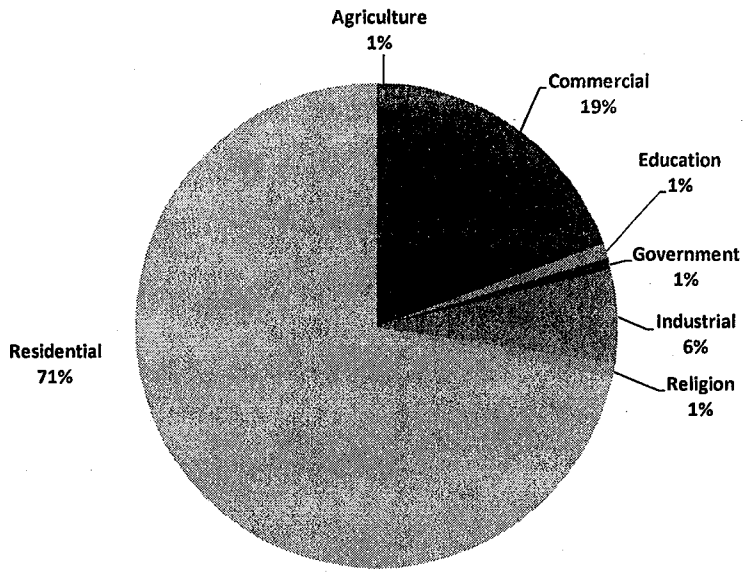


Figure 33. Replacement value of buildings and contents at risk of 100-year flood event with a 1.4 m sea-level rise along the Pacific coast, by major economic sector

San Francisco Bay

The value of assets at risk on San Francisco Bay is substantially higher than along the Pacific coast. Table 22 shows the replacement value of buildings and their contents vulnerable to a 100-year flood event with a 0.5 m, 1.0 m, and 1.4 m sea-level rise. Note that the model used to develop inundation maps for San Francisco Bay allows us to determine the property at risk from any flood intensity. Assets at risk during a 100-year flood increase from about $29 billion in 2000 to $36 billion, $49 billion, and $62 billion (in year 2000 dollars) with a 0.5 m, 1.0 m, and 1.4 m sea-level rise, respectively.

The assets at risk are not evenly distributed among the counties on San Francisco Bay (Table 22). San Mateo and Alameda counties have the greatest assets at risk, accounting for about 60% of the total assets at risk with sea-level rise. Marin, Santa Clara, and San Francisco counties are also exposed to a high degree of risk; exposure to risk in these counties is higher than in all other counties along the Pacific coast, with the exception of Orange County. Exposure to risk in Sonoma and Napa counties is relatively modest.

Table 22. Replacement value of buildings and contents at risk of a 100-year flood on San Francisco Bay, by county (in millions of year 2000 dollars)

County	Current Risk	Risk with sea-level rise			Percent Increase (1.4 m)
		0.5 m	1.0 m	1.4 m	
Alameda	3,300	5,300	10,000	15,000	+ 370%
Contra Costa	190	330	620	980	+ 430%
Marin	4,700	5,900	7,400	8,500	+ 79%
Napa	220	260	320	410	+ 89%
San Francisco	110	370	1,400	4,000	+ 3400%
San Mateo	16,000	18,000	21,000	23,000	+ 41%
Santa Clara	3,700	4,700	6,400	7,800	+ 110%
Solano	620	940	1,400	1,900	+ 210%
Sonoma	150	180	240	280	+ 82%
Total	29,000	**36,000**	**49,000**	**62,000**	**+ 110%**

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

As it is along the Pacific coast, the residential sector on San Francisco Bay faces the greatest risk. Figure 34 shows the buildings and contents at risk of a 100-year flood by major economic sector on San Francisco Bay (specific sectors, such as transportation, are discussed in Section 3.1.4). Of the $62 billion of property at risk with a 1.4 m sea-level rise, about 50% of the assets at risk are residential, substantially smaller than along the Pacific coast. The commercial and industrial sectors face much greater risk on San Francisco Bay than on the Pacific coast. Agriculture, education, religion, and government each account for about 1% of the assets at risk, thus their exposure to risk is fairly small.

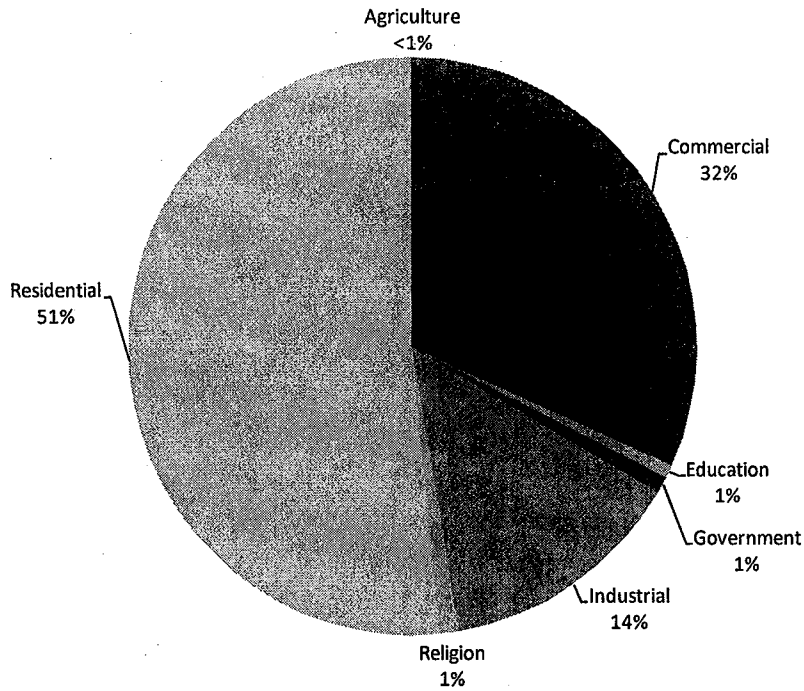


Figure 34. Replacement value of buildings and contents at risk of a 100-year flood with a 1.4 m sea-level rise on San Francisco Bay, by major economic sector

3.1.7. Saltwater Intrusion to Groundwater Aquifers

Saltwater intrusion into aquifers is a man-made problem in many places in California, resulting from over-pumping, but it will be accelerated and made worse by sea level rise. It occurs where saline water moves inland into a freshwater aquifer, contaminating it with salts and making it unsuitable for water supply or irrigation. Pumping coastal aquifers in excess of natural recharge rates draws down the surface of the aquifer. When the ocean has a higher "potentiometric surface," or water elevation, it causes the saltwater wedge to intrude further inland (Figure 35). Seawater intrusion is already problematic in California's coastal aquifers throughout Central and Southern California, including the Pajaro and Salinas Valleys and aquifers in Orange and Los Angeles Counties.

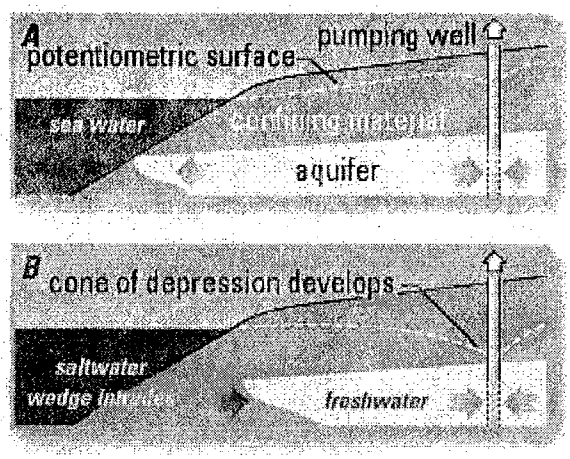


Figure 35. Saltwater intrusion

Source: Edwards and Evans 2002

Sea-level rise will increase saltwater intrusion into coastal aquifers. This in turn will increase water insecurity, as communities that rely on groundwater for all or part of their water supply will be forced to search for alternatives, which could include costly surface water transfers from outside their basin or desalination. Farmers who irrigate with groundwater may be unable to secure another reasonably-priced water source, forcing them to retire the land. None of these costs are quantified here, but they are not zero and should be studied in future work.

A number of actions can help mitigate saltwater intrusion. Significant investments in water conservation and efficiency improvements can allow water managers to reduce pumping. Enhancing natural recharge by limiting impervious areas (pavement), adopting low-impact development techniques, and building infiltration basins can also reduce intrusion. Another option is to artificially recharge the aquifer with freshwater imported from outside the basin. Additional work is needed to understand the impacts of sea-level rise on California's coastal aquifers and to develop ways to mitigate those impacts.

3.1.8. Cost of Protection

Approximately 1,100 miles of new or modified coastal protection structures are needed on the Pacific Coast and San Francisco Bay (Table 23). The total cost of building new or upgrading existing structures is estimated at about $14 billion (in year 2000 dollars). The majority of the investment is needed in Southern California. Nearly 20% of that investment would be needed in Los Angeles County alone. Significant investments would also be needed in Orange and San Diego counties. Mendocino would need the least amount of coastal armoring, although this area is particularly vulnerable to erosion, which is not reflected in this analysis. We estimate that operating and maintaining the protection structures would cost approximately 10 percent of the initial capital investment, or around another $1.4 billion per year.

Table 23. Estimated length (in miles) and capital cost of required defenses needed to guard against flooding from a 1.4 m sea-level rise, by county.

County	Raise levee (miles)	New levee (miles)	New seawall (miles)	Total (miles)	Capital Cost (millions of year 2000 dollars)
Alameda	45	49	16	110	950
Contra Costa	26	29	8.0	63	520
Del Norte	-	38	1.0	39	330
Humboldt	-	36	6.6	42	460
Los Angeles	0.88	2.5	94	97	2,600
Marin	43	77	7.7	130	930
Mendocino	-	0.29	1.2	1.4	34
Monterey	27	6.4	19	53	650
Napa	2.8	62	-	64	490
Orange	-	11	66	77	1,900
San Diego	-	-	47	47	1,300
San Francisco	-	10	21	31	680
San Luis Obispo	-	7.4	5.4	13	210
San Mateo	35	29	9.2	73	580
Santa Barbara	2.4	5.6	4.5	13	180
Santa Clara	47	4.0	-	51	160
Santa Cruz	3.9	1.6	9.3	15	280
Solano	2.7	63	8.0	73	720
Sonoma	30	15	1.3	47	240
Ventura	-	0.35	28	29	790
Total	**270**	**450**	**350**	**1,100**	**14,000**

3.2. Erosion-Related Risks

3.2.1. Population at Risk from Erosion

The erosion hazard zone totals 41 square miles within the 11 coastal counties evaluated in this analysis (Table 24). There is significant variation in the areas at risk of erosion. In Humboldt County, for example, 6.1 square miles of coast would be lost by 2100 under a sea-level rise scenario of 1.4 meters. In San Francisco, however, the erosion-related risk is small.

Table 24. Erosion with a 1.4 m sea-level rise, by county.

County	Dune erosion (sq. miles)	Cliff erosion (sq. miles)	Total erosion (sq. miles)
Del Norte	1.9	2.6	4.5
Humboldt	3.7	2.4	6.1
Marin	1.0	3.7	4.7
Mendocino	0.74	7.5	8.3
Monterey	1.9	2.5	4.4
San Francisco	0.23	0.30	0.53
San Luis Obispo	1.4	1.5	2.9
San Mateo	0.82	2.4	3.2
Santa Barbara	0.62	1.9	2.6
Santa Cruz	0.87	0.9	1.8
Sonoma	0.60	1.6	2.2
Total	**14**	**27**	**41**

As discussed in Section 2.3.2, dunes and cliffs will exhibit differential responses to rising sea levels. Our results indicated that cliffs will erode an average distance of about 66 m by the year 2100 (Table 25). In some areas, however, erosion is projected to be much higher. In Del Norte County, for example, cliffs erode a maximum distance of 520 m. Cliff erosion is much less severe in the other counties along the coast, although still significant. Dunes exhibit much less resistance to erosion. On average, dunes will erode about 170 m by 2100. In Humboldt County, however, dunes are projected to erode nearly 600 m by 2100.

Table 25. Average and maximum erosion distance in 2000 for cliffs and dunes, by county

	Dune erosion		Cliff erosion	
County	Average distance (m)	Maximum distance (m)	Average distance (m)	Maximum distance (m)
Del Norte	180	400	160	520
Humboldt	160	600	61	260
Marin	140	270	110	240
Mendocino	190	440	33	160
Monterey	180	400	37	220
San Francisco	150	230	90	220
San Luis Obispo	140	330	78	280
San Mateo	230	430	31	220
Santa Barbara	190	320	54	240
Santa Cruz	170	340	36	130
Sonoma	150	320	41	190
Average	**170**	**370**	**66**	**240**

Table 26 shows the population at risk from erosion with a 1.4 m sea-level rise in 2100. Flood-related risk is shown for comparative purposes. In the 11 coastal counties north of Santa Barbara, a total of 14,000 people live within areas at risk of erosion. In comparison, 63,000 people are vulnerable to a 100-year flood event within these counties. In most counties, the flood-related risk is substantially higher than the erosion-related risk. In Mendocino and Sonoma Counties, however, erosion poses a greater threat than flooding. In Marin and San Luis Obispo Counties, the flood-related and erosion-related risks are comparable. In addition to those who live in areas vulnerable to erosion, approximately 6,600 people are employed in facilities located there, of which 95% are employed in the commercial sector and the remaining 5% are employed in the industrial sector.

Table 26. Population vulnerable to flood and erosion from a 1.4 m sea-level rise along the Pacific coast, by county

County	Flood-related Risk	Erosion-related Risk
Del Norte	2,600	620
Humboldt	7,800	580
Marin	630	570
Mendocino	650	930
Monterey	14,000	820
San Francisco	6,500	1,200
San Luis Obispo	1,300	1,100
San Mateo	5,900	2,900
Santa Barbara	6,700	2,100
Santa Cruz	16,000	2,600
Sonoma	700	300
Total	**63,000**	**14,000**

Note: Numbers may not add up due to rounding.

3.2.2. Emergency and Healthcare Facilities at Risk from Erosion

Emergency and healthcare facilities at risk from erosion along the California coast are limited. The analysis identified a single health care facility near Pacifica that is vulnerable to erosion. There are no schools or fire and police stations within the erosion hazard zone.

3.2.3. Infrastructure at Risk from Erosion

Roads and Railways

Significant transportation-related infrastructure is vulnerable to erosion. Nearly 240 miles of highways and roads and 10 miles of railways are at risk of erosion in the 11 coastal counties north of Santa Barbara (Table 27). This is far fewer than the transportation-related infrastructure at risk from flooding but as mentioned previously, erosion causes far greater and potentially more permanent damage than flooding. In addition, areas such as Big Sur already have significant routine highway maintenance costs due to existing erosion conditions and these costs are likely to increase as erosion rates increase (Figure 36).

Other than roads and railways, little critical infrastructure is located within the erosion hazard zone. We identified no wastewater treatment plants, power plants, schools, police, or fire stations within the area at risk of erosion.

Table 27. Miles of roads and railways vulnerable to erosion and flood from a 1.4 m sea-level rise along the Pacific coast, by county and type

County	Highways (miles)		Roads (miles)		Railways (miles)	
	Erosion-risk	Flood-risk	Erosion-risk	Flood-risk	Erosion-risk	Flood-risk
Del Norte	4.3	8.2	14	80	-	-
Humboldt	6.0	58	20	190	-	28
Marin	2.1	4.1	19	27	-	-
Mendocino	13	7.9	25	41	-	4.0
Monterey	11	31	15	110	2.1	23
San Francisco	0	8.0	17	25	-	-
San Luis Obispo	2.5	0.4	18	22	-	0.3
San Mateo	9.8	11	18	67	-	-
Santa Barbara	0.74	7.4	12	21	6.4	7.0
Santa Cruz	2.4	5.0	20	30	1.6	5.5
Sonoma	6.2	8.0	8.4	57	-	-
Total	**58**		**180**		**10**	

Note: Numbers may not add up due to rounding.

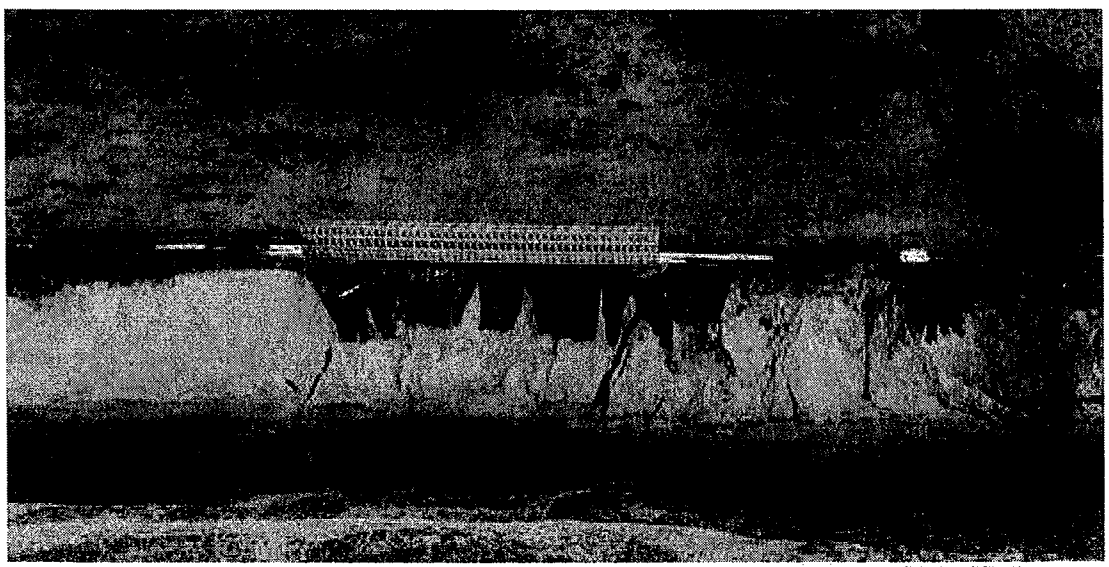


Figure 36. Road erosion along Highway 1 with deployment of erosion mitigation strategy

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3.2.4. *Property at Risk from Erosion*

Land on or near the coast is highly desirable and often commands a premium price. Homes lost to erosion cannot be replaced because the land will have disappeared. As a result, the replacement values reported in the HAZUS database cannot be used to evaluate erosion. A detailed estimate of the value of land and homes that would be completely lost was beyond the scope of this analysis. In order to bound the problem, however, we sought to determine the number of parcels at risk by overlaying the erosion hazard zone layer with the available parcel data. Note that the erosion hazard zone was identified for portions of 11 of California's coastal counties. Eight of these 11 counties had parcel data in digital format.

Parcels are used by counties to levy property taxes. Assessor's offices divide entire counties into parcels, which can represent publicly-owned land, roads, lakes, and other features. A single parcel may also contain an apartment building with many hundreds of residences. Thus, this is an imprecise way of estimating how much property may be lost to coastal erosion. This is an area of study that can and should be pursued in more detail by local governments and regional planning agencies.

We estimate that approximately 10,000 parcels lie within the erosion hazard zone, as summarized in Table 28. Of these parcels, 66%, or two-thirds, lie entirely in the erosion hazard zone, meaning the property would be lost completely. The remaining third are partially eroded. If we assume that the value of the average coastal parcel is $1.4 million (Heinz Center 2000), then the economic cost to property of erosion from a 1.4 m sea-level rise would total $14 billion. More work on the economic consequences of erosion is needed.

Table 28. Number of properties within the erosion zone hazard zone with a 1.4 m sea-level rise, by county

County	Number of parcels
Del Norte	No data
Humboldt	570
Marin	1,300
Mendocino	No data
Monterey	1,600
San Francisco	850
San Luis Obispo	No data
San Mateo	1,900
Santa Barbara	580
Santa Cruz	3,000
Sonoma	500
Total	**10,000**

Note: Numbers may not add up due to rounding.

4.0 Conclusions and Recommendations

4.1. Conclusions

Rising sea levels will be among the most significant impacts of climate change to California. Sea level will rise as a result of thermal expansion of the oceans and an increase in ocean volume as land ice melts and runs off. Over the past century, sea level has risen nearly eight inches along the California coast and general circulation model scenarios suggest very substantial increases in sea level due to climate change over the coming century. This study evaluates the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the coast. The sea-level rise scenario was developed by the State of California from medium to medium-high greenhouse gas emissions scenarios from the Intergovernmental Panel on Climate Change (IPCC) but does not reflect the worst case sea-level rise that could occur.

We estimate that a 1.4 m sea-level rise will put 480,000 people at risk of a 100-year flood event. Among those affected are large numbers of low-income people and communities of color, which are especially vulnerable. A wide range of critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and wetlands is also vulnerable. In addition, $100 billion (in year 2000 dollars) worth of property is at risk of coastal flooding. A number of structural and non-structural policies and actions could be implemented to reduce these risks. For example, we estimate that protecting vulnerable areas from flooding by building seawalls and levees will cost $14 billion (in year 2000 dollars), along with an additional $1.4 billion per year (in year 2000 dollars) in maintenance costs. Continued development in vulnerable areas will put additional assets at risk and raise protection costs. Determining what to protect, how to pay for it, and how those choices are made raises concerns over equity and environmental justice.

Large sections of the Pacific coast are not vulnerable to flooding, but are highly susceptible to erosion. We estimate that a 1.4 m sea-level rise will accelerate erosion, resulting in a loss of 41 square miles of California's coast by 2100. A total of 14,000 people live in areas at risk of erosion. In addition, significant transportation-related infrastructure and property are also at risk. Throughout most of the state, flood risk exceeds erosion risk, but in some counties, coastal erosion poses a greater risk. We also provide, below, a set of recommendations for actions and policies that can reduce future risks and vulnerabilities.

4.2. Recommendations

Climate changes are inevitable, and adaptation to unavoidable impacts must be evaluated, tested, and implemented. Sea levels have risen observably in the past century, and scientists forecast that sea-level rise will continue for centuries, even if we stop emitting greenhouse gases immediately. As a result, coastal areas will be subject to increasing risk of inundation and erosion. Below, we provide a series of recommendations and principles to guide the adaptation process.

4.2.1. Principles for Adaptation

The decisions about what to protect, how to protect it, and who will have to pay will be both challenging and controversial. Given the complexity of these issues, it is important to develop an open and transparent process involving all affected stakeholders. Below, we provide some general principles to guide this process:

- Human life must be protected.
- Critical ecological systems should be preserved.
- Development and protection of the coast should be governed by the principles of sustainability. Simply stated, this means "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987).
- Equal and full participation must be a central element of any decision-making process. No social or economic group should be excluded from decision-making that will affect its well-being.
- Communities must determine the resources and features they value, e.g., beaches, public access, fisheries, etc., and develop plans to protect those resources.
- Consideration should be given to equitable distribution and apportionment of costs and benefits of adaptation measures.
- Adaptation strategies should account for the distinct vulnerabilities of potentially affected subpopulations.
- Local and regional planning processes must begin early to incorporate estimates of sea-level rise and strategies for adaptation.

4.2.2. Recommended Practices and Policies

Climate change must be integrated into the design of all coastal structures.

Current efforts to build, maintain, or modify structures in coastal areas at risk of sea-level rise must now be based on estimates of that rise. The costs of modifying structures in the design phase are often far lower than the costs of later reconstruction or flood damage.

The federal government and the insurance industry should develop and implement a methodology for integrating climate change into insurance policies and strategies.

Properly designed insurance policies are vital for helping landowners choose whether to protect or abandon risky property. The design, availability, and cost of flood insurance will be a key instrument in implementing floodplain policy. For example, the government should not continue to subsidize flood insurance for properties that have suffered repetitive losses. Nor should insurance be available for properties highly likely to be inundated under future conditions.

We do not propose that flood insurance policies be taken away from business or homeowners. We do suggest, however, that policyholders in areas that are exposed to increased risk should not be allowed to rebuild or make major repairs to a structure after it has been damaged, nor should they be allowed to expand or make significant improvements, and that long-term insurance policies take into account changes in coastal risks.

Federal flood insurance maps should include information on future flood risks due to sea-level rise.

The Federal Emergency Management Agency's official flood insurance studies show hazard zones that reflect past or present flood risks. Because these are the *de facto* planning documents used by most local governments, they should be updated to show the *future* hazard areas and include the current science on climate change and sea-level rise.

Wetlands and the potential migratory paths should be protected.

Development should be prohibited on natural lands that are immediately adjacent to wetlands at risk. These buffer areas may be the only areas suitable for future wetland restorations projects.

Future development should be limited in areas that are at risk from rising seas.

In regions at risk that are not yet heavily developed, local communities and coastal planning agencies have the opportunity to limit development and reduce future threats to life and property. Policies that maintain such low-lying areas will help to accommodate rising seas. In addition to insurance policies, discussed above, such policies may include local ordinances, statewide coastal development policies, and explicit purchases of land for conservation purposes. This is often the least expensive option for currently undeveloped areas.

While limiting coastal development is the most effective way to reduce risk, this approach can incur costs today. Development permits designed to provide flexibility for future generations to address sea-level rise will reduce today's cost. For example, permits might allow development but stipulate that the area reverts to nature if seas rise by a specified amount.

Local planning processes need to involve communities most vulnerable to harm when developing appropriate preparation and adaptation strategies.

The particular needs of vulnerable communities, and appropriate adaptation policies, are best identified and developed through processes in which the affected communities are at the center of decision making. The vulnerabilities to sea-level rise created by access to transportation, legal residency, income, and language abilities can only be fully understood and protected when members of these communities are directly involved in the process.

Consider phased abandonment of low- and medium-density areas at high risk.

In some low- and medium- density areas, the monetary and environmental cost of holding back the sea may become unacceptably high. The lowest-cost option may be to allow natural processes take place. Policies that prevent flood-damaged homes or businesses from rebuilding may help ease this transition.

Protect vital societal resources, especially those that are "coastal-dependent."

In many cases, the value of an area's infrastructure far exceeds the cost to raise structures or build protective barriers. For example, the San Francisco airport and the Port of Long Beach are extremely important to the state and national economy. In choosing what to protect, we should favor infrastructure that necessarily belongs on the coast, such as ports, bridges, and marinas.

Cost-benefit analyses should explicitly evaluate the social and environmental costs of building coastal protection structures.

Armoring the coastline can save lives and property, but it also comes at a cost. The natural dynamics that occur between water and land are disrupted. Beaches and wetlands disappear and habitat is lost. Traditional cost-benefit analyses, such as those required for all US Army Corps of Engineers projects, do not adequately account for these inherent tradeoffs.

Coastal emergencies are inevitable. Coastal communities should improve disaster response and recovery.

In this analysis, we have focused on increased risk of coastal flooding and erosion as a result of sea-level rise. California is also subject to tsunamis, earthquakes, wildfires, terrorist attack, and other hazards. Improving community preparedness provides benefits for responding to any type of emergency. Before a disaster strikes, communities must plan for evacuation routes, emergency action plans, and shelters, and take into account the specific needs of vulnerable populations. In addition, roles and responsibilities must be clearly defined among local, state, and federal agencies.

Coastal managers should consider adopting the principles of "No Adverse Impact" when designing and permitting flood protection, beach nourishment, and other coastal protection projects.

Current coastal protection projects are often done with no regard for how they will affect adjacent portions of the coast. According to the Association of State Floodplain Managers (ASFM): "Over the past 50 years a system has developed through which local and individual accountability has been supplanted by federal programs for flood control, disaster assistance, and tax incentives that encourage and subsidize floodplain occupation and development." We recommend that coastal managers consider adopting a policy similar to "No Adverse Impact"

where the "actions of one property owner are not allowed to adversely affect the rights of other property owners" (ASFM 2008).

4.2.3. Additional Research and Analysis

Local governments or regional planning agencies should conduct detailed studies to better understand the potential impacts of sea-level rise in their communities.

The analysis presented here provides an initial estimate of the impacts of sea-level rise along the California coast. More detailed assessments of local impacts and potential response strategies are needed. While the effects of sea-level rise, responses, and threatened resources must all be evaluated at a local level, broader regional effects must also be incorporated into final protection strategies.

Our analysis was hindered by inadequate data on existing coastal structures. Existing levees and other flood defenses should be surveyed, assessed, and cataloged.

The U.S. Congress passed the Water Resources Development Act of 2007, creating a National Levee Safety. The act requires the establishment and maintenance of an inventory of the nation's levees and inspection of all federally owned, operated, or constructed levees. This program should be fully funded and quickly implemented, and the information it compiles should be made readily available to residents, local government, and others.

Conduct further research focused on all vulnerable subpopulations, including children, elderly, homeless, physically disabled, and people with limited mobility (e.g., incarcerated residents and healthcare facility patients), accurately measuring and analyzing the potential human costs of sea-level rise and adaptation measures.

This analysis does not include various demographic groups that can be expected to have unique vulnerabilities to potential disasters. For pre-disaster, disaster response, and recovery efforts to effectively safeguard all Californians, further study is needed to identify all vulnerable populations and assess the unique vulnerabilities of each group.

Assess the environmental justice implications of potential mitigation measures, and develop strategies to effectively safeguard all communities.

The measures taken to adapt to sea-level rise must not distribute costs and benefits of protection in ways that place a disproportionate burden on the low-income households and communities of color who are most vulnerable to a potential disaster. The means of prioritizing protection measures must be analyzed with and held to the principles of environmental justice.

Natural ecosystems are at serious risk from sea-level rise, but are undervalued or ignored in traditional economic analyses. Improved methods for incorporating them into future studies are needed.

Wetlands are highly diverse ecosystems that provide a variety of goods and services, including flood protection, water purification, wildlife habitat, recreational opportunities, and carbon sequestration. Large tracts of wetlands along the California coast are vulnerable to sea-level rise. No satisfactory method for incorporating their environmental values has been developed, and we thus risk ignoring them when we make policy decisions. This would be a serious mistake. Additional work is needed to evaluate the costs and values of natural ecosystems.

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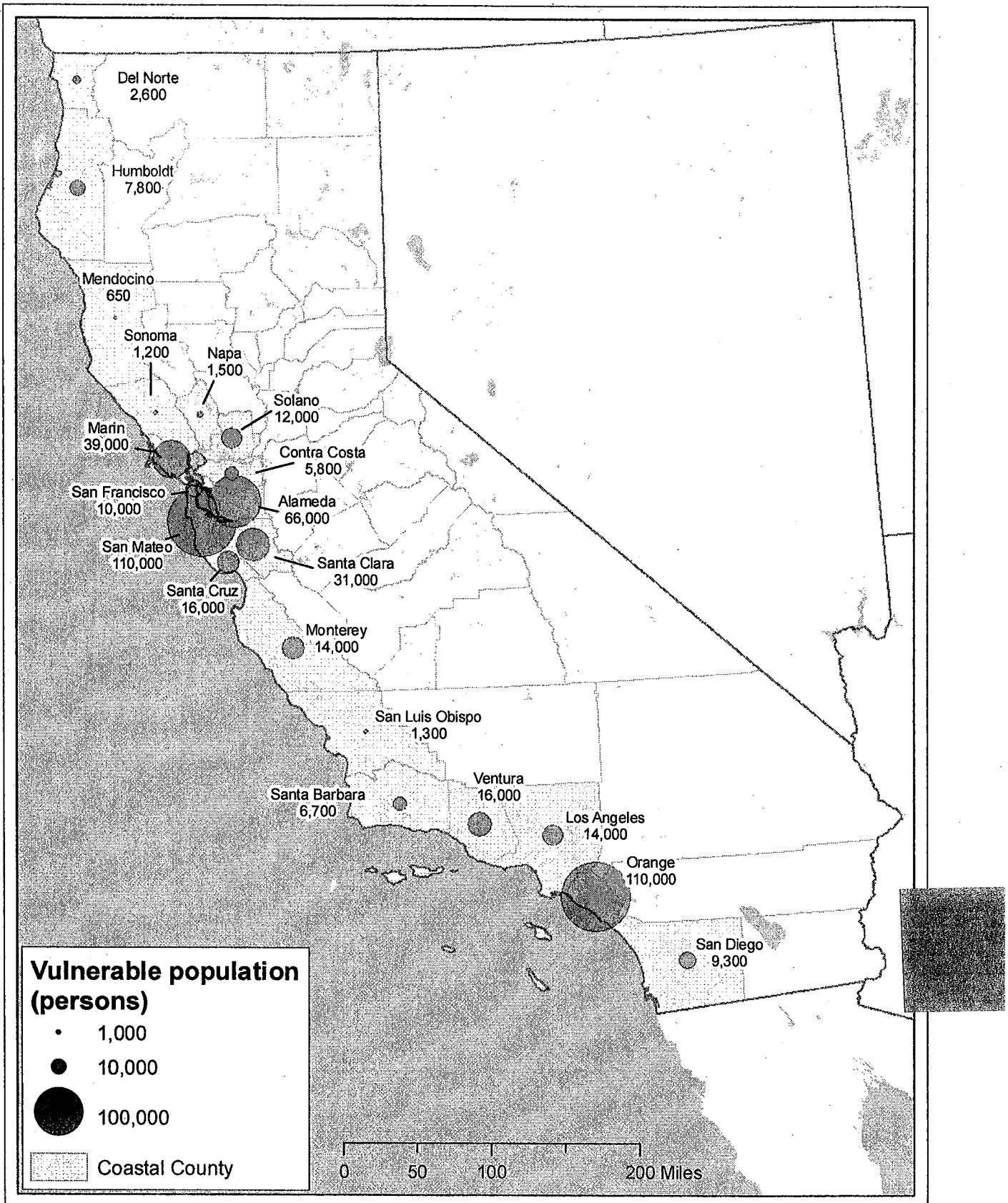
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6.0 Acronyms and Abbreviations

ALACE	Airborne LIDAR Assessment of Coastal Erosion
ASFM	Association of State Floodplain Managers
BFE	Base flood elevation; elevation of floodwaters with an annual probability of 1%. Also referred to as the 100-year flood.
CALSIM	A computer simulation model of river basins developed by California's Department of Water Resources
CASCADE	Computational Assessments of Scenarios of Climate Change in the Delta Ecosystem; a suite of computer models of the hydrology and biology of California's Sacramento/San Joaquin river delta developed by the US Geological Survey
C-CAP	Coastal Change Analysis Program, a NOAA initiative
CCC	California Coastal Commission
CCSM	Community Climate System Model

CNRM	Centre National de Recherches Météorologiques (France's National Center for Meteorological Research)
DEM	Digital Elevation Model, a digital database of land surface elevations
DFIRM	Digital Flood Insurance Map, electronic maps and databases published by FEMA
FEMA	Federal Emergency Management Agency
GFDL	Geophysical Fluids Dynamics Laboratory
GIS	Geographic Information System
HAZUS	Hazards U.S. Multi-Hazard, a computer model for estimating damages from natural disasters
IFRCC	International Federation of Red Cross and Red Crescent Societies
IFSAR	Interferometric Synthetic Aperture Radar
IPCC	Intergovernmental Panel on Climate Change
LIDAR	Light Detection and Ranging, a remote sensing technology used to collect terrain elevation data
MGD	million gallons per day
MHHW	Mean higher-high water
MHW	Mean high water
MHWS	Mean high water springs
MIROC	The Model for Interdisciplinary Research on Climate
MLLW	Mean lower-low water
MLW	Mean low water
MSL	Mean sea level
MTC	Metropolitan Transportation Commission
MW	Megawatt
NASA	National Aeronautics and Space Administration
NAVD88	North American Vertical Datum of 1988; modern reference system for measuring heights above the earth's surface
NCAR	National Center for Atmospheric Research
NPDES	National Pollutant Discharge Elimination System

NGVD29	National Geodetic Vertical Datum of 1929; a reference system for measuring heights above the earth's surface, superseded by NAVD88
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System; an EPA program to track and regulate pollutants discharged to surface waters of the United States
NRC	National Research Council
NWI	National Wetlands Inventory, a geographic database of US wetlands published by the US Fish and Wildlife Service
PCM	Parallel Climate Model
PCS	Permit Compliance System; an EPA database of licensed discharges to the surface waters of the United States
PIER	Public Interest Energy Research
PWA	Philip Williams and Associates
SRES	Special Report on Emissions Scenarios
TWL	Total water level
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCED	World Commission on Environment and Development



Population vulnerable to a 100-year coastal flood with a 1.4 meter sea-level rise

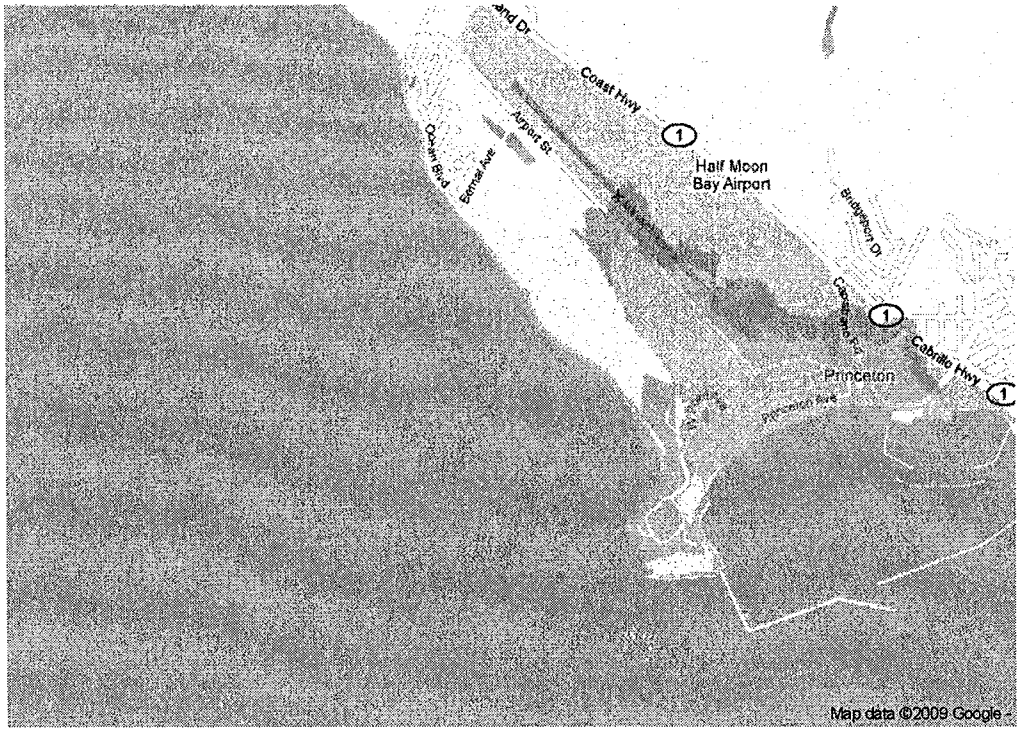
Data sources: USGS/Scripps Institution of Oceanography, U.S. Census Bureau, CaSIL, ESRI.
http://www.pacinst.org/reports/sea_level_rise

PACIFIC INSTITUTE

Impacts of Sea Level Rise on the California Coast

Areas and infastructure vulnerable to flooding and erosion

Please see full report for assumptions, methods, and conclusions.



Pacific Institute

Hazard Zones

- ☑ Area at risk from a 100-year coastal flood event
  - Current area at risk
  - Area at risk with a 1.4 meter sea-level rise
- ☐ Erosion
  - Area at risk from erosion in 2100 with a 1.4 meter sea-level rise
- ☐ Wetland Frontier
  - Areas where wetlands may migrate by 2100 if unimpeded

Data Layer Opacity

1/4 1/2 3/4 Solid

Infrastructure at Risk

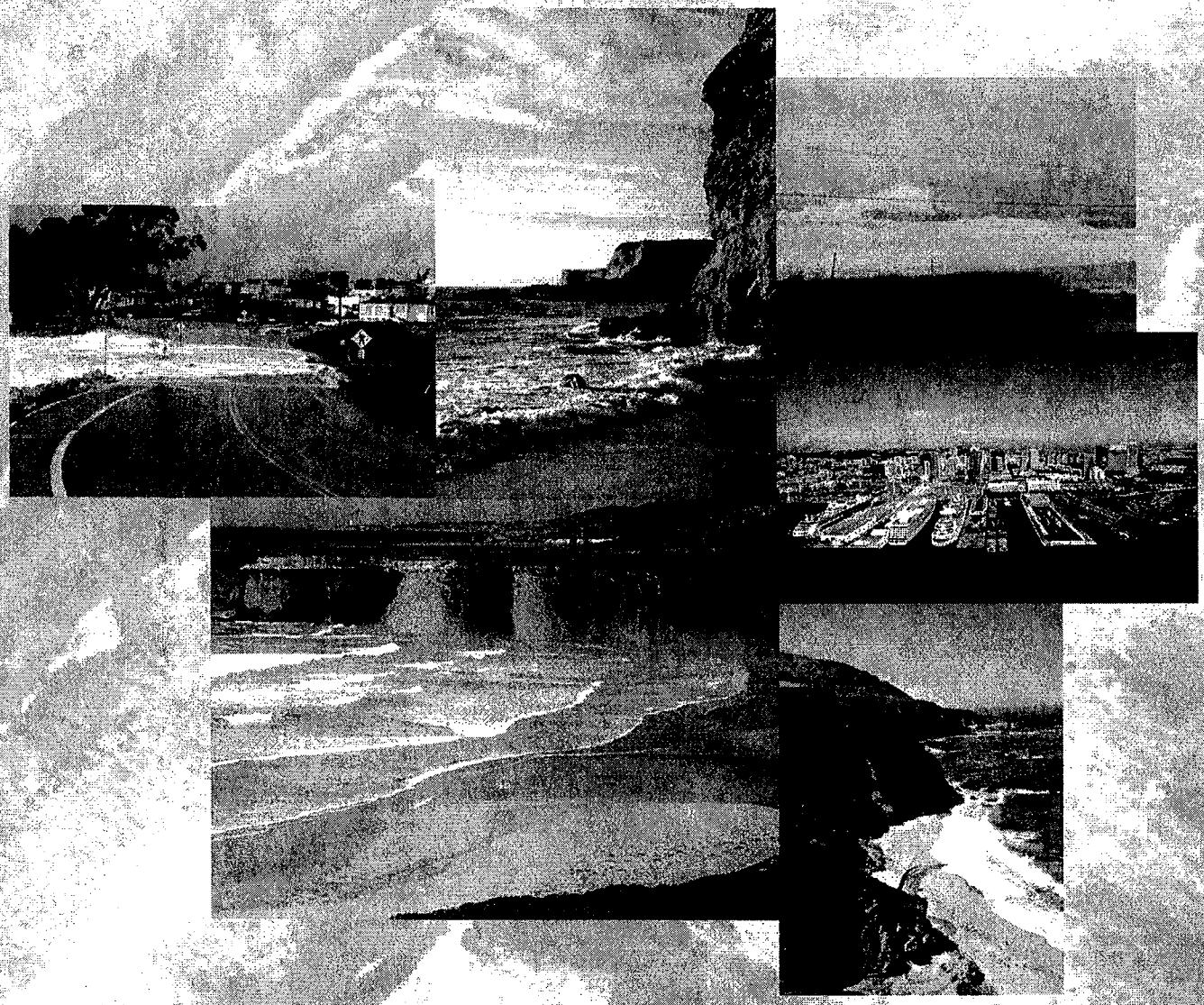
Click map icon for details

- ☐ CA Coastal Zone
- ☐ Health-care facilities
- ☐ Schools
- ☐ Police stations
- ☐ Fire stations
- ☐ Wastewater treatment plants
- ☐ EPA-regulated sites

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This information is being made available for informational purposes only. Users of this information agree by their use to hold blameless the State of California, and its respective officers, employees, agents, contractors, and subcontractors for any liability associated with its use in any form. This work shall not be used to assess actual coastal hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

A REPORT ON SEA LEVEL RISE PREPAREDNESS



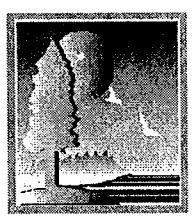
Staff Report to the

California State Lands Commission

December 2009

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A REPORT ON
SEA LEVEL RISE
PREPAREDNESS



Staff Report to the

California State Lands Commission

December 2009

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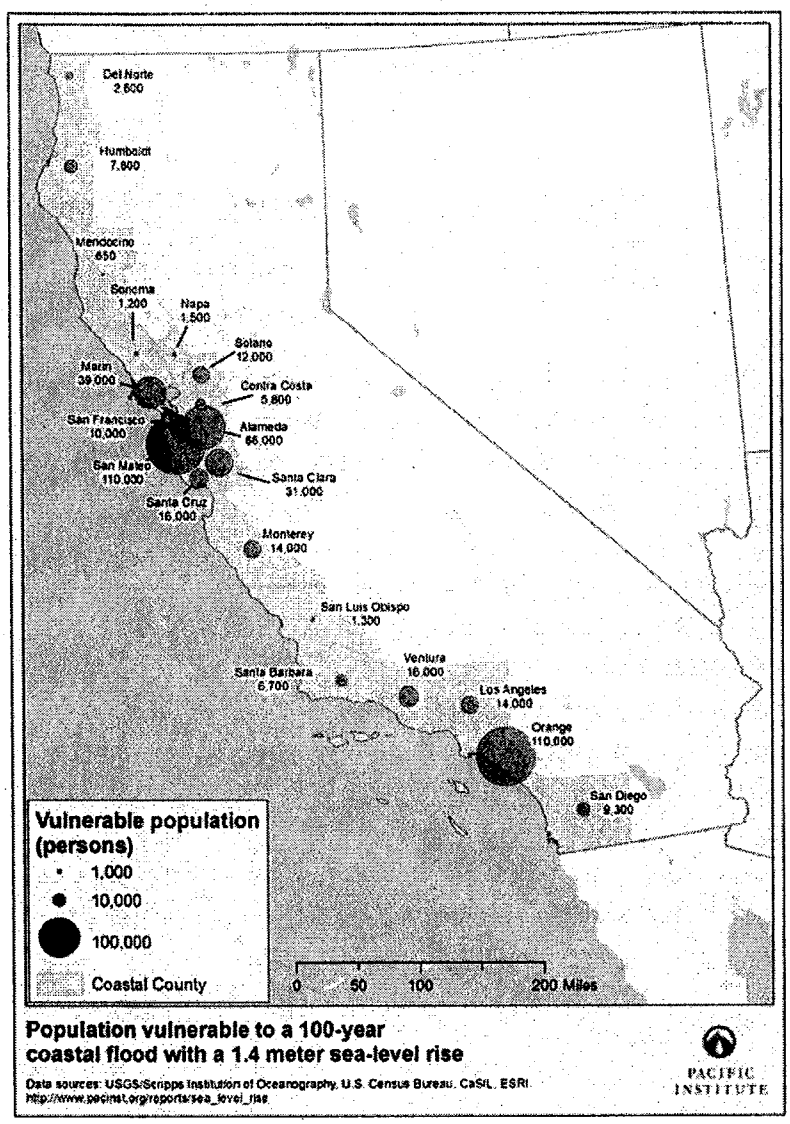
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Executive Summary

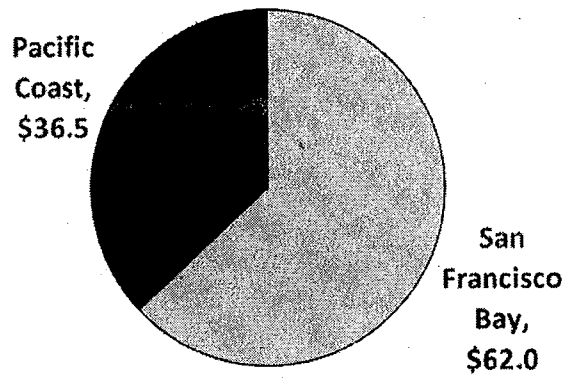


Source: *Pacific Institute Report,* 2009.

The effects of changes to the atmosphere, including climate change and sea level rise, will have global consequences for the world and the United States. According to a paper prepared by researchers from Scripps Institution of Oceanography, the University of California San Diego, the U. S. Geological Survey, Santa Clara University, the California Department of Boating and Waterways, and Hydrologic Research Center, sea level is projected to rise 16" by 2050, and 55" by 2100.[1] Efforts are underway at various international, national, and state levels aimed at developing policies, innovative approaches, and adaptation strategies to lessen the impacts of climate change and sea level rise.

Sea level rise is an issue that has far reaching consequences for California, including the lands under the jurisdiction of the California State Lands Commission (Commission). Sea level rise threatens coastal communities and infrastructure, including transportation facilities; electric utility systems and power plants; storm water systems and wastewater treatment plants and outfalls; vast areas of wetlands; and many other human and natural systems. According to a report by the California Climate Change Center, nearly half a million people, thousands of

miles of roads and railways, major ports, airports, power plants and wastewater treatment plants are at risk from a 100-year flood event as a result of a 1.4 meter (55") rise in sea level.[2] It is believed that, in the coming decades, California will face intensifying climate changes from the amount of emissions already released into the atmosphere.[3]



Replacement value (in billions of year 2000 dollars) of buildings and contents at risk of a 100-year flood event with a 1.4 m sea-level rise, by region

Note: Counties with borders on the Pacific coast and San Francisco Bay (e.g., San Mateo) were separated based on the shoreline affected.

Source: *Pacific Institute Report,* 2009.

California is one of the leading states in the nation in addressing the impacts of climate change, including sea level rise. In 1988, under legislative mandate, the California Energy Commission issued a report on the potential impacts of climate change in California. In the late 1990s, under a research program sponsored by the National Oceanic and Atmospheric Administration, the California Applications Program was created at the Scripps Institute of Oceanography to research various aspects of climate change. The California Energy Commission's Public Interest Energy Research (PIER) program was created in 2001 to research potential impacts of climate change in a variety of areas. Executive Orders signed by Governor Schwarzenegger in 2005 and 2008 further direct California to address global warming, climate change and sea level rise. The *2009 California Climate Adaptation Strategy* summarizes the most recent science in predicting potential climate change impacts and recommends response strategies.[4]

Lands under the Commission's jurisdiction are already vulnerable to a range of natural events, including storms and extreme high tides. While some of these lands remain undeveloped, a significant portion have been developed either pursuant to a lease from the Commission or pursuant to a legislative grant to a local jurisdiction. Increased storm intensity and sea level rise may lead to the loss of sandy beaches in some areas along the coast, while some areas may see an increase in the amount of sand deposited on the beach. This, coupled with the potential increase in shoreline protective devices, could reduce or eliminate public access along the coastline.

The Commission has an important role to play in addressing the issue of sea level rise. The primary responsibility of the Commission will most likely be focused on assuring that development of lands managed by the Commission considers the impacts of sea level rise. Without this oversight existing developments could become hazards and important public infrastructure could become threatened, which could have significant economic consequences for California.

This report has been prepared to address concerns expressed on the issue of sea level rise and the implications for California's economic and social future by members of the Commission at the Commission meeting held on June 1, 2009. The Commissioners requested that staff conduct a survey to assess the extent to which the major grantees and sublessees, and the Commission's lessees have considered the potential impacts of sea level rise on facilities located on sovereign lands.

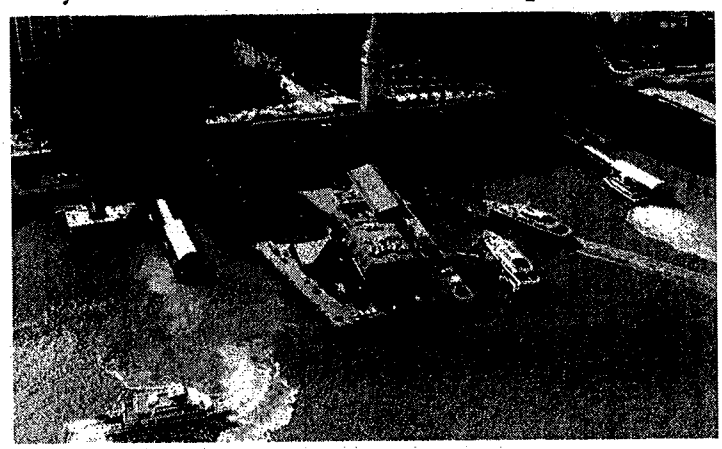
This report summarizes the results of the survey (Appendix), and the efforts of California, federal agencies, and other coastal states to address sea level rise. The report will also discuss the legal implications of sea level rise on the state's tideland boundaries and offer recommendations to better assess the impacts of sea level rise on existing facilities, as well as future development proposals that may be considered by the Commission. The recommendations include proposed changes to the Commission's application package to incorporate a sea level rise analysis, if appropriate, as well as other actions staff can implement to lessen the impacts of sea level rise, some of which may require additional budgetary appropriations in order to achieve.

Introduction and Background

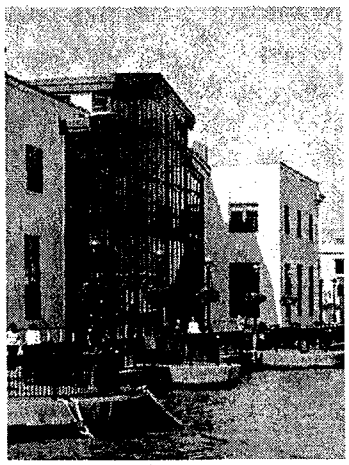
The Commission has jurisdiction over all ungranted tidelands and submerged lands within the state. Such lands include, but are not limited, to the beds of more than 120 navigable rivers and sloughs, nearly 40 navigable lakes, tidal bays, inlets, straits, lagoons and estuaries, and the three-mile wide band of tide and submerged lands adjacent to the coast and offshore islands of the State. The Commission has certain residual and review authority for tide and submerged lands legislatively granted in trust to local jurisdictions (Public Resources Code §6301 and §6306). All sovereign lands, granted or ungranted, are impressed with the Common Law Public Trust, which governs the uses to which these lands may be put.

The California Legislature has transferred, by statute, certain sovereign lands in trust to 85 cities, counties, and harbor districts. These lands are known as "granted lands" and include the major ports of Los Angeles, Long Beach, San Diego, San Francisco, Oakland, Richmond, Benicia, and Eureka. Commission staff monitors the granted lands to ensure compliance with the terms of the statutory grants, the California Constitution and the Public Trust Doctrine.

On August 10, 2009, Commission staff sent out 104 surveys to all its major grantees and lessees of major facilities along the coast and San Francisco Bay. Of those 104 surveys, 40 responses were received. All of the survey results are included in Appendix A. The survey included questions related to identifying existing facilities and the life expectancy of these facilities; whether the respondent has considered the effect of sea level rise on its facilities; how its facilities would be impacted by a sea level rise of 16" and 55" (projected increases in sea level rise by the years 2050 and 2100); what actions the respondents were considering to address sea level rise, including an estimate of cost; and whether the respondents were considering adaptation strategies to mitigate for sea level rise. Based on the answers provided, it became apparent to Commission staff that the majority of the respondents have not yet begun to comprehensively consider the impacts of sea level rise. Those respondents that have considered sea level rise are summarized in this report.



Source: *Port of San Francisco*



Source: *Port of San Francisco*

Grantees

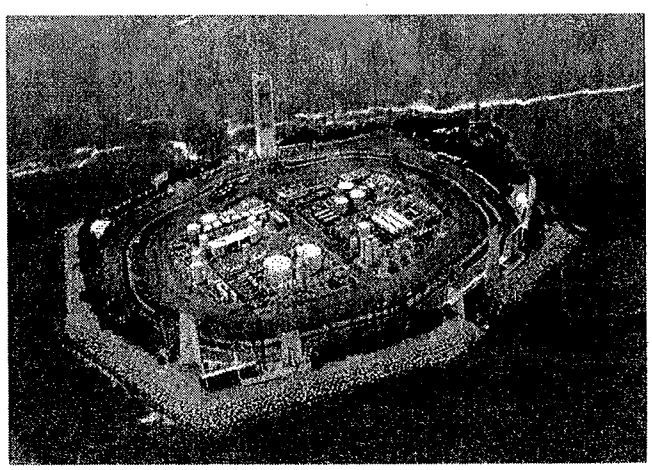
The Port of San Francisco responded that its facilities have a life expectancy of 100 years. The facilities maintained by the Port of Oakland have a projected life expectancy of 50 years. Both Ports responded that its facilities would be impacted by occasional to frequent flooding based on sea level rises of 16" and 55". In addition, both Ports believe that adaptation strategies to address sea level rise in the Bay Area must be considered on a regional and state level, such as the proposed amendments to the San Francisco Bay Conservation and Development Commission's Bay Plan, a more detailed discussion of which occurs later in this Report.

The San Diego Unified Port District (SDUPD) responded that the life expectancy of its facilities span from 30 – 50 years. Many of its existing facilities would not be greatly impacted by a sea level rise of 16"; however a 55" rise in the sea level would likely result in substantial impacts and potential inundation of certain facilities in both urban and wildlife areas. The SDUPD's environmental review process requires the consideration of sea level rise for substantial modifications to existing facilities and for all new development. The SDUPD will be preparing a Climate Action Plan that will include identifying strategies to adapt to the effects of climate change and sea level rise.

The Port of Los Angeles (POLA) reported that most of its facilities are designed for a 50-year life expectancy. The Port responded that some possible flooding and wave damage would occur from a 55" rise in sea level. POLA is planning a study to identify vulnerable facilities and developing a response option analysis plan and will also be identifying sea level rise considerations in its design guidelines.

Lessees

Several of the respondents maintain marine terminals and oil and gas facilities on sovereign lands. These lessees generally concluded that their facilities will not be impacted by sea level rise.



Offshore Oil Island White, Long Beach

California Efforts

At the closing of the Governor's Global Climate Summit 2 on October 2, 2009, Governor Schwarzenegger joined 30 global leaders in signing a declaration reaffirming the Goals of the 2008 Global Climate Solutions Declaration. The declaration acknowledges the need for greater efforts in the fight against global warming, including climate change.[5]

In California, a myriad of state agencies, departments, boards, commissions, and universities are involved in California's efforts in addressing climate change and sea level rise. This report will summarize some of the major efforts underway in California.

Executive Order S-13-08

On November 14, 2008, Governor Schwarzenegger signed Executive Order S-13-08 to create statewide consistency in planning for sea level rise. The executive order calls for, among other things, the completion of a Sea Level Rise Assessment Report, the consideration of sea level rise scenarios for the years 2050 and 2100, and the development of a Climate Adaptation Strategy.

- The Sea Level Rise Assessment Report will be drafted by an independent panel of experts and completed by December 1, 2010. The report will advise how California should plan for future sea level rise and include information on sea level rise projections, impacts on state infrastructure, and a discussion of future research needs.

- The consideration of sea level rise scenarios for the years 2050 and 2100 shall be conducted by all state agencies under the administration that are planning construction projects in areas vulnerable to sea level rise. The purpose of considering these scenarios is to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. These scenarios should be considered by the relevant state agencies before the final Sea Level Rise Assessment Report is released.

- The Climate Adaptation Strategy will summarize the best known science on climate change impacts to California, assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A 161 page

discussion draft of the Climate Adaptation Strategy, which was developed by the California Natural Resources Agency's Climate Action Team, was released on August 3, 2009 and went through a 45 day public comment period. The discussion draft, among other things, recommends the establishment of a Climate Adaptation Advisory Panel to further assess the state's climate change risks, the consideration of project alternatives that avoid significant new development in areas prone to sea-level rise, and changes to water use policies.

California Climate Change Portal

The California Climate Change Portal is an on-line website containing information on the impacts of climate change on California and the state's policies relating to global warming. It is also the home of the California Climate Change Center, a "virtual" research and information website operated by the California Energy Commission through its Public Interest Energy Research (PIER) Program. The website originally was created in 1998 by the California Energy Commission (CEC) and was expanded into a website Portal to combine the CEC's efforts with input from other state agencies.

Climate Action Team

The Climate Action Team (CAT) was established pursuant to Executive Order S-3-05 signed by Governor Schwarzenegger on June 1, 2005. The CAT is lead by the Secretary of the California Environmental Protection Agency (CalEPA) and includes the Secretary of the Business, Transportation, and Housing Agency, the Secretary of the Department of Food and Agriculture, the Secretary of the Resources Agency, the Chairperson of the Air Resources Board, the Chairperson of the Energy Commission, and the President of the Public Utilities Commission. The members of the CAT coordinate statewide efforts to implement global warming emission reduction programs and the state's Climate Adaptation Strategy. The CAT is also responsible for reporting on the progress made toward meeting the statewide greenhouse gas (GHG) targets that were established in the executive order and further defined under the Global Warming Solutions Act of 2006 (Chapter 488, Statutes of 2006).

To date, the CAT has released three reports pursuant to the mandates of Executive Order S-3-05. The first Assessment Report was released in March 2006, followed by the 2008 Assessment Report, which recommended the development of new climate and sea-level projections. The March 2009 Draft *Biennial Report*, is the latest assessment and includes a discussion on proposed adaptation strategies developed by the Ocean Protection Council and the San Francisco Bay Conservation and

Development Commission to address climate change impacts in coastal areas for existing development, new development and ecosystems. For existing development these strategies include rolling easements, relocating structures from high-risk areas, government purchases of vulnerable properties, seawalls and levees, and planned retreat. Strategies for new development include the use of new building materials, and new designs that help protect development from flooding and storm surges, smart growth and clustered development, mandatory setbacks to restrict development in vulnerable areas, and development of expendable or movable structures in high-risk areas. Ecosystem strategies include regional sediment management planning, beach nourishment, creation of "buffer zones" to allow for wetland migration, creation of new wetlands, and the creation of Marine Protected Areas.[6]

California Resources Agency

The California Resources Agency has a key role in promoting and implementing climate change policies. Pursuant to Governor Schwarzenegger's Executive Order S-13-08, the California Resources Agency was directed to ask the National Academy of Sciences (NAS) to convene an independent panel made up of state, national and international experts to complete the first California Sea Level Rise Assessment Report. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California. The Report is to be completed as soon as possible, but no later than December 1, 2010.

As previously mentioned, in August 2009, the Resources Agency released the *2009 California Climate Adaptation Strategy Discussion Draft (CCAS)*. The CCAS proposes a comprehensive set of recommendations to inform and guide California decision makers in developing policies that will protect the state, its residents and its resources from a range of climate change impacts, including sea level rise.

The Commission, the Ocean Protection Council, California Coastal Conservancy, California Coastal Commission, Department of Fish and Game, State Parks, and the Bay Conservation and Development Commission, as members of the Climate Adaptation Working Group, contributed to the Ocean and Coastal Resources section of the CCAS. The working group identified six priority strategies in addressing climate adaptation for state agencies. The strategies include both near-term (actions which can be initiated or completed by 2010, with statutory or regulatory changes,

and long-term actions (those that will require support from and collaboration with multiple state agencies or that require significant legal or regulatory changes). Three of the strategies deal specifically with sea level rise.[7]

Strategy 3 State Agencies Should Prepare Sea-Level Rise and Adaptation Plans

Near-term – By September 2010, the State Lands Commission and other state agencies responsible for the management and regulation of resources and infrastructure subject to potential sea-level rise should prepare agency-specific adaptation plans, guidance, and criteria, as appropriate.

Long-term – State agencies should regularly update, modify, and refine these adaptation guidance documents and plans based on new information.

Strategy 4 Support Local Planning for Addressing Sea-Level Rise Impacts

Near-term – The Ocean Protection Council, in consultation with other state resource agencies will coordinate public outreach programs and work to identify possible funding sources to assist state agencies and local governments in revising state and local plans. All State agencies should encourage local jurisdictions to incorporate adaptive strategies when updating plans. Finally, by 2011, or after development of guidance and when funding is secured, all coastal jurisdictions, in coordination with the California Coastal Commission and the San Francisco Bay Conservation and Development Commission, should begin development of amended Local Coastal Plans and general plans that include climate change impacts.

Strategy 5 Complete a Statewide Sea-Level Rise Vulnerability Assessment Every Five Years

Long-term action: The Ocean Protection Council, in coordination with other state agencies, should produce a coastal and ocean vulnerability assessment every five years that builds upon existing efforts by the California Energy Commission and other agencies.

California Coastal Commission

In 2001, staff of the California Coastal Commission (CCC) prepared a report intended to provide information about sea level rise and to investigate possible effects to California's coast from sea level rise. The report discusses various actions that can be taken in response to sea level rise including hard engineering (seawalls, revetments, breakwaters, levees, etc.), soft engineering (beach nourishment or buffer areas), accommodation/adaptation and retreat.

The CCC's regulatory process currently requires setbacks, review of engineering designs, establishment of wetland buffers, assumption of risk notification to property owners and prohibitions on future seawalls for new developments. The CCC has participated in studies on shoreline change which has led to an improved understanding of shoreline retreat and erosion. The CCC is also coordinating with the California Coastal Conservancy to encourage acquisition of property in high risk areas.[8]

CCC staff consider sea level rise in most applications for projects along the coast -- either for the design of shoreline protection or for the siting of new development. In many cases, project proponents are asked to look at the consequences of a range of sea levels in an effort to understand if and when a property may be really at risk from rising sea level.[9]

A recently approved amendment to the Crescent City Local Coastal Program (LCP) recommends modifications to the LCP's Land Use Plan LUP to address the threat of rising sea level. One of those recommended modifications would "require that all geological, geo-technical, engineering and hydrologic evaluations include in their analyses the effects of sea level rise." The city of Redondo Beach is considering a similar amendment to its LCP.[10]

California Energy Commission

Since 1988, the California Energy Commission (CEC) has played an important role in coordinating activities addressing climate change. The CEC's activities include a number of efforts supporting the California Global Warming Solutions Act of 2006, serving as a member of the CAT and various subgroups, providing policy guidance and monitoring international, national and regional developments that impact clean energy and climate change.[11]

One of the CEC's programs is the Public Interest Energy Research Program (PIER). The PIER program was created in 2001, to research potential impacts of climate change in a variety of areas. One of those research efforts is a March 2009 Paper prepared by the Pacific Institute, *The Impacts of Sea-Level Rise on the California Coast*. This Paper states that, over the past century, sea level has risen nearly eight inches along the California coast, and that modeling scenarios suggest substantial increases in sea level over the coming century. The Paper concludes that sea level rise will inevitably change the character of the California coast, and that adaptation strategies must be evaluated, tested, and implemented if the risks identified are to be reduced or avoided.[12]

California Ocean Protection Council

The Commission is a member of the Ocean Protection Council (OPC). The OPC was created pursuant to the California Ocean Protection Act which was

signed into law in 2004 by Governor Arnold Schwarzenegger.

The OPC will establish policies to guide agencies responsible for ocean protection and will help coordinate California's efforts to adapt to the ocean impacts of climate change. The OPC is working to determine potential impacts along the coast due to sea level rise, including impacts to public infrastructure.[13]

Delta Protection Commission

Under the guidance of the Delta Vision Blue Ribbon Task Force, the Delta Protection Commission is in the process of updating its 1995 Land Use and Resource Management Plan which will include policies and recommendations for action that can be taken by local and state government to address the impacts of climate change on the Delta.[14]

San Francisco Bay Conservation and Development Commission

The potential impacts to the San Francisco Bay Region based on the current estimates of projected sea level rise will be significant. Impacts include loss of valuable real estate, critical public infrastructure, and natural resources. Since the late 1980s, the San Francisco Bay Conservation and Development Commission (BCDC) has been studying and developing policies to address sea level rise.

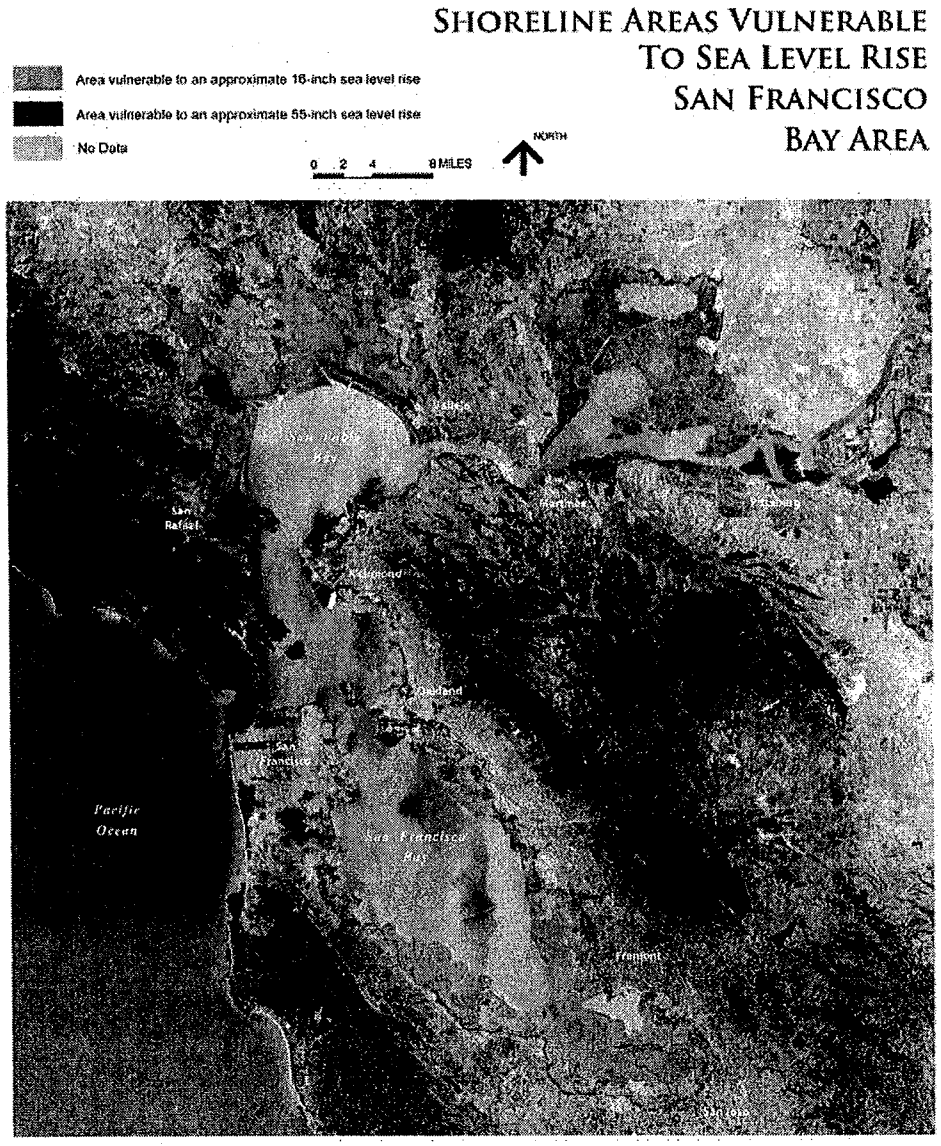
In 2006, BCDC released a series of maps depicting the lands most vulnerable to sea level rise. Using data provided by the United States Geological Survey, BCDC has updated its sea level rise maps that show the low-lying areas around the Bay that are most in danger from projected sea level rise scenarios of 16" and 55".[15]

In response to its 2008 Strategic Plan, BCDC staff issued a staff report on February 27, 2009 titled "Using the Public Trust Doctrine to Adapt to Climate Change in San Francisco Bay,"[16] which examines the relationship between the takings clause of the United States Constitution and the Public Trust Doctrine. The staff report concluded that while the Public Trust Doctrine does not give BCDC additional regulatory authority, it can be used to support decisions made by BCDC in its efforts to address the impacts of climate change and sea level rise.

Through its Climate Change Planning Project, BCDC has developed draft findings and policies on climate change and a background report that reflects the current state of knowledge regarding the potential impacts of climate change on the region. The draft staff report issued April 7, 2009, *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*,[17] identifies vulnerabilities in the Bay Area's economic and environmental systems, as well as the potential impacts of climate change on public health and safety. The information in the Report provided the basis for BCDC staff's proposed revisions to the San Francisco Bay Plan, which, as of this writing, are under consideration by BCDC.

Earlier this year, BCDC sponsored an international design competition, *Rising Tides*, in an effort to solicit innovative design concepts that address the various design challenges for both existing and future development that is unique to San Francisco Bay.

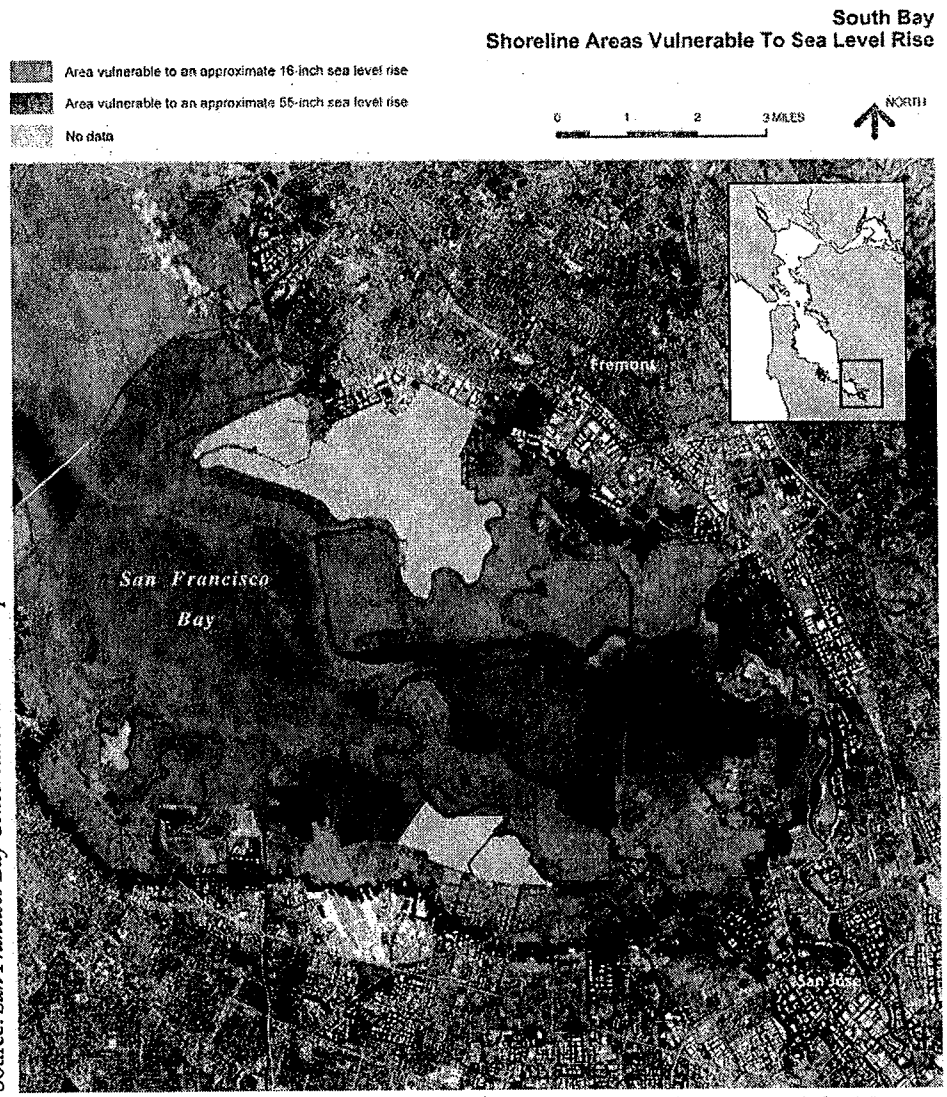
BCDC has formed a partnership with the Netherlands and in late September, at a symposium held in San Francisco, a group of Dutch experts presented strategies to address sea level rise in San Francisco Bay and the Sacramento-San Joaquin Delta. The Dutch strategies focus on determining what types of development should exist in specific areas. High economic value development could continue to exist with the help of levees and seawalls. In other areas, the Dutch suggest "tidal embracing development", involving urban tidal canals or parking lots with underground storm water retention.[18]



Source: *San Francisco Bay Conservation and Development Commission*

Source: Inundation data from Knowles, 2008. Additional salt pond elevation data by Siegel and Bachand, 2002. Aerial imagery is NAIP 2005 data.

DISCLAIMER: Inundation data does not account for existing shoreline protection or wave activity. These maps are for informational purposes only. Users, by their use, agree to hold harmless and blameless the State of California and its representatives and its agents for any liability associated with its use in any form. The maps and data shall not be used to assess actual coastal hazards, insurance requirements, or property values or be used in lieu of Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).



Source: *San Francisco Bay Conservation and Development Commission*

Department of Water Resources

The Department of Water Resources (DWR) is an active member of the state's Climate Action Team. The DWR is responsible for investigating and responding to global climate change as it affects water resources and delivery systems through statewide water planning as set by the California Water Plan. An integrated approach to the Department's activities will allow priorities to be set based on statewide strategic water plans to meet present and future beneficial uses. Formal stakeholder involvement in the Water Plan Advisory Committee will be useful in assisting local agencies responding to climate change impacts by facilitating the dissemination of climate change information and modeling studies.[19]

In October 2008, the DWR released its report, *Managing an Uncertain Future Climate Change Adaptation Strategies for California's Water*, which proposes

adaptation strategies for state and local water managers in the face of a changing climate. The report recommends that the state establish an interim range of sea level rise projections for short-term planning purposes. It also supports the convening of a scientific panel of the National Research Council to provide expert guidance and recommends that the DWR, in collaboration with other state agencies, develop long-range sea level rise scenarios and response strategies to be included in the California Water Plan Update 2013.[20]

California Department of Transportation

Under the direction of the Business, Transportation, and Housing Agency, the California Department of Transportation (Cal Trans) participates as a member of the Climate Adaptation Working Group. Cal Trans and the CEC developed the infrastructure adaptation strategies included in the state's Climate Adaptation Strategy. Those strategies include assessing environmental impacts from climate change in siting and re-licensing of new energy facilities; developing a detailed climate vulnerability assessment and adaptation plan for California's transportation infrastructure; incorporating climate change vulnerability assessment planning tools, policies, and strategies into existing transportation and investment decisions; developing transportation design and engineering standards to minimize climate change risks to vulnerable transportation infrastructure; assessing environmental impacts from climate change in rehabilitating the transportation system and siting of new transportation projects; and incorporating climate change impact considerations into disaster preparedness planning for all transportation modes.[21]

Federal Efforts

United States Policy

The U.S. Congress is considering proposals that plan for sea level rise. Most notably, H.R. 2454 (Waxman-Markey) and S. 1733 (Kerry-Boxer), which are commonly referred to as the "cap-and trade" bills, create a National Climate Change Adaptation Program to increase the overall effectiveness of federal climate change adaptation efforts. These bills include specific sections that provide climate change safeguards for natural resources conservation as well as funding for states that carry out adaptation activities.

The Coastal Zone Management Act (CZMA) was passed by Congress in 1972 to address high growth in coastal areas. A 1996 amendment to the CZMA administered by the National Oceanic and Atmospheric Administration (NOAA), called for greater coastal resource management and balancing economic development with conservation. These goals are met through state management coastal programs. These two programs include the National Coastal Zone Management Program and the National Estuarine Research Reserve System. The 1996 amendment also established the Coastal Zone Enhancement Program that allows states to request funding to amend their coastal programs. The CZMA does mention sea level rise and calls for states to "anticipate and plan for sea-level rise ...",[22] but lacks specifics on how states can accomplish this.

Department of the Interior

On September 14, 2009, Ken Salazar, the Secretary of the Interior signed Secretarial Order No. 3289, *Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources.* The Order establishes a framework through which the Department's bureaus will coordinate climate change science and resource management strategies to address the impacts of climate change on tribal lands and the nation's natural and cultural resources. The framework will establish:

- a new Climate Change Response Council within the Office of the Secretary that is responsible for coordinating a strategy among the Department's agencies and bureaus to increase scientific understanding and development of effective adaptive management tools;

- eight regional Climate Change Response Centers to synthesize existing climate change data and management strategies, help resource managers implement those strategies, and conduct public outreach;

- a network of Landscape Conservation Cooperatives that will coordinate with the Department and federal, state and local agencies and partners and the public to develop landscape-level strategies to manage climate change impacts.[23]

The Order suggests possible acquisition of upland habitat and creation of wetlands and other natural filters and barriers to protect against sea level rise and storm surges, and the possible relocation of certain iconic and culturally historic structures.[24]

U.S. Global Change Research Program

The U.S. Global Change Research Program (USGCRP) coordinates and integrates federal research on changes in the global environment and the implications for society. It began as a presidential initiative in 1989, and was mandated by Congress in the Global Change Research Act of 1990 (P.L. 101-606), which called for "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change."[25]

Thirteen departments and agencies participate in the USGCRP. Pursuant to the Global Change Research Act of 1990, the USGCRP is required to prepare annual reports to Congress detailing its achievements and progress. The latest report titled *Our Changing Planet: The U.S. Global Change Research Program for Fiscal Year 2010*[26] was submitted to Congress in October 2009.

Other Federal Agencies

In January 2009, the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA), with additional contributions from the U.S. Department of Transportation, released a report addressing the issues of sea level rise. The report, titled *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, provides a detailed assessment of the effects of sea level rise and examines multiple opportunities for governments and coastal communities to plan for and adapt to rising sea levels. Although the issues apply to coastal regions nationwide, the report focuses on the mid-Atlantic region of the United States, where rates of sea level rise are moderately high, severe storms are fairly common, and a large extent of critical marsh habitat, high population densities, and infrastructure exist in low-lying areas.[27]

One part of adapting to sea level rise is amending flood insurance policies, provisions and plans. The National Flood Insurance Plan (NFIP) contains provisions that restrict certain types of flood proofing in certain Federal Emergency Management Area (FEMA) zones. Incorporating sea level rise considerations into the NFIP would allow rates to reflect changing risk and allow local governments to effectively manage coastal floodplains. FEMA and the National Academy of Sciences supported a study by the Heinz Center recommending to Congress that insurance rates reflect the risks from coastal erosion.[28]

National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) is a key participating agency in the USGCRP. NOAA's Office of Coastal Resource Management (OCRM), provides national leadership, strategic direction and guidance to state and territory coastal programs and estuarine research reserves. Through its support, either directly or through its partners, the OCRM is helping coastal or ocean managers address the causes and impacts of climate change. The OCRM distributes the CZMA Climate Change and Coastal Hazards E-News Update to keep state and territory coastal program managers and climate change/coastal hazards staff informed about climate change. NOAA also maintains an interactive website, which shows regional trends in sea level, including direction and magnitude of change figures for specific locations.[29]

The OCRM provides coastal managers with information about shoreline management techniques emphasizing "alternative" shoreline management techniques including soft, non-structural, hybrid, or planning and policy approaches. Its online website includes general resource information, case studies and links to other useful resources.[30]

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency's (EPA) climate change programs and activities are an integral part of the EPA's mission to protect human health and the environment. EPA's Climate Change Web site offers the public the most current and accurate information on the broad issue of climate change.[31]

U.S. Geological Survey

The U.S. Geological Survey (USGS) provides scientific information in an effort to reduce loss of life and property from natural disasters.[32] The USGS is creating a vulnerability index of coastal environments that will aid in determining how coastal environments might physically change due to sea level rise. This Coastal Vulnerability Index (CVI) will be used for long-term resource management plans, national park facilities planning, and assessing long-term threats to cultural and iconic resources. Pilot plans have already been completed for Cape Code National

Seashore in Massachusetts, the Gulf Islands National Seashore in Mississippi and Florida, and Olympic National Park in Washington.[33] In California, the National Park Service is beginning a planning process to adapt the parking and visitor access facilities at the Point Reyes National Seashore to accommodate potential impacts of sea level rise.

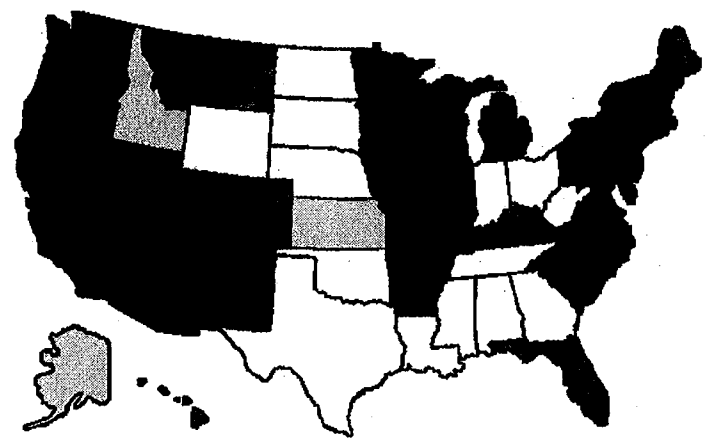
U.S. Army Corps of Engineers

The mission of the U.S. Army Corps of Engineers (Corps) is to, "provide vital public engineering services in peace and war to strengthen our Nations security, energize the economy, and reduce risks from disasters."[34] The Corps is responsible for the design and construction of dams, canals, and flood protection projects.

On July 1, 2009, the USACE issued Circular No. 1165-2-211 which requires that potential sea level rise changes are to be considered in every Corps coastal activity as far inland as the extent of estimated tidal influence. Future sea level rise projections must also be incorporated in the management, planning, engineering, design, construction, operation and maintenance of its projects.[35] The policy will help levee districts plan for the projected gradual changes in sea levels.

Other Coastal States

Many coastal states are taking steps to address the potential impacts of sea level rise. Governors of several states, including Florida, Louisiana, Maryland, New Jersey, New York, South Carolina, Virginia, and Washington have issued Executive Orders establishing various climate change commissions and advisory committees to consider the potential effects of global climate change, including sea level rise. According to the Pew Center on Global Climate Change, some 36 states have completed or are in the process of completing comprehensive Climate Action Plans. The plans detail steps that the states can take to reduce their contribution to climate change.[36] This report will summarize some of those various state efforts.



Climate Action Plans
Source: *Pew Center on Global Climate Change*

On September 18, 2006, the Governors of California, Oregon and Washington announced the *West Coast Governors' Agreement on Ocean Health.*[37] The Agreement launched a proactive regional collaboration to protect and manage the ocean and coastal resources along the entire West Coast, as called for in the recommendations of the U.S. Commission on Ocean Policy and the Pew Oceans Commission. The West Coast states will focus initial efforts, in collaboration with the federal government, on a West Coast-wide assessment of shoreline changes and anticipated impacts to coastal areas and communities due to climate change over the next several decades, and work together to develop actions to mitigate and adapt to the impacts of climate change and related coastal hazards. One of the major tasks identified will focus on the issue of global and local sea level rise and the development of adaptation strategies to address impacts from sea level rise, guidance for coastal adaptation planning, and identification of information and research need for coastal adaptation.

On September 14, 2007, Governor Sarah Palin signed Administrative Order No. 238, officially forming the Alaska Climate Change Sub-Cabinet. The Sub-Cabinet is charged with preparing and implementing an Alaska Climate Change Strategy. This will be a transparent document which deals with state policies for anticipated climate change. The Sub-Cabinet's strategy will discuss building the state's knowledge of the actual and foreseeable effects of climate warming in Alaska; developing appropriate measures and policies to prepare communities in Alaska for the anticipated impacts from climate change; and providing guidance regarding Alaska's participation in regional and national efforts addressing causes and effects of climate change.[38]

On June 4, 2009, Governors of the states of Delaware, Maryland, New Jersey, New York, and Virginia signed the *Mid-Atlantic Governors' Agreement on Ocean Conservation.* The Agreement establishes the Mid-Atlantic Regional Council on the Ocean and will include representatives from each state and the appropriate federal agencies. The Agreement recognizes that the states in the Mid-Atlantic region will benefit by participating in a concerted regional effort focused, initially, on developing an integrated approach to the assessment of infrastructure vulnerability, as well as a collective undertaking to frame sea level rise adaptation strategies to address infrastructure, critical coastal habitat and shoreline management needs.[39]

In Connecticut, the Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (GSC) is assessing the impacts of climate change on infrastructure, natural resources and ecological habitats, public health, and agriculture and will recommend adaptation strategies in accordance with the requirements of Public Act 08-98. The Subcommittee will report to the GSC by early January 2010 on climate change impacts, and by mid-2010, the Subcommittee will report to the legislature on recommendations for changes to programs and laws that would enable state and local governments to adapt to such impacts.[40] Connecticut's Coastal Program has recommended a Habitat Restoration Committee to create new strategies in addressing estuarine restoration that include avoiding restoration of tidal wetlands adjacent to lands where sea inundation could occur. The state is also working to acquire high-resolution digital elevation maps that can be used in coastal hazard planning.[41]

Florida Governor Charlie Crist established the Action Team on Energy and Climate Change (Action Team) by signing Executive Order 07-128 on July 13, 2007. On October 15, 2008, the Action Team submitted its final report on Florida's Energy & Climate Change Action Plan. The Report includes policy recommendations that will provide a framework for climate change adaptation strategies to guide Florida over the coming years and decades. The Action Team recommends that:

- local, state, and regional comprehensive plans be amended based on the best available data, include goals, objectives, and policies that will prepare the state for adapting to the future impacts of climate change, such as sea level rise.
- future policies should use incentives to encourage desired actions, including encouragement not to repeat past decisions that will leave new development exposed to sea level rise and other climate change consequences.
- local governments should review their coastal management elements to determine necessary amendments to make their coastal areas (especially the coastal high - hazard area) resilient to the future impacts of climate change, including sea level rise.
- Florida statutes, regulations, policies, and the Florida Administrative Code should be reviewed by the Florida Attorney General to determine potential conflicts between private property rights and the state and local governments' responsibility to protect communities.[42]

In 2008, the Florida Legislature established the Energy and Climate Commission (Commission). The Commission holds a variety of responsibilities, including administering financial incentive programs; completing annual assessments of Florida's Energy and Climate Change Action Plan; and providing recommendations to the Governor and the Legislature. The Commission will also work cooperatively with other state entities, including the Florida Public Service Commission, the Florida Department of Environmental Protection, the Florida Department of Community Affairs, and the Florida Energy Systems Consortium, to develop state energy and climate change policies and programs, including adaptation strategies.[43]

The state of Maine prohibits the building of structures that have been damaged by storms if there is a reasonable expectation that the new construction could be damaged in the next 100 years.[44] On April 23, 2009, the Maine Legislature signed a Resolve to Evaluate Climate Change Adaptation Options for the State. The Resolve requires the state's Department of Environmental Protection (Department) to create a stakeholder group consisting of representatives from state government, business, industry, trade, and nongovernmental organizations to evaluate options and actions available to prepare for and adapt to the most likely impacts of climate change. The Department is to report recommendations to the Joint Standing Committee on Natural Resources by February 27, 2010. The report may include proposals for legislation that may be considered by Maine's Legislature.[45]

Maryland's Commission on Climate Change (Commission) was formed pursuant to a 2007 Executive Order and is charged with preparing the state's Climate Action Plan. The principal charge of the Commission is to develop a Plan of

Action (the Climate Action Plan) to address the drivers of climate change, to prepare for its likely impacts in Maryland, and to establish goals and timetables for implementation. The Plan was released in August 2008, and includes specific priority policy recommendations to address short-term and long-term adaptation and response measures, planning and policy integration, education and outreach, performance measurement, and where necessary, identifies new legislation and/or modifications to existing laws. The Plan presents the final priority policy recommendations in support of the Commission's vision for protecting Maryland's future economic well-being, environmental heritage and public safety.[46]

The State of Maryland's Coastal Program has an interactive web portal (Shorelines Online) that houses information and data on coastal hazards management and sea level rise. The Coastal Program also works with local governments to integrate various data and mapping into land use planning changes and amendments.[47]

In August 2008, Massachusetts Governor Deval Patrick signed into law the Global Warming Solutions Act (GWSA), making Massachusetts one of the first states in the nation to move forward with a comprehensive regulatory program to address Climate Change. The GWSA created the Climate Change Adaptation Advisory Committee to study and make recommendations on strategies for adapting to climate change. The Advisory Committee's report will be presented to the Legislature by December 31, 2009.[48]

The New York State Legislature created the Sea Level Rise Task Force in 2007, which is charged with applying the best available science to evaluate ways to protect New York's remaining coastal ecosystems and natural habitats, and increase coastal community resilience in the face of sea level rise. The final report, due by January 1, 2011, will include an assessment of the anticipated impacts of sea level rise; recommendations to provide more protective standards for coastal development, wetlands protection, shoreline armoring and post-storm recovery; recommendations of measures to protect and connect habitats to facilitate range shifts, protect and restore critical habitats and ecosystem services; identification and monitoring of climate change effects on natural biota; integrate climate change adaptation strategies into state environmental plans; and recommendations on regulatory and/or statutory alterations to respond to sea level rise.[49]

North Carolina is preparing a risk assessment and mitigation strategy study to evaluate the potential changes in coastal flooding hazards due to sea level rise and changes in storm frequency and intensity associated with climate change in coastal North Carolina. The primary goal of this study is to inform state and federal policy makers on the subject of the sea level rise impacts and foster development of risk management policy.[50]

Oregon's Governor Ted Kulongoski established the Governor's Climate Change Integration Group (Group) in May 2006. The Governor's charge to the

Group is to continue and expand on the work of the Global Warming Advisory Group to develop a climate change strategy for Oregon that provides long-term sustainability for the environment, protect public health, consider social equity, create economic opportunity, and expand public awareness. In January 2008, the Group published its final report titled *A Framework for Addressing Rapid Climate Change.* The report proposes that Oregon takes steps toward developing a framework that will assist individuals, businesses, and governments to incorporate climate change into their planning processes.[51]

Washington Governor Christine O. Gregoire has directed the state's Department of Ecology to evaluate the potential impacts of sea level rise on the state's shoreline. A progress report is to be provided to the Governor by December 31, 2010.[52] The state formed a Climate Advisory Team (CAT) in response to Executive Order 09-05. In February 2008, the CAT published an interim report, *Leading the Way on Climate Change: The Challenge of Our Time.* The interim report includes strategies for incorporating climate change and its impacts into planning and decision making processes. Specific sea level rise strategies include revising state land use, shoreline, and flood control planning statutes and regulations, and clarifying the State Environmental Policy Act (SEPA) to effectively address sea level rise and other climate change impacts; incorporating climate change considerations into emergency planning; incorporating best available sea level rise and other climate change data and information into state and local government planning to promote resiliency of ecological systems and communities; incorporating future sea level rise concerns and other climate change impacts in prioritization for funding, design, and post-project operation and maintenance.[53]

California State Lands Commission

Sea Level Rise and Sovereign Boundaries

As sea level continues to rise, it will have an impact on California's sovereign lands and shoreline boundaries. Under the Equal Footing Doctrine, as a fundamental right upon its admission to the Union on September 9, 1850, California took title, in trust as a sovereign state on behalf of its citizens, to the beds of all tidal and navigable waterways within its borders, not previously conveyed by the Spanish or Mexican government. California holds its navigable and tidal waters in a sovereign trust for the public.[54] These sovereign lands or Public Trust lands include tide and submerged lands including those adjacent to the coast and offshore islands of the State and within bays, rivers, streams, sloughs, inlets, straits, estuaries, lagoons, and lakes. As a result of the unique nature of these lands, there are no patents, lists or other documents conveying sovereign lands from the federal government to the State. These lands may only be used for public purposes consistent with the provisions of California's Common Law Public Trust Doctrine.

The societal concept of a public commons regarding waters and access to them, as reflected in what is today referred to as the Public Trust Doctrine, as well as the fact of sea level rise and adaptation to it, have been aspects of human interaction with the intersection of land and water for thousands of years. Emperor Justinian (533 CE) is credited with first codifying, in *Corpus Juris Civilis: Institutes 2.1*, certain ancient and accepted concepts of natural law in described by Gaius in the 2nd Century of the common era. These legal precepts included *"By the law of nature these things are common to mankind – the air, running water, the sea and consequently the shores of the sea."*[55]

Generally, sea level rise is not a recent phenomenon and has been occurring for more than 12,000 years, since the last ice age. This is evidenced by the archaeological record left of early Native American sites offshore of the current California coast.[56]

On tidal waterways, by various statutory and judicial decrees, the landward boundary between sovereign tidelands and the adjacent uplands in California is defined by the ordinary high water mark (OHWM), except for areas affected by fill or artificial accretion, whether the location is in San Francisco Bay, Malibu or San Diego Bay. Cal. Civ. Code § 670 and § 830. The United States Supreme Court has held, with some limited exceptions, that individual states have the right to define the boundaries of and interests in land held in trust for the public.[57]

California's coastal water boundaries are ambulatory, changing as the shoreline erodes or accretes under natural conditions. The common law doctrines of accretion, erosion, and avulsion generally govern changes to water boundaries. Accretion and erosion are "gradual and imperceptible" gains and losses to an upland property, respectively. A boundary marked by a water line is a shifting boundary, going landward with erosion and waterward with accretion.[58] Such changes effectively alter the property boundary, the rationale being that a riparian property owner stands to gain as often as they stand to lose from such gradual, imperceptible changes. Avulsion, on the other hand, is a swift or rapid change in the location of a waterway, typically induced by a flooding event. Changes wrought by avulsion generally do not affect property boundaries. "The augmentation of existing upland by gradual natural accretion alters the boundary of that upland accordingly. When such augmentation occurs as a result of sudden avulsion or by accretion caused by the works of man, however, the boundary is not altered."[59] These rules have been codified under Cal. Civ. Code §§ 1014 and 1015 for rivers and streams and applied by the Courts to tidal and open coast shorelines.[60]

Like avulsion, under California law "artificial" accretion caused by human action does not alter tidal water boundaries: "in a controversy between the state, or its grantees, and the upland owner, artificial accretions belong to the state, or its grantees, as the owner of the tidelands."[61] The rationale for this rule is partly grounded in the policy that certain sovereign public lands cannot be conveyed into private ownership, whether by grant or by artificial means.[62] Natural, gradual and imperceptible changes, which result in accreted lands, generally, are the only way in which an upland property owner may claim ownership of formerly submerged or tidal land. In order to permanently fix a water boundary between the State and an upland owner, the natural shoreline must no longer exist and the State and the upland owner must either enter into an agreement establishing an agreed boundary or litigate the boundary through a quiet title action.

Regardless of whether human activity contributes to the increased levels of greenhouse gases in the atmosphere, which in turn contributes to climate change and an increase in the rate of the rising sea levels, the increase in the rise of the sea remains in the eyes of the law gradual and imperceptible – sea level rise, even taking into account the increase in the rate of the rise, while measureable over periods of years, is still not noticeable or detectable by the naked eye. As such, the current rubric of statutory law and case law governing coastal boundaries in California remains valid and effective in determining the boundaries between California's sovereign ownership of its waterways and the uplands along tidal waterways. As has been the case generally throughout California's legal history, coastal boundaries and the State's sovereign ownership should continue to move with ever shifting sands and seas. But Commission staff should continue to analyze each project on a case by case basis, in determining the boundary between the State's sovereign ownership and uplands along California's coastline and tidal waterways.

Recommendations

Commission staff has compiled a list of proposed recommended actions for Commission consideration.

1. Direct staff to continue giving careful consideration to the effects of sea level rise, including impacts to hydrology, soils, geology, transportation, recreation, and other resource categories in all environmental determinations. Direct staff to recommend feasible alternatives, project modifications, mitigation, or a combination of these measures, to avoid or reduce significant impacts.

2. Direct staff to undertake an inventory of existing leases to identify improvements/infrastructure vulnerable to projected sea level rises of 16" and 55".

3. Direct staff to add a request for information concerning the potential effect of sea level rise on the proposed project to the Commission's Surface Leasing Application Form, Part III, Section B: Assessment of Environmental Impacts. If applicable, require applicants to indicate how they plan to address sea level rise and what adaptation strategies are planned during the projected life of the project.

4. Consider amending the Commission's Application Package to require that all new coastal development projects consider the implications of and include adaptation strategies for projected sea level rises of 16" and 55", depending on the projected life expectancy of the project.

5. Where appropriate, staff should recommend project modifications that would eliminate or reduce potentially adverse impacts from sea level rise, including adverse impacts on public access.

6. Adopt engineering design standards requiring major facilities to withstand a defined storm event, such as a 100-year storm, taking into account sea level rise over the life of the project.

   The Commission is addressing the effects of rising sea level on marine oil terminals through a revision to its Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS). A revision to the 2007 California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 31F, Marine Oil Terminals includes a new Section 3103F.5.3.4 Sea Level Rise (SLR), which will require all marine oil terminals to consider the predicted sea level rise over the remaining life of the terminal. Upon approval

by the California Building Standards Commission, the revisions should go into effect January 1, 2011.

7. Include a provision in future leases requiring Lessees to comply with any provisions or standards that may be adopted by any regulatory agency that addresses sea level rise.
8. Continue to monitor changes from sea level rise in California and coordinate with and seek advice and expertise from other federal, state, or local agencies on this issue.
9. Give careful consideration to future Boundary Line Agreements and Title Settlements. Include a standard provision in such agreements stating that the Public Trust easement will move with submergence or when subject to the ebb and flow of the tide.
10. Collect current information on the mean high tide line including, if necessary, conducting boundary surveys along the coastline and bays, and possibly some inland waterways.
11. Evaluate structures (wharves, docks, levees, breakwaters, piers, seawalls, flood control structures, etc.) subject to the ocean environment for structural integrity and potential hazards as sea levels rise.
12. Continue to evaluate offshore platforms in state waters based on American Petroleum Institute Recommended Practices.
13. Send the proposed changes to the Commission's Application Package addressing sea level rise to all grantees for their consideration and use.
14. Provide copies of this Report to the survey recipients for their consideration and use and post the Report on the Commission's website.
15. Report back to the Commission in one year on the progress made by Commission staff and its grantees.

It is important to note that additional budget appropriations may be necessary in order for Commission staff to implement Recommendations 2, 10, and 11. Commission staff does not anticipate the need for legislation at this time. However, Commission staff may make further recommendations, including legislation, depending upon the annual review recommended by staff of progress made to address sea level rise.

Conclusions

The survey results confirm that the Commission's major grantees and lessees are just beginning to address the issue of sea level rise. It is clear that sea level rise will impact sovereign lands under the jurisdiction of the California State Lands Commission. One of the most significant impacts will be to property boundaries from the resultant changes in the elevation of the mean high tide line. In areas with coastal bluffs, sea level rise may increase bluff retreat rates due to higher high tides, storm surges, and continued bluff exposure to wave action. The erosion of coastal bluffs could lead to an increase in demand for shoreline protective devices. All of these impacts could result in a reduction or elimination of public access along the coastline. Potential impacts to the San Francisco Bay/Delta area can result from a rise in sea level and the resulting saltwater intrusions into estuaries, wetlands, freshwater systems and groundwater aquifers. Projected rises in sea level can be expected to compound the vulnerability of Delta islands to levee failure and increase upstream backwater flooding.

The recommendations included in this report are based on what is currently known about climate change and potential sea level rise. The Commission and its staff should continue to coordinate with and seek advice from key stakeholders, including federal, state, and local agencies. Through its participation with other state agencies and departments in developing California's Climate Adaptation Strategy, the Commission will be in the forefront of efforts to mitigate the impacts of climate change and sea level rise on the lands and natural resources under its jurisdiction.

Appendix

STATE OF CALIFORNIA — ARNOLD SCHWARZENEGGER, *Governor*

CALIFORNIA STATE LANDS COMMISSION
100 Howe Avenue, Suite 100-South
Sacramento, CA 95825-8202

PAUL D. THAYER, *Executive Officer*
(916) 574-1800 FAX (916) 574-1810
California Relay Service from TDD Phone **1-800-735-2929**
from Voice Phone **1-800-735-2922**

Contact Phone: **(916) 574-1892**
Contact FAX: **(916) 574-1925**



August 10, 2009

Dear Grantee/Lessee/Sublessee:

Subject: Sea Level Rise

As you are probably aware, the California State Lands Commission (Commission) has jurisdiction over sovereign lands underlying the State's navigable waterways. Such lands include, but are not limited to, the beds of more than 120 navigable rivers and sloughs, nearly 40 navigable lakes, and the three-mile wide band of tide and submerged lands adjacent to the coast and offshore islands of the State. All sovereign lands, granted or ungranted, are impressed with the Common Law Public Trust.

These sovereign lands are vulnerable to a range of natural events, including storms, extreme high tides, and rising sea levels. While some of these lands remain undeveloped, a significant portion have been developed either pursuant to a lease from the Commission or pursuant to a legislative grant to a local jurisdiction.

As such, staff of the Commission has been asked to assess the extent to which major users of state-owned sovereign lands have considered the potential impacts of sea level rise on facilities that are located on sovereign lands and has prepared the attached survey questionnaire in an effort to gather this information. If you could, please take a few moments to answer those survey questions applicable to your operations. If the facilities are subleased, it would be helpful if a copy of the questionnaire could be forwarded to each sublessee for additional response.

It would be appreciated if the survey response could be returned by September 10, 2009, by mail or email to:

Jane E. Smith
Public Land Management Specialist
100 Howe Avenue, Suite 100-South
Sacramento, CA 95825-8202
(smithj@slc.ca.gov)

For your convenience, the questionnaire is also available on the Commission's website at www.slc.ca.gov. If you have any questions, please contact Jane Smith at (916) 574-1892. Thank you, in advance, for your participation.

Sincerely,

Barbara Dugal, Chief
Land Management Division

Attachment
cc: Jane Smith

Questions	Response: City of Benicia
What existing facilities are operated and maintained within granted lands or lease premises?	(1) First Street Promenade, (2) Fishing Pier, (3) East Fifth Street Pier, Marina
What is the estimated remaining life expectancy of these facilities?	(1)-Indefinite, (2)-10 years, (3)-Indefinite
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes.
If yes to 3, what sea level rise projections are you using; and on what are they based?	BCDC
How would these facilities be impacted by a sea level rise of 16" and 55"?	16"- No effect, 55"- Damage to 5th Street Pier
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	5th Street Pier will need repair or, more likely, demolition.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	Tens of thousands of dollars to modify/remove. No plans for new construction.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Not Necessary
For Grantees/Public agency only; are you considering modifying your permit requirements?	No additional shoreline development anticipated.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Possibly levee construction in selected areas.

Questions	Response: City of Capitola
What existing facilities are operated and maintained within granted lands or lease premises?	Capitola Wharf
What is the estimated remaining life expectancy of these facilities?	With continued maintenance and piling replacement, the structure could reasonably be expected to last another 20-50 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No
If yes to 3, what sea level rise projections are you using; and on what are they based?	
How would these facilities be impacted by a sea level rise of 16" and 55"?	A 16"-55" rise in sea level would not compromise use of this structure although the damage caused by storm events could be anticipated to increase as wave action would break higher on the structure.
Have you observed any impacts to your facilities from sea level rise?	No
What actions are you considering to address sea level rise on existing or proposed facilities?	N/A
Have you estimated the cost of modifying existing facilities or constructing new facilities?	To mitigate sea level rise, the structure would need to be rebuilt at a higher elevation. The cost would be in the millions.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not yet
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Not at this time.

Questions	Response: Carmel Area Water District
What existing facilities are operated and maintained within granted lands or lease premises?	Watershed Facilities
What is the estimated remaining life expectancy of these facilities?	50 plus years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	We view this as a regional or higher issue. District will not fund protection until situation clarifies.
If yes to 3, what sea level rise projections are you using; and on what are they based?	16"- no impact, 50"- no dry weather impact
How would these facilities be impacted by a sea level rise of 16" and 55"?	No.
Have you observed any impacts to your facilities from sea level rise?	Facilities are designed for 100 year flood. Access to facilities would need modification.
What actions are you considering to address sea level rise on existing or proposed facilities?	Modifications cost unknown. New facilities would cost approximately 100 million dollars.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	N/A
For Grantees/Public agency only; are you considering modifying your permit requirements?	No unmet needs
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: City of Carpinteria
What existing facilities are operated and maintained within granted lands or lease premises?	Pier, crude oil and natural gas transmission lines, electrical transmission lines
What is the estimated remaining life expectancy of these facilities?	30 years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	16" - probably no effect 55" - require pier deck to be raised
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Yes, City is in the process with a Army Corps storm wave damage reduction study.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not at this time.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	55" sea rise would flood low lying areas at high tide. The City would need major government assistance in this scenario.

Questions	Response: City of Hermosa Beach
What existing facilities are operated and maintained within granted lands or lease premises?	Pier
What is the estimated remaining life expectancy of these facilities?	We will maintain in perpetuity.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	We are most concerned about beach front facilities and homes. We'll probably be able to deal with 16" but 55"!!!
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	We have not, but seawalls may not handle 55" rise!
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not at this time.
	This survey has certainly quantified the seriousness of the situation.

Questions	Response: City of Laguna Beach
What existing facilities are operated and maintained within granted lands or lease premises?	None
What is the estimated remaining life expectancy of these facilities?	
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	
If yes to 3, what sea level rise projections are you using; and on what are they based?	
How would these facilities be impacted by a sea level rise of 16" and 55"?	
Have you observed any impacts to your facilities from sea level rise?	
What actions are you considering to address sea level rise on existing or proposed facilities?	
Have you estimated the cost of modifying existing facilities or constructing new facilities?	
Have you considered other adaptation strategies to mitigate sea level rise impacts?	
For Grantees/Public agency only; are you considering modifying your permit requirements?	
Have you identified any unmet needs? If so, can the State Lands Commission assist?	

Questions	Response: City of Long Beach
What existing facilities are operated and maintained within granted lands or lease premises?	Facilities exist on land, container piers and terminals.
What is the estimated remaining life expectancy of these facilities?	Estimated life of facilities is 25 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Timeline for projected sea level rises exceed economic life of facilities.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	No.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Petro-Diamond Terminal, Long Beach
What existing facilities are operated and maintained within granted lands or lease premises?	Petro-Diamond Terminal Company 1920 Lugger Way Long Beach, CA / POLB - Channel 2 - Pier B
What is the estimated remaining life expectancy of these facilities?	50 years +
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No, motems in process.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Little impact
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None yet - Depends on outcomes of Motems Analysis
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No - Dock is property of Port of Long Beach
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: Port of L.A.
What existing facilities are operated and maintained within granted lands or lease premises?	Automobile (1), Breakbulk (3), Dry Bulk (2), Liquid Bulk (7), Passenger/Ferry (2), Warehouse (4), 7,500 acres (4,300 land/3,200 water), 17 Marinas (3,800 recreational boat slips), 270 Berths, 43 miles of Waterfront, 1 Recreational Beach, 1 Fishing Pier
What is the estimated remaining life expectancy of these facilities?	Estimated life varies per facility and use. Most facilities are designed to a 50 year life. In practice these structures will and have a longer useful life. While some structures are approaching 100 years of port service, many of the current container terminals range in age between 30-70 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Sea level rise was considered during preparation of the Port's 2020 Plan (late 1980's). At that time it was recommended not to consider the effect of sea level rise because the design life of the facilities and equipment was less than the expected time frame for sea level rise to make any impact on operations.
If yes to 3, what sea level rise projections are you using; and on what are they based?	Unknown
How would these facilities be impacted by a sea level rise of 16" and 55"?	No major impacts anticipated with a 16" rise. Possible flooding and wave damage at a 55" rise. Other potential impacts may occur due to a rise in ground water (uplift forces on tanks) and negative effects on depth sensitive plant life.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	We are currently planning to conduct a study to identify vulnerable facilities and develop a response option analysis plan. We will also be identifying sea level rise considerations in our design guidelines.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not at this time. We will wait for completion of our vulnerability and option analysis before modifying our permits.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Not at this time

Questions	Response: Metropolitan Water District of Southern, CA
What existing facilities are operated and maintained within granted lands or lease premises?	N/A
What is the estimated remaining life expectancy of these facilities?	N/A
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	N/A
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	N/A
Have you observed any impacts to your facilities from sea level rise?	N/A
What actions are you considering to address sea level rise on existing or proposed facilities?	No facilities that may impacted by rising sea levels.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	Cost estimates have not been done as there has been no action taken to address sea level rise on proposed Metropolitan facilities.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	N/A
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	The effects of sea level rise have not been evaluated because Metropolitan does not have existing facilities nor proposed that would or were anticipated to be affected.

Questions	Response: City of Monterey
What existing facilities are operated and maintained within granted lands or lease premises?	Three wharves, Marina, Cannery Row commercial district
What is the estimated remaining life expectancy of these facilities?	N/A
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Not to date
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	N/A
Have you observed any impacts to your facilities from sea level rise?	N/A
What actions are you considering to address sea level rise on existing or proposed facilities?	City is working with a regional workgroup to determine the impacts of coastal erosion and as level rise. Workgroup includes: National Marine Sanctuary, CA Coastal Commission, subject matter experts, public utility reps, local government reps. Group published an initial study, "Coastal Regional Sediment Management Plan for Southern Monterey Bay."
Have you estimated the cost of modifying existing facilities or constructing new facilities?	N/A
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Land use controls, structural changes, nonstructural changes
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: City of Newport Beach
What existing facilities are operated and maintained within granted lands or lease premises?	Mostly residential (75%) & commercial (25%). Almost all of these properties are on private waterfront property.
What is the estimated remaining life expectancy of these facilities?	Difficult to estimate, due to hundreds of property owners around the harbor.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes. Our Harbor Area Management Plan (soon to be adopted) addresses sea level rise.
If yes to 3, what sea level rise projections are you using; and on what are they based?	Projections based on various reports, suggesting a 1-3' rise by 2100.
How would these facilities be impacted by a sea level rise of 16" and 55"?	Possible flooding over most of our bulkheads which are to a mean low low water when coupled with storm surge.
Have you observed any impacts to your facilities from sea level rise?	Not definitively
What actions are you considering to address sea level rise on existing or proposed facilities?	Considering changing our design standards for bulkhead height in the coming years.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Increase seawall height.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Yes, See #7.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: Port of Oakland
What existing facilities are operated and maintained within granted lands or lease premises?	The Port of Oakland (Port) owns and controls approximately 19 miles of waterfront. All the Port's lands are used for airports and related purposes, seaport marine terminals and related purposes, railroad terminals, roadways, utilities, marinas, parks, offices, and other commercial-related businesses, such as Jack London Square and the Airport Business Park. Some of the property on which Oakland International airport, the seaport's marine terminals, and other facilities are located is owned by the City of Oakland, acting by and through its Board of Port Commissioners (the "Port"), subject to a trust imposed pursuant to more than a dozen tideland grants from the State of California. Other property was acquired using money generated from trust land. Where answers to survey questions are different for the Port's three business lines (Seaport, Airport and Commercial Real Estate (CRE)), each is addresses in a separate bullet point.
What is the estimated remaining life expectancy of these facilities?	• Seaport: Remaining life expectancy varies, since facilities were originally built and renovated at different times. Wharves, for example, generally are assigned a 50 year asset life. However, some have been rebuilt prior to the end of their useful life due to changes in marine industry. The use of containers to ship cargo, for example, was introduced to the Port less than 50 years ago. Nearly all of the wharves and terminals have been rebuilt to accommodate the change in equipment and technology required by containerization. • Airport: Remaining life expectancy of Airport facilities (runways, aprons, terminal buildings, etc. also varies, with some facilities already past their asset life. The maximum asset life is approximately 50 years. • CRE: Varies, depending on year and type of construction. Most structures and improvements in the CRE area have an asset life shorter than 50 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	•Seaport: To some degree. Wharves and container cranes are designed to accommodate some variation in sea level rise (tidal ranges and moderate storm surge) and different ship configurations. Port staff is monitoring the studies and reports prepared by the State of California's Climate Action Team and by the San Francisco Bay Conservation and Development Commission (BCDC). • Airport: Effects on the main South Field runway are being studied. According to the 2009 draft "Improvements Strategy Report for Perimeter Dike, Oakland International Airport" (ISR), by URS Corporation, it is estimated that the dike can support 36 inches of sea level rise at Mean High High Water (MWWH). The ISR for the perimeter dike evaluated flood, seepage, stability, and seismic, as well as sea level rise issues. •CRE: It is not known at this time. BCDC is developing a Climate Change Adaptation Strategy that will address impacts to the shoreline.
If yes to 3, what sea level rise projections are you using; and on what are they based?	For discussion purposes, Port staff is using a projection of 55" in sea level rise by 2100. This represents the high end range of projcted sea level rise as presented in the State of California's "DRAFT 2009 Climate Action Team Biennial Report to the Governor and Legislature" (March 2009).

Questions	Response: Port of Oakland
How would these facilities be impacted by a sea level rise of 16" and 55"?	• Seaport – According to the BCDC draft staff report, "Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline", April 7, 2009, Bay Area ports are most vulnerable in terms of their broader logistics chain, with difficulty moving goods via highways and rail. Flooding of low-lying areas is expected to impact regional goods movement. The region's ports are projected to experience moderate flooding of 4-20% of total acreage. See the enclosed map of the Port of Oakland area, which is excerpted from the BCDC draft staff report (p. 75, Figure 2.6, Central Bay Transportation Network and Shoreline Priority Use Areas Vulnerable to Sea Level Rise). • Airport – The dike can currently support 36" of sea level rise at MHHW (7 ft). • CRE – It is not known at this time. BCDC is developing a Climate Change Adaptation Strategy that will address impacts to the shoreline.
Have you observed any impacts to your facilities from sea level rise?	No impacts of sea level rise are yet apparent in Port facilities.
What actions are you considering to address sea level rise on existing or proposed facilities?	•Seaport: Port staff are monitoring current sea level rise projections. As facilities are redeveloped, engineers will consider the effect of sea level rise over the life of each project. • Airport: Per the ISR for Perimeter Dike, recommendations for improvements include raising portions of the dike that are lower than 12ft (still water level plus two feet) and raising portions of the dike crest (total water plus two feet). • CRE: None at this time. Project life of CRE facilities is generally less than the sea level rise planning horizon.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	•Seaport: No. •Airport: Estimated costs for improvements to the perimeter dike will encompass flood protection, stability, seismic safety, and sea level rise. •CRE: No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	•Seaport: Not yet. Best practices regarding such strategies have not yet been developed for shoreline-dependent industries. •Airport: Other ideas have been discussed, but they are more involved and costly than shoring up the dike. •CRE: Not yet.
For Grantees/Public agency only; are you considering modifying your permit requirements?	The Port of Oakland does issue development permits to tenants and entities within its planning jurisdiction. While sea level rise is not yet addressed in such permit, it may be in the future.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	• Seaport – Accurate and updated projections about the timing and scale of sea level rise are best provided by state, national and international agencies. Best management practices concerning treatment of sea level rise in long-range planning and project-specific design and construction should be developed and promulgated by national and international bodies. •Airport – Yes. One obstacle is getting other property owners that are adjacent/upstream from the Oakland International Airport to address sea level rise issues that could impact the airport. For example, if San Leandro does not improve their perimeter dike, OAK could be flooded in the south-eastern portion of the airport. Funding for sea level rise-related improvements will be important. •CRE – Yes. One obstacle is getting other property owners that are adjacent/upstream from the Port to address sea level rise issues that could impact the Port property.

Questions	Response: City of Oceanside
What existing facilities are operated and maintained within granted lands or lease premises?	Breakwaters (2), fishing pier (1) including restaurant, restroom & bait shop, storm drain outlets
What is the estimated remaining life expectancy of these facilities?	Breakwater - 30 years, Fishing Pier & Buildings - 20 years, Storm Drains - 10 years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	16" - probably no impact, 55" - possibly some wave run-up
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Orange County, Dana Point Harbor
What existing facilities are operated and maintained within granted lands or lease premises?	Two marinas (2,400 slips, visitor docks, boat launch, surface boat storage, boat rental, shipyard, fuel dock, yacht clubs, beach area with non-motorized vessel hand launch, Ocean Institute (Education & research facility), Sailing & Events Center, Retail, restaurants, offices, sports fishing, harbor, patrol, commercial fishing, fishing pier, park areas, parking, roads, bridge
What is the estimated remaining life expectancy of these facilities?	A 75 year design life for the concrete structures and 100+ for breakwater. U.S. Army Corps of Engineers would have best info for Design Life of the facilities contained in the Breakwater and Quay Wall.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Not at this time.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Qauy Wall and Launch Ramp at 10 MLLW (Approx 7.28' Elevation) The Breakwater is at 14 MLLW (approx 11.28' Elevation) Extreme High Tide in the 8' range therefore existing approx 2 feet of freeboard. So an increase of 16" leaves approx 8" of freeboard and a 55" rise over tops by approximately 31" at an extreme high tide of 8'.
Have you observed any impacts to your facilities from sea level rise?	Not at this time.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Not at this time.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not at this time.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Not at this time.

Questions	Response: Orange County (OC Parks)
What existing facilities are operated and maintained within granted lands or lease premises?	Marina facilities at Newport Dunes and Sunset Aquatic Marina. Floating dock systems with bulkhead shore protection at various locations in Newport Beach and ecological preserve at Upper Newport Bay.
What is the estimated remaining life expectancy of these facilities?	Original construction of the seawall structures occurred in the late 1960's/early 70's. Given an estimated design life of 50 years, many of the structures are showing wear and will be due for rehabilitation in the next 5 to 10 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes.
If yes to 3, what sea level rise projections are you using; and on what are they based?	Sea level rise was estimated at 20cm per century (CCSTWS, 2002) in the design of the existing structures. Guidelines related to predictions associated with accelerated sea level rise in 50 to 100 years have not been adopted.
How would these facilities be impacted by a sea level rise of 16" and 55"?	The lease areas are home to critical habitat, recreational facilities, public infrastructure and valuable real estate. Many of the existing seawalls would be overtopped, an increase in flooding and erosion would be expected and ecosystems would change.
Have you observed any impacts to your facilities from sea level rise?	No. Tide gauge data from La Jolla suggest that local sea level off southern California rose more slowly than the predicted 20 cm per century since about 1980 (Flick, R.E. and L.C. Ewing, 2009).
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this point.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Not at this time.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Not at this time.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	A better understanding of the climate forecasts is needed which wold facilitate better planning and adaptation requirements. A dedicated state-wide program should be implemented to collect data to make reliable assessments and projections of mean sea level rise. Assistance would be needed for a monitoring program to observe and mark maximum runup elevations to determine locations most vulnerable to damage now, and therefore most vulnerable to SLR in the future.

Questions	Response: City of Pittsburg
What existing facilities are operated and maintained within granted lands or lease premises?	Four private terminals that operate within Granted Lands: Tesero Refinery, Isle Capital, USS/POSCO Industries, Dow Chemical Company
What is the estimated remaining life expectancy of these facilities?	All facilities in continuous operation, with no plans to cease operations.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Not to our knowledge.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	All of these facilities are well above 6' at the shoreline.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	No.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	N/A
Have you considered other adaptation strategies to mitigate sea level rise impacts?	N/A
For Grantees/Public agency only; are you considering modifying your permit requirements?	Yes, we will make sure that any future permits address the projected rise in sea level.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Not at this time.

Questions	City of Richmond
What existing facilities are operated and maintained within granted lands or lease premises?	Terminal 1,3 & 4 in State Lands area.
What is the estimated remaining life expectancy of these facilities?	Terminal 1 & 4 are beyond service life but functioning; terminal 3 is expecting to provide another additional 20 years of service.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes.
If yes to 3, what sea level rise projections are you using; and on what are they based?	BCDC; GIS maps. 1' rise model.
How would these facilities be impacted by a sea level rise of 16" and 55"?	3' - tidal changes 16" - no changes 10' - above MSL 16' - no effect 55' effect: during high tide & storm surge. Some areas may experience flooding & damage due to storm surge.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	Needs further study.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	Needs further study.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Use shoreline protection structures such as rip-rap & seawalls.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No permit authority; port not a regulatory agency.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Needs further studies; SLC can provide funding.

Questions	Response: San Diego- Mission Beach
What existing facilities are operated and maintained within granted lands or lease premises?	Amusement rides, historic roller coaster built in 1925.
What is the estimated remaining life expectancy of these facilities?	Indefinite, National landmark
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Not sure.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Youth Tennis of San Diego
What existing facilities are operated and maintained within granted lands or lease premises?	Tennis Facility
What is the estimated remaining life expectancy of these facilities?	60 plus years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	N/A - We are not close enough to the sea to be affected.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	N/A
Have you observed any impacts to your facilities from sea level rise?	N/A
What actions are you considering to address sea level rise on existing or proposed facilities?	N/A
Have you estimated the cost of modifying existing facilities or constructing new facilities?	N/A
Have you considered other adaptation strategies to mitigate sea level rise impacts?	N/A
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: Port of San Francisco
What existing facilities are operated and maintained within granted lands or lease premises?	The Port of S.F. manages and regulates 7 1/2 miles of S.F. Bay waterfront properties including piers, wharfs, seawalls, breakwaters, waterfront buildings and sheds, ferry terminals, ballpark, marina, roadways, and elaborate utility infrastructure systems.
What is the estimated remaining life expectancy of these facilities?	These facilities are continuously inspected and maintained leading to a 100 + year life expectancy. A number of the Port's facilities are condemned or severely load-restricted and may not be improved .
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	The Port is participating in two working groups to examine the consequences of sea level rise, one sponsored by the S.F. Planning and Urban Research Association (SPUR) and the other by Mayor Gavin Newsom. The Port is also reviewing proposed amendments to the BCDC Bay Plan which would set forth findings related to sea level rise and construction in current or future floodplains. To date, no construction standards or restrictions to account for sea level rise have been developed by the Port. Without new flood control measures, rising sea level will eventually cause flooding of future facilities.
If yes to 3, what sea level rise projections are you using; and on what are they based?	The Port is familiar with the sea level rise projections provided in Question #5 below, but has not adopted a standard for building code purposes.
How would these facilities be impacted by a sea level rise of 16" and 55"?	A 16" sea level rise will cause flooding of some of the Port's facilities. A 55" sea level rise will cause frequent flooding of the majority of the Port's facilities including the waterfront roadway, the Embarcadero and portions of Mission Bay.
Have you observed any impacts to your facilities from sea level rise?	Not to date.
What actions are you considering to address sea level rise on existing or proposed facilities?	The Port is willing to participate in a Bay Area statewide working group to develop options which could be installed to mitigate the impacts of sea level rise.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No, the mitigation options need to be developed first. Since the Port has significant existing infrastructure that has been designed and constructed to yesterday's sea level elevation, sea level rise solutions requiring modification to the Port's existing structures will be very costly. Local solutions such as creating dikes or barrier walls at the water or piers edge will be costly, and difficult to install and maintain. Elevating existing structures above the anticipated sea level rise is expected to be cost-prohibitive.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Given the full nature and elevation of downtown S.F., sea level rise is a matter for Citywide analysis and planning. Given the constructed nature of the Port's waterfront, abandonment of the existing S.F. waterfront by allowing sea level rise to inundate and reclaim these lands is not a reasonable solution. Engineering solutions to sea level rise, developed through a local and/or regional planning effort, would appear to be the only option.
For Grantees/Public agency only; are you considering modifying your permit requirements?	The development of building code requirements will depend on State of California consensus regarding projected levels of sea level rise and coordination with regional entities such as the U.S. Army Corps of Engineers and FEMA.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	See response to #7

Questions	Response: Port of San Luis Harbor District
What existing facilities are operated and maintained within granted lands or lease premises?	2 wood piers, travel hoist boat launch, floating docks for trailer boat launch, moorings, maintenance office, retail buildings on land filled areas
What is the estimated remaining life expectancy of these facilities?	50 + years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Wave run studies conducted prior to construction of restroom facilities in 2008.
If yes to 3, what sea level rise projections are you using; and on what are they based?	100 year projections from marine environmental firm.
How would these facilities be impacted by a sea level rise of 16" and 55"?	16"- minimal impact 55" - serious issues to functionality of harbor district
Have you observed any impacts to your facilities from sea level rise?	No
What actions are you considering to address sea level rise on existing or proposed facilities?	Design for increased elevation at first floor level
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No
Have you considered other adaptation strategies to mitigate sea level rise impacts?	We have no options for planned retreat, etc.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: San Mateo Harbor District
What existing facilities are operated and maintained within granted lands or lease premises?	Pillar Point Harbor: 369 Berth Commercial, sport fishing, and recreational boating harbor; 3 piers (one closed for safety reasons) 40 public boat moorings and private moorings; inner protective breakwater; outer federally maintained breakwater; boat launch ramp
What is the estimated remaining life expectancy of these facilities?	Variable: 10-40 years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	We are doing so as part of our planning priority set.
If yes to 3, what sea level rise projections are you using; and on what are they based?	Pacific Institute: 1.4 meter rise by end-century. From: State C.A.T. Biennial Report, 2009
How would these facilities be impacted by a sea level rise of 16" and 55"?	16"- Hinged connections for gangways to docks and for utilities needed, shoreline erosion along inner and outer harbor shoreline and trails 55" - All future developments including new bulkheads, above 4ft. Piling extensions, raising piers, trails, parking lots, launch ramps, bulkheads
Have you observed any impacts to your facilities from sea level rise?	Extreme high tides now stress gangway and utility hinges. Further erosion of surface beach (outside outer breakwater) threatening highway 1 may be partially attributed to sea level rise.
What actions are you considering to address sea level rise on existing or proposed facilities?	See #5
Have you estimated the cost of modifying existing facilities or constructing new facilities?	Not yet but will do so: gangway & hinge retrofit
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Bulkheads & seawalls, raising certain facilities, beach nourishment and/or other methods at surfers beach and Princeton beach
For Grantees/Public agency only; are you considering modifying your permit requirements?	We will do so when new relevant permits requests arise. None are presently before us.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Grants for gangway & utility connections, inner break wall, shoreline & trail

Questions	Response: City of Santa Barbara
What existing facilities are operated and maintained within granted lands or lease premises?	Santa Barbara Harbor included marinas, piers, wharf, breakwater, mooring area, landside parking, and commercial buildings.
What is the estimated remaining life expectancy of these facilities?	This question is difficult to answer without qualifying whether or not maintenance , storm and other factors are to be taken into consideration. Assuming that public agencies would continue to operate and maintain these facilities, I would estimate most facilities could easily be around 50 to 75 years from nor or maybe longer.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No. Only on a preliminary conceptual basis.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	A sea level rise of 16" would likely not have any significant immediate impact overall. However, a rise of 55" would basically flood or inundate the entire area, destroying most all facilities as currently constructed.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	Nothing specific.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: City of Santa Monica
What existing facilities are operated and maintained within granted lands or lease premises?	Santa Monica Pier, various public restroom facilities, concession stands, parking lots, bike and pedestrian paths, lifeguard stands, and storm drains.
What is the estimated remaining life expectancy of these facilities?	Most should last 25 years or more.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	The storm drains would become inundated with ocean water thereby reducing the capacity of the drain. Parking lots, concession stands, bike and pedestrian paths would periodically be flooded.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	None.

Questions	Response: City of Vallejo
What existing facilities are operated and maintained within granted lands or lease premises?	Subleased properties, water and sewage treatment, marina and boating operations, U.S. Coast Guard, Marina, Yacht Club, Ferry Terminals and Maintained Facility, Fishing Pier, White Slough, River Front Park, Vallejo Water Front Promenade, Marina Green, City Parks, Sea Walls/breaks and parking lots
What is the estimated remaining life expectancy of these facilities?	1-25 years, a study would be required to access the remaining physical life of these assets with respect to current condition and guidelines being provided by the State
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Not at this time
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Improvements that is well past their life would be implemented in both scenarios, maintaince would need to be increased, and studied, remedial actions and planning guidelines will need to be addressed.
Have you observed any impacts to your facilities from sea level rise?	No observable changes that have immediate impact.
What actions are you considering to address sea level rise on existing or proposed facilities?	Participate in regional planning efforts to evaluate potential impact and course of action.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No attempt has been made to date to project the impact of the planning guidelines and the impact on existing facilities; planning and new development of SLC impacted property.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Not at this time.
For Grantees/Public agency only; are you considering modifying your permit requirements?	We believe that the City's planning process will evolve to include considerations for global warming change and rising sea level. We fully expect that the change will be driven by a coordinated regional planning response due to the dynamics of the Bay, Delta, Rivers and tributaries influencing most of the City's situated on the Bay.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	Formalize planning guidelines, measure changes that may be occurring and accurately predict time table, have planning tools made available to assist Agencies in land use assessment, fully understand inter-agency strategies that have impact on other agencies, timely communication to tenants with long term leases to understand and mitigate impacts o f sea level rise, integrate city adopted planning guidelines with other agencies to assure consistency of approaches, methodology, and understanding of long term social and financial impacts.

Questions	Response: City of Ventura
What existing facilities are operated and maintained within granted lands or lease premises?	Ventura Pier
What is the estimated remaining life expectancy of these facilities?	Indefinite- At this time the City of Ventura does not foresee a time when the pier will cease to exist.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes.
If yes to 3, what sea level rise projections are you using; and on what are they based?	NOAA mean sea level trend: 1.25 +/- 1.82 mm/yr
How would these facilities be impacted by a sea level rise of 16" and 55"?	Increased maintenance due to wave activity
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None
Have you estimated the cost of modifying existing facilities or constructing new facilities?	N/A
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No, not at this time.

Questions	Response: Port of San Diego
What existing facilities are operated and maintained within granted lands or lease premises?	Nearly 2,500 acres including restrooms, parks, parking lots, businesses, restaurants, marine repair, docking, mooring, sport fishing, beaches, boat launching, yacht clubs, etc. See attached list of Port District's facilities.
What is the estimated remaining life expectancy of these facilities?	The life expectancy varies depending on use and renovations. [For example the Broadway Pier was built in 1912 with an expected life span of 50 years. The Pier has been modified significantly twice, and fully structurally upgraded recently. Lastly it has been seismically upgraded and a new Cruise Ship Terminal building is under construction on the Pier today.] The following is a general approximation of the intended lifespan of Port properties. Buildings: 50 years, Marine Structures: 40-50 years, Landscaping: Indefinite, Railroads: 40-50 years, Pavement: 20 years, Utilities: 20-30 years, Other (playgrounds, public art, etc.): 0-30 years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No - not for unmodified use of existing facilities. Yes - for new development and substantial modifications to existing facilities. Our environmental review process requires consideration of sea level rise.
If yes to 3, what sea level rise projections are you using; and on what are they based?	16 inches by the end of the century (2100) based on the *Fourth Assessment Report* (2007) and the California Climate Change Centers, *Projecting Future Sea Level* (March 2008).
How would these facilities be impacted by a sea level rise of 16" and 55"?	Many existing facilities would not be greatly impacted by a rise in sea level of 16" because they are currently at elevation above that (e.g. the Embarcadero areas of the urban downtown waterfront, including piers, are generally at elevations of above 18" above current sea level). There may be areas where facilities would be affected by the 16" rise in sea levels by 2050, including wildlife areas though these would likely adapt. A 55" rise in sea levels would likely result in substantial impacts and potential inundation of some facilities in both urban and wildlife areas.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	The Port is about to embark on a comprehensive Climate Action Plan that will include identifying strategies for adapting to the effects of climate change. The most notable effects of climate change for the Port is sea level rise. New developments are currently factoring a rise in sea level into the design parameters, such as raised pads.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Yes. Adaptation strategies to sea level rise, such as those listed, will be considered and prudent strategies identified as part of the comprehensive Climate Action Plan.
For Grantees/Public agency only; are you considering modifying your permit requirements?	Yes. Evaluation of exposure to sea level rise as an effect of climate change for new developments and substantial changes to existing facilities is part of our environmental review process. All documents undertaken by the Port in accordance with the California Environmental Quality Act include this consideration. Where the environmental review process identifies necessary measures, including addressing potential sea level rise, such measures are made and included into the Coastal Development Permit issued by the Port.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	The Port is keen to establish dialogue with the State Lands Commission regarding potential adaptation strategies. Opportunities to share research, expertise, and knowledge of examples would be of great use to the Port.

Questions	Response: Continental Maritime of San Diego (subsidiary of Northrop Grumman)
What existing facilities are operated and maintained within granted lands or lease premises?	Continental Maritime operates a shipyard on the San Diego Bay and repairs ships at its wharf and piers. The shipyard's landing area is on approximately 14 acres of filled tidelands. The yard has several office and shop buildings located at the site.
What is the estimated remaining life expectancy of these facilities?	Fifty (50) years of remaining life is reasonably estimated.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Yes
If yes to 3, what sea level rise projections are you using; and on what are they based?	We have relied on the work of Dr. Dan Cayan of the Scripps Institute of Oceanography, here in San Diego. His projections are from 1m to 1.4m by the year 2100.
How would these facilities be impacted by a sea level rise of 16" and 55"?	The datum from the top of the shipyard's quay walls, wharf and piers is 12.87' above MLLW. The extreme high tide here in San Diego Bay at our location is 7.75' and an increase of 1.33' (16") by 2050 would leave a height of 3.79'; ostensibly a safe elevation from inundation caused by extreme conditions. Along the Southern California Bight's coastline and especially in the San Diego Bay, storms surges and waves rarely have caused problems. A projection of 3.79' (55") by the year 2100 would only leave a height of .54' (6 1/2") and problems from extreme conditions would occur.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	In long range planning for yard facilities the rise in sea level is being taken into account.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	The most apparent adaptation strategy would be to raise the yard's quay walls and additional fill into the yard's land area.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	None.

Questions	General Dynamics, National Steel & Shipbuilding Company
What existing facilities are operated and maintained within granted lands or lease premises?	General Dynamics, National Steel & Shipbuilding Company (NASSCO) operates a ship construction and repair facility on 81 acres of land and 47 acres of water leased from the Unified Port of San Diego. The facility includes 2 inclined building ways, 1 building dock, 6 piers, and 5912 feet of seawall, quay wall and dock gate waterfront.
What is the estimated remaining life expectancy of these facilities?	The overall life expectancy is indefinite. Some structures are nearing the end of their useful life while others are newly constructed and have many years of life remaining.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	The NASSCO shipyard is on average 11.5' above MLLW. An extreme high tide of 8' is still 3.5' below the shipyard's seawalls. A sea level rise of 16" (1.3') would have little or no affect to shipyard operations. A sea level rise of 55" (or 4.6') would result in an unusable shipyard without significant investment.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Aera Energy
What existing facilities are operated and maintained within granted lands or lease premises?	Offshore oil production platform (Emmy); oil and natural gas wells and related facilities located onshore for onshore and offshore oil and gas leases.
What is the estimated remaining life expectancy of these facilities?	Not determined.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Assuming the survey concerns possible future sea level rise due to global warming, no.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	See Response to question 3.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	See Response to question 3.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	See Response to question 3.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	See Response to question 3.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	See Response to question 3.

Questions	Response: BP West Coast Products LLC (Arco Terminal within Port of Long Beach)
What existing facilities are operated and maintained within granted lands or lease premises?	Marine Terminal (Petroleum)
What is the estimated remaining life expectancy of these facilities?	Fifty years +
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	16" would have minimal impact. 55" would impact loading/offloading operations because of the change in the height of ships versus the height of the on-shore facilities (chiksans), fixed fendering will likely require adjustments as well.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None currently
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	Not at this time.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	We have not addressed the issue of "sea level rise" as of yet, so we are not aware of any unmet needs.

Questions	Response: Chevron Estero Terminal
What existing facilities are operated and maintained within granted lands or lease premises?	Existing facilities consist of two offshore loading lines and one wastewater pipeline and associated onshore valve boxes and appurtenances, in addition to a former pier bulkhead. All facilities are "idle" and "on-hold-over status" until appropriate regulatory permits and/or approvals are received to facilitate decommissioning per the existing CSLC lease agreement.
What is the estimated remaining life expectancy of these facilities?	As indicated above, facilities will be decommissioned upon receipt of regulatory agency permits/approvals. This is expected to occur within the next 3 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	N/A
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	N/A
Have you considered other adaptation strategies to mitigate sea level rise impacts?	N/A
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	N/A

Questions	Response: DCOR - Oil Platforms Eva & Esther
What existing facilities are operated and maintained within granted lands or lease premises?	Offshore oil platforms Eva and Esther
What is the estimated remaining life expectancy of these facilities?	Based on the most recent Reserve Reports as prepared by an independent Petroleum Engineer, the economic life expectancy of Platform Eva is approximately 17 years and the economic life expectancy of Platform Esther is approximately 11 years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Given the expected economic lives of these facilities, DCOR, LLC has not considered the effect of rising sea levels on the facilities.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Because it is reasonably expected that both facilities will be removed prior to 2050, it is meaningless for us to speculate how the facilities will be impacted by the increased sea levels quoted.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None, because the estimated reaming economic lives of these facilities are less than that point in time in which we may experience a noticeable rise in sea level.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No, due to the reason specified in Answer #7 above.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No, due to the reason specified in Answer #7 above.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Greka Rincon Island
What existing facilities are operated and maintained within granted lands or lease premises?	Rincon Island (offshore oil production facility) and connecting causeway to shore.
What is the estimated remaining life expectancy of these facilities?	N/A
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Rising or lower sea levels do not disturn our operations.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Not sure if there will be an impact.
Have you observed any impacts to your facilities from sea level rise?	Not currently.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	None at this time.

Questions	Response NRG Energy
What existing facilities are operated and maintained within granted lands or lease premises?	There are three facilities: 1) El Segundo Power Station, El Segundo, CA 2) CA Encina Power Station, Carlsbad, CA 3) Long Beach Power Station, Long Beach, CA
What is the estimated remaining life expectancy of these facilities?	In their current configuration 1) El Segundo: 2017 2) Encina: 2020 3) Long Beach: 2017 However, any of these sites may be repowered with longer life expectancy.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	El Segundo - No impact. Lowest elevation is +20 feet above mean sealevel. Encina - Ni impact. Ground elevation for plant is +60 feet above mean sealevel. Long Beach - May be impacted as the plant elevation is 18 feet below current mean sealevel. Currently protected by an earthen dike. Redevopment would require replacement of the current dike.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	No.
Have you identified any unmet needs? If so, can the State Lands Commission assist?	None.

Questions	Response: Pacific Operators Offshore LLC
What existing facilities are operated and maintained within granted lands or lease premises?	PACOPS operates one onshore facility as located in Ventura County and within the three mile mean tide line adjacent band. PACOPS also operates two offshore oil and gas producing platforms; however these facilities are located in Federal Waters lying beyind the three mile mark.
What is the estimated remaining life expectancy of these facilities?	Approximately twenty years.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Remaining project lifetime projections egate the cecessity for such consideration.
Have you observed any impacts to your facilities from sea level rise?	No. (See item Five)
What actions are you considering to address sea level rise on existing or proposed facilities?	None.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No. (See item Five)
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No. (See item Five)
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.None

Questions	Response: Tesoro - L.A. Refinery
What existing facilities are operated and maintained within granted lands or lease premises?	Marine Terminal
What is the estimated remaining life expectancy of these facilities?	50 years
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Have not considered
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None planned in short term.
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	No.

Questions	Response: Thums- Long Beach Harbor
What existing facilities are operated and maintained within granted lands or lease premises?	Thums operates four (4) manmade islands in Long Beach Harbor that function as oil and gas extraction sites. Thums also leases several sites from the Port of Long Beach that function as oil extraction sites or that provide ancillary support to Thums operations (warehouse, offices, processing facilities, maintenance facilities, crew boat/barge facilities, etc.)
What is the estimated remaining life expectancy of these facilities?	The estimated remaining life expectancy is approximately 30 years. This estimate is based on the economic life of the operation and is dependent on numerous factors. After the end of operations, future uses/disposition of the islands would be determined by the City of Long Beach. The Port of Long Beach leases would be relinquished to the Port.
Have you or your sublessee considered the effect of a rising sea level on these existing facilities?	Not at this time. However, Thums is closely following the possible removal or reconfiguration of the Long Beach Breakwater. This breakwater shelters the islands from open wave impacts and its removal or reconfiguration could have a significant ocean impacts to the islands.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	Per question 2, the operations are estimated to end approximately 10 years before the year 2050. However, assuming the continued presence of the islands, it is reasonable to assume a 16" rise in 2050 would result in increasing threat of wave/storm damage to the islands. This would potentially require modifications to the rock perimeter of the islands and boat/dock facilities (if maintained). A 55" rise by 2100 would likely make the above rock perimeter and boat/dock facility modifications (if maintained) mandatory. The 2050 and 2100 potential impact to the former Port of Long Beach lease would be addressed by the Port of Long Beach.
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None at this time. (Per question 3, the more immediate concern is possible removal/reconfiguration of the Long Beach Breakwater).
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	N/A
Have you identified any unmet needs? If so, can the State Lands Commission assist?	

Questions	Response: Venoco, Inc.
What existing facilities are operated and maintained within granted lands or lease premises?	1) Platform Holly, 2) Ellwood Marine Terminal, 3) Ellwood Pier, 4) Gathering Lines under Suisun Bay, 5) Gathering Lines under Grizzly Slough
What is the estimated remaining life expectancy of these facilities?	1) 30 + years, 2) 5 years, 3) 30 + years, 4) 30 + years, 5) 30 + years
Have you or your subiessee considered the effect of a rising sea level on these existing facilities?	No.
If yes to 3, what sea level rise projections are you using; and on what are they based?	N/A
How would these facilities be impacted by a sea level rise of 16" and 55"?	No impact
Have you observed any impacts to your facilities from sea level rise?	No.
What actions are you considering to address sea level rise on existing or proposed facilities?	None
Have you estimated the cost of modifying existing facilities or constructing new facilities?	No.
Have you considered other adaptation strategies to mitigate sea level rise impacts?	No.
For Grantees/Public agency only; are you considering modifying your permit requirements?	None.
Have you identifled any unmet needs? If so, can the State Lands Commission assist?	No.

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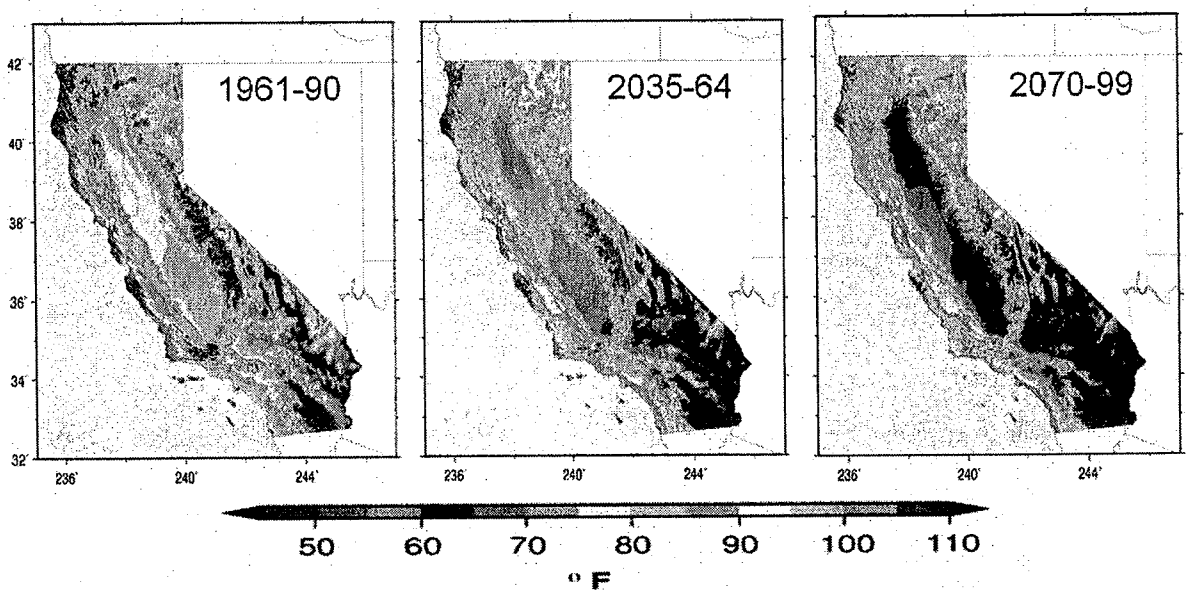
2009 California Climate Adaptation Strategy

A Report to the Governor of the State of California
in Response to Executive Order S-13-2008



California Natural Resources Agency

Figure 1. California Historical & Projected July Temperature Increase 1961-2099



Source: Dan Cayan et al. 2009.

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EXECUTIVE SUMMARY

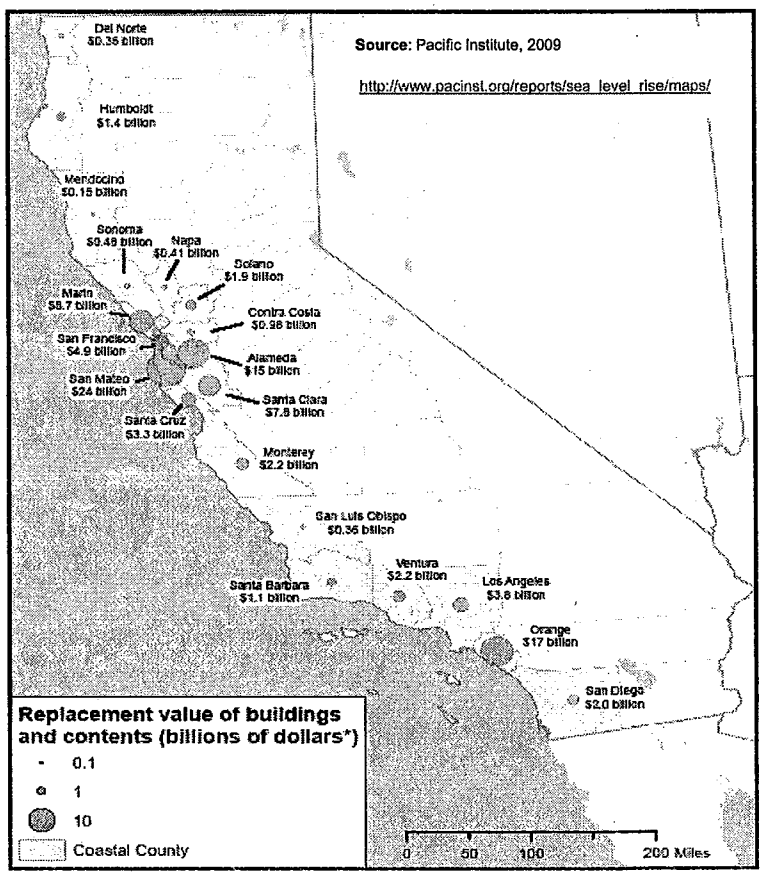
The Golden State at Risk

Climate change is already affecting California. Sea levels have risen by as much as seven inches along the California coast over the last century, increasing erosion and pressure on the state's infrastructure, water supplies, and natural resources. The state has also seen increased average temperatures, more extreme hot days, fewer cold nights, a lengthening of the growing season, shifts in the water cycle with less winter precipitation falling as snow, and both snowmelt and rainwater running off sooner in the year.

These climate driven changes affect resources critical to the health and prosperity of California. For example, forest wildland fires are becoming more frequent and intense due to dry seasons that start earlier and end later. The state's water supply, already stressed under current demands and expected population growth, will shrink under even the most conservative climate change scenario. Almost half a million Californians, many without the means to adjust to expected impacts, will be at risk from sea level rise along bay and coastal areas. California's infrastructure is already stressed and will face additional burdens from climate risks. And as the Central Valley becomes more urbanized, more people will be at risk from intense heat waves.

If the state were to take no action to reduce or minimize expected impacts from future climate change, the costs could be severe. A 2008 report by the University of California, Berkeley and the non-profit organization Next 10 estimates that if no such action is taken in California, damages across sectors would result in "tens of billions of dollars per year in direct costs" and "expose ***trillions*** of dollars of assets to collateral risk." More specifically, the report suggests that of the state's $4 trillion in real estate assets "$2.5 trillion is at risk from extreme weather events, sea level rise, and wildfires" with a projected annual price tag of up to $3.9 billion over this century depending on climate scenarios (www.next10.org/research/research_ccrr.html). The figure at right, from a study by the Pacific Institute, shows coastal property at risk from projected sea level rise by county with replacement values as high as $24 billion in San Mateo County.

Figure 2: *Replacement value of buildings and contents vulnerable to a 100 year coastal flood with 1.4 meters of sea level rise. Land values and relocation costs due to coastal erosion are not included.*



Source: Heberger et al. 2009.

California understands the importance of addressing climate impacts today. The state strengthened its commitment to managing the impacts from sea level rise, increased temperatures, shifting precipitation and extreme weather events when Governor Arnold Schwarzenegger signed Executive Order (EO) S-13-08 on November 14, 2008. The order called on state agencies to develop California's first strategy to identify and prepare for these expected climate impacts.

The *2009 California Climate Adaptation Strategy (CAS)* report summarizes the best known science on climate change impacts in the state to assess vulnerability and outlines possible solutions that can be implemented within and across state agencies to promote resiliency. This is the first step in an ongoing, evolving process to reduce California's vulnerability to climate impacts.

The California Natural Resources Agency (CNRA) has taken the lead in developing this adaptation strategy, working through the Climate Action Team (CAT). Seven sector-specific working groups led by 12 state agencies, boards and commissions, and numerous stakeholders were convened for this effort. The strategy proposes a comprehensive set of recommendations designed to inform and guide California decision makers as they begin to develop policies that will protect the state, its residents and its resources from a range of climate change impacts. Following a 45-day public comment period since its release as a Discussion Draft in August 2009, the CNRA and sector working groups have revised the strategy incorporating public stakeholder input. All public comments can be seen on the adaptation Web site at www.climatechange.ca.gov. Not all material has been incorporated at this time, but will potentially be added later to accommodate additional information and expand upon as strategies are implemented and more organizations and processes become involved. This document will be updated approximately every two years to incorporate progress in strategies and changing climate science.

California's Climate Adaptation Strategy

As the climate changes, so must California. To effectively address the challenges that a changing climate will bring, climate adaptation and mitigation (i.e., reducing state greenhouse gas (GHG) emissions) policies must complement each other, and efforts within and across sectors must be coordinated. For years, the two approaches have been viewed as alternatives, rather than as complementary and equally necessary approaches.

Adaptation is a relatively new concept in California policy. The term generally refers to efforts that respond to the *impacts* of climate change – adjustments in natural or human systems to actual or expected climate changes to minimize harm or take advantage of beneficial opportunities.

California's ability to manage its climate risks through adaptation depends on a number of critical factors including its baseline and projected economic resources, technologies, infrastructure, institutional support and effective governance, public awareness, access to the best available scientific information, sustainably-managed natural resources, and equity in access to these resources.

As the *2009 California Climate Adaptation Strategy* illustrates, the state has the ability to strengthen its capacity in all of these areas. In December 2008, the California Air Resources Board released the state's *Climate Change Scoping Plan*, which outlines a range of strategies necessary for the state to reduce its GHG emissions to 1990 levels by 2020. Many climate mitigation strategies, like promoting water and energy efficiency, are also climate adaptation strategies. By building an adaptation strategy on existing climate science and frameworks like the Scoping Plan, California has begun to effectively anticipate future challenges and change actions that will ultimately reduce the vulnerability of residents, resources

and industries to the consequences of a variable and changing climate. Now that the state has produced plans for climate mitigation and adaptation, closer coordination is needed to implement both approaches. The strategies included in this report were approved by the CAT Team, which represents all of state government. Now, the CAT will lead in the coordination of measures and push to develop the necessary tools to effect adaptation protocols. California's mitigation (CAT) and adaptation (CAS) processes will be further integrated through extensive information exchange and consolidation of working groups from both efforts.

To ensure a coordinated effort in adapting to the unavoidable impacts of climate change, the *2009 California Climate Adaptation Strategy* was developed using a set of guiding principles:

- Use the best available science in identifying climate change risks and adaptation strategies.
- Understand that data continues to be collected and that knowledge about climate change is still evolving. As such, an effective adaptation strategy is "living" and will itself be adapted to account for new science.
- Involve all relevant stakeholders in identifying, reviewing, and refining the state's adaptation strategy.
- Establish and retain strong partnerships with federal, state, and local governments, tribes, private business and landowners, and non-governmental organizations to develop and implement adaptation strategy recommendations over time.
- Give priority to adaptation strategies that initiate, foster, and enhance existing efforts that improve economic and social well-being, public safety and security, public health, environmental justice, species and habitat protection, and ecological function.
- When possible, give priority to adaptation strategies that modify and enhance existing policies rather than solutions that require new funding and new staffing.
- Understand the need for adaptation policies that are effective and flexible enough for circumstances that may not yet be fully predictable.
- Ensure that climate change adaptation strategies are coordinated with the California Air Resources Board's AB 32 Scoping Plan process when appropriate, as well as with other local, state, national and international efforts to reduce GHG emissions.

The *2009 California Climate Adaptation Strategy* takes into account the long-term, complex, and uncertain nature of climate change and establishes a proactive foundation for an ongoing adaptation process. Rather than address the detailed impacts, vulnerabilities, and adaptation needs of every sector, those determined to be at greatest risk are prioritized.

The development of the adaptation strategies presented within this report was spearheaded by the state's resource management agencies. CNRA staff worked with seven sector-based Climate Adaptation Working Groups (CAWGs) focused on the following areas: public health; ocean and coastal resources; water supply and flood protection; agriculture; forestry; biodiversity and habitat; and transportation and energy infrastructure.

Working group experts have an intimate knowledge of California's resources, environments, and communities, and also of the state's existing policy framework and management capabilities. This understanding informs the adaptation strategy and ensures a realistic assessment of adaptive capacities, current limitations, and future needs.

A Collaborative Approach

This adaptation strategy could not have been developed without the involvement of numerous stakeholders. Converging missions, common interests, inherent needs for cooperation, and the fact that climate change impacts cut across jurisdictional boundaries will require governments, businesses, non-governmental organizations, and individuals to minimize risks and take advantage of potential planning opportunities.

Throughout the development of this report, it became increasingly clear that overlapping missions and goals will require agencies and organizations at all levels to work together to develop close partnerships with regard to climate adaptation. This is the only means by which the far reaching effects of climate impacts can be addressed efficiently and effectively while avoiding potential conflicts. The Comprehensive State Adaptation Strategies chapter underscores the need for collaboration and identifies where cross-sector relationships are necessary.

To further enhance stakeholder participation the CAWGs initiated a process that allowed for consultation with stakeholders through public workshops and review opportunities. This input has considerably shaped the content and refinement of this report. However, future updates of the adaptation strategy will require ongoing input through active stakeholder engagement and an even closer integration of state agency efforts.

In order to best analyze climate change risks, the *2009 California Climate Adaptation Strategy* draws on years of state-specific science and impacts research, largely funded through the California Energy Commission's Public Interest Energy Research (PIER) Program and an engaged research community. The research provides for an understanding of the climate-related risks California will face and has significantly contributed to greater public awareness of climate change. As data continues to be developed and collected, the state's adaptation strategy will be updated to reflect current findings.

All participating agencies prepared this report with existing resources amidst a serious state financial crisis. It is clear that more funding will be needed to address all aspects of climate adaptation and that potential sources will need to be sought from agencies and organizations at all levels to address the full scope of the problem. At this time CNRA is currently seeking additional funding for climate adaptation work.

Preliminary Recommendations

The preliminary recommendations outlined in the adaptation strategy were developed by CNRA staff, CAWGs, the CAT, and from public comments. Public comments were sought beginning August 3, 2009 when the CAS was released as a discussion draft. During the ensuing 45-day public comment period 83 comments were received, totaling over 400 pages of suggested revisions to the strategy. These comments provided substantive feedback, drawing on the expertise of many organizations and countless individuals offering different perspectives on effective approaches to climate adaptation. Stakeholder comments covered many topics, with the most common being the need for more coordination and guidance, funding, and outreach. Many comments offered excellent ideas supported by the working groups and were incorporated into this report where possible; Others will be better addressed once additional information comes in through the implementation of key strategies outlined in the report or

when supporting information, resources and funding issues change. All comments will be kept on record as consideration for future updates of this strategy, complemented by additional opportunities for public input. All public input on the *CAS Discussion Draft* can be viewed on the web at: www.climatechange.ca.gov/adaptation/.

It is recognized that implementation of the following strategies will require significant collaboration among multiple stakeholders to ensure they are carried out in a rational, yet progressive manner over the long term. These strategies distinguish between near-term actions that will be completed by the end of 2010 and long-term actions to be developed over time, and are covered in more detail in the sector chapters in Part II of this report as well as in initial efforts.[i]

Key recommendations include:

1. A Climate Adaptation Advisory Panel (CAAP) will be appointed to assess the greatest risks to California from climate change and recommend strategies to reduce those risks building on California's Climate Adaptation Strategy. This panel will be convened by the California Natural Resources Agency, in coordination with the Governor's Climate Action Team, to complete a report by December 2010. The state will partner with the Pacific Council on International Policy to assemble this panel. A list of panel members can be found on the California adaptation Web site. (CS-1).

2. California must change its water management and uses because climate change will likely create greater competition for limited water supplies needed by the environment, agriculture, and cities. As directed by the recently signed water legislation (Senate Bill X71), state agencies must implement strategies to achieve a statewide 20 percent reduction in per capita water use by 2020, expand surface and groundwater storage, implement efforts to fix Delta water supply, quality, and ecosystem conditions, support agricultural water use efficiency, improve state-wide water quality, and improve Delta ecosystem conditions and stabilize water supplies as developed in the Bay Delta Conservation Plan. (BH-2, W-3, 6, and 7; A-1; TEI-3).

3. Consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding, wildfire and erosion due to climate change. The most risk-averse approach for minimizing the adverse effects of sea level rise and storm activities is to carefully consider new development within areas vulnerable to inundation and erosion. State agencies should generally not plan, develop, or build any new significant structure in a place where that structure will require significant protection from sea level rise, storm surges, or coastal erosion during the expected life of the structure. However, vulnerable shoreline areas containing existing development that have regionally significant economic, cultural, or social value may have to be protected, and in-fill development in these areas may be accommodated. State agencies should incorporate this policy into their decisions and other levels of government are also encouraged to do so. (CS-2; OCR-1 and 2; W-4 and 9; TEI -2 and 7).

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[i] Each of the twelve Executive Summary strategies is drawn from multiple strategies within the subsequent sector specific and cross-sector adaptation strategy chapters. The recommendations here may not reflect exact wording of individual sector recommendations but relate to their core message. Each Executive Summary recommendation here lists the sector and recommendation number using the following acronyms to identify the sector: Public Health (PH), Biodiversity and Habitat (BH), Ocean and Coastal Resources (OCR), Water Management (W), Agriculture (A), Forestry (F), Transportation and Energy Infrastructure (TEI), and Cross-Sector (CS).

4. All state agencies responsible for the management and regulation of public health, infrastructure or habitat subject to significant climate change should prepare as appropriate agency-specific adaptation plans, guidance, or criteria by September 2010. (PH-3 and 5; BH-1, 2, and 6; OCR-3; F-1 and 2; TEI-2 and 5).

5. To the extent required by CEQA Guidelines Section 15126.2, all significant state projects, including infrastructure projects, must consider the potential impacts of locating such projects in areas susceptible to hazards resulting from climate change. Section 15126.2 is currently being proposed for revision by CNRA to direct lead agencies to evaluate the impacts of locating development in areas susceptible to hazardous conditions, including hazards potentially exacerbated by climate change. Locating state projects in such areas may require additional guidance that in part depends on planning tools that the CAS recommendations call for (see key recommendations 3, 6, 8, 9, and 10; BH-3; OCR-1; TEI-2).

6. The California Emergency Management Agency (Cal EMA) will collaborate with CNRA, the CAT, the Energy Commission, and the CAAP to assess California's vulnerability to climate change, identify impacts to state assets, and promote climate adaptation/mitigation awareness through the Hazard Mitigation Web Portal and My Hazards Website as well as other appropriate sites. The transportation sector CAWG, led by Caltrans, will specifically assess how transportation nodes are vulnerable and the type of information that will be necessary to assist response to district emergencies. Special attention will be paid to the most vulnerable communities impacted by climate change in all studies. (CS-3 and 4; PH-4 and 5; OCR-5; W-4; F-2 and 3; TEI-2, 5, 6 and 8).

7. Using existing research the state should identify key California land and aquatic habitats that could change significantly during this century due to climate change. Based on this identification, the state should develop a plan for expanding existing protected areas or altering land and water management practices to minimize adverse effects from climate change induced phenomena. (BH-1; W-5; F-5).

8. The best long-term strategy to avoid increased health impacts associated with climate change is to ensure communities are healthy to build resilience to increased spread of disease and temperature increases. The California Department of Public Health will develop guidance by September 2010 for use by local health departments and other agencies to assess mitigation and adaptation strategies, which include impacts on vulnerable populations and communities and assessment of cumulative health impacts. This includes assessments of land use, housing and transportation proposals that could impact health, GHG emissions, and community resilience for climate change, such as in the 2008 Senate Bill 375 regarding Sustainable Communities. (PH-3).

9. The most effective adaptation strategies relate to short and long-term decisions. Most of these decisions are the responsibility of local community planning entities. As a result, communities with General Plans and Local Coastal Plans should begin, when possible, to amend their plans to assess climate change impacts, identify areas most vulnerable to these impacts, and develop reasonable and rational risk reduction strategies using the CAS as guidance. Every effort will be made to provide tools, such as interactive climate impact maps, to assist in these efforts. (BH-1; OCR– 2 and 4; CS-2).

10. State fire fighting agencies should begin immediately to include climate change impact information into fire program planning to inform future planning efforts. Enhanced wildfire risk from climate change will likely increase public health and safety risks, property damage, fire suppression and emergency response costs to government, watershed and water quality impacts, and vegetation conversions and habitat fragmentation. (PH-4 and 5; F-1; TEI-2).

11. State agencies should meet projected population growth and increased energy demand with greater energy conservation and an increased use of renewable energy. Renewable energy supplies should be enhanced through the Desert Renewable Energy Conservation Plan that will protect sensitive habitat that will while helping to reach the state goal of having 33 percent of California's energy supply from renewable sources by 2020. (TEI-2).

12. Existing and planned climate change research can and should be used for state planning and public outreach purposes; new climate change impact research should be broadened and funded. By September 2010, the California Energy Commission will develop the CalAdapt Web site that will synthesize existing California climate change scenarios and climate impact research and to encourage its use in a way that is beneficial for local decision-makers. Every effort will be made to increase funding for climate change research, focusing on three areas: linkages with federal funding resources, developing Energy Commission -led vulnerability studies, and synthesizing the latest climate information into useable information for local needs through the CalAdapt tool. (CS-4; PH-7; BH-4; OCR-6; W-8, 9, and 10; A – 8; F-4 and 5; TEI-3 and 9).

PART I:

PLANNING FOR CLIMATE CHANGE

I. INTRODUCTION

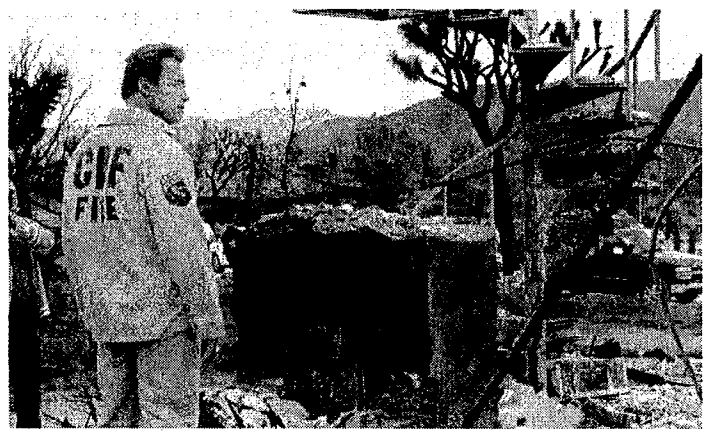
Recognizing the Need to Adapt

With the growing recognition that climate change is already underway and science that suggests additional impacts are inevitable despite mitigation efforts, adaptation planning is rapidly becoming an important policy focus in the United States and internationally.

In many states, efforts are beginning in nearly every sector of society, ranging from coastal planning for higher sea levels and reviews of water and drought management strategies, to climate-cognizant species preservation and habitat conservation planning, to adjustments in the financial sector.

Historically, California state agencies and private entities have adjusted their practices to account for climate impacts. For example, reservoirs and levees have been built to protect against common winter and springtime floods and periods of summer drought. In agriculture, improvements in irrigation efficiency have been made to better guarantee water reliability and supply. For public safety, local health departments have opened cooling centers during heat emergencies.

Figure 3: *Governor Schwarzenegger assesses the site of a recent wildfire*



To expand upon these efforts based on the most current science, Governor Schwarzenegger's Executive Order S-13-08 provides clear direction in developing California's first statewide climate adaptation effort. This report focuses on Article 7 of the order, which goes on to; (1) request that the National Academy of Science (NAS) establish an expert panel to report on sea level rise impacts in California to inform state planning and development efforts (Articles 1-3); (2) review the NAS assessment every two years or as necessary (Article 4); (3) issue interim guidance to state agencies about how to plan for sea level rise in designated coastal and floodplain areas for new projects (Article 5); and (4) initiate a report on critical existing and planned infrastructure projects vulnerable to sea level rise (Articles 6 and 8).

Article 7 states:

"By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by the Energy Commission's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish

and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts."

Climate Modeling

In order for California to ensure coping capacity and long-term resiliency, researchers have previously developed two distinct approaches: (1) projecting the amount of climate change that may occur and (2) assessing the natural or human system's ability to cope with and adapt to change. In recent years, these approaches have been seen as complementary and as such, both are needed to understand climate risks, vulnerabilities, and interventions that can help society and ecosystems adapt successfully.

(1) Hazards-Based Approach

In the hazards-based approach, emissions scenarios are identified to allow scientists to evaluate the degree of climate change projected. Typically, these climate changes are projected for decades or centuries using increasingly sophisticated, computer-based global climate models. These projections are used to assess the physical, ecological, or economic consequences for specific sectors and environments.

In this approach, any changes identified outside of the historical norm would then require adaptation. For example, if the impact is estimated to be substantial, then substantial adaptation is required; if the impact is determined to be gradual, there is time to engage in adaptation planning. In a hazards-based approach, various non-climatic factors are not addressed; nor are specific adaptation plans identified.

(2) Vulnerability-Based Approach

Conversely, the vulnerability-based approach is focused on the socioeconomic and ecological factors that determine a system's vulnerability and ability to cope with and adapt to climate change. Typically, such an assessment also explicitly examines past experience with climate variability and extremes to see how systems have responded. The conditions that influence vulnerability for a given area can provide a baseline that, when combined with existing conditions, communities may use to determine what actions are needed to respond to climate impacts. It is also important to understand how existing conditions will react to the additional influence of climate change. A good example is looking at how existing drought cycles could be exacerbated by changing weather patterns from climate change.

Both the hazards-based and the vulnerability-based approaches are ultimately needed for any long-term and iterative process of climate change adaptation. They will allow California to identify the most important climate risks, establish priorities, assess options and barriers, and evaluate the effectiveness of adaptive responses in a place-based context given the stresses and demands on resources. Adaptation planning requires an understanding of climate impacts and substantial input from the social, economic, engineering, and ecological sciences on those factors that affect vulnerability and adaptation.

Drawing on currently available science, this report includes the most recent climate projections and related impacts studies identified as part of a hazards-based approach. What are needed now are future vulnerability-based assessments.

Adaptation Strategy Vision, Objectives and Principles

The basic purpose and overarching goal of the *2009 California Climate Adaptation Strategy* is to begin a statewide, ongoing, and committed process of adapting to a changing climate in the context of other changes in the environment, the economy, and society.

To achieve this goal, the adaptation strategy pursues the following specific objectives:

Analyze climate change risks. Synthesize to the greatest extent possible how temperature rise, extreme weather events, precipitation changes, seasonal shifts, and sea level rise will exacerbate existing fire, flood, water supply and quality, air quality, habitat loss, and human health risks. Assess how these changes will impact the state's economy, infrastructure, human populations, and environment.

Identify sector-specific, and to the extent possible, cross-sectoral adaptation strategies that help reduce vulnerabilities and build climate resilience. Attention should be given to strategies that help (a) avoid, prevent, or minimize climate change impacts to public health, biodiversity, working landscapes, and infrastructure, (b) improve preparedness for climate change impacts and extreme events, (c) enhance the state's response capacity in case of extremes, and (d) facilitate recovery from impacts and extremes in order to enhance the state's resilience.

Explore cross-cutting supportive strategies. Identify governance efforts (such as leadership, policy or rule changes, procedural adjustments, etc.) and resources needed to enable the development and implementation of identified adaptation strategies.

Formalize criteria for prioritizing identified adaptation strategies. The applicability of these criteria may vary across sectors, and should ideally include but not be limited to social, environmental, equity, technical, staffing, institutional, policy, and financial/economic considerations.

Specify future direction. Indicate areas where further work will be required to increase the existing understanding of climate risks (including the possibility of catastrophic climate change), environmental and societal vulnerabilities, and adaptation options and barriers. Identify additional cross-cutting, supportive strategies such as public engagement, networking, decision support, monitoring, periodic review of adaptation effectiveness, and fundamental policy changes. Establish feedback mechanisms that provide for the modification of strategies when needed.

Provide recommendations for immediate and near-term priorities for implementing identified adaptation strategies. This may include management actions and policy changes based on the information developed in other stated objectives.

Inform and engage the California public about climate risks and adaptation strategies. Californians must be informed of existing and future climate change risks and of the need for a comprehensive approach to managing climate change risks through mitigation and adaptation. They must be provided with guidance about what actions they can initiate to adapt to climate change, or reduce their consumption of energy and resources. This information is critical, and will serve as the foundation for residents to actively engage in discussion, refinement, and implementation of those actions needed to build a climate-resilient California.

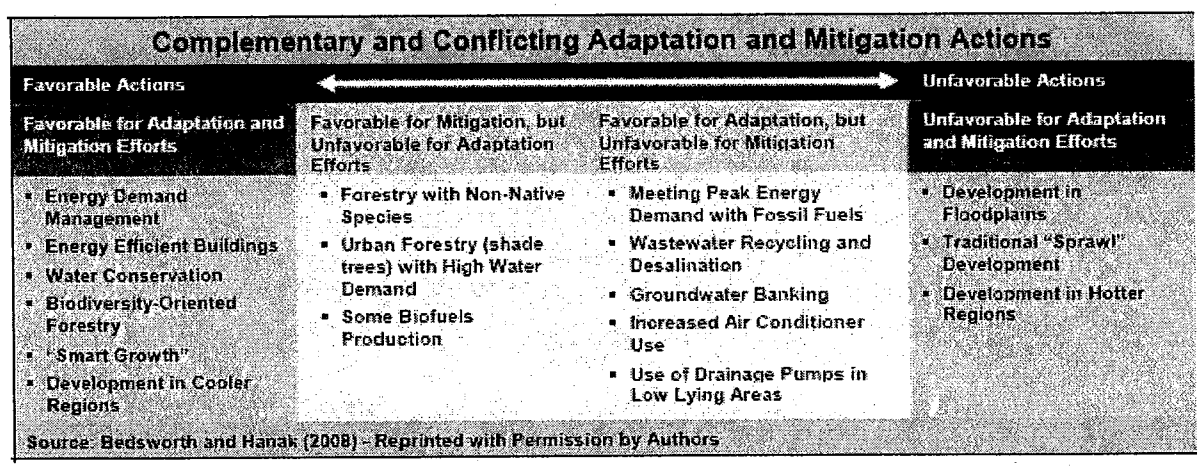
Adaptation and Mitigation: Both Needed to Manage Risks

While this effort focuses on climate adaptation, it is clear that managing impending climate risks (adaptation) must be a co-equal and integrated approach to avoiding climate extremes through reduction of GHG emissions (mitigation). While adaptation and mitigation measures are often complementary and overlapping, there may be unintended negative consequences without coordinated efforts (see Figure 4).

The changes in climate observed to date are the result of the emissions released into the atmosphere over the past several centuries. Likewise, climatic conditions that will manifest 30 to 40 years from now will be the result of today's emissions. The reduction of GHG emissions is thus a priority required to minimize long-term climate change and concomitant impacts on California's environment and society. While many GHG emission reduction efforts can produce immediate air quality improvements and cost savings, the long-term climate benefits of these mitigation efforts will take several decades to become apparent. Accordingly, it is imperative to begin adaptation responses to climate change already set in motion to maintain productivity of the state's ecosystems and economy, and the well-being of all Californians.

Part II of this report examines the potential impacts on seven climate-sensitive sectors that may result from the climate changes described in Chapter Two. Strategies that have been proposed by CAWGs to reduce these risks and adapt to the inevitable changes are also outlined. Some strategies are applicable to multiple sectors and require cross-sector collaboration. Others require a long-term commitment.

Figure 4: *Examples of complementary and conflicting actions between adaptation and mitigation efforts.*



II. California's Climate Future

The 2009 Climate Change Projection Emissions Scenarios

To begin to assess the climate change risks that Californians may face, it is important to first examine the changes that have already occurred.

California can draw on substantial scientific research conducted by experts at various state universities and research institutions. With more than a decade of concerted research, scientists have established that the early signs of climate change are already evident in the state – as shown, for example, in increased average temperatures, changes in temperature extremes, reduced snowpack in the Sierra Nevada, sea-level rise, and ecological shifts.[1]

Many of these changes are accelerating – locally, across the country, and around the globe. As a result of emissions already released into the atmosphere, California will face intensifying climate changes in coming decades. The state's 2009 Climate Change Impacts Assessment (the 2009 Scenarios Project) provides the scientific basis from which statewide climate impacts were synthesized for this adaptation strategy. The 2009 Scenarios Project examined future projections for changes in average temperatures, precipitation patterns, sea-level rise, and extreme events, as well as resulting impacts on particularly climate-sensitive sectors.[2] These scientific findings are summarized in resulting chapters to set the stage for expected impacts and California's adaptation strategies.

Generally, research indicates that California should expect overall hotter and drier conditions with a continued reduction in winter snow (with concurrent increases in winter rains), as well as increased average temperatures, and accelerating sea-level rise.[3] In addition to changes in average temperatures, sea level, and precipitation patterns, the intensity of extreme weather events is also changing. The impacts assessment indicates that extreme weather events, such as heat waves, wildfires, droughts, and floods are likely to be some of the earliest climate impacts experienced.[4] As a result, dealing with a growing number of extreme climatic events will be an important aspect of the state's adaptation to climate change.

For the 2009 Scenarios Project, a set of six global climate models were run using two emissions scenarios. These emissions scenarios are part of a family of common scenarios used by the Intergovernmental Panel on Climate Change (IPCC) in its 2007 assessment.[5] The scenarios signify plausible pathways of how global emissions may change as a result of economic, technological, and population changes over the 21st century. One scenario depicts a higher-emissions scenario (A2), the other a lower-emissions scenario (B1).[6] The A2 scenario represents a more competitive world that lacks cooperation in development and portrays a future in which economic growth is uneven, leading to a growing income gap between developed and developing parts of the world. The B1 scenario denotes a future that reflects a high level of environmental and social consciousness combined with global cooperation for sustainable development.

Anticipated Climate Changes

Temperature:
- ☐ 2 - 5 °F by 2050
- ☐ 4 - 9 °F by 2100

Precipitation:
- ☐ 12 - 35% by 2050

Sea Level:
- ☐ 12 – 18 inches by 2050
- ☐ 21 - 55 inches by 2100

Source: 2009 Scenarios Project

It is important to note that these two scenarios do not bracket the entire range of possible future emissions and resulting climatic changes, as even higher emissions or lower emissions futures are possible. Moreover, it is impossible to say with scientific confidence which of the two scenarios is more likely. Thus, the IPCC has not offered probabilities (likelihood statements) attached to either of the emissions pathways. Since the IPCC's release of these two scenarios, the world has followed a "business as usual" emissions pathway, which most closely resembles the A2 scenario.[7]

While neither scenario assumes explicit climate change policies, many researchers view the B1 scenario as a "quasi-policy scenario" as it results in significantly lower GHG emissions than the "business as usual" pathway. A considerable difference emerges between A2 and B1 in the ultimate atmospheric GHG concentrations, and consequently in the degree of climate warming by the end of the 21st century (Figure 5).

To put these projections in historical perspective, one should consider that pre-industrial[8] concentrations of carbon dioxide in the atmosphere were about 280 parts per million by volume (ppmv). By 1960, carbon dioxide concentrations had crept up slowly to about 315 ppmv – an increase of just over 10 percent in about 200 years. The warming effect of those GHG concentrations is currently being felt. In the five intervening decades, with considerable economic growth worldwide that is fueled by the burning of carbon-based fossil fuels such as coal, gas, and oil, and extensive land use changes, there has been a staggering increase in atmospheric carbon dioxide. Recent measurements indicate global carbon dioxide concentrations in the atmosphere of 386 ppmv, a 38 percent increase over pre-industrial times.[9] The rate of annual increase of CO_2 continues to accelerate, largely determining future warming for the next few decades. In addition, other GHGs such as methane, nitrous oxide, and other gases, have dramatically increased over the last 200 years, adding to the heat-trapping effect of the atmosphere.

As Figure 5 illustrates, there is considerable uncertainty regarding future levels of GHG emissions due to the difficulty of predicting societal choices. It is compounded by scientific uncertainty over how the climate will respond to a given amount of GHG emissions. Global climate models also differ to some extent in how they treat atmospheric, terrestrial and hydrological processes, resulting in different levels of warming, and sometimes divergent patterns of precipitation. In the absence of better tools or methods to project future climate, the best approach is to use several climate models, driven by the same emissions scenarios, to produce a large set of model simulations. The range of simulations can then be averaged to obtain a general trend, with the spread among simulations giving a sense of the uncertainty associated with a given emissions scenario. In short, the models provide a coarse but plausible set of projections of the future, as opposed to detailed predictions.[10] For the 2009 Scenarios Project, these California-specific projections have been "downscaled" to produce regional and small-scale projections that are useful for impacts studies.

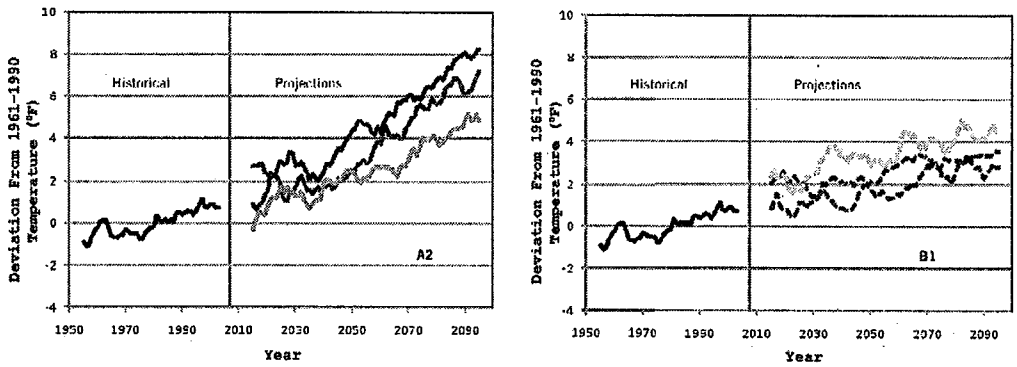
Temperature Projections

Climate change temperature projections generated for the 2009 Scenarios Project suggest the following[11]:

- Average temperature increase is expected to be more pronounced in the summer than in the winter season.
- Inland areas are likely to experience more pronounced warming than coastal regions.
- Heat waves are expected to increase in frequency, with individual heat waves also showing a tendency toward becoming longer, and extending over a larger area, thus more likely to encompass multiple population centers in California at the same time.
- As GHGs remain in the atmosphere for decades, temperature changes over the next 30 to 40 years are already largely determined by past emissions. By 2050, temperatures are projected to increase by an additional 1.8 to 5.4 °F; similar for both the A2 and B1 scenarios (an increase one to three times as large as that which occurred over the entire 20th century).
- After the middle of the century, temperature projections clearly diverge for the A2 and B1 scenarios (as a result of emissions choices made in the early part of the 21st century), with A2 projections leading to significantly greater warming. By 2100, the models project temperature increases between 3.6 to 9 °F.

All model projections for California suggest increased temperatures, with the level of emissions representing the biggest uncertainty: temperature levels will rise faster and higher by the end of this century in the A2 scenario as compared with the B1 scenario (Figure 5). These graphs starkly illustrate the dual imperative to begin adaptation now to address the impacts already set in motion, and to achieve GHG emissions reductions through global cooperation to avoid the more dramatic impacts of climate change later in the century. Stringent emission reductions now could limit climate changes and therefore allow society and ecosystems to be able to adapt more easily at a future date.

Figure 5: *Historical/projected annual average temperature for California using three GCM's (A2 and B1 Emissions Scenarios)*

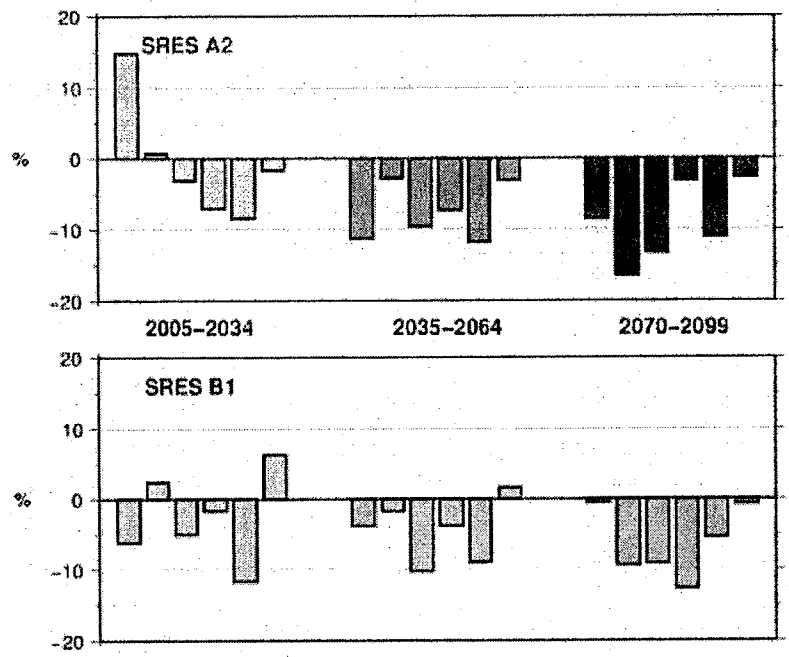


Source: Moser, et al 2009.

Precipitation Projections

Current climate change projections suggest that California will continue to enjoy a Mediterranean climate with the typical seasonal pattern of relatively cool and wet winters and hot, dry summers. While precipitation levels are expected to change over the 21st century, models differ in determining where and how much rain and snowfall patterns will change under different emissions scenarios. Figure 6 shows the projected changes in northern California precipitation (the source of much of the state's water supply) relative to 1961-1990 average precipitation using six climate models with both A2 and B1 emissions scenarios. While the precipitation results vary more than the temperature projections, 11 out of 12 precipitation models run by the Scripps Institution of Oceanography suggest a small to significant (12-35 percent) overall decrease in precipitation levels by mid-century. In addition, higher temperatures increase evaporation and make for a generally drier climate, as higher temperatures hasten snowmelt and increase evaporation and make for a generally drier climate. Moreover, the 2009 Scenarios Project concludes that more precipitation will fall as rain rather than as snow, with important implications for water management in the state. California communities have largely depended on runoff from yearly established snowpack to provide the water supplies during the warmer, drier months of late spring, summer, and early autumn. With rainfall and meltwater running off earlier in the year, the state will face increasing challenges of storing the water for the dry season while protecting Californians downstream from floodwaters during the wet season.

Figure 6: *Predicted changes in Northern California precipitation levels show a generally drier future.*

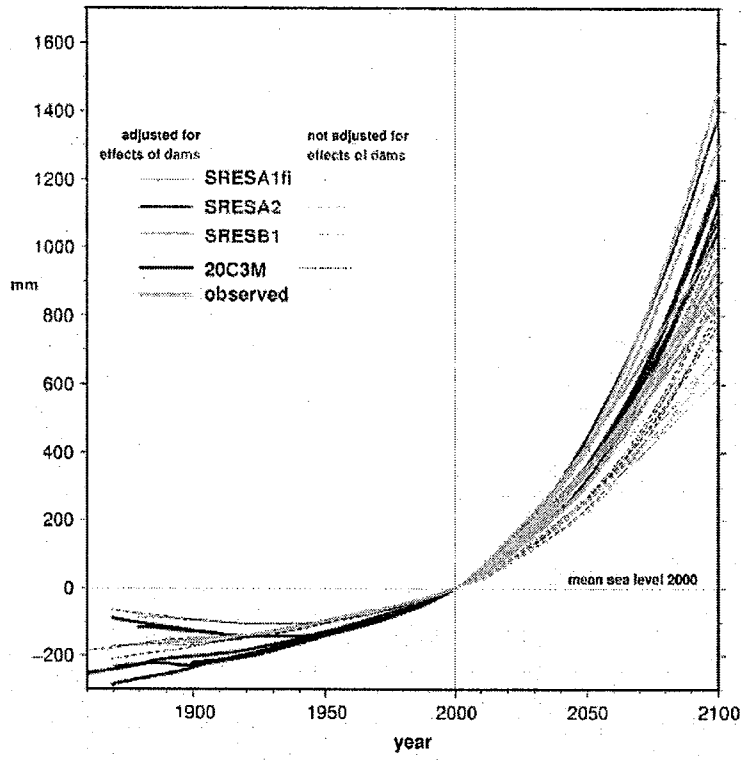


Models used:
1: CNRM CM3 – 2: GFDL CM2.1 – 3: MIROC3.2 (med)
4: MPI ECHAMS – 5: NCAR CCSM3 – 6: NCAR PCM1Source:
Cayan, et al. 2009.

Sea-Level Rise Projections

Over the 20th century, sea level has risen by about seven inches along the California coast. Replacing previous projections of relatively modest increases of sea-level rise for the 21st century, the 2009 Scenarios Project built on scientific findings that became available in the last two years to produce estimates of up to 55 inches (1.4 meters) of sea-level rise under the A2 emissions scenario by the end of this century (Figure 7). This projection accounts for the global growth of dams and reservoirs and how they can affect surface runoff into the oceans, but it does not account for the possibility of substantial ice melting from Greenland or the West Antarctic Ice Sheet, which would drive sea levels along the California coast even higher. Projections of sea level rise under the B1 scenario are still several times the rate of historical sea-level rise, and would barely differ under a stringent "policy scenario" in which global emissions would be drastically reduced. This suggests that while mitigation will be important to minimize many climatic and ecological impacts, adaptation is the only way to deal with the impacts of sea-level rise that is anticipated under either emissions scenario during the 21st century.[12] In short, even on a lower emissions trajectory and without the addition of meltwater from the major continental ice sheets, sea levels in the 21st century can be expected to be much higher than sea levels in the 20th century.

Figure 7: Projected changes in sea level rise over the 21st Century



Source: Rahmstorf (2007) from six models 500-2009-014-D (i.e., Cayan, et al. 2009)

Projection of Extreme Events

Changes in average temperature, precipitation and sea level are significant, especially under the higher emissions (A2) scenario. Yet gradual changes in average conditions are not all for which California must prepare. In the next few decades, it is likely that the state will face a growing number of climate change-related extreme events such as heat waves, wildfires, droughts, and floods. Because communities, infrastructure, and other assets are at risk, such events can cause significant damages and are already responsible for a large fraction of near-term climate-related impacts every year.[13]

One recent study, conducted as part of the 2009 Scenarios Project, synthesized existing research to characterize the direct impacts of extreme events across different sectors of California's economy, including public health, energy, agriculture, and natural ecosystems. It also analyzed how impacts from extreme events "spill over" from one sector into other sectors and produced new projections of the future frequency and intensity of extreme events for all counties in California.[14]

Consistent with other studies, researchers found that significant increases in the frequency and magnitude of both maximum and minimum temperature extremes are possible in many areas across the state. For example, in many regions of California, the study projected at least a tenfold increase in the frequency of extreme temperatures currently estimated to occur once every 100 years, even under the moderate B1 emissions scenario. Under the A2 emissions scenario, these 100-year temperature extremes are projected to occur close to annually in most regions. Projections of precipitation extremes vary by model and downscaling method used, and expected changes tend to vary across the state. In general, however, it appears longer dry spells will become more common over the 21st century, interspersed with the occasional intense rainfall event.[15]

The July 2006 heat wave and the December 1998 freezing spell represent rather memorable extreme events in recent California history. Researchers in the 2009 Scenarios Project asked how the frequency of similar events may change with climate warming. Not surprisingly, they found that heat waves similar in length and intensity to those experienced in 2006 may become more frequent all across the state in the 21st century, with some simulations using the higher emissions scenario suggesting that such events could become *annual* occurrences by the end of this century.

In contrast, freezing spells such as that in 1998 are projected to become less frequent across the state even in locations where they are currently a yearly event. Over large portions of the state, freezing events may occur once every ten years or less by the end of the 21st century.

According to the 2009 Scenarios Project, the frequency of large coastal storms and heavy precipitation events do not appear to change significantly over the 21st century.[16] However, even if storm intensity or frequency were not to change, storms will impact the California coast more severely due to higher average sea levels that can result in higher storm surges, more extensive inland flooding, and increased erosion along the state's coastline. Future research should improve our understanding of these extreme precipitation events and their potential impacts on coastal erosion and floods.

Abrupt Climate Changes

Most climate projections developed to date, including those used in this report, produce gradual if sometimes substantial changes for a given climate variable. In the past, rapid climate changes have been observed and scientists are increasingly concerned about additional abrupt changes that could push natural systems past thresholds beyond which they could not recover. Such events have been recorded in paleoclimatological records but current global climate models cannot predict when they may occur again. Such abrupt changes have been shown to occur over very short periods of time (a few years to decades) and thus represent the most challenging situations to which society and ecosystems would need to adapt.[17]

Short of being able to predict such abrupt changes, scientists are focusing their attention on aspects of the climate and Earth system called "tipping elements" that can rapidly bring about abrupt changes. Tipping elements refer to thresholds where increases in temperature cause a chain reaction of mutually reinforcing physical processes in the Earth's dynamic cycles. The most dangerous of these include the following:

- A reduction in Arctic sea ice, which allows the (darker) polar oceans to absorb more sunlight, thereby increasing regional warming, accelerating sea ice melting even further, and enhancing Arctic warming over neighboring (currently frozen) land areas.
- The release of methane (a potent GHG), which is currently trapped in frozen ground (permafrost) in the Arctic tundra, will increase with regional warming and melting of the ground, leading to further and more rapid warming and resulting in increased permafrost melting.
- Continued warming in the Amazon could cause significant rainfall loss and large scale dying of forest vegetation, which will further release CO_2.
- The accelerated melting of Greenland and West Antarctic Ice Sheets observed in recent times, together with regional warming over land and in the oceans, involves mechanisms that can reinforce the loss of ice and increase the rate of global sea-level rise.

The temperature increases that could trigger these chain reaction events are still the subject of research, but estimates range from 1 to 3 °F of additional warming for widespread, rapid (10 year) Arctic sea ice melt; 2 to 4 °F for irreversible melting of the Greenland Ice Sheet (over the next 300 years or more); 5 to 9 °F for the irreversible melting of the West Antarctic Ice Sheet (also over 300 or more years), and 5 to 7 °F for Amazon forest die-back. Should these thresholds be crossed in the coming decades, the Earth's sea level would be on an irreversible course destined to rise 7-12 meters (as much as 23-40 feet) over the course of several centuries—a rate not seen in human history.[18]

Another tipping element that could have a significant effect on California's long-term climate variability is the potential intensification of the El Niño Southern Oscillation (ENSO) cycles over the Pacific Ocean. ENSO is one key factor in California's wet year and drought year cycles and intensification would mean stormier wet years and even drier (or extended periods of) drought years. It would also mean more severe coastal storms during the winter months and hence more erosion and coastal flooding. Current research indicates that a tipping point of 6 to 11 °F could trigger this intensification of ENSO cycles.[19]

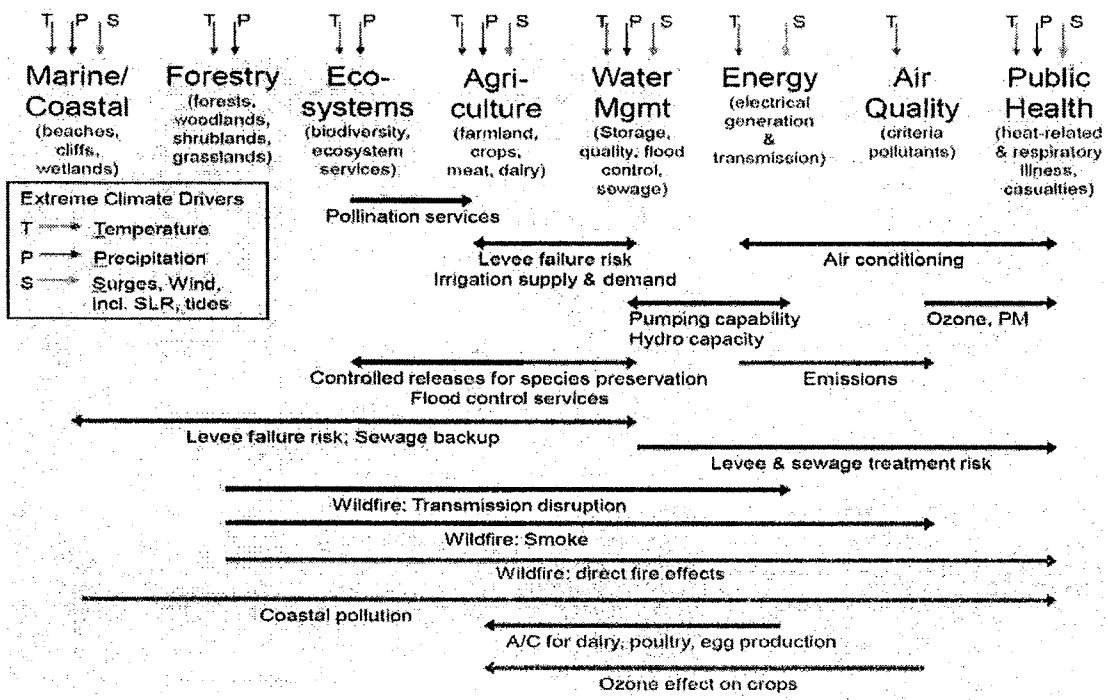
III. Comprehensive State Adaptation Strategies

Cross Sector Collaboration

Navigating the complex science and policy needs to reduce California's vulnerability to future climate impacts will require an unprecedented level of collaboration and leadership. Most state sectors and departments leading climate adaptation strategy development share management responsibilities, have overlapping jurisdictions, and in many instances, depend upon one another to accomplish their organizational mandates. Through the development of the *2009 California Climate Adaptation Strategy* the primary need identified by all sectors and most stakeholders is to improve coordination within and across state government.

Reducing sea level rise risks provides one example of the need for cross-sector collaboration. The state, recognizing this as a global issue, prefers that all agencies work together from an agreed upon reference point from which to coordinate their approaches to sea level rise impacts. Currently, various state agencies have different policies and regulations requiring consideration of and adaptation to sea-level rise. These agencies are working with best available scientific information to continue executing their ongoing responsibilities, but the lack of coordinated state-wide estimates of future sea-level rise can create confusion and uncertainty among stakeholders, waste money through duplicative efforts, and potentially reduce attention toward more vulnerable locations. Policy coordination for sea level rise, and all climate impacts, is necessary to increase overall awareness of climate change, to encourage the efficient use of resources and expertise, to streamline interagency permitting processes and prevent or reduce the possibility of unintended consequences. Figure 8 shows how sea level rise, temperature and precipitation change spread impacts across a range of sectors requiring multiple adaptation measures.

Figure 8: *Extreme climate drivers and inter-sector interactions*



Source: Mastrandreaet al 2009.

This chapter identifies comprehensive state adaptation planning strategies that were identified by all climate adaptation sectors in Section II. The four strategies identified here are expected to be in place or completed by the end of 2010 and will increase efficiencies across all climate adaptation strategies when complete. Subsequent chapters of this report focus on sector specific climate adaptation strategies.

Strategy 1) Promote Comprehensive State Agency Adaptation Planning

Adapting to climate change and reducing greenhouse gas emissions must be institutionalized into state planning processes, budgets, and policy development to ensure efficiencies are realized and impacts are minimized. This institutionalization requires state leadership and coordination with the climate science community to ensure the best research is utilized for policy making.

Many agencies have already made climate change a central focus of their policies and plans, while others have just begun to implement plans or actions. For example, water agencies are required to plan for climate variability inherent to California's Mediterranean, semi-arid and drought-prone precipitation patterns. Coastal agencies consider sea level rise in their planning processes but are now grappling with ways to address the accelerating rates of climate change and uncertainty of future conditions that are now anticipated. All agencies responsible for the management of California's natural resources have an opportunity to mainstream adaptation given current climate-related hazards and the sensitivities that they currently face. The state should eventually provide support and funding for comprehensive adaptation planning by all state agencies where significant vulnerabilities and hazards are identified.

Without new additional support, the state is promoting comprehensive adaptation planning and policy efforts through three efforts. The first is through the implementation and tracking of the sector-specific strategies outlined in Section II that require new climate adaptation planning in twelve state agencies responsible for completing these strategies. The second is coordination of strategy implementation across state agencies by CNRA and through the development of tools to promote collaboration. Finally, the CAT will be responsible for coordinating climate mitigation and adaptation policies to ensure all climate policies are coordinated to reduce inefficiencies and maximize success.

The Energy Commission's Climate Change Center has provided, and will continue to provide, state agencies with world-class climate change science. Greater collaboration will occur between the Climate Change Center and the CAT through the CAT research group. There will also be a strong need for state agencies to increase collaboration with the growing number of adaptation centers beginning at Stanford University; the University of California, San Diego; and the University of California, Berkeley. Using the information and strategies identified in this report, these centers should coordinate to rapidly build the state's scientific foundation to adapt to climate change.

The state of California is currently in a budget crisis, and therefore most of the strategies within the CAS are being implemented using existing resources. However, successful implementation of all measures will surely require additional funding in the future. Local communities will also be challenged in implementing many adaptation measures since many of the strategies can only be implemented at the local level such as updating general plans and incorporating new policies.

Near-Term Actions:

a. *Establish a framework for promoting collaboration within and among state agencies to implement climate change adaptation strategies. Three different levels of coordination will be established to promote comprehensive state adaptation planning. First, individual agencies are responsible for implementing the short-term climate adaptation strategies identified in this report. Second, the CNRA will be responsible for monitoring overall progress on implementing adaptation measures in this report and to develop cross-sector strategies. Finally, the CAT will monitor progress on climate adaptation measures through the CNRA and will coordinate state integration of mitigation and adaptation measures within the CAT working groups.*

b. *Develop a Climate Adaptation Advisory Panel (CAAP) made up of world class science, business and government leaders to recommend improved opportunities for collaboration across state government on climate adaptation. The CAAP will also identify climate adaptation strategies outside the scope of California's climate adaptation strategy that identify near term priority strategies that will reduce California's vulnerability to climate change in the shortest time at the lowest long-term cost.*

Strategy 2) Integrate Land Use Planning and Climate Adaptation Planning

Land use decisions are a central component of preparing for and minimizing climate change impacts. In order for California to succeed with its adaptation strategies, local and regional governments and planning efforts must be integral parts of the adaptation process.

Many, if not most, land use decisions in California are made at the local level and increasingly at the regional level. Decisions made by cities and counties through general plan and local planning processes direct local land uses. Given the long-range view of general plans, cities and counties should consider how a changing climate and environment will affect nearly all aspects of general plans and long-term development.

Through the implementation of Senate Bill 375 (Steinberg; Chapter 728, Statutes 2008) Metropolitan Planning Organizations (MPOs) will have greater influence on planning efforts and outcomes at the regional and local level. Regional Transportation Plans, due to SB 375, developed through a "Sustainable Communities Strategy" will have to take into account GHG reduction measures related to land use and transportation, identify the general location of uses, residential densities, and building intensities within the region, and identify areas within the region sufficient to house all the population of the region. The state plays a role in local development patterns through the development and funding of the state transportation system, the siting requirements for school facilities and other infrastructure projects and funding mechanisms.

Development decisions along the coast, in floodplains or at the wildland-urban interface will impact the ability of the state to adapt to climate change impacts. Decisions related to urban forestry, the connectivity of biological reserves, and the routing of roads and other infrastructure also play a role in implementing state adaptation strategies. Local land use planning should be cognizant of the growing risks from climate change as well as the land-use related needs to implement effective adaptation strategies. To the extent local land use is coordinated with regional, state and federal adaptation strategies, impacts from climate change are likely to be minimized, and in turn have less significant effects on local communities. The long-term vision and development goals of general plans should therefore address climate change as soon as possible. Coordination and consultation mechanisms need to be established or strengthened to ensure local, state, and other jurisdictions do not work at cross-purposes (see cross-jurisdictional coordination above).

In order to accurately address the vulnerability, resilience, and future growth of areas prone to climate change impacts, a city or county should take three distinct steps: First, cities and counties should use information provided by state and federal agencies about where climate change could impact the human and natural systems including risks affecting public safety and emergency response. The *CalAdapt* mapping tools will offer a preliminary review of impacts by specific location. This could be used to focus local planning on areas vulnerable to climate change impacts such as floodplains, coastal areas, and fire hazard areas. Critical infrastructure such as roads, power lines, and water/wastewater pipelines that may be affected by climate change should be identified. Second, planning organizations should recognize climate impacts that may affect federal, state or local parks, as these systems offer valuable recreational opportunities critical to the well being of all communities. Third, sources of water that may be reduced by increased temperatures and decreased Sierra snowpack-dependent reservoir storage should be identified.

Once these potential areas have been identified, cities and counties should focus, when appropriate, on areas that are particularly vulnerable to climate change. Using the best available resources, local governments should note which areas can or cannot withstand changes in sea level, water use, temperature, and other climate change impacts. Areas that cannot withstand changes can be prioritized

by potential safety risks, potential biological or natural impacts, or other factors. The local government should determine which areas will need the most attention to avert these risks. The *2009 California Climate Adaptation Strategy* can be a valuable resource in making these determinations if effective adaptation planning tools are continually developed.

There are a number of ways to address climate change impacts. For future land use decisions, general plan amendments may be needed. Safety risks may be outlined and mitigated in a Local Hazard Mitigation Plan. To address public infrastructure, a public works plan may be needed. A climate action plan may be used to prioritize actions that are immediately needed and which actions can be implemented over time.

One tool that has been successful in helping to bring together many levels of government to look at long range planning on the regional and local scale is the California Regional Blueprints Program. Through the development of scenario-based integrated plans, regions and local governments can develop different planning scenarios that achieve a variety of objectives and goals, including GHG reduction and climate change adaptation. Further, the blueprint planning process can help identify areas vulnerable to climate change and identify ways to address those vulnerabilities in an integrated and comprehensive manner. Another tool that can regionally integrate different levels of government around climate adaptation is through the Department of Conservation's Statewide Watershed Program.

As the state works to meet its GHG reduction goals, adapt and plan for climate change impacts, and restore the economy, the entire state, including all levels of government, non-profits, businesses, private property owners and the general population should, when appropriate, evaluate how and where critical infrastructure is developed, what types of structures are allowed to be built in certain locations, and how to best protect natural resources.

Finally, more and more infrastructure projects will need to account for climate change impacts to the project. Currently, to the extent required by CEQA Guidelines Section 15126.2, all significant state projects, including infrastructure projects, must consider the potential impacts of locating such projects in areas susceptible to hazards resulting from climate change. Section 15126.2 is currently being proposed for revision by CNRA to direct lead agencies to evaluate the impacts of locating development in areas susceptible to hazardous conditions, including hazards potentially exacerbated by climate change. Locating state projects in such areas may require additional guidance that in part depends on planning tools that the CAS recommendations call for.

Near-Term Actions:

a. *Revise* Section 15126.2 of the *CEQA guidelines to direct lead agencies to evaluate the impacts of locating development in areas susceptible to hazardous conditions, including hazards potentially exacerbated by climate change.*

b. *Incorporate climate adaptation considerations into the Strategic Growth Council and Sustainable Community Strategy processes to ensure incentives are provided to communities that are most vulnerable and are preparing for climate change impacts.*

Strategy 3) Improve Emergency Preparedness and Response Capacity for Climate Change Impacts

Even with the best adaptation efforts, not all risks are preventable. As climate change is likely to increase the frequency and in some instances the intensity of extreme events (i.e. heat, drought, flooding, or fires), agencies must periodically review their changing capacity needs. As catastrophic events become more frequent and each draws heavily on private and public resources, every effort must be made to avoid or minimize exposure to these extremes, so as not to overwhelm emergency response capacity.

While it is more effective and less costly to engage in anticipatory planning (prevention and preparation), it is also important to limit the consequences of unforeseen yet inevitable extremes (response, hazard mitigation). Additionally, all sectors with resources or operational processes at risk from climatic extremes

will need to build their level of preparedness, emergency response capacity, and ability to facilitate rapid and climate-cognizant recovery.

Contingency and emergency planning provides an enhanced capacity to respond to the immediate impacts of extreme weather events at an accelerated rate. When coupled with long-term planning, enhanced emergency preparedness can build adaptive capacity. Further, a sustained hazard mitigation effort will reduce the impacts of these climate change impacts. This constitutes a proactive strategy for addressing impacts and forms a strong foundation for all phases of adaptation planning (mitigate, prepare, respond, recover).

Effective emergency response to climate impacts will require unprecedented coordination across all service levels. Strategic planning efforts will need to include contingencies for tiered responses to a given impact, depending on level of severity. A flood or heat wave with only local impacts, for example, would be handled by municipal emergency response services. Responses to more serious events would trigger county, state or even federal-level assistance. While emergency systems are already coordinated under the Standardized Emergency Management System (SEMS), there are no comprehensive emergency response planning efforts that consider the widespread and recurring nature of climate-driven impacts.

An equally important component needed to support this level of coordination during emergencies is access to easily accessible information required for inter-organizational real-time planning. With the potential scale of impacts resulting from climate change, informational tools and new technologies for immediate, accurate and accessible situational awareness will be essential. This requires improving information systems as well as developing planning tools to better manage the increased frequency of emergencies under climate change.

The need to plan for climate impacts before they happen is important; not only with effective and coordinated response, but also proactively when making land use planning decisions. Examples include avoiding development in potential flood zones, core habitat reserve areas, and areas prone to wildfires that will occur as a result of these climate changes. The increase in hazard areas due to climate change will put a strain on emergency services as the impacts become more commonplace in these expanded hazard areas.

Near-Term Actions:

a. *CNRA will coordinate with OPR, Cal EMA, CEC, and Cal Poly SLO to update the State Emergency Plan, the State Hazard Mitigation Plan (SHMP), and to strengthen consideration of climate impacts to hazard assessment planning, implementation priorities, and emergency response. This effort will be directly linked with the Climate Change Center vulnerability report identified in Strategy Four and the Climate Change Advisory Panel identified in Strategy One of this Chapter.*

Strategy 4) Expand California's Climate Change Research and Science Programs and Expand Public Outreach of Research to Policy-Makers and General Public

California has, arguably, the world's best downscaled climate change research program. The research funded over the last decade within Energy Commission's Public Interest Energy Research (PIER) Program is the foundation for Chapter 2 in this report, and serves as the scientific foundation for this adaptation strategy and most climate change programs across the state. Despite the significant progress in climate research in California, the state will need significantly more research in the future funded and supported by a much broader list of partnerships. Figure 9 provides a list of climate adaptation research questions highlighted in the 2009 CAT report showing the depth of topics needing immediate research.

Future research will need to identify what, where, when, and how climate impacts either will, or are, increasing the state's vulnerability to climate change. More importantly, researchers will need to better communicate this information in a way that is useful for policy-makers while having to make decisions in a world with increasing uncertainty regarding climate changes.

Vulnerability Assessment: A key research need is to develop a statewide climate impact vulnerability assessment. California's adaptation strategy was developed using the "hazard-based assessment approach" (explained in Chapter 2), which is useful but limited in the information it can provide to inform policy direction. Now, California should move toward developing a "vulnerability assessment approach" that quantifies the probability that certain consequences under different future climate scenarios will occur, and identifies the resulting vulnerabilities. PIER is currently prepared to develop such research now through 2011.

A vulnerability assessment integrates the risk with the likely sensitivity and response capacity of natural and human systems that are at risk of experiencing these consequences. This requires several steps beyond what is presented in this report including: (1) further research to identify the probability and resulting risks of the existing climate scenarios and resulting consequences; (2) link policy-makers with climate scientists to identify adaptation policy options and barriers, along with costs and benefits, to best reduce and manage the identified risks; and (3) a broad public stakeholder process to communicate the options available to reduce climate risks and to work toward a prioritization of where the state should focus its limited resources in implementing priority strategies.

A key motivation for completing a vulnerability assessment is to identify and help the most vulnerable communities, populations, sectors, and natural systems. For example, Gleick et al. (2008) reports that up to 500,000 low–income individuals in "communities of color" are vulnerable to future sea level rise in the San Francisco Bay Area. This raises important political and economic questions regarding how the state plans to mitigate future climate change impacts. Answers will require difficult trade-offs and require significant input from stakeholders ensuring environmental justice concerns are adequately addressed.

All sectors engaged in the development of the 2009 California Climate Adaptation Strategy recognize their obligation to work closely with all stakeholders and that environmental justice concerns should be incorporated and mainstreamed into all strategies where it is possible. It is also necessary to ensure climate adaptation strategies can assist toward the greater goal of ensuring all California residents have the opportunity to live, learn, and work without regard to race, age, culture, income, or geographic locations. State agencies will also interact with California Indian Tribes respectfully and on a government-to-government basis. Because traditional knowledge will have a role in combating climate change, indigenous communities should be involved in climate change adaptation actions that will directly impact their people, waterways, cultural resources, or lands; all of which are intimately associated.

There is growing understanding that climate change is happening now and that human induced GHG emissions are to blame. Unfortunately, there is less public knowledge of current and projected climate impacts, who and what systems are at greatest risk, and the actions necessary to reduce these risks. This is partly due to the rapidly changing information, but also about the lack of a state-coordinated public outreach effort to inform the public about *how* to reduce climate-related risks. The CNRA has taken steps to increase public outreach and stakeholder participation with regard to climate adaptation strategies. The California Climate Change Portal (www.climatechange.ca.gov/adaptation) provides a readily accessible tool for communicating the state's work to tackle climate change. California will increase use of this site as it develops this adaptation strategy so that stakeholders have the ability to track development and integration of climate policies. The ultimate success of an outreach campaign is based on providing information and tools to the public that can be used to reduce the state's vulnerability to climate change.

The state will work towards improving public outreach of both climate impact research and adaptation strategies in the Beta version of the Caladapt website released with the state adaptation strategy. The Caladapt website will allow individuals to view climate change temperature, sea level and precipitation projections at a scale of seven by seven kilometers anywhere in the state of California. Ideally, this information will be linked with the state natural hazard interactive map (myhazards.calema.ca.gov) with the goal of localizing all natural hazard information.

Monitoring: Vulnerability assessments and PIER's research efforts largely focus on modeling future changes. Monitoring existing climate changes is as important as modelling future changes. Unfortunately, California's existing monitoring network was not established with climate change in mind. Temperature monitoring states are based on areas where people and resources exist instead of locations that could act as an "early warning system" of greater climate change to social, environmental and economic systems. For example, expanded surveillance of pests, invasive species, or disease vectors could identify where crops or populations that are most vulnerable and provide lead times to develop new pesticides or vaccines.

Near-Term Actions:

a. *The State Climate Action Team Research Group will develop a strategic plan by September 2010 that will identify: priority state climate adaptation research and monitoring needs; proposed resources and timeframes to implement the plan; and potential for research co-funding and collaboration with local, state, and national agencies, universities and other research institutions. The CAT Sub-Group should develop a comprehensive research project catalog and continue to biannually publish key state sponsored climate research on the California Climate Change web-portal.*

b. *Develop a California Climate Vulnerability Assessment (CCVA) to ensure the best available science informs climate adaptation decision making. State agencies will work through the CNRA to develop the state's first CCVA focused on sharing information, providing opportunities for public discussion on climate risk research and policies, and developing cross-sector strategies. The development of a CCVA will include public outreach to prioritize risk reduction strategies and will be completed by January 1, 2011 (depending on contracting and funding this study by January 1, 2010). The final CCVA will allow policy-makers the ability to develop a more systematic approach to funding risk reduction efforts. Every effort will be paid to identify and assist those communities expected to be most at risk from future climate change.*

c. *Develop the "CalAdapt" web-based portal that uses Google Earth to show state supported research (and other research) in a way most relevant and useful to policy-makers and local communities as a public outreach tool for the California climate adaptation strategy. The tool will show basic climate impact information at a scale that allows local communities to develop their own climate adaptation strategies based on this information. CNRA will coordinate with CEC and the State Chief Information Officer to develop the CalAdapt Tool and outreach in a way that ensures the portal will be used and developed over time and integrated with other state programs.*

PART II:

CLIMATE CHANGE - IMPACTS, RISKS AND STRATEGIES BY SECTOR

In this first effort to develop an approach for statewide climate adaptation planning, state agencies were organized into resource-based sector working groups. These working groups were tasked with assessing climate impacts to their respective resource areas based on the PIER research-based statewide impacts (see "California's Future Climate"), and identifying preliminary adaptation strategies organized by the necessity and/or ability to implement short term (by December 2010) and longer term. As these working groups stem from differing resource management issues, there is variability in the applied long-term climate adaptation planning horizon (50, 75, 100 years). The following sections focus on each sector, respectively:

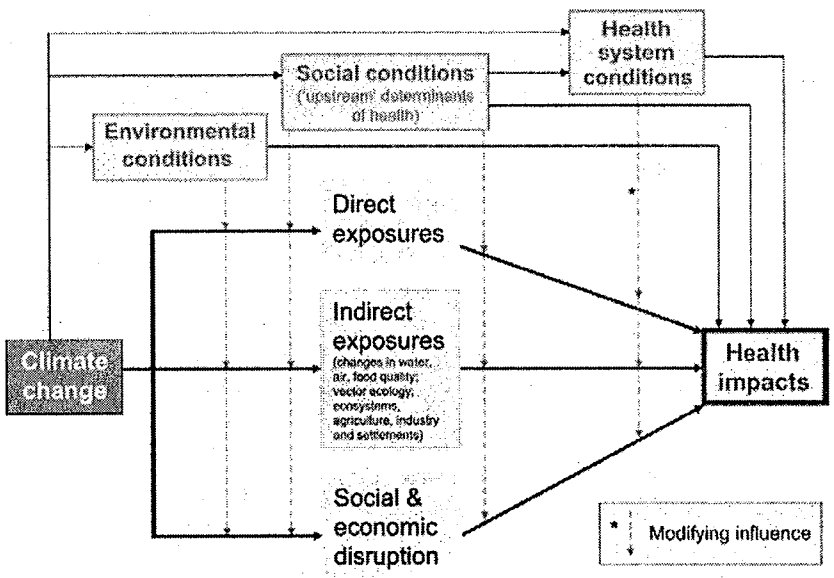
- Public Health
- Biodiversity and Habitat
- Oceans and Coastal Resources
- Water Supply
- Agriculture
- Forestry
- Transportation and Energy Infrastructure

IV. PUBLIC HEALTH

Introduction

Climate change threatens the health and well-being of all Californians through a variety of environmental changes including more severe extreme heat and other weather events, a decline in air quality, increases in allergenic plant pollen, more frequent wildfires, and altered environmental conditions that foster the spread of communicable and vector-borne diseases. Climate change also threatens the basic life support systems on which humans depend – our water, food, shelter and security. Among the segments of the population that are at greatest risk include the elderly, infants, individuals suffering from chronic heart or lung disease, persons with mental disabilities, the socially and/or economically disadvantaged, and those who work outdoors.

Figure 10: *Flow diagram showing inter-relationships of climate impacts to conditions affecting public health. Source: IPCC Fourth Assessment Report. 2007.*



The effects of climate change are already becoming evident in California, and we will witness to more climate change in the coming decades due to the effects of greenhouse gases already in the atmosphere. Thus, implementation of a public health climate adaptation strategy is imperative. However, a strong public health voice for climate change mitigation is also imperative, because without strong mitigation actions, our adaptation efforts will likely be overwhelmed by more severe climate impacts. Many climate mitigation strategies offer significant public health co-benefits, and these should be prioritized. For example, reducing vehicle miles traveled reduces greenhouse gas emissions, increases physical activity, and leads to reduced rates of obesity and chronic illnesses such as cancer, diabetes, and cardiovascular disease that account for over 2/3 of deaths in the U.S.

Climate change introduces varying levels of vulnerability based on geographic location, community and individual characteristics, and the preparedness and response capacity of individuals and communities. It is important that adaptation planners assess the potential health co-benefits or adverse consequences of adaptation strategies, so that they do not increase vulnerability or adverse health impacts. Examples are increased use of pesticides to control agricultural and vector borne diseases, and increased use of air conditioning, which could increase emissions of GHG and criteria pollutants.

Criteria should be developed during the planning process to evaluate measures and determine the appropriate response in the development of an adaptation strategy. This will require collaboration across agencies.

Future Climate Change Impacts to Public Health

A. Increased Temperature and Extreme Weather Events

PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS DUE TO WARMING

- Higher Rates of Mortality & Morbidity
- Increased Air Pollution
- Seasonal Changes & Increases in Allergens
- Changes in Prevalence & Spread of Disease Vectors
- Possible Decrease in Food Quality & Security
- Reduction in Water Availability
- Increased Pesticide Use

Climate change is expected to lead to an increase in ambient (i.e., outdoor) average air temperature, with greater increases expected in summer than in winter months. Larger temperature increases are anticipated in inland communities as compared to the California coast. The potential health impacts from sustained and significantly higher than average temperatures include heat stroke, heat exhaustion, and the exacerbation of existing medical conditions such as cardiovascular and respiratory diseases, diabetes, nervous system disorders, emphysema, and epilepsy.[1] Numerous studies have indicated that there are generally more deaths during periods of sustained higher temperatures, and these are due to cardiovascular causes and other chronic diseases.[2] The elderly, infants, and socially-isolated people with pre-existing illnesses who lack access to air conditioning or cooling spaces are among the most at risk during heat waves.[3]

Extreme Heat Events

Climate change is expected to lead to increases in the frequency, intensity, and duration of extreme heat events and heat waves in California.[4] There is no universal definition of an extreme heat event (i.e., heat wave) since it depends on the locale, but in most parts of the U.S., three days over 90 degrees Fahrenheit is considered a heat wave. Extreme heat events can also be defined as temperatures that rise to the highest 10 percent of all temperatures that were recorded during the summer months from 1961-90 in a given locale.[5] Heat waves can be characterized by above-normal averages, or maximum daily temperatures, which may be accompanied by higher nighttime minimum temperatures.[6] There is evidence of a trend in heat waves in California toward higher nighttime (i.e., higher minimum) temperatures as compared with the historical record, with daytime maximum temperatures being more similar to past heat waves.[7] Higher nighttime temperatures mean there is less chance for people to physiologically recover and cool off, and for the built environment (indoors or outdoor) to cool; this contributes to continued heat stress overnight and compounds the effects of high temperatures the following day. In 2006, a ten-day heat wave set multiple records, including maximum

ADAPTATION - COUNTY OF SONOMA HEAT WAVE GUIDELINES:

- **Drink** - Drink plenty of cool fluids.
- **Dress** - Wear lightweight, light-colored, loose-fitting clothing. If outdoors, wear a wide-brimmed hat, sunglasses and sunscreen.
- **Decrease** - Limit physical activity and stay indoors in an air-conditioned space (home, library or shopping mall). In an ***extreme heat event***, listen to the radio for the location of emergency cooling centers.
- **Defend** - If working outside, monitor your coworkers. Check on elderly friends and family at least twice a day. Check infants and children frequently. Check on those who are overweight or in poor health.
- **Demonstrate** - Avoid hot foods and heavy meals. Make sure animals and pets have plenty of fresh water and shade. Consider bringing pets inside and wet down outside animals.
- **Don't** - Do not leave children, adults or pets in a parked car for any length of time.

daily and minimum overnight temperatures, leading to 140 deaths from heat exposure according to county coroners.[8] A more accurate analysis estimated 655 excess deaths during the heat wave. More heat waves of similar length and intensity are expected to occur on an annual basis by the end of the century if the world follows a higher GHG emissions (A2) pathway.[9]

The anticipated increase in heat waves is expected to increase mortality in California, although further modeling is required to more accurately estimate the magnitude of likely increased deaths. Over the past 15 years, heat waves have claimed more lives in the state than all other declared disaster events combined.[10] This trend is likely to continue as the number of heat waves increase, and thereby lead to potentially hundreds of climate-related fatalities every year. Even though coastal areas will not see the greatest increases in average temperature, the largest increases in mortality rates are expected to occur in coastal cities such as Los Angeles and San Francisco, since these populations are relatively unaccustomed to extreme heat and thus less acclimatized when such events occur (e.g., less adequate access to air conditioning).[11]

Increased heat waves can exacerbate higher occurrences of chronic disease or heat-related illness. Compared to baseline conditions, there were 16,166 excess emergency room visits and 1,182 extra hospitalizations linked to the July 2006 heat wave throughout California.[12] As record-breaking heat waves occur more frequently in California, excess morbidity will also increase during the summer months. This will require greater preparedness by health care providers and facilities, and will place a strain on California's health care system. Heat waves also necessitate an increase in energy use for cooling and air conditioning, which can lead to electricity shortages and blackouts. A reduction in energy availability can further impact public health by limiting access to air conditioning and refrigeration which can increase the risk of food-borne illnesses.

Urban Heat Islands: The "Urban Heat Island" is due to the greater heat retention of buildings and paved surfaces compared to vegetated surfaces. During heat waves, urban heat islands are especially dangerous because they are both hotter during the day and do not cool down at night, increasing the risk of heat-related illness.

Adaptation - County of Fresno

How to Reduce the Effects of Heat

Seasonal Readiness:

- Educate the public on the greatest risks of heat
- Identify and prepare cooling centers
- Identify resources to transport citizens to cooling centers
- Coordinate community resources
- Encourage residents to check on family and friends at risk
- Initiate data collection on heat related deaths and illnesses by the Community Health Department Epidemiologist

Heat Emergency Responses:

- Open cooling centers
- Releasing heat response information to the media, local organizations and community groups
- Provide transportation resources for people unable to reach cooling centers
- Coordinate local heat-related resources, donations and volunteers
- Monitor the health of vulnerable populations by county agencies and community groups
- Monitor medical reports of heat-related illnesses and deaths; and
- Provide information to the public regarding available utility bill (air conditioning) assistance resources

Health Inequities Issues: Several factors could contribute to health inequities related to increased heat exposure:

a. Chronic illness co-morbidities: Low income and minority communities have an increased prevalence of chronic illnesses that place individuals at greater risk of heat-related illness.
b. Exposure to urban heat island effect: Low-income individuals and people of color are often concentrated in urban areas subject to the heat island effect.
c. Access to air-conditioning: Low income individuals and people of color are less likely to have air conditioning.
d. Occupation: Agricultural workers are especially at risk of heat illness due to the combination of outdoor work in hot climates (e.g. Central and Imperial valleys) and jobs demanding physical exertion.
e. Fear of crime: Low income and minority communities may be reluctant to open doors and windows for ventilation during heat waves for fear of crime.

Fewer Freezing Spells

Currently, freezing events occur on an annual basis in many areas of California. When temperatures drop below freezing, heat is lost from the body more rapidly and can lead to hypothermia. People without shelter, or who live in a poorly insulated home or lack a source of heat are at higher risk of cold-related health effects, as are children and the elderly.

Freezing spells are likely to become less frequent in California as climate temperatures increase; if emissions follow higher pathways, freezing events could occur only once per decade in a sizable portion of the state by the second half of the 21st century.[13] While fewer freezing spells would decrease cold-related health effects, too few freezes could lead to increased incidence of disease as vectors and pathogens do not die off.

Changes in Air Quality

Many Californians living in or near urban areas currently experience the worst air quality in the nation, with associated economic costs reaching tens of billions every year.[14] Research indicates that climate change influences on atmospheric processes will promote formation of ground-level pollutants, such as ozone and secondary aerosols (particulate matter), and that these increases could offset much of the potential gains achieved through air pollution control measures, a phenomenon referred to as the "climate penalty".[15]

Short-term effects of air pollution include irritation to the eyes, nose and throat, as well as increased incidence of upper respiratory inflammation. In addition, short-term air pollution tends to aggravate the medical conditions of individuals with asthma and emphysema. Similar to heat waves, public health impacts from particulate matter are highest among the elderly, followed by infants and young children.[16] Recent evidence shows that ozone and particulate matter exposures can initiate cardiovascular and lung disease resulting in increased overall mortality.[17]

An increase of ground-level (tropospheric) ozone can cause decreases in lung function and increase airway reactivity and inflammation. Particulate matter can aggravate existing respiratory and cardiovascular disease and damage the lungs, leading to premature death; it may also contribute to increased risk of cancer. According to the California Air Resources Board (CARB), current exposures to just two common air pollutants – ozone and particulate matter (PM) cause around 8,800 deaths, 9,500 hospitalizations, 200,000 cases of asthma and lower respiratory symptoms, and nearly 5 million school absences in California each year (www.arb.ca.gov/research/health/qhe/qhe.htm). Other air pollutants – such as sulfur and nitrogen oxides – also affect the respiratory and cardiovascular systems.

Aero-allergens: Both increased temperatures and increased carbon dioxide concentrations are expected to increase plant production of pollens, and may also increase fungal growth and spore release. Pollen and mold spores are allergens; they can induce and/or aggravate allergic rhinitis, asthma (already the

most common childhood chronic illness), and chronic obstructive pulmonary disease. Allergic diseases are the sixth leading cause of chronic disease in the U.S. and impose a substantial burden on the U.S. population. Some experts have suggested that the global rise in asthma is an early health effect of climate change. (http://www.cdc.gov/climatechange/effects/allergens.htm)

Changes in temperature affect atmospheric chemistry and the amount of some pollutants like ozone that are in the air. The relationship between temperature change, air quality and human health is complex and synergistic. Four specific dimensions of the relationship have been studied to different degrees: 1) direct effects of temperature on health; 2) direct effects of air pollution on health; 3) temperature and geographic factors that modify pollution effects on health; and 4) pollution factors that modify temperature effects on health.

Climate change can affect exposure to air pollution in several ways:[18]

1. Increasing air temperatures increase ozone levels, which are formed by reactions between nitrogen oxides and hydrocarbons released from motor vehicle combustion of fuel.
2. Increasing temperatures can change human behavior in ways that increase air pollution – for example, through increased fuel combustion to meet electricity demand for increased air conditioner use
3. Climate change can effect patterns of air mixing and air flow that transport pollutants
4. Increased temperatures can increase the emission of pollutants called volatile organic compounds from plants and vegetation.

Knowledge of air pollution direct health effects has resulted in regulations for criteria air pollutants and hazardous air pollutants. Changes in air pollutant levels due to temperature changes will result in more non-attainment days and greater risks of disease to the involved populations. Recent research suggests that changes in temperature and geographic location will further modify the effect of air pollutants on respiratory and cardiovascular health and mortality. Conversely, it has been demonstrated that changes in ozone or particulate matter levels modify the effect of heat on cardio-vascular mortality.[19] One recent study estimated that each one degree (Celsius) increase in temperature would cause about 1,000 additional deaths in the U.S. associated with air pollution.[20]

Health Equity Issues: Air pollution levels in poor urban neighborhoods are often substantially higher than those in other areas, due to closer proximity to freeways and other motor vehicle arterials, and industrial pollutant sources.[21] Asthma rates are higher in low income and minority children in California. Increases in air pollutants and/or aero-allergens may exacerbate these existing health inequities, unless special care is taken to reduce pollution sources; recent action by the CARB to reduce diesel truck pollution is a good example of a policy that could reduce these health inequities.

B. Precipitation Changes and Extreme Events

Changes in precipitation patterns will affect public health primarily through extreme events such as floods, droughts and wildfires. In addition, higher temperatures combined with changes in precipitation patterns create conditions that are more conducive to the occurrence and spread of infectious diseases.

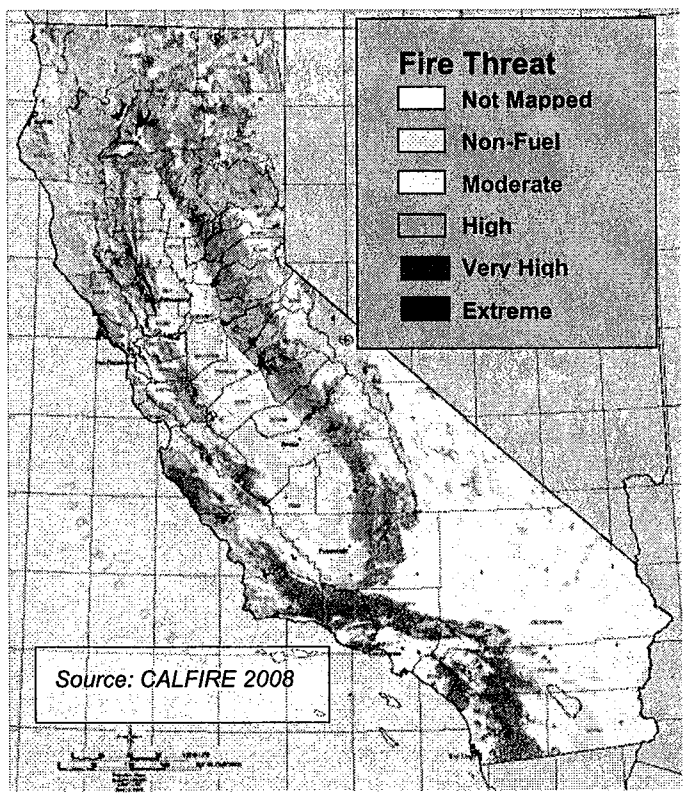
Floods and Droughts

The impacts of flooding can be significant. Results may include population displacement, severe psychosocial stress with resulting mental health impacts, exacerbation of pre-existing chronic conditions, and infectious disease[22]. Additionally, impacts can include a loss of personal belongings, and the emotional ramifications from such loss, to direct injury and/or mortality. Preparation and emergency response plans are therefore needed to address anticipated flooding, especially in urban areas with high population densities which can potentially overwhelm emergency services and medical facilities.

Drinking water contamination outbreaks in the U.S. are associated with extreme precipitation events.[23].Runoff from rainfall is also associated with coastal contamination that can lead to contamination of shellfish and contribute to food-borne illness.[24] Flood waters may contain household, industrial and agricultural chemicals as well as sewage and animal waste. Flooding and heavy rainfall events can wash pathogens and chemicals from contaminated soils, farms, and streets into drinking water supplies. Flooding may also overload storm and wastewater systems, or flood septic systems, also leading to possible contamination of drinking water systems.

Drought impacts develop more slowly over time. Risks to public health that Californians may face from drought include impacts on water supply and quality, food production (both agricultural and commercial fisheries), and risks of waterborne illness. As the amount of surface water supplies are reduced as a result of drought conditions, the amount of groundwater pumping is expected to increase to make up for the water shortfall. The increase in groundwater pumping has the potential to lower the water tables and cause land subsidence. Communities that utilize well water will be adversely effected both by drops in water tables or through changes in water quality. Groundwater supplies have higher levels of total dissolved solids compared to surface waters. This introduces a set of effects for consumers, such as repair and maintenance costs associated with mineral deposits in water heaters and other plumbing fixtures, and on public water system infrastructure designed for lower salinity surface water supplies. Drought may also lead to increased concentration of contaminants in drinking water supplies.

Figure 11: *Increasing Wildfire Risk*



Wildfires

Drought also results in increased frequency and duration of wildfires; another significant risk to public health. Wildfire frequency and intensity is expected to grow as temperatures increase and vegetation dries due to longer dry seasons.[25] In addition to the associated direct risk of fatalities, wildfires can lead to immediate and long-term adverse public health problems due to exposure to smoke. Smoke from wildfires is a mixture of carbon dioxide, water vapor, carbon monoxide, hydrocarbons and other organic chemicals, nitrogen oxides, trace metals, and fine particulate matter from burning trees, plants, and built structures. During wildfires, large populations can be exposed to a complex mixture of pollutant gases and particles, which can have both acute and chronic health impacts. Smoke can irritate the eyes, harm the respiratory system, and worsen chronic heart and lung diseases, including asthma.[26] People with existing cardiopulmonary diseases are generally at the greatest risk from smoke inhalation, with age being a complicating risk factor for the exposed population.

PUBLIC HEALTH IMPACTS DUE TO SEA-LEVEL RISE

- Wastewater issues with flooding of septic systems near coastline
- Salt water intrusion – risks to drinking water
- Threats of injury and even death during coastal storms
- Emotional and mental health impacts related to more coastal flooding and erosion
- Emotional and mental health impacts related to internal displacement and migration of coastal residents

C. Sea-level rise

As sea level rises, the flood risks will be exacerbated in coastal areas as higher storm surges cause greater tidal damage and flooding, and reach into inland areas that have been historically untouched by sea waters. Potential impacts include physical injury, loss of property and belongings, and emotional trauma from such events. In one study conducted for the 2008 Climate Change Impacts Assessment, researchers assessed the areas, population, and assets at risk from inundation during a coastal storm after sea level had risen by ~5 feet (1.4 m). In the face of the encroaching ocean, up to 480,000 people and their residential assets (homes and property) were found to be at risk (70 percent of all at-risk assets) by the end of the century from such flooding events.[27] In short, much of California's prime real estate will be affected in coming decades by accelerating sea-level rise.

Sea-level rise also increases the likelihood of saline intrusion into drinking water sources and agricultural water supplies. Such events have already occurred along the Los Angeles and Orange county coastal areas since the 1950's. In response, sea water intrusion barriers were built and operated to protect these aquifers. As sea levels rise, more effort will be needed to protect these and other coastal communities from salt water intrusion into the water supply.

Infectious Diseases

Climate change could affect the range, incidence and spread of infectious diseases, including vector-borne diseases, zoonotic diseases, (i.e., animal diseases that are transmissible to humans), water-and food-borne diseases, and diseases with environmental reservoirs (e.g., endemic fungal diseases).[28] In California, predictions for more frequent wildfires, droughts and heat waves are associated with possibilities for forced migration of communities which could enhance transmission of disease due to crowding, homelessness, poverty and scarce resources – here at home and abroad. Large scale migrations have been associated with surges in communicable disease and emergence of not previously noted novel infections throughout recorded history. These new demands will occur in an environment of global travel, emerging novel viruses such as H1N1, multiple drug resistance, and immune disorders (including HIV/AIDS) with their associated increased risk of tuberculosis and other infections.

Vector-Borne Diseases

Changes in temperature and precipitation are likely to cause changes both in the geographic distribution and the quantity of vectors (such as ticks and mosquitoes) that carry human disease. In California, three vector-borne diseases are of particular concern: human hantavirus cardiopulmonary syndrome, Lyme disease, and West Nile virus. These diseases vary in their response to climate-related factors such as temperature, humidity, and rainfall.[29] The distribution of vectors may change as humid areas become drier and less suitable habitats, while other areas may become wetter, allowing for the vectors to exist where they previously did not. Abundance of small mammal reservoirs may similarly be affected.

In California, the adult or sub-adult (nymph) western black-legged tick can transmit a Lyme disease agent to humans. Lyme disease-carrying ticks are found in patchy distribution patterns in moist, humid environments such as coastal redwood or hardwood forests, and the risk of Lyme disease is highly correlated with exposure to habitats where these ticks live.[30] Exposure to the western black-legged tick in California is most often through recreation or occupation where ticks are prevalent, although exposure also occurs with increased development in previously wild areas.

Though increased rainfall may temporarily provide increased mosquito breeding sites, in fact, rainfall has little effect on West Nile Virus (WNV) transmission since urban mosquitoes breeding in municipal water systems may benefit from below-normal rainfall. However, an increase in summer rainfall could make California more at risk for the introduction and establishment of exotic vectors such as the principle mosquito vectors of dengue and yellow fever. Each of these climate-related variables – along with unrelated changes in land use and land cover – can modify the geographic range of vectors, thereby raising the possibility that some of these vector-borne diseases may become more common in California. According to the CDC the first West Nile virus infection was detected in 2003 in California and the transmission appeared to increase and spread soon after.[31]

Climate change may affect rodent populations through the availability or increase in food supplies.[32] Prolonged rainfall and/or flood can increase the food supply for rodents, thereby increasing the risk that human populations will become infected by diseases carried by rodents. Wild rodents can also act as hosts to ticks and fleas that can transmit diseases such as Lyme disease, plague, tularemia, and rickettsial infections. Humans can also contract hantavirus cardiopulmonary syndrome when they come into contact with infected rodents or their urine and droppings.

Water- and Food-Borne Diseases

The risk of water- and food-borne diseases such as mild gastrointestinal illnesses could increase as California's drinking, irrigation, and recreational waters are impacted by climate change. Such infections and illnesses can become chronic and even fatal in infants, the elderly, pregnant women, and people with weakened immune systems.

Historically, outbreaks of water-borne diseases have been linked to heavy rainfall and subsequent runoff, which results in a decline in the quality of surface water arriving at water treatment plants.[33] In California, the expected increase in the intensity of rainfall could result in periodic deterioration of the quality of drinking water, and require not only more careful monitoring, but also additional water treatment to maintain adequate water quality. People can contract water- and food-borne diseases by drinking contaminated water, eating seafood from contaminated water, and eating produce irrigated with contaminated water. They can also be exposed to water-borne infectious illnesses while fishing or swimming in affected waters. Higher water temperatures, as a result of warming, can accelerate the spread of water-borne diseases.

Harmful algae blooms, which produce nerve and liver toxins, have been noted to be of longer duration and larger intensity, and are suspected to be tied both to increased temperatures due to climate change and nutrient runoff. Exposure to marine life has resulted in death and poisonings of California sea lions. Human exposure is of concern both through drinking water contamination and recreational exposure. Human exposure to these blooms can cause eye and skin irritation, vomiting and stomach cramps,

diarrhea, fever, headache, pains in muscles and joints, and weakness. Chronic exposure in drinking water supplies is suspected to have links with liver damage and cancer.[34]

The Food Supply

Marine Biotoxins: Warming oceans and rising sea level may have a dramatic impact on both commercial and recreational shellfish harvesting. Increased water temperatures could lead to an increase in the frequency and distribution of naturally-occurring pathogens such as Vibrio parahaemolyticus, which has caused hundreds of illnesses linked to shellfish consumption. Likewise, increased temperatures, combined with decreased salinity from greater rainfall, could result in increases of the deadly V. vulnificus bacterium currently found predominantly in the Gulf of Mexico.

Exceptionally clean water is necessary to ensure that filter feeding shellfish are safe for consumption. Rising sea level will inundate coastal structures, flooding septic systems and other low-lying sewage collection systems. As a result, coastal waters, particularly in bays and estuaries, will be too polluted for shellfish culture, harvesting and consumption.

Marine biotoxins are naturally occurring neurotoxins produced by a small number of single-celled marine algae called phytoplankton. Phytoplankton populations are affected by a variety of physical processes (e.g., sea surface temperature, upwelling, nutrient flux, salinity) that could dramatically change due to global warming. Marine toxins are bioconcentrated by filter-feeding organisms such as bivalve shellfish (e.g., mussels, clams, oysters, scallops), omnivorous crustaceans (e.g., Dungeness crab, lobster), and small finfish (e.g., anchovy, sardines). The occurrence of these toxins in seafood presents serious health risks to human consumers as well as marine life such as sea lions and sea otters California has had illnesses and deaths associated with the paralytic shellfish poisoning (PSP) toxins documented in coastal tribes predating written history. Domoic acid, a new toxin which produced four deaths and hundreds of illnesses in 1987 in Canada, was identified just four years later in California, where it caused hundreds of deaths in marine birds in Monterey Bay.

Crop yields: Climate change could present serious negative impacts to the crop yields of California's agricultural system, including both annual and perennial crops. Crop yield is likely to be impacted by climate change effects on water supply, as well as by reduced freezes required for many crops such as stone-fruits. Not only is the food produced in California necessary to feed Californians, especially fresh fruits and vegetables that are a critical part of a healthy diet, but many of the crops are produced for export outside of the state and to other countries, and result in significant tourism (e.g., wine grapes). Any significant decrease in crop yields endangers food availability to Californians, the multibillion agricultural system, and also the employment of many low-paid migrant farm workers.

Fisheries: Changes in ocean conditions will also substantially change the distribution and abundance of major fish stocks. Diminshed stream flows, warming ocean water temperatures, and ocean acidification could all contribute to fisheries declines. Impacts to fisheries related to El Nino/Southern Oscillation illustrate how climate directly impacts marine fisheries on short term scales. Higher sea surface temperatures in 1997-1998 during the El Nino had a great impact on market squid, California's largest fishery by volume. The California Regional Assessment reports that landings fell to less than 1,000 metric tons in that season, down from 110,000 tons in the 1996-1997 season. Other unusual events also occurred such as poor salmon returns, a series of plankton blooms, and seabird die-offs. As with agricultural crop yields, significant declines in fisheries will adversely affect the availability and price of fish (an important component of a healthy diet) and employment of workers in this industry. Additionally, food systems may be under stress due to disruptions in transportation systems (e.g. extreme weather conditions, heat buckling of roads or railways).

Health inequities: Declines in crop yields and fisheries may contribute to substantial increases in food prices, which would disproportionately impact low income communities who already spend a higher percentage of their income on food. Reduced agricultural employment will impact low income farm workers and their families.

D. Risks to Public Health

In summary, climate change brings significant public health risks. Climate change is expected to lead to increases in the frequency, intensity, and duration of extreme heat events and heat waves in California, which is likely to increase the risk of mortality and morbidity due to heat-related illness and exacerbation of existing chronic health conditions. Those most at risk and vulnerable to climate-related illness are the elderly, individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses, infants, the socially or economically disadvantaged, and those who work outdoors.

The expected increase in extremely high temperatures and increased ultraviolet radiation due to climate change is likely to exacerbate existing air quality problems unless measures are taken to reduce GHG as well as air pollutants and their precursors. Climate change can lead to an increase in the occurrence and severity of respiratory illnesses as a result of declining air quality combined with higher temperatures. It can also alter the timing and/or duration of seasonal allergies.

Changes in precipitation patterns affect public health primarily through potential for altered water supplies, and extreme events such as floods, droughts, and wildfires. These extreme events are likely to increase, thereby exposing the population to the risk of direct injury and/or mortality, respiratory illness associated with wildfires, property loss, displacement, and associated emotional distress. Adequate preparation is needed to provide sufficient emergency services and access to medical facilities. The direct risk of injury and fatalities from a combination of wildfires, higher temperatures, and longer dry seasons will contribute to an increase in poor air quality and related respiratory illnesses.

Wide ranging and unpredictable communicable disease impacts that are likely to result from climate change highlight the need to strengthen public health infrastructure related to electronic disease surveillance, food and water safety, control of insect vectors, control of animal reservoirs of diseases, and increasing the capacity of infectious disease outbreak response.[35]

Public Health Adaptation Strategies

Introduction

The goal of these Public Health Adaptation Strategies is to minimize the negative health impacts of climate change. This will require an increased awareness of potential climate change-related public health impacts, improved surveillance and monitoring of climate risks and related outcomes, maintenance of a robust public health infrastructure, expanded research, and most importantly, healthy, equitable, and resilient communities that are able to mitigate and respond to climate change and protect vulnerable populations. Failure to control greenhouse gas emissions will result in more extreme and possibly catastrophic climate change that will likely overwhelm our capacity to adapt; the Public Health climate change adaptation work group has thus incorporated climate mitigation strategies with health co-benefits in its strategy to increase community resilience to climate change. Implementation of a credible public health climate change adaptation strategy will require dedicated and sustained resources.

Adaptation Strategies and Actions

The Public Health Climate Change Adaptation Work Group, in concert with the Department of Public Health, has identified the following priorities for public health adaptation for climate change. The near-term actions referenced below are those identified actions which can be initiated by 2010 (contingent on available and sustained funding). The long-term actions include those recommended actions that will require support from the state and collaboration with multiple state agencies and are identified as cross-sector strategies.

Strategy 1: Promote Community Resilience to Reduce Vulnerability to Climate Change.

Near-Term Actions:

a. **Promote Healthy Built Environments** – CDPH should continue working in collaboration with local health departments, community based organizations (CBOs), and other state and local planning and transportation agencies to improve community planning and design to promote healthy living, and to balance integration of social, economic and environmental concerns. CDPH should identify mechanisms to institutionalize the consideration of health in local and regional land use and transportation decision-making in, for example, local general plans, regional transportation plans, or CEQA guidelines, and through the use of Health Impact. CDPH should develop guidelines for health impact assessment, for use by local health departments and other agencies.

b. **Identify and Reduce Health Vulnerabilities** -- CDPH should provide tools for use by local health departments, other agencies, and CBOs to identify and reduce climate-related health vulnerabilities For example, community wide assessments could identify the homes occupied by disabled persons and seniors, assess the safety, energy and water use efficiency of these homes, and modify or retrofit homes, for example weatherproofing, energy efficient appliances, and shade cover. Identification of urban heat islands could lead to targeted efforts to increase shading and reduce heat-reflecting pavement through,[36] for example, expansion of parks and community gardens. Increased efforts to reduce air pollution in "toxic hot spots" would also decrease vulnerability to the health effects of increased air pollution with rising temperatures.

c. **Food Security and Quality**– CDPH should work in partnership with USDA, CDFA, and CDSS to maintain commitment to healthy foods and nutrition programs that improve access to healthy foods in low-income communities DPH should partner with Local Hea'th Departments and CBOs to promote healthy sustainable local food systems through working for consideration of healthy food access in agricultural, land use, and other policies (e.g., zoning to allow farmers markets, incentives for farm to school/business/consumer, community and school gardens, and strong state support for programs such as Women, Infants and Children (WIC), SNAP-Ed, etc). CDPH should partner with CDFA and local health and environmental agencies to enhance capacity for surveillance and response for food-borne illness outbreaks.

Long -Term Actions:

d. **Food Sustainability** – CDPH should promote sustainable local food systems to reduce reliance on food that requires a high amount of "vehicle miles traveled". This could be done through supporting projects with mutual partners and/or through media/outreach campaigns, such as school and community gardens, peri-urban "ring" agriculture, farmland preservation, etc. CDPH should consider working in conjunction with the Natural Resources Agency and the CDFA to discuss/to develop a work group on food and climate change to assure the implementation of sustainable food practices, and policies including promoting a wider range of organic and local foods to California residents and California programs

e. **Reduce Heat Islands** – CDPH should partner with academia, local, state and federal agencies, and other climate change experts to identify urban heat islands, and work with state and federal agencies such as CAL FIRE, USFS Urban Forestry Program and DPR (Department of Parks and Recreation), and community partners to increase ground cover and shading by expanding urban forests, community gardens, parks, and native vegetation-covered, as well as open spaces.

f. **Support Social and Community Engagement** – The experience of Hurricane Katrina suggests how important neighbors and local support networks can be in response to climate emergencies and in rebuilding after disasters. Community-based approaches will be more likely to result in meeting the needs of all communities, rather than top down approaches administered at the state level. CDPH should incorporate concepts of social and community engagement into its work with local health departments and CBOs, and develop climate change communication tools and messages that promote active community engagement, to build resilient communities, identify vulnerable populations, and promote social support networks.

g. **Health Access** – State departments and agencies that have a direct role in health access (e.g., Department of Health Care Services, MRMIB, Department of Managed Health Care, and CDPH) should promote increased access to health care, in order to ensure that at-risk populations are prepared for gradual and extreme climate change events. .

Strategy 2: Educate, Empower and Engage California Citizens, Organizations and Businesses to Take Actions to Reduce Individual and Community Vulnerability to Climate Changes through Mitigation and Adaptation.

Near -Term Actions:

a. **Educational Outreach Campaign** – Incorporate climate change and public health messages into existing education and media outreach efforts. Develop diverse educational materials for diverse populations (e.g., vulnerable communities, school-age children, business, and labor) that focus on the health impacts of climate change. Conduct focused outreach to clinicians and the health sector about the health impacts of climate change, actions the health sector can take to mitigate and adapt to climate change, and prevention and management of climate-related illnesses (e.g., heat illness). Utilize existing resources to disseminate climate-related health information (e.g., bepreparedcalifornia.ca.gov., public health advisories).

b. **Specific Outreach to Vulnerable Populations** – Identify dissemination networks (e.g., CBOs, local government, philanthropic organizations) that can reach vulnerable populations (e.g., outdoor workers and their employers, residents in urban heat islands, asthmatics, immigrants with literacy/language needs) and provide them with information on what they need to know about the risks of climate change, and what they can do to address them, both individually and at the community and state levels.

Long-Term Actions:

c. **Proactive Social Marketing Campaign** – CDPH should encourage and participate in partnerships with local, state and federal agencies, business, and NGOs to develop coordinated social marketing campaigns to reduce greenhouse gas emissions and implement climate adaptation strategies; these campaigns should support local efforts and empower communities to act on their own behalf to minimize the health impacts of climate change.

Strategy 3: Identify and Promote Mitigation and Adaptation Strategies with Public Health Co-benefits.

Near -Term Actions:

a. **Identify and Prioritize Strategies with Co-benefits** – CDPH should identify public health and climate change mitigation and adaptation strategies that offer health and climate co-benefits; strategies with co-benefits should be prioritized. For example, community design ("smart growth") that promotes walking and bicycling to increase physical activity and decrease motor vehicle greenhouse gas and toxic pollutants. When possible, adaptation strategies that increase health risks and/or greenhouse gas emissions should be avoided. (e.g. promoting air conditioner use without changes in electricity production reliance on fossil fuel combustion). Strive to institutionalize the inclusion of public health considerations in all applicable climate change policies.

Strategy 4: Establish, Improve and Maintain Mechanisms for Robust Rapid Surveillance of Environmental Conditions, Climate-related Illness, Vulnerabilities, Protective factors and Adaptive Capacities.

Near -Term Actions:

a. **Monitor Outcomes at State and Local Level** – CDPH should work with local health departments and the health care services sector to increase capacity to monitor the climate related deaths and illnesses associated with heat-related and other events, as well as other climate related illnesses, environmental risks, vulnerabilities, protective factors, and adaptive capacities. Maintain operation of the California Environmental Health Tracking Program, and incorporate the climate health indicators recommended by the Council of State and Territorial Epidemiologists.

b. **Environmental Contaminant Biomonitoring** – CDPH and Cal/EPA (California Environmental Protection Agency) should encourage the development of the existing California Environmental Contaminant Biomonitoring Program to determine the level of contaminants in California residents to help reduce baseline illness and increase community resiliency.

c. **Water Accessibility Information** – Maintain and upgrade the existing Safe Drinking Water Information System, which provides information about public water systems and their violations of EPA's drinking water regulations regarding maximum contaminant levels, treatment techniques, and monitoring and reporting requirements, in order to ensure safe and reliable public water resources.

d. **Heat Warning Systems** – Work with the CDPH Emergency Preparedness Office EPO, CalEMA, and local health and emergency response agencies to develop heat warning systems for regions of the State that have not yet adopted them. These systems should be coupled with existing heat emergency response plans.

Long -Term Actions:

e. **Electronic Surveillance Systems** – The CDPH should continue actions to improve disease reporting, management and surveillance by replacing the current paper based system with a secure electronic system, (CDC is exploring ways to develop rapid surveillance by coordinating with larger entities such as the Regional Health information Organizations (RHIOs) and Health
f. Information Exchanges (HIE). Expand the Electronic Death Reporting System for the continuous monitoring of abnormal death patterns, asthma, and heat deaths. Actions should be taken to consider mandatory reporting of climate-sensitive morbidity and mortality.

g. **Emergency (Event) Monitoring** – Build a real-time data collection system for the daily monitoring of emergencies based on daily hospitalizations data, emergency department care, and diagnostic, laboratory, and prescription information.

Strategy 5: Improve Public Health Preparedness and Emergency Response

Near -Term Actions:

a. **Preparedness Response** – CDPH and local health departments should refine existing emergency preparedness plans and conduct exercises to augment preparedness for events likely to increase with climate change (e.g., heat waves, wildfires, floods), and should develop plans for anticipated impacts such as sea level rise, saline intrusion into drinking water, etc. Public health agencies should also be prepared for the more frequent occurrence of severe heat events in geographic areas where they have previously been very rare (e.g., coastal areas). Fomally request the Centers for Disease Control and Prevention to incorporate climate change response and preparedness as an acceptable use of federal funds for public health preparedness.

Strategy 6: Work in Partnership with Multiple Agencies (e.g., Environmental, Agricultural, Transportation, and Education at Local, State and Federal levels, as well as Business, Labor, Schools and Community-based Organizations).

Near -Term Actions:

a. **Institutional Capacity** – CDPH should work with appropriate state and local agencies to expand training and education to build capacity to respond appropriately to the public health risks of climate change. Institutional capacity needs should be addressed in local health departments, health and social services providers, and mental health agencies (e.g. for post-disaster recovery).

Strategy 7: Conduct Research to Enable Enhanced Promotion and Protection of Human Health in Light of Climate Change.

Near -Term Actions:

a. **Vulnerability Assessments** – CDPH should conduct detailed vulnerability assessments for all the leading climate-change health outcomes (e.g., heat morbidity, valley fever, flooding, wild fires) utilizing locally scaled-down emergency and environmental shift scenarios, including assessments of impacts on vulnerable populations and cumulative impacts, and risk and resilience factors.

b. **Research Collaboration:** – CDPH should encourage the California Energy Commission PIER program to devote more substantial attention to a public health research agenda. CDPH should develop a closer working relationship with the University of California and other universities and NGO's involved with climate change analysis and impacts, and provide greater input to federal agencies conducting climate change research to increase funding and focus on public health impacts.

Long -Term Actions:

c. **Assess Local Impacts of Climate Change on Health** – Apply downscaled climate change predictions and modeling to provide analysis of anticipated local impacts on health.

Strategy 8: Implement Policy Changes at Local, Regional and National Levels.

Near -Term Actions:

a. **Policy Collaboration**: Work with stakeholders to develop federal and state policies to implement adaptation strategies that reduce public health risks related to climate change.

b. **Occupational Safety Standards** – Advise and revise occupational health and safety standards to identify occupations at risk due to climate change.

Long -Term Actions:

c. **Model Policies & Training** – Identify model adaptation policies for local communities, and provide supportive training and technical assistance to facilitate implementation.

d. **Public Engagement** – Initiate the engagement of all sectors of government, thereby including public health issues in all climate change policies they that offer possible co-benefits for climate change adaptation.

Strategy 9: Identify, Develop and Maintain Adequate Funding for Implementation of Public Health Climate Adaptation Strategy.

Near -Term Actions:

a. **Funding Mechanisms** – Develop a comprehensive funding strategy for public health adaptation strategies that utilize a broad range of funding strategies including fees, taxes and grants. Funds should be allocated to both statewide and local efforts, and specifically to local health departments.

Long -Term Actions:

b. **Funding Mechanisms/AB32** – Develop proportional funding proposals for public health research, adaptation and climate resiliency education that addresses Environmental Justice, and is based upon market mechanisms such as carbon auctions and carbon trading.

V. BIODIVERSITY AND HABITAT

Introduction

California is one of the most biologically diverse regions of the world and its vast array of species and habitats make it one of the 25 biodiversity "hotspots" on earth.[1] Hot spots are areas where at least 1,500 species of vascular plants (> 0.5 percent of the world's total) are endemics and where at least 70 percent of the original habitat has been lost. Of all 50 states, California has the most unique plant and animal species, as well as the greatest number of endangered species.[2] The state's extensive biodiversity stems from its varied climate and assorted landscapes which have resulted in numerous habitats where species have evolved and adapted over time. The state's ecological communities include coastal mountain ranges, coastal dunes, wetlands, rivers, lakes, streams, deserts, grasslands, chaparral, and inland forested mountains among others. The vast number of endemic species found in California, combined with the high level of threats to their persistence, makes California a 'hotspot' for biodiversity.[3]

California is one of only five regions in the world with a Mediterranean climate. Habitats in these climatic regions are considered to be more threatened by climate change than tropical forests, since over 40 percent of these lands worldwide have been converted to other uses and less than five percent are protected worldwide.[4] According to some estimates, more than 20 percent of the naturally occurring species of amphibians, reptiles, birds, and mammals in California are classified as either endangered, threatened, or "of special concern" to state and federal agencies.[5] Therefore, the preservation of California's unique biological heritage is of ever-increasing importance given the forecasted impacts associated with climate change.

The economy and the natural resources that sustain human life are dependent upon the state's biodiversity. These species and ecosystems provide numerous goods and services, including provisioning services (e.g., food and timber production, medicines, water and fuels), regulating services (e.g., water purification and carbon sequestration), supporting services (e.g., climate regulation and nutrient cycling) and cultural services (e.g., aesthetic values, and sense of place).[6] Not only do these goods and services support California's economy but they support numerous recreational activities for residents.

Future Climate Change Impacts to Biodiversity and Habitat

A. Increased Temperature

Every species has a temperature range in which it thrives and can survive. Brief exposures to extreme temperature events or repeated occurrences of temperatures outside of the range will stress plants and animals, and will exacerbate environmental pressures exerted by competitors, predators, pests and invasive species, habitat change, varying food and water supplies, diseases, and anthropogenic stressors such as contaminants and habitat fragmentation. As average temperatures rise, plant and animal species will increasingly be confronted by thermal stress This kind of thermal stress will force terrestrial plant and animal species to either adapt to these changing conditions and/or shift their geographical range to more favorable conditions. Shifts in geographical range depend upon availability and accessibility of appropriate habitat, as well as the necessary behavioral and life history characteristics that promote rapid dispersal and establishment of new populations. If species are unable to adapt *in situ* or shift their ranges, local populations may be extirpated and species may face extinction. (Figure 5.2).

Species that cannot adapt in their existing communities may, over time, shift in their ranges if appropriate habitat is available, accessible, and if their behavioral characteristics allow. If they are unable to shift their ranges, they face the threat of local extirpation, if not extinction. The amount of future warming

expected in California may likely exceed the tolerance of endemic species (i.e., those that are native to a specific location and that occur only there) given their limited distribution and microclimate.

Species that have the capacity to shift their ranges will require movement corridors that are not blocked by natural landscape features or human development. Planning to maintain natural corridors in anticipation of predicted climate changes should be factored into future local and regional habitat conservation planning efforts.

Based on current research, we can assume that species occurring together in communities will move independently from each other, not as groups. As a result, communities will reorganize and look differently from what we are familiar with today. For example, cores of fossil pollen from dozens of sites around North America show that in the last Ice Age, boreal tree pollen, which today occurs in the boreal zone in Northern Canada, was common in the Corn Belt of the United States and in areas where mixed hardwood forests exist today. Pollen cores show us that different tree species that were living together then are no longer found together.[7]

Similar stresses and barriers apply to aquatic species whose migratory/movement limitations may be even more limited. Vernal pool and freshwater lake species are likely to be more susceptible to extirpation because their habitats may disappear entirely or if they are unable to emigrate to a new aquatic environment. For example, fish and amphibian species will experience increased stream and lake temperatures that will affect their food supply and fitness. Warmer air and water conditions could also influence the introduction and spread of undesirable species or diseases.

Invasive Species

BIODIVERSITY AND HABITAT IMPACTS DUE TO WARMING

- Barriers to Species Migration and Movement
- Temperature Rise - Lakes, Streams, and Oceans
- Increase in Invasive Species Potential
- Changes in Natural Community Structure
- Threats to Rare, Threatened, or Endangered Species
- Altered Timing of Phenological Events
- Timing Disruptions Between Predators and Prey and Pollinators and Plants
- Loss of Ecosystem Goods and Services

As climate change related impacts increase, the ranges occupied by certain species will change. For example, grassland and desert habitats may expand in the future due to climate change, but these ecosystems' temperature, precipitation and seasonal cycles will be altered by climate change. A changing climate would be expected to shift plant distribution, as well as animal distribution. Although desert plants and animals are adapted to live in extreme environments, even small changes in the components of an ecosystem like temperature, precipitation, seasonal variations can be amplified to cause large changes in ecosystem function[8]. In certain areas of the Sonoran and Mojave Deserts this could mean less species diversity. For example, a Conservation Policy Brief titled "Curbing Greenhouse Gas Emissions will Reduce Future California Bird Loss" published by Audubon California (Monahan, William B. and Gary Langham. "Curbing Greenhouse Gas Emissions will Reduce Future California Bird Loss." Audubon California. February 2009.) predicts that under a high emissions scenario parts of the Sonoran and Mojave Desert will lose 25-50% of their bird species while other areas will lose 50-100% of their bird species. As a result, even species that are native to certain California regions may spread into other regions, creating a new category of 'native invasives' that may alter community structure and species interactions in native habitats.

Disturbance events or extreme weather events thought to increase due to climate change generally benefit invasive species given their tolerance to a wide range of environmental conditions. Invasive species often have greater flexibility and can survive under variable and extreme conditions, such as

flood events or drought. Invasive species also tend to produce large numbers of seeds or young and are capable of long distance dispersal; or have the ability to outcompete native species (especially plants that require no pollination or seed development).

Californians have benefited from the introduction of plant and animal species necessary for food or other human pursuits; however, there are many other introduced species that can wreak havoc on the state's environment and economy. Invasive species threaten the diversity or abundance of native species through competition for resources, predation, parasitism, interbreeding with native populations, transmitting diseases, or causing physical or chemical changes to the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy. Examples of direct impact to human activities include the clogging of navigable waterways and water delivery systems, weakening flood control structures, damaging crops, introducing diseases to animals that are raised or harvested commercially, and diminishing sport fish populations.

Changes to Community Composition and Interactions

Warming has already impacted the seasonal timing of biological events in California, including flowering times, leaf emergence, fall bird migration, and insect emergence[9]. In addition, interactions between climate change, habitat fragmentation and agricultural practices may have critical impacts on pollination services for crops and wild plants. A change in composition can disrupt biological interactions and impact ecosystem dynamics by displacing existing biological interactions and replacing it with another. For example, an earlier occurrence of flowering may result in futile reproduction efforts for pollinators if they are unable to adjust quickly to the change in availability of resources. Changes in pollinator activity will affect dependent species throughout the natural and human food chain.

It is important not to over generalize individual species responses to climate change as either adapting to warmer temperatures or moving to higher latitudes or altitudes[10]. Expected range shifts in response to precipitation and temperature changes may differ[11], and responses to novel climates are difficult to predict. California's complex topography will allow for small-scale changes in slope or aspect as a means of tracking a species preferred climate, and–due to the influence of the ocean–range shifts west and downhill, towards the coast, may occur for some taxa. Furthermore, the state of downscaling global climate model to meaningful ecological scales is still lacking in predictive ability at fine spatial scales.

Ecosystem Services:

Biodiversity in natural ecosystems and working landscapes supports a wide range of ecosystem services that sustain human well-being and the economy of California. Ecosystem services are simply defined as the benefits people obtain from ecosystems[12]. These include carbon sequestration, forage production, timber production, water storage and filtration, crop pollination, soil fertility, fish and game habitat, tourism, recreation and aesthetic values. Ecosystem services can be categorized as **provisioning services** (food, water, timber, and fiber), **regulating services** (the regulation of climate, floods, disease, wastes, and water quality), and **cultural services** such as recreation, aesthetic enjoyment, and spiritual fulfillment; and **supporting services** such as soil formation, photosynthesis, and nutrient cycling. (Millennium Ecosystem Assessment 2005).

Warming, changes in precipitation and increases in extreme events (drought, storms, heat waves, etc.) are expected to alter many ecosystem services, due to impacts on biodiversity and on the structure and functioning of ecosystems[13]. Changes in the geographic distribution of individual species and major habitats will alter the distribution of ecosystem services across the state. For example, potential conversion of conifer forest to evergreen woodlands, forecast for regions of the Sierra Nevada and northern Coast Ranges, would reduce and redistribute timber production. Reduced snowpack, changes in water flows, expansion of reservoirs, and warmer water temperatures will impact freshwater ecosystems, with likely negative effects on many native species. Conflicts between human water uses and management of game and non-game fish populations are expected to increase under future climates.

While demands for ecosystem services such as food and clean water are growing, climate change and other anthropogenic forcings are reducing the capacity of ecosystems to meet these demands (MEA 2005). "By the end of the twenty-first century, climate change and its impacts may be the dominant direct driver of biodiversity loss and changes in ecosystem services globally." (MEA 2005). Managing natural resources within an ecosystems services framework that explicitly acknowledges linkages between ecosystem processes and consequent outcomes to human welfare may be the most effective and economically viable means for protecting people from unsafe drinking water, flooding, and climate change[14] and maximizing conservation of biodiversity[15].

Carbon sequestration is of special interest due to its importance as a tool to offset GHG emissions and contribute to mitigation of global climate change. Proper management of California's ecosystems, including forests, open spaces, and wetlands, may provide significant capture and sequestration of greenhouse gases while simultaneously providing habitats necessary for the long-term conservation of California's biodiversity. As an example, tidal marsh restoration provides protection against erosion, flood control, habitat for many endangered or threatened species, and carbon sequestration services. Hotter and drier climates are projected to cause significant declines in carbon storage in standing tree stocks, and reduced extent of productive conifer forest vegetation[1]. Increased wildfire is also likely to reduce above- and below-ground carbon storage by forests, though the effects will depend on forest management practices[16]. Carbon sequestration represents a critical interface of climate mitigation and adaptation strategy in relation to biodiversity conservation, forest management, and wildfire; the potential contribution of non-forest ecosystems (grasslands, shrublands rangelands, chaparral, and wetlands) is poorly understood and deserves greater attention. Adaptation strategies that simultaneously enhance biodiversity conservation and ecosystem services are critically important to promote sustainable natural ecosystems and human well-being.

B. Precipitation Changes and Extreme Events

Changes in Stream Flow

Flowing water is important because it moves organic material and energy[17]. This movement facilitates the exchange of nutrients between aquatic and terrestrial areas. In terrestrial areas, aquatically derived nutrients help support vegetation and wildlife[18]. Emerging aquatic insects are prey for birds and bats foraging and breeding in riparian areas[19]. Equally important, flowing water moves terrestrial organisms and detritus, which play an important role in aquatic food webs[20].

Current projections for California suggest that precipitation and temperature events will be more extreme. For example, more frequent and intense heat waves can impact heat-sensitive species, reducing fitness and increasing mortality. With more precipitation falling as rain (less snow pack), river flows during the winter and spring seasons will be greater; while reduced snowfall in the winter will result in reduced snowmelt and subsequently lower stream flows during summer months.

One of the first species groups impacted by stream flow change will be fish. Fish reproduction is affected by stream flows in several ways. Increases in winter runoff and earlier spring peak flows are likely to lead to increases in the number of flooding events during these seasons. Early-spring, high-runoff periods or flooding may occur during egg incubation periods for many fish species, thus impacting reproduction. High stream flow could additionally shift streambed gravel, and heighten the risk of damage to incubating eggs; while the emergence of juveniles can be displaced, undermining the reproductive success of species.[21]

Mosquitoes will proliferate in areas where flooding combines with higher springtime temperatures. If these areas are chemically treated to protect human health, non-target invertebrates that feed fish and other aquatic species will be affected. Introduced toxins will have unintended consequences for the entire food chain. (See also Public Health chapter for additional information on climate change impacts to public health.)

As a result of a decrease in snow pack and earlier snowmelt, stream flows are expected to be lower during the summer months and extending into the fall. In addition, reduced stream water depth and higher air temperatures will increase stream water temperatures, to levels that are potentially unhealthy for coldwater fish. Salmonids are temperature-sensitive and rely on precipitation and snow melt. The projected changes in inland water temperatures with changing seasonal flows is projected to place additional stress on these species (Figure 5.3), contributing to the need for increased resources for monitoring and restoration efforts. It is common for adult fish migrating to spawning grounds to encounter obstacles that require high flow conditions in order to pass. If climate change results in reduced stream flows this could impede or halt their progress. A delay in the arrival to spawning grounds may decrease reproductive success and increase fish mortality. Repeated low stream flows during spawning migration periods may naturally select against large adult body sizes.[22]

The projected changes in temperature and precipitation patterns will also affect the distribution and longevity of available surface water. Changes in the composition and structure of riparian communities may result from changes in precipitation and flow and could contribute to increased management conflicts as the needs of humans and wildlife compete for limited resources. Changes in temperature and precipitation associated with climate change may lead to less stored water and will have a direct effect on the survival of aquatic species and the preservation of wetland habitats.[23]

Other factors impacting aquatic species may be exacerbated by changes in precipitation including the timing and amount of river and stream diversions, temperature changes and pollution or sediment load. Alterations in timing and magnitude of high or low water events could impact riparian vegetation and the species that depend on it[24]. Of the 11 California Partners In Flight focal riparian bird species that have suffered population declines over the past 50 years, seven prefer to nest in early successional riparian habitat, particularly willow/alder shrub habitats with dense understory cover (RHJV 2004). One species (Bank Swallow) depends on regular high-water events to create exposed riverbank sites for nesting, but abrupt changes in water level during breeding can cause total reproductive failure (RHJV 2004). To flourish, early successional habitats depend upon natural hydrology, including flooding, soil deposition, and point bar formation, for establishment[25]. Seed dispersal and natural tree regeneration and growth can be compromised due to the absence of high peak flows or seasonal fluctuations in water levels[26].

BIODIVERSITY AND HABITAT IMPACTS DUE TO PRECIPITATION CHANGES

- Stream Flows - Impact to Fish Passage
- Distribution/Longevity of Surface Water, Impact to Wildlife
- Changes in Riparian Communities and Structure
- Decreased Water Availability – Fish, Wildlife, and Plants
- Water Temperature, Pollution and Sediment Load Changes
- Impacts to Water Dependent Species
- Surface Water Allocations - Impact All Water Users (humans & wildlife)
- Increased Susceptibility to Pests, Disease, Wildfires & Invasive Species
- Habitat Conversions - Changes in Biodiversity

Floods and Droughts

Aside from the impacts of high-runoff events and flooding on stream habitats and fish populations, periodic floods have always been a part of the formation of landscapes and ecosystem processes. Species and ecosystems in riparian habitats are largely adapted to such events. Many California land use decisions, however, have created conditions that have separated streams and rivers from their historical floodplains through either construction of levees, development on floodplains, or both. These activities reduce the adaptive capacity of remnant riparian ecosystems, especially if flooding is projected to increase in late winter and spring as a result of climate change. When riparian habitats are adjacent to urbanized areas, increased flooding can burden these ecosystems with heavier and sometimes more toxic sediment deposits. In the highly developed coastal floodplains, where storm-related coastal flooding may coincide with high tides and stream runoff,

ecosystems will face great challenges. Likewise, the projected increase in drought conditions will further impact stream and terrestrial habitat quality as well as the adaptive capacity of ecosystems to continue to provide their goods and services.

Prolonged periods of drought can make ecosystems vulnerable to pests, non-native species invasions and frequent and intense wildfires. Moreover, reduced rainfall and snowmelt will lead to less water infiltrating the soil, stressing plants and animals. This reduced infiltration rate will also diminish groundwater recharge. Lowered levels of groundwater, combined in coastal areas with saltwater intrusion, will exacerbate dry conditions and further stress species and habitats. As an example, likely reductions in precipitation and higher variability in precipitation, both within and among years are likely to reduce survival of young seedlings, which are particularly susceptible to drought stress and has serious implications for the ability of ecosystems to recover from disturbance both natural and by active restoration (See also Forestry sector). Together, all these changes in water availability can cause landscape transformations as conditions select for species that require less water (see the Water chapter for more discussion on climate change impacts on freshwater ecosystems and species).

Wildfires

Fire plays an important role in the condition, function, and distribution of many of California's natural habitats and has done prior to and since human settlement. Aspects of fire regime, frequency, intensity, severity, magnitude, and pattern, have fluctuated over time. Since the 1980s, the state has recognized apparent changes in the frequency, intensity, and duration of wildfire, especially in conifer-dominant ecosystems in the Sierra Nevada and chaparral ecosystems in coastal and interior southern California.. Land-use, land management, and fire suppression policies, particularly in conifer forest and chaparral communities, are thought to have affected attributes of fire regimes throughout human history. In recent years, researchers have determined that changes in climate have had an important role in altering fire regimes. Current information suggested an extension of the fire season and increasing the number of large wildfires, as well as wildfire intensity. Particularly, higher spring and summer temperatures and earlier spring snowmelt are thought to have contributed to these changes.[27] Wildfire occurrence statewide could increase from 57 percent to 169 percent by 2085 under the A2 (higher) emissions scenario and by more than 100 percent in most northern California forest in all SRES A2 scenarios by 2085[28].

In one climate change scenario, potential fire fuels can build up during wet years when plant production is high. Preconditions for catastrophic wildfires will occur if ensuing weather conditions include decreased precipitation or drought that dries out the accumulated fuel. Large scale and intense wildfires could result in vegetation and habitat alterations, resulting in displacement of local species for variable amounts of time, sometimes years or complete extirpation. In addition, the recruitment of invasive grass species in fire-disturbed areas can increase fine fuel loads, resulting in greater fuel continuity, frequency, and rate of spread.[29]

Most California vegetative communities experience fire on a regular basis, but it is essential to take note that historical fire regimes differ enormously between different vegetation types, and these differences lead to very different management challenges. Exclusion of fire or altering its regional fire regime attributes will alter the systems and both eliminate animal species and change, if not decrease, existing biodiversity. Some of the wildlife benefits of wildfire include the (1) recycling of dead and downed vegetation and creation of new deadwood and snags,[ii] (2) cycling of soil nutrients, (3) removal of excess, woody vegetation which provides for herbaceous plants and younger plants to grow and new and palatable vegetation for herbivores, (4) opening up of the under story for browsing for larger wildlife species, and (5) creation of tree holes utilized by cavity-nesting birds, bats, and arboreal mammals. These benefits are typically derived from low- to moderate intensity fires, and in some cases, depending on the vegetation community, infrequent, high-intensity fires. However, benefits are not derived from the

[ii] One of the most crucial habitat elements for woodland and forest invertebrates, vertebrates, and fungi.

more frequent, high intensity wildfires that California has experienced in recent years, especially in conifer systems in the western Sierra Nevada and chaparral systems in southern California.

More frequent fires help manage fuel loads in forested communities. However, some lands do not behave this way ecologically and will not survive the increase in fire frequency that has occurred and is likely to be exacerbated by climate change. For example, in southern California coastal and interior chaparral (including coastal sage scrub communities) increased fire frequency is the primary threat to maintaining ecological integrity and ecosystem services over time. These systems are adapted to a fire return interval of 60-150 years[30] on average and too frequent fire has been shown to cause habitat type conversion in addition to increasing pathways for invasive occurrences. This altered frequency has resulted from an increase in the human presence at the wildlife urban interface and associated increase in the anthropogenic ignition combined with extreme wind events. Because of this, management strategies for fire in southern California chaparral and areas of similar circumstance might need to focus on ignition prevention.

Vegetation and wildfire management, including mechanical vegetation reduction, prescribed fire, use of wildland fire, and restoring lands post-wildfire, have to consider the current fire regime operating in the vegetation type and ecological zone and the desired fire regime. The "right kind of fire" is the fire that will enable a vegetation community to sustain itself within all the other ecological considerations [soil dynamics, hydrology, biotic community, weather and climate, etc.). How vegetation fuels management is done and how fire prevention activities are carried out should always focus on being able to re-establish the landscape to support an appropriate, acceptable fire regime. Strategies related to fire must consider these differences, focusing on the idea of the 'right kind of fire' in different systems. For example, California State Parks burns under controlled conditions about five percent of what they deem necessary. Prescribed burning in many forested areas, including old growth, is not possible until heavy understory fuel accumulations have been reduced manually or by mechanical means before burning takes place. Regulatory requirements, e.g., air quality and listed species protection, can also impact or reduce prescribed burning activities.

When it comes to current vegetation community and fuel condition versus desired vegetation and fuel conditions, land managers [fire, fuels, etc.] should have a plan that can be used over a period of time to alter conditions as appropriate within fiscal, time, management, and ecological constraints. This type of integrated fire and fuels management and planning are important given climate change concerns. Agency(ies) should have a land management plan that clearly articulates how and when vegetation will be altered in order to achieve a level of composition and structure that is both viable ecologically [including fire regime] and socio-politically. As an example, the Department of Fish and Game, includes a fire and fuels management section within land management plans for all properties owned or managed by the Department.

Fire prevention and natural resource managers across the state must work together to support key fuels management measures to find a balance between protecting the public, existing infrastructure, and the essential ecological role that fires play in ecosystems (see the Forestry chapter for additional information on climate change impacts on forests and wildfire).

C. Sea-level rise

California's coastal areas include a variety of habitats that range in their characteristics from purely aquatic, to semi-aquatic, to terrestrial. All habitats are influenced by periodic flooding by tidal waters, rainfall, or runoff. These wetlands, dunes, and rocky habitats are home to a vast number of organisms, including many endangered species. During certain periods, wetlands harbor juveniles of numerous aquatic species including fish and shellfish. Wetland habitats from the Sacramento Valley southward to

the Salton Sea and the tidal marshes of San Francisco Bay also provide essential wintering habitat for hundreds of thousands of birds as they migrate north and south along the Pacific Flyway. Humans additionally benefit from the ability of healthy wetlands to buffer storm impacts, reduce shoreline erosion, improve water quality, and provide beautiful areas for recreation.[31]

Located between sea and land, coastal habitats have developed as a result of dynamic changes over time. Accelerating sea-level rise may overwhelm their natural capacity to keep up and concurrent stresses and pressures due to development and land use decisions further threaten these habitats. Existing stresses include ongoing discharge of organic wastes fostering eutrophication, legacy of organic pollutants and other toxic substances, pathogen loading, sediment and freshwater delivery alteration, thermal pollution, direct wetland infill and destruction with subsequent habitat loss, bottom disturbance from fishing practices and recreational boating, extraction of living and non-living material and influx of invasive species.[32] Thus, the biodiversity and habitats of coastal areas may be particularly impacted by sea-level rise and other climatic changes.

Some coastal habitats, such as wetlands and dune habitats can become permanently inundated and eroded if sea level rises faster than these ecosystems can move inland. Moreover, inland migration is frequently hindered by development such as bulkheads, seawalls, roads, and buildings. Continued growth and development in coastal areas will only increase the direct pressure on remaining habitats and make inland migration more difficult. Sea-level rise, especially at the increasing rates projected for the 21st century, may result in the loss of substantial areas of critical habitat for a variety of coastal species.[33]

The degradation of sensitive ecosystems can be brought about not just by higher sea levels but also by other climate changes, including higher temperatures and changes in precipitation patterns, which together can facilitate the establishment of invasive species such as European beach grass. Both aquatic and terrestrial coastal ecosystems may thus see further increases in problems with invasive species.[34]

Sea-level rise will also result in salt water intrusion into fresh water resources near the coast, reducing the amount of fresh water available for plants, wildlife, and competing agricultural and metropolitan uses. Species with greater salt tolerances may have a selection advantage where habitats can naturally transform, without human interference. Sea-level rise, in conjunction with coastal storms, may also lead to coastal flooding that extends further inland, thus increasing the risk of pollution, runoff, and sedimentation in fresh water sources of previously unaffected areas. This degradation of fresh water in near-coastal areas may aggravate conflicts over water for human uses versus ecosystem and species needs.

There will also be shifts in the type and location of agriculture as saltwater intrudes into coastal aquifers and natural recharge of groundwater resources decreases with the drying climate. Water transfer and management impacts may become increasingly complex, as there may be impacts to hydropower and hatchery project operations as well as water diversion projects.

Changes to the timing and intensity of freshwater input may impact marine and near shore populations through increased runoff resulting in pollution and sedimentation contamination and shifts in urban growth and development will place new or increased pressure on existing coastal resources and available habitat. Inundation of coastal infrastructure could cause widespread pollution and contamination further jeopardizing marine and near-marine environments. Changes in ocean circulation and ocean warming will impact pelagic species distribution and community structure. In addition, ocean acidification could impact shellfish species as well as their prey base. Protected areas such as ecological reserves, wildlife areas, undesignated lands, mitigation sites and easements could also be affected, and require management decisions that protect California's natural resources. These challenges and many more will require close coordination with those entities implementing the oceans and coastal adaptation strategies. Please refer to the Oceans and Coastal Resources chapter for additional information.

Monitoring and Adaptive Management

Adaptive management is a key element of implementing effective conservation programs especially in light of some of the uncertainties associated with climate change. Natural communities, ecosystems, species population dynamics, and the effects of stressors on the environment are inherently complex. Wildlife and resource managers often are called upon to implement conservation strategies or actions based upon limited scientific information and despite considerable uncertainties.

Adaptive management combines data from monitoring species and natural systems with new information from management and targeted studies to continually assess the effectiveness of, and adjust and improve, conservation actions. It is important to keep in mind that the outcomes of management interventions in the face of climate change differ markedly in their predictability and while some management strategies will be robust to different future climates, others will not. Successful management will require strategies in which management actions are coupled with monitoring to provide informative feedback loops however, despite uncertainties in future projections; managers can begin to actively address climate change now[35]. .California's Wildlife Action Plan summarizes an approach to adaptive management and addresses the steps and considerations needed to design a monitoring program in an adaptive management context.[36] California's Wildlife Action Plan also provides a framework for establishing monitoring programs central to the implementation specific climate change adaptation strategies detailed in this document.

D. Risks for Biodiversity and Habitats

In summary, some of the current and future climate change impacts to biodiversity expected in California include:

- Temperature-sensitive terrestrial plant and animal species must adapt to warmer temperatures within their existing ranges and/or shift their geographical range in response to climate changes. These shifts may occur towards higher latitudes, higher elevations, cooler coastal environments, or local microclimatic refuges, depending upon interactions with precipitation, topography and soils, and species behavioral and life history characteristics.

- The amount of additional warming expected in California in the future may exceed the tolerance of some species, particularly endemic ones. Where relocation access is blocked off by natural landscape features or human development, species will need corridors to establish habitat connectivity or face a growing risk of extinction.

- Similar stresses and barriers apply to aquatic species, but their migratory limitations may be greater.

- The problem of invasive species is likely to become even more challenging in the future, as invasive species are typically more competitive than native species especially in damaged/degraded environments.

- Species migration/movement and invasions, along with changes in behavior of climate-sensitive species, will alter species interactions and community dynamics; these changes may have negative effects on critical ecosystem services.

- Changes in precipitation patterns will alter stream flow and severely affect fish populations during their life cycle. Low-flow conditions and higher stream flow temperatures are particularly threatening to coldwater fish.

- Human activities across the state have reduced the ecological integrity of many areas as well as the levels of biodiversity. Climate change will act synergistically with existing stressors to have an even greater impact on already stressed ecosystems.

- Longer fire season trends over the last three decades and increased numbers of large, intense wildfires are projected to continue, increasing the risk of vegetation and habitat conversion, spread of invasive species and losses in biodiversity, and ecosystem goods and services.

- Accelerating sea-level rise, especially at the increasing rates projected for the 21st century, may result in the loss of substantial areas of critical habitat for a variety of coastal species. Both aquatic and terrestrial coastal ecosystems may see growing problems with invasive species.

- Sea-level rise will result in salt water intrusion into fresh water resources near the coast and reduce the amount of fresh water available for plants, wildlife, and competing agricultural and metropolitan uses.

- The preservation of healthy, resilient ecosystems with a rich plant and animal biodiversity is critical to the health, safety, and welfare of human populations. Human development has already reduced, degraded, and fragmented natural communities. This alone threatens the survival of individual species and some rare ecosystems.

BIODIVERSITY & HABITAT IMPACTS DUE TO SEA-LEVEL RISE

- Inundation of Permanent Coastal Habitat
  - Alteration of Dune Habitat & Coastal Wetlands
  - Coastal Habitat Loss of Migratory Birds, Shellfish & Endangered Plants
- Reduction of Fresh Water Resources Due to Salt Water Intrusion
- Sedimentation Increases May Increase Pollution and Run Off
- Degradation of Aquatic Ecosystem
- Increase in Invasive Species
- Competition for Coastal Land Areas
  - Shifts in Urban Growth and Development
  - Agricultural Relocation
  - Alterations of Ecological Reserves, Wildlife Areas, Undesignated Lands, Mitigations Sites & Easements
- Groundwater Recharge & Overdrafting
- Water Management & Water Transfer Conflicts
- Reduction in Wetland Habitat on Commercial and Sport Fisheries

Biodiversity and Habitat Adaptation Strategies

Introduction

The impacts of climate change will be significant and far reaching; requiring coordinated and targeted efforts to protect California's biodiversity. The adaptation strategies developed for this document provide a roadmap of actions that help maintain and restore processes that enhance ecosystem function and protect California's rich biodiversity. Existing stressors such as growth and development, water management conflicts, invasive species, and other widespread stressors identified in California's Wildlife Action Plan will act synergistically with climate change.[37] Investing and implementing these strategies will increase the capacity to deal with uncertainty and ensure that California's natural resources are maintained for generations to come. The state agencies that participated in the Biodiversity Sector Working Group (Department of Fish and Game and State Parks) developed the following strategies and are committed to implementing these strategies as capacity and resources allow. The strategies detailed in this document are part of a more detailed effort that can be reviewed on the Department of Fish and Game's climate change web page.[38] Please note that the strategies developed for this document generally address all natural areas above high tide. The continuum of habitat below high tide includes bays, estuaries, coastal wetlands and open ocean waters were not included (for additional information see the Oceans and Coastal Resources chapter).

Climate Change Adaptation Strategies to Conserve California's Biodiversity

- Create a large scale well connected, sustainable system of protected areas across the State.
- Manage for restoring and enhancing ecosystem function to conserve both species and habitats in a changing climate.
- Adjust management actions as appropriate for threatened and endangered species
- Prioritize research needs and pursue collaborative partnerships with the research community to ensure that the best available science is informing management actions.
- Re-evaluate existing policies and programs to incorporate climate change and seek regulatory changes as appropriate
- Pursue endeavors that will support implementation of the strategies including funding, capacity building, collaborative partnerships, and education and outreach.

The Biodiversity/Habitat adaptation strategies provide a range of goals and objectives to help conserve biodiversity in the face of a changing climate. Detailed planning and subsequent actions are needed to implement these strategies. Before meaningful action can be undertaken, the Departments under the Natural Resources Agency should evaluate existing programs and projects that might contribute to the overall goals detailed in the following strategies and actions and carefully examine adaptation strategies in other sectors that may enhance or detract from the facilitation of biodiversity adaptation. Examples include long-term collaborative efforts that will help the state reach its goal of preserving and sustaining the largest possible array of biological diversity and habitat in all ecological regions of California. In the face of a changing climate it is imperative that Departments work to maintain healthy, connected, genetically diverse populations; improve and enhance ecosystem function of existing habitats; reduce non-climate stressors on ecosystems; develop adaptive management models for game and commercial species management; and adopt adaptation approaches that reduce risks to species and habitats while providing adequate time for species evolution and development if appropriate.

At the heart of these strategies is the need to create and maintain a network of reserve areas across the state that builds on existing conservation investments (e.g., acquisitions, easements), and provides refuge areas, and aids the movement of species within reserve areas as they adjust to changing conditions associated with climate change. Establishing a system of priority sustainable habitat reserves should provide for protection of habitat in all nine ecological bioregions identified in California's Wildlife

Action Plan. Reserves should represent to the extent practical all aspects of ecosystem structure, composition, and function within aquatic, terrestrial, and near-shore marine habitats. In addition, any effort to establish a system of priority reserve areas should follow the basic principles of reserve design that will provide protection for species in the interim before species migration/movement due to climate change is wholly understood. In the future, a reexamination of the reserve system and species movement must take place and modifications for future protected areas identified.

The reserve system is intended to provide connectivity for species movement between current and future suitable habitats (primarily within each identified reserve), while also accommodating range shifts of regionally-limited native plant species, and offering protection from catastrophic loss (e.g., through fire, flood, disease, invasive species). Climate change corridors should facilitate movement and incorporate temperature, soil and elevational gradients that benefit a suite of species. Management and restoration efforts on the network of reserve areas should be elevated in priority and focus on reducing the environmental stressors on plant and animal species and habitats.

Reserve system areas should be identified in the near-term for use in current and future land use planning efforts. It is important to acquire and protect habitat linkages found within and around designated reserve areas. Other important acquisitions may include acquiring fee title or conservation easements that focus on but are not limited to the following parameters: (1) increase soil, latitudinal and elevational gradients, (2) accommodate movement and migration of multiple endemic species, (3) reduce outside threats by improving reserve boundary configuration, and (4) protect evolutionary hotspots. Individually or collectively all these measures increase the overall protected area and provide for greater heterogeneity.

Identifying, improving, and connecting these reserve areas will help maintain and increase ecological integrity and provide healthy, resilient habitat and refuge areas to help species persist in a changing climate. For some species these areas may allow them to adapt to new conditions associated with climate change. Adapting to climate change through evolutionary change is an important factor affecting the fate of many plant and animal species. The success of the strategies identified in this document will be in part driven by when and how species may adapt or adjust to their surroundings. A better understanding of natural rates of adaptation through evolutionary change may permit effective management strategies that will help species persist and guide future conservation activities and investments. Species are pushed more rapidly to change where strong natural selection is working in a single direction. However, it is unknown if a single climate change factor will be strong enough to push rapid adaptation. For example, higher temperatures and drought stress may not exert similar selection pressures. Rapid evolutionary change provides a greater chance of species survival and is an important factor in establishing strategies for adaptation of biodiversity and habitat.

Adaptation Strategies and Actions

Over the last year the Department of Fish and Game and California State Parks have made climate change a priority in addressing the complex and large scale challenges needed for conserving biodiversity and habitat. Both of these Departments are an important part of the climate change solution and are working collaboratively with stakeholders to create strategies for addressing climate change impacts while responding to public needs. Initial planning efforts will lay the ground work for achieving the goals of these strategies as efforts are made to help species persist in a changing environment. As a first step, the Department of Fish and Game and California State Parks are committed to building upon the existing frameworks and programs, addressing internal policies related to regulatory responsibilities, and communicating openly with our partners and the public.

To this end, the Department of Fish and Game has created a new climate change advisor position to coordinate the Department's activities. Efforts are also underway at California State Parks (pending available funding) to develop a similar staff position. To meet the growing activities surrounding climate change, existing staff have been tasked with new climate change responsibilities and in some cases have been redirected to work on climate change issues.

The following climate adaptation strategies include both near-term actions which have been either identified, proposed, initiated, or can be completed by 2010. The long-term actions include those recommendations that will require additional collaborative efforts with multiple state agencies, as well as sustainable funding and long-term state support.

Adaptation Strategies and Actions

Strategy 1: Establish a System of Sustainable Habitat Reserves

The intent of this strategy is to identify and improve a statewide landscape reserve system to protect the maximum number of representative plant and animal species in California. The system should include relatively large (e.g., 150,000 plus acres), if possible, reserves in all ecological regions. This size should be adequate to support the maintenance of ecological processes and entire ecosystem function and populations of target species. It is a fair assumption that larger reserves generally have greater carrying capacity and built-in connectivity between included habitats, however, the potential contribution of a mosaic of smaller interconnected reserves is significant, with increased attention to the biodiversity value of intervening working landscapes; in many places, such a network may be the only feasible alternative left due to habitat fragmentation. Reserves should include federal, state, local and nonprofit protected habitat areas and matrix lands consisting of working landscapes (i.e., industrial timberland, agricultural lands, and rangelands) conservation easements, and mitigation lands. Conservation priorities will need to consider sites that have landscape features that are better able to buffer the projected changes in climate. Examples of these types of landscape features include, but are not limited to climatic and elevational gradients; microclimates; groundwater resources; and low fragmentation. Each reserve should include a core area(s) of protected, heterogeneous habitat, including representative aquatic and terrestrial environments..

Near -Term Actions:

- **Organization of Collaborating Entities** – Initiate the development of a working structure that would include a facilitator and key entities (including a scientific panel) that will work together to identify a statewide reserve system and provide scientific expertise. Participants should be from the major land management and acquisition entities around the state, and federal and multi-organizational partnerships including but not be limited to the State Department of Fish and Game, State Parks, State Coastal Conservancy, the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, US Geological Survey, Bureau of Land Management, academia including the University of California Natural Reserve System, representatives of working landscapes, and the Nature Conservancy and other conservation partners. In addition, multi-organizational partnerships provide important opportunities to engage and help achieve goals including the USGS Global Change Science Strategy, USFWS Climate Change Strategic Plan, and the Bay Area Ecosystem Climate Change Coalition.

  a. **(See Strategy 4.a)**

    i. **Incorporate Latest Science** – Participants identified in strategy 1a should establish policies, priorities, and actions based upon the best available science and incorporate new scientific information into adaptive strategies (iterative approach) when available. Give research priority to monitoring keystone species, selected species, species interactions and the influence of abiotic ecosystem components on species adaptation or movement relative to reserves and unprotected lands.. In addition pursue opportunities to centralize database management and increase information sharing.

    ii. **Incentives for Private Conservation** – Participants identified in strategy 1a should provide, where feasible, incentives for the conservation of private lands and working

landscapes (including the creation and maintenance of habitat on private lands) and prioritize those at greatest risk.

b. **Best use of California's Wildlife Action Plan (Action Plan)** – The Action Plan is already proving to be an important blueprint for how the Department of Fish and Game will address future and current climate change challenges and will play a significant role in identifying a course of action.

c. **Setting Priorities for Conservation** – The Department of Fish and Game's Areas of Conservation Emphasis (ACE) mapping effort involved a statewide prioritization of areas considered to be of highest conservation value. The ACE effort is still in its preliminary mapping phase but is intended as a tool to directly support efforts to create a system of priority sustainable habitat reserves across California. The ACE mapping effort will to the extent practical incorporate climate change projections and vulnerabilities. In addition, the ACE can be used in conjunction with other mapping efforts to identify areas overlooked within biological subregions to ensure representative examples of every ecotype have been accounted for. This effort will also help identify linkages and corridors that will help aid species movement and migration. The Department of Fish and Game is committed to continuing coordination with our conservation partners as the final ACE maps are developed and informing all levels of government to better build collaboration and focus resources to the highest priorities. Additional conservation priorities will include consideration of California State Parks reports identifying Key and Representation Parklands and Key Watersheds. These areas have been found to be the most significant habitat areas that are linked to other large blocks of protected habitat. TNC's priority conservation areas should be included in the overall review of conservation strategies in all ecoregions.

Long -Term Actions:

d. **Update Existing Statewide Priorities** – Each entity in the above strategy should consider updating existing statewide planning priorities as appropriate to contribute to the design of a state reserve system. Statewide planning efforts include California's Wildlife Action Plan, Areas of Conservation Emphasis mapping effort (Department of Fish and Game), Natural Communities Conservation Planning (Department of Fish and Game), key and representative large natural parks (DPR), and statewide portfolio areas (The Nature Conservancy).

e. **Reserve Design** – Collaborating entities should use public ownership and other protected area maps and priority areas in efforts to design reserves in all ecological regions.

f. **State Agency Review** – Review of draft reserves and the connectivity corridors should take place with key state agencies and their associated departments such as the California Natural Resources Agency, the Department of Transportation, the Department of Food and Agriculture, CAL FIRE, and the Department of Water Resources to ensure the adaptation plans from each department are complementary. Where synergies exist, focus would be on utilizing resources efficiently. Where potential conflicts in plans and their implementation exist, solutions should be negotiated to provide maximum flexibility for adaptive responses.

g. **Regional Review** – Review of draft plans for location of reserve areas should take place with key regional conservation planning groups in all regions. In addition, for each reserve participants should assess risk of habitat conversion, general condition and integrity, methods for land protection, and public access.

h. **Ratification** – Final design should be adopted by state and federal land management and acquisition agencies of the California Biodiversity Council. In order to better facilitate improvement and focus of the reserves over time, lead agencies should be identified for each reserve.

i. **Develop implementation incentives for participation by private landowners and local land use agencies** – Pursue incentives to increase participation in implementation by private landowners and regional and local land use authorities. Private landowners are often able to effectively and efficiently provide critical habitat on working landscapes and are a key component of this strategy.

j. **Improve Reserve System Functionality** – Support research that indicates how to improve ecological integrity in reserve areas through acquisition or other forms of land protection that do the following: provide internal and external connectivity, increase soil elevational or latitudinal gradients, protect private lands from habitat conversions, enlarge the reserve consistent with endemic species movement, improve configuration of protected lands, and protect evolutionary hot spots.

k. **Adaptive Management-Review of Reserve System** – Periodically the state will need to evaluate and review the long-term success of the Statewide Reserve System in conserving species and new habitat configurations associated with climate change. Determine degree of success of reserves and their improvements in light of keystone species movement as well as monitoring population numbers and viability. This kind of monitoring will be key to understanding what is and is not working to inform management actions and make decisions about whether to adopt new strategies, e.g., modifications to reserve system as appropriate.

l. **Remove Federal Barriers** – Pursue modifications to laws, regulations and practices that provide barriers to linking protected areas especially those that impede the National Park Service, U.S. Forest Service and U.S. Fish and Wildlife Service from land acquisition that creates important landscape linkages and improves the reserve system beyond Congressional boundaries and encourages federal assistance that would strengthen the landscape reserve system.

Strategy 2: Management of Watersheds, Habitat, and Vulnerable Species

Maintaining and restoring ecosystem function is a cornerstone of natural resource adaptation. As appropriate the State will need to determine whether to pursue actions that increase the resistance to climate change, promoting resilience, enable ecosystem responses, or realign restoration and management activities to reflect changing conditions[39]. Actions intended to resist climate change forestall undesired effects of change and/or manage ecosystems so they are better able to resist changes resulting from climate change. Resilience focuses on managing for "viable" ecosystems to increase the likelihood that they will accommodate gradual changes related to climate and tend to return toward a prior condition after disturbance. Response is an intentional management action intended to accommodate change rather than resist it by actively or passively facilitating ecosystems to respond as environmental changes accrue.

Realigning management activities focuses on the idea that rather than restoring habitats to historic conditions, or managing for historic range of variability the managing entity would realign "restoration" and management approaches to current and anticipated future conditions[40]. Since species will respond differently to climate change and strategies will need to evolve as research and monitoring produce new information the State will need to establish a clear process to identify priority species and systems for adaptation management projects as a short-term action and include an adaptive management response.

Near -Term Actions:

a. **Integrate Climate Change into Field Management** – Each land managing entity in the state should commit to reviewing and modifying current land and resource management objectives and practices to reduce environmental stressors and improve watershed conditions and ecosystem services on major holdings.

b. **California Wildlife Action Plan (Action Plan)** – Local, regional, and state wide land use and conservation plans should incorporate important regional actions to improve habitat and animal populations identified in the Action Plan. These actions should be considered priorities for implementation of stewardship efforts.

c. **Use and Improve Existing Conservation Efforts** – Department of Fish and Game's Natural Communities Conservation Program, Areas of Conservation Emphasis and mitigation banking should be continually supported as effective methods of identifying and protecting priority habitat areas. With appropriate resources these programs could use dynamic habitat-based models to improve identification of conservation areas.

d. **Field Restoration and Improved Protection** – Managers of conservation lands, including working landscapes, should continue restoration and other land stewardship practices. State and federal agencies should seek resources and expertise that will help them expand capacity to reduce environmental stressors, improve watershed conditions and restore ecosystem services on priority lands Reducing stressors includes but is not limited to:

   i. Eliminating or controlling invasive species
   ii. Restoring natural processes as appropriate
   iii. Maintaining natural disturbance regimes
   iv. Reduce unnatural sediment flows by improving drainage and maintenance of unpaved roads
   v. Remove barriers to terrestrial and aquatic species movement
   vi. Reduce risks of catastrophic wildfire
   vii. Reduce and/or control pollution from runoff and flooding.

e. **Restore Aquatic Habitat** – With appropriate resources prioritize conservation and management actions on aquatic systems (including but not limited to associated floodplains, riparian zones, springs, and marshes) for monitoring and restoration efforts that will reduce stress on species resulting from events associated with climate change (i.e., increased sedimentation from flooding events). Management actions to assist in the reduction of existing stressors include, but are not limited to:

   i. Maintain and increase genetic diversity of all native anadromous spawning runs
   ii. Protect cold water resources
   iii. Maintain habitat complexity
   iv. Connect river/streams and floodplains
   v. Protect high elevation alpine meadows, springs, and riparian areas
   vi. To the extent possible limit interaction between wild and hatchery fish
   vii. Temper unusual high and low flows
   viii. Restore estuaries, sloughs and marshes

Long-Term Actions:

f. **Managing Endemic and Other Priority Species** – Identify movement patterns of key species, especially latitudinal and elevational movement patterns in order to inform restoration and other stewardship activities that will aid in the conservation and management of species and habitats.

   i. Identify climate change impacts to declining and vulnerable species and integrate climate change adaptation strategies into their management.

   ii. Develop and implement recovery plans that analyze, among other factors, the effects of climate change on declining and vulnerable species and outline conservation strategies for their persistence and recovery under changing climate conditions.

   iii. Prioritize monitoring and research necessary to identify species threatened by climate change.

g. **Restoration Cost/Benefit Assessment and Climate Change** – Develop guidance for restoration practitioners to determine whether the objectives of large-scale restoration project take into account climate change scenarios and encourage the use of risk analysis to inform project planning and implementation.

h. **Minimizing catastrophic events and habitat conversions** – Develop management recommendations that minimize habitat conversions and other large scale losses from catastrophic events, including crown fire, flooding, invasive species, diseases, pests and pathogens.

i. **Establishing Priorities** – Develop criteria for determining where limited conservation resources should be placed in order to have the most benefit.

j. **Water: Enhance and Sustain Ecosystems** (see also Water Management Chapter)
   i. Water management systems should protect and reestablish contiguous habitat and migration and movement corridors for plant and animal species related to rivers and riparian or wetland ecosystems.
   ii. Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains.
   iii. The state should work with dam owners and operators, federal resource management agencies, and other stakeholders to evaluate opportunities to introduce or reintroduce anadromous fish to upper watersheds.
   iv. The state should identify and strategically prioritize for protection lands at the boundaries of the San Francisco Bay and Sacramento-San Joaquin Delta that will provide the habitat range for tidal wetlands to adapt to sea-level rise.
   v. The state should prioritize and expand Delta island subsidence reversal and land accretion projects to create equilibrium between land and estuary elevations along select Delta fringes and islands.
   vi. The state should consider actions to protect, enhance and restore upper watershed forests and meadow systems that act as natural water and snow storage.
   vii. The state should consider whether there are other geographic regions where these assessments should also be applied.

Strategy 3 - Regulatory Requirements

Near-Term Actions:

a. **CEQA Review/Wildlife** – The Departments within the Natural Resources Agency will continue to use the California Environmental Quality Act (CEQA) process to address the climate change impacts from projects on wildlife, including cumulative impacts.

b. **CEQA Review/Department Guidance** – The Department of Fish and Game will initiate the development of internal guidance for staff to help address climate adaptation and to ensure climate change impacts are appropriately addressed in CEQA documents

Long-Term Actions:

c. **Adaptive Capacity/CEQA Thresholds** – Based on climate change scenarios, the Department of Fish and Game should work to develop thresholds of significance for the adaptive capacity of species related to any direct, indirect and cumulative impacts of projects.

d. **Local Government Collaboration** – State Agencies that have regulatory authority and the Governor's Office of Planning and Research (OPR) should work with local land use planners and encourage local governments to adopt climate change adaptation actions for conservation, land use, research and regulatory measures.

e. **Sustainable Funding Mechanisms** – Achieve consistency in state and local regulations, general plans, and ordinances and develop sustainable funding mechanisms to support climate change planning efforts that focus on biodiversity conservation.
   i. The Natural Resources Agency and appropriate Departments should review and make recommendations to amend regulations to achieve consistency. This could be done through the Strategic Growth Council (SGC).
   ii. The state could work with local governments to develop consistency between state goals and local general plans and ordinances.
   iii. The SGC could develop funding programs to institute sustainable funding mechanisms to support climate change planning. The SGC may need to propose legislation to institute those funding mechanisms.

f. **Climate Change Models** – The state should continue to support climate change research and modeling efforts that support conservation and management of biodiversity in a changing climate. These kinds of modeling activities might include but are not limited to flow requirements for fish bearing streams that will help the Department of Fish and Game dedicate new instream flow requirements and develop new policies to address variances.

Strategy 4 - Research and Guidelines

Long-Term Actions:

Establish a Permanent Biodiversity Research Team – Appoint a permanent team of researchers and land managers to ensure that the best available science is used in management, restoration, and species protection. This team will be responsible for ensuring that state funded research is properly reviewed, annotated, and made publicly available to the conservation community and land use planners. In addition, the team will be responsible for identifying data gaps and research needs and coming up with a plan to deal with data management and finding ways to link ongoing and new monitoring and research efforts.

a. **Team activities and associated deliverables shall incorporate an open and transparent process that encourages stakeholder participation.**
   i. **Develop a technical Scientific Panel to facilitate credible use of climate, ecosystem and species data to inform planning** – Developing a new approach to reserve design for adaptation to climate change will require increased sophistication of the use of data. A Science Panel should be formed to determine data and criteria for the use of data as inputs into the planning process. The Science Panel would be formed of scientists from academia, state and federal agencies and non-profit organizations. This team will determine selected plant and animal species for long-term monitoring and help identify and establish monitoring protocols with objectives of determining rapid evolution if appropriate, range shifts that will inform adaptation efforts, or other key information that will inform management actions.

b. **Climate Change Monitoring** – With appropriate resources, Department of Fish and Game along with other sister state agencies should work together to develop a statewide, long-term monitoring effort that evaluates climate related changes affecting indicator species, populations, communities and ecosystems. Short and long term data from climate change monitoring is essential to the identification, assessment, selection, evaluation, and adjustment of adaptation strategies. The structure and application of a monitoring program will need to be clearly articulated and incorporate the contributions of citizen scientists.

c. **Climate Change Models** – The state should continue to support climate change research, including priority modeling efforts that clearly support conservation and management of biodiversity in a changing climate.

d. **Link Climate Change Science to Climate Adaptation** – Baseline data and impacts should be studied. For example, Save the Redwoods League and the CA Natural Resources Agency should track and monitor old growth forest responses to climate change and use the information to establish baseline records for potential landscape-level impacts.

e. **Prioritize Reserve System Related Research**
   i. Protected Area Planning
   ii. Species and community responses
   iii. Ecosystem services
   iv. Restoration efforts to increase connectivity and enhance ecosystem function
   v. Past effects of climate change

f. **Evolutionary Development** – While climate change and its impact on species are taking place rapidly, evolutionary change is generally unable to keep pace. However, recent research on genetics and evolution, illustrate examples where rapid change within generations is enabling species to adapt to new conditions. Research in the field of evolutionary biology will provide significant information to aid adaptation strategies in the future and should be integrated and funded to the extent possible.

Strategy 5 - Education and Outreach

Near-Term and Long-Term Actions:

a. **Public Outreach** – Given climate change and its associated impacts a commitment to ongoing public communication and outreach is essential, and should articulate the role of organizations in the protection of biodiversity.

b. **Citizen Scientists** - In order to pursue efforts to engage the public, build support to reduce impacts and support adaptation and mitigation strategies, citizen scientists should be engaged to help collect important information including but not limited to phenology observations, stream monitoring, and weather data. This will result in data collected across many locations with limited costs.

c. **Public Interpretation and Classroom Education** – A public education campaign on interpretation and climate change, developed by California State Parks includes ten priority components, and will help the 85 million visitors each year understand climate change. Elementary schools will be offered three programs that teach climate change, given the availability of funding. The Department of Fish and Game should pursue similar outreach and education initiatives to inform the public regarding the effects of climate change on natural environments and species. In addition, the State should provide materials to the extensive environmental education community of California,

Strategy 6 – Implementation of Adaptation Strategies

Near-Term and Long-Term Actions:

a. **Policy Development** – All state agencies should review existing policies, criteria, and directives to initiate adaptation measures in response to climate change impacts.

b. **Capacity and Continuity** – In order to accomplish and maintain actions associated with the adaptation strategies, new funding sources should be identified to support new full time permanent civil servant positions that are dedicated to climate change adaptation.

c. **Success Measurements** – Establish quantifiable and qualitative near-term targets, mid-term and long-term milestones to measure success.

d. **Implementation Timing** – The Natural Resources Agency should convene a group of stakeholders and state agency staff to identify sustainable funding for climate change adaptation, prioritize recommendations and opportunities for securing funding.

e. **Adaptive Management** – Adaptive management is a key element of implementing effective conservation programs especially in light of the uncertainties associated with climate change related impacts on natural resources. The State should establish a clear process to identify priority species and systems for adaptation management projects as a short-term action and include an adaptive management response. A statewide knowledge base should be pulled together as soon as possible with the assistance of the scientific community to support the State's efforts to employ an adaptive management framework.

f. **Cross Sector Cooperation** – Interagency cooperation and collaboration are critical to the implementation and long term success of the strategies particularly in regards to the overlap between biodiversity and habitat concerns and all other sectors of this report. In addition, this same spirit of collaboration needs to be extended to other partners and stakeholders that can provide the data, research, and support to help achieve these goals.

VI. Ocean and Coastal Resources

Introduction

Approximately 85 percent of California's residents live and work in coastal counties; these populations will be at risk from a range of climate impacts that are specific to these regions.[1] California's coastal areas are home to unique and threatened ecosystems that offer unmatched recreation and tourism opportunities for people, provide invaluable habitat for rare species, and buffer coastal communities from flood and erosion. Yet, between 1980 and 2003, California's coastal population grew more than any other state's coastal population, increasing by a total of 9.9 million people, or 1,179 persons *every day.*[2] By 2025, the coastal population is expected to grow – albeit at a slower rate – to over 32 million people.[3] Along with people, infrastructure and assets are also concentrated along the coast. According to recent estimates developed for the 2009 California climate change impacts assessment, a 100-year flood event after a 1.4 meter (55 inches) sea-level rise will put 480,000 people at risk and nearly $100 billion in property.[4] In addition, California residents and out-of-state visitors make well over 500 million visits to the state's ocean beaches every year. People go to the coast to enjoy sun and sand, the vistas, and the unrivaled diversity of plants and animals that inhabit the region. All of these visits contribute greatly to California's ocean-dependent economy, which is estimated to be $46 billion per year.[5]

In 2006, the California Climate Change Center reported a historic sea-level rise of 7 inches in the last century and projected an additional rise of 22–35 inches by the end of this century. Since that time numerous other studies have published projected ranges of 7–23 inches,[6] 20–55 inches,[7] and 32–79 inches[8] of sea-level rise for this same period, with the differences in these projections attributable to different methodologies used and how well or whether glacier ice melt is included in the calculations. This report uses the 20-55 inch projection, as it was the best available science at the time of the 2009 impacts assessment. Future sea-level rise estimates will vary based on future GHG emissions.

Much of the damage from this accelerated sea-level rise will likely be caused by an increase in the frequency and intensity of coastal flooding and erosion associated with extreme weather events and storm surges. In addition to sea-level rise, California's coastal and ocean resources are expected to experience additional dramatic changes. These include more severe atmospheric events (e.g., El Niño events); changes in ocean chemistry (e.g., temperature and pH) and estuarine chemistry (e.g., temperature, pH, and salinity); and changes in ecosystem processes (e.g., nutrient upwelling).

While the exact future of the coast is uncertain, one thing is clear: we're going to have to change the way we think about managing our natural assets and human development. Existing laws (such as the California Coastal Act) provide state and local governments with tools for addressing the effects of climate change, but also impose some significant limitations. Laws written in and designed for the 20th century will need to be updated to reflect new ideas about climate change in the 21st century.

Californians will need to make tough decisions about which critical assets we want to protect, which ones can be relocated, which ones will have to be removed, and what is economically reasonable. Development and land-use is already putting stress on coastal ecosystems and resources, constraining their natural ability to adapt to a highly dynamic environment. New development along the coast should be designed and sited to anticipate expected sea-level rise, minimize future hazards, and maintain the biological productivity of the coastal environment. Yet, it will not always be possible to achieve the multiple goals of continued development, protection of critical infrastructure, sustained coastal recreation, and ecosystem protection. For example, shoreline protection structures negatively impact beach access, beach size, shoreline processes, recreation, tourism, and coastal habitats. Ultimately, when these goals are in conflict there will likely be winners and losers. We need to recognize this fact and develop priorities and the regulatory authorities that will allow decisions to be made in a reasonable manner that takes into account numerous factors and interests.

Future Climate Impacts to Oceans and Coastal Resources

A. Increased Temperature and Extreme Events

Air temperatures are expected to rise in coastal California at a slower pace than inland areas due to the cooling influence of the Pacific Ocean.[9] This may draw greater numbers of Californians to the coast. The implications of this possible migration for the economy, housing market, transportation infrastructure, coastal ecosystems, and quality of life have not been assessed to date but could be significant.

Ocean water temperatures will rise as air temperatures rise, causing changes in marine and coastal species behavior and distribution. Species within California's coastal and ocean environments are adapted for life within a particular range of temperatures.[10] Temperatures above or below optimal range can affect the metabolism, growth, and reproduction of stressed aquatic species.[11] As such, temperature is one of the primary environmental factors that determine the geographic range of a species.[12] Shallow coastal waters (e.g., bays and estuaries) will warm sooner than the deeper parts of the oceans, thus warming temperatures should have a direct impact first in the coastal ocean, including bays, estuaries, lagoons, and wetlands. One direct impact of changing water temperatures is a change in coastal water quality because warmer water holds less oxygen.

Increases in water temperatures off the coast of California have already led to a shift in the geographic range of species. As atmospheric and ocean temperatures continue to rise, species that currently have a geographic range from Point Conception south to the Mexican border will begin to shift their geographic range northward up the coast to find ocean temperatures within their physiological range. This has already been observed with the Humboldt squid that used to be an occasional visitor and is now a permanent resident in central California's coastal waters.[13] Just as on land, non-native/invasive species will migrate from more southern areas adding further displacement pressure on native species and taking hold in ocean and coastal ecosystems disturbed by climate change.[14]

Warming can also affect the ocean food web in indirect ways. El Niño patterns or Santa Ana winter wind intensity could significantly alter the nutrient cycling that underpins the marine food web and current species assemblages.[15] Santa Ana winds coincide with cool sea surface temperatures, upwelling, and a spike in biological activity. These winds are projected to decline in intensity, but it is not known how marine nutrient availability and food webs will change.[16]

Ocean and Coastal Resources Impacts due to Warming

- Population Changes in Coastal Areas Anticipated
- Public Health Education and Planning Needed for Extreme Heat
- Relocation of Marine Species and Southern and Exotic Species May Become Invasive
- Changes in Marine Food Systems (Upwelling and Nutrient Availability)
- Changes in Commercial and Recreational Ocean Fishery and Economic Impacts

Warmer ocean temperatures together with changed nutrient availability could result in a decrease in fish populations or a shift in the geographic range of harvested species.[17] During the 1997-1998 El Niño, California's commercial squid industry realized the vulnerability of the fishing industry to water conditions. Squid landings (the number or poundage of fish brought to shore by fishermen) decreased from 110,000 metric tons in 1996-1997 to just 1,000 metric tons over the course of the El Niño season.[18] Together with expected changes in coastal estuaries and wetland habitat resulting from sea-level rise (see below), commercial and recreational fish species may experience lower reproductive success and population decline.

While climate change may reduce or shift the habitable range of current fishery species, it may also allow new fish populations to move north. Some of these new species may become economically significant commercial or recreational fish populations (e.g., the Humboldt squid). The net effect upon the marine fishing industry is currently unknown and should be a subject of future study. Transitional costs (e.g., harvesting gear, marketing activity) to adapt to any new fishery would be expected. The health of California's fisheries will depend on each species' adaptive capabilities, the rate and complexity of interactions in the marine food web as a result of climate change, and the state's ability to implement measures to limit catches to sustainable levels and protect coastal habitats.

B. Precipitation Changes and Extreme Events

In California's coastal areas precipitation falls almost exclusively as rain, even in winter. Coastal fog also plays a large role in providing the moisture required for the maintenance of terrestrial coastal ecosystems; changes in coastal fog density will impact coastal forest types. A general pattern of a drying climate over the 21st century could result in rainstorms that are fewer in number, but greater in intensity; and less coastal fog. Changes to the timing and intensity of freshwater input from rainstorms could impact marine and near shore species. Changing precipitation patterns will potentially increase the occurrences of flooding in coastal drainages. In coastal floodplain areas, runoff from land may coincide with the coastal storm surge (also higher due to sea-level rise) and lead to greater flooding risks in the immediate coastal zone.[19]

Less frequent but more intense rainfall patterns could have serious consequences on water quality. With an increase in frequency and intensity of wildfires,[20] increased runoff and flooding will remain a considerable risk and may also result in higher levels of pollution and sediment runoff. The first flush during storm events is frequently heavily contaminated with toxins deposited on roads, driveways, parking lots and rooftops. Heavy runoff also offers a medium for infectious disease vectors to multiply and spread. Large amounts of runoff may overwhelm the capacity of sewers and sewage treatment plants to absorb and adequately cleanse waters before they reach coastal waters and beaches. Thus, both coastal and marine species and human health are at greater risk in the period following heavy storms (see the Public Health chapter). Infectious diseases in coastal waters and seafood may spread, and invasive species well-suited to more extreme conditions may flourish.[21] If the intensity of such extreme events increases, both human populations and natural habitats will be exposed to increased stresses and have less time to recover between occurrences.[22]

Potentially the most damaging extreme events in coastal California will be winter ocean storms. Past El Niño events have resulted in significant financial damages and exposed large numbers of people to flooding hazards. Climate change will likely exacerbate these impacts with larger waves and higher water levels. These storms will also affect coastal erosion and sediment transport patterns; larger and longer period winter waves have already been observed and may be a growing trend.[23]

Ocean and Coastal Resources Impacts due to Precipitation Changes

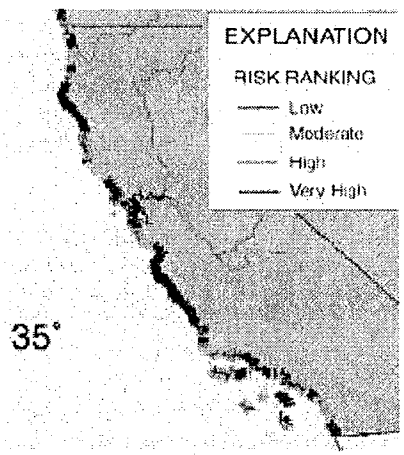
- Higher Runoff and Flooding
- Flood Risks from Inland and Coastal Flooding
- Contamination from Sewage Distribution and Treatment Systems
- Health Risks from Contaminated Runoff
- Increased Marine Pollution

C. Sea-level rise

Coastal Flooding and Permanent Inundation

California's coast is home to major population centers, many of which are situated in low-lying floodplains. Large numbers of people and important assets will be increasingly at risk from inundation during coastal storms as higher sea levels, high tides, storm surges, and inland flooding coincide.[24] Some low-lying areas will also be permanently inundated unless they are protected. Increasing rates of coastal erosion, beach loss, salinity intrusion into estuaries, and saltwater intrusion into groundwater will need to be addressed in future coastal land management decisions.

Figure 12: *Vulnerability of California coastal areas to sea level rise*



Source: Kahrl and Roland-Holst, 2008

Given the extent of high-value development already located in at-risk flood zones, California's coastal cities are not only at risk from storm-related inundation and flood-related damages, but also permanent property loss where land is eroded or constantly inundated. Currently, over 260,000 Californians live in areas designated as at-risk in a 100-year flood event (a one percent chance of occurring every year).[25] What we currently define to be the 100-year flood today will occur much more frequently as sea level rises; therefore, the number of people exposed to risks from 100-year floods will increase substantially as a result of sea-level rise in coming decades.[26]

Studies indicate that a 1.4 m (~5 feet) rise in the level of the San Francisco Bay by 2100 would place 33 percent more land at risk from flood-related inundation than is at risk today.[27] Without accounting for future growth and land use change, the amount of developed land at risk in the Bay area could more than double from current levels by the end of the century.[28] A majority of the structures at risk in that region are designated as residential property. The initial estimates of development in San Francisco Bay in 2100 indicate that over $62 billion worth of building and contents could be at risk.[29]

On the open ocean coast, challenges are similarly daunting. For example, the City of Santa Cruz has a levee system that protects some low-lying parts of the city against a 100-year flood. With a sea-level rise of approximately one foot, the anticipated 100-year flood event in Santa Cruz is expected to occur every 10 years, increasing the likelihood of storm-related inundation.[30] Over the entire California coast, over $100 billion worth of assets (buildings and contents) would be at risk from a 100-year flood in 2100 assuming a 1.4m (~5 feet) rise in sea level.[31]

Providing insurance coverage for coastal development under even a moderate sea-level rise scenario will be costly. One study estimated that the National Flood Insurance Program (NFIP), which provides

backing for flood insurance in participating U.S. communities, will be confronted with an increase in insured property by 36 to 58 percent for a one-foot rise in sea level; and by 102 to 200 percent for a three-foot rise.[32] Not accounting for development and growth, this older study is indicative of the growing flood risk due to sea-level rise alone. The Federal Emergency Management Agency (FEMA) and the national treasury will more often be tapped to deal with growing flood damages in coastal areas unless insurance rates are increased to keep the program actuarially sound.

In addition to private property at risk, infrastructure is also at great risk from coastal flooding and erosion (see the Infrastructure chapter). A complex network of highways and roads, large ports, numerous airports, water supply canals, wastewater treatment facilities, and power plants are located in coastal areas, sometimes directly in floodplains, to support the region's and the state's economy and growing population. This coastal infrastructure is vulnerable to increased heat and flood events, potentially limiting the ability to deliver vital public services.

Impacts on transportation systems will include flooding of roads, railways, transit systems, and airport runways in coastal areas because of rising sea levels and higher storm surges. A substantial amount of ground transportation infrastructure is predicted to be at risk from sea-level rise by 2100, including 2,500 miles of roads and rails.[33] Such infrastructure is vital to the state's economy for both the movement of commercial freight and the ability of Californians to get to work and school. In the San Francisco Bay, the major airports of San Francisco and Oakland are near sea level and would require additional elevation, protection, or relocation to remain functional.

Municipal and industrial infrastructure would be directly and indirectly at risk from alteration of coastal resources due to climate change. Accelerated sea-level rise and storm-related flooding (from the coastal and the inland side) could threaten California's vital but aging levee and water transport system.[34] Additionally, water backflow could impair coastal water sanitary sewage systems during flood events.[35] Inundation of coastal infrastructure can also cause widespread pollution and contamination, jeopardizing marine and near-marine environments.

Ocean and Coastal Resources Impacts due to Sea-Level Rise

- Increased Risks of Coastal Flooding in Low-Lying Areas
  - More People and Assets - At Risk
  - Public Infrastructure - Increased Risk of Inundation
  - Levees and Structures - Require Retrofit
  - Coastal Wetlands - Potential Loss
- Increased Erosion of Beaches, Cliffs and Dunes
  - Private Property and Structures - At Risk
  - Beach Recreation and Tourism - May Decrease in Select Areas
  - Greater Expenditures for Beach Maintenance
- Increased Saltwater Intrusion into Coastal Groundwater Resources
  - Agricultural Land - Degraded by Saltwater

Wetland Loss and Habitat Degradation

Increasing sea levels will submerge many low-lying portions of California's coastal wetlands. Of particular concern are coastal salt marshes, which have already been decreased by 91 percent from historical levels.[36] If vegetation and sediment accretion occurs rapidly, wetlands could maintain their present location and the wetland footprint would not decline. For example, while some very high accretion rates occur in the San Francisco Bay region (i.e., up to 80 mm per year), the average rate is approximately 1-2 mm per year. This rate has kept pace with recent sea level rise, but will likely fall short of the projected future sea-level rise of 2-3 mm (or more) per year.[37] The high degree of development and infrastructure placed in near-shore areas restricts the inland migration of wetlands in many locations, thus more coastal wetlands are likely to be lost.[38]

If wetlands are submerged by rising water levels, one consequence would be that wave energy would be less attenuated and erosional forces against upland levees, such as within San Francisco Bay, would increase.[39] Additional potential impacts to wetlands due to sea-level rise include: changes to estuarine mixing, water quality, and carbon cycling; changes to upland habitats and sediment loads into downstream wetlands; and changes to wetland biological habitat, diversity, and changes in biological distribution which will potentially impact foraging opportunities and rearing habitats for key ocean species.[40] Furthermore, the degradation of sensitive ecosystems can be brought about not just by higher sea levels but also by other climate changes, including increased water and air temperatures and changes in precipitation patterns, which together can increase the abundance of invasive species. Changes in the abundance and distribution of critical native species can also have cascading, significant effects on sensitive coastal and ocean habitats.

Increased Coastal Erosion

In addition to coastal flooding, the rate of coastal erosion will also increase as a result of sea-level rise. Loss or movement of beach sand and increased cliff and bluff erosion would jeopardize the stability of many coastal developments and recreation areas. The extent of this impact on California's coastline will vary by the type of coast, the width of the beach, and the presence or absence of protective structures. Damage to coastal infrastructure will be more severe where extreme wave conditions combine with elevated sea levels to impact unprotected and/or erodible coastal areas.

The U.S. Geological Survey (USGS) has developed a preliminary map in 2000 classifying areas of the U.S. Pacific coast based on their physical vulnerability to coastal change due to sea-level rise. Areas classified as "very high" risk are those that have already experienced significant erosion problems, and are concentrated mainly around the state's major bays including the Humboldt, San Francisco, and Monterey Bays as well as Los Angeles and San Diego.[41]

Increased coastal erosion will impact private property owners and beach-dependent sectors of the state's economy. Beach recreation and tourism generate the largest economic value of all economic sectors in the California coastal zone.[42] The economic value of beach recreation and tourism is of particular importance in southern California, as expenditures in just three counties in southern California accounted for 44 percent of the state's total tourism-related spending in 2007.[43] Many of the state's intensively used beaches are backed by seawalls, bulkheads, roads, parking lots, or other infrastructure, which prevents landward migration. These beaches will gradually be inundated or will be reduced in width as sea level rises, translating into a reduction on beach area. These physical effects of climate change could significantly decrease the viability and attractiveness of coastal tourism locations, including a shift in tourist attendance patterns among local beaches.[44] Such changes would generate either direct or transitional costs for the expanse of tourism-related businesses within the service economy of coastal California. The incidence of beach erosion and accretion at individual California beaches indicates a net negative effect from both gradual sea-level rise and extreme events on the order of an $8.6 million loss in total annual expenditures and a $36.7 million decline in consumer surplus. However, these impacts will vary regionally. In addition to economic impacts associated with the loss of beaches, the ecological impacts will be significant as California beaches support hundreds of organisms, act as buffers to interior habitat during storms, and are essential for the persistence of rare dune habitats.

According to one recent study for southern California, erosion rates are expected to accelerate by 20 percent for a sea-level rise of 39.4 inches (100 cm).[45] Several alternatives exist to deal with rising sea level and the issues of coastal erosion and inundation: armor, nourishment, and a planned retreat. Each will have tradeoffs in terms of impacts and costs, dictated by the magnitude of sea-level rise that is expected and the amount of property, infrastructure, or public resources threatened. Creating protective structures can limit or alter the functioning of natural habitats, which in turn can decrease the overall adaptive capacity of coastal ecosystems. Ten percent (or 110 miles) of the entire coast of California is now armored, and 33 percent of the shoreline of the four most southerly California counties has been hardened. We can expect more applications and pressure on permitting agencies (local governments as

well as the Coastal Commission) to approve additional hardened structures in the future as sea level continues to rise.

Saltwater Intrusion

Sea-level rise and changes in the intensity of storm events could impact low lying coastal areas and result in the loss or inundation of coastal wetlands and dune habitat resulting in salt water intrusion and loss of fresh water resources for fish and wildlife. Sea-level rise will also adversely affect coastal water supplies through saltwater intrusion into coastal aquifers, potentially increasing the need for other water sources (such as desalination) to address coastal water shortages and impact groundwater resources tapped for irrigation.[46] Compounding the problem, low-lying farmland such as the Oxnard Plain and the Bay-Delta region may also be inundated with salt water.[47]

Ocean Acidification

Coastal ecosystems and the industries that depend upon them are being significantly impacted by increased acidification of the ocean due to increases in atmospheric CO_2 concentrations. Globally, the ocean absorbs 30-50 percent of the annual emissions of CO_2.[48] As CO_2 is dissolved into ocean and estuarine waters, carbonic acid is formed lowering the pH of the water. This increased acidity can hamper the ability of a wide variety of marine organisms ranging from coral to abalone to form calcium carbonate shells and skeletal structures.

Acidification limits the growth and survival of species such as crabs, sea urchins, abalones, oysters and significant plankton species that have calcium carbonate shells and skeletons. The decreased survival of these calcifying organisms has rippling impacts on species that feed upon them (e.g., the loss of key plankton species will negatively impact the salmonids, seabirds, and other species that feed on them). Commercially important shellfish species are likely to be negatively affected: under a moderate emissions scenario (750 ppm CO_2 by 2100), calcification rates of mussel and oyster species are predicted to decline by 25 and 10 percent, respectively, by the end of the century.[49] The declining pH levels also impact fertilization, development, and metabolic function of many marine species including kelp, which is an essential component of productive coastal ecosystems on the West Coast, and a commercially harvested species. Acidification also affects the toxicity of a variety of substances and the biological availability of important nutrients and other compounds.

D. Risks for Ocean and Coastal Resources

To summarize the changing risks that California's ocean and coastal resources may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The resulting risk profile for California's oceans and coastal areas can be characterized as follows:

- Sea-level rise will increase the risks of coastal flooding in low-lying areas, inundating private property more frequently and exposing more people and more assets to flooding risks. Infrastructure, public facilities and industrial sites will also experience growing flooding risks. Levees, protective structures, and development may need to be elevated and flood-proofed to maintain protection.
- Threats to coastal wetlands are increasing. If wetlands cannot migrate inland due to man-made or natural barriers, wetland habitat will be lost.
- Sea-level rise will increase erosion of beaches, cliffs, and bluffs, threatening public and private property and structures and causing social, economic, and resource losses to coastal recreation and tourism through reduction in or damage to beaches, access ways, parks, trails, and scenic vistas.
- Loss of wetland, beach, and other coastal habitat will negatively impact many fish, bird, and other species, and diminish biodiversity.

- Californians are likely to experience a more moderate increase in average temperatures in coastal areas than in inland areas due to the cooling effect of the ocean, yet may suffer disproportionately from extreme heat waves.
- Warmer water temperatures will cause shifts in the distribution of coastal and marine species; southern species may extend their range northward. Additionally, exotic species may become invasive in new areas and new pathogens may appear. Together with other climate-driven changes in wind patterns, upwelling, nutrient availability, and hard-to-predict changes in the marine food web, warmer water temperatures may cause recreational and commercial fishing species to decline in abundance or shift their range, leading to widespread economic impacts on these fisheries.
- Fewer, but possibly more intense, rainstorm events will produce high runoff and flooding. In the immediate coastal areas, such inland flooding may coincide with coastal flooding, posing particularly high risks to communities and structures in coastal floodplains.
- High runoff may overwhelm storm drains and sewage treatment plants, potentially contaminating coastal ecosystems and beaches.
- Sea-level rise will increase saltwater intrusion into coastal aquifers (groundwater resources), degrading agricultural land and coastal groundwater resources.
- Rising temperatures and ocean acidification have the potential to negatively impact ecosystems and fisheries.

Ocean and Coastal Resources Adaptation Strategies

Introduction

The state agencies in the Coastal and Ocean Working Group (Ocean Protection Council, California Coastal Conservancy, California Coastal Commission, State Lands Commission, Department of Fish and Game, State Parks, and the Bay Conservation and Development Commission) contributed to the development of the following strategies and each organization will be essential to the successful implementation of the strategies. Given the extent of the threats predicted by current climate models, sea level projections, and the considerable value of California's coastal lands, resources, and development, coastal planning must adapt to prepare California for a variety of potentially significant outcomes of climate change. Preparing California's coastal infrastructure, industries, and ecosystems for the impacts of climate changes will be an expensive endeavor. Decision-makers will need to make short- and long-term risk-management decisions to address future impacts that will include deciding which human developments should be maintained, retrofitted, and protected; where hazard avoidance is not possible; where planned retreat is appropriate; and where natural systems should be protected, rehabilitated, or enhanced.

These decisions should be made using the following principles for guidance:

- California must protect public health and safety and critical infrastructure.
- California must protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well being depend.
- California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources.
- New development and communities must be planned and designed for long-term sustainability in the face of climate change.
- California must look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
- California must begin now to adapt to the impacts of climate change. We can no longer act as if nothing is changing.

Adaptation to sea-level rise drives most of the Ocean and Coastal Resources adaptation strategies presented in this report. The priority strategy is for state agencies to avoid establishing or permitting new

development inside future hazard zones in most cases if new protective structures would be necessary (strategy 1a). Additional strategies include (1) directives to promote innovative approaches to redesigning coastal structures, where feasible, that are resilient to the impacts of climate change and can serve to protect existing development in low-lying areas (strategy 1b), and (2) creation of statewide guidance and regional planning forums to help local governments update local plans and make planning decisions in light of sea-level rise (strategies 2a and 4c).

All levels of government are encouraged to consider:

- Incentive programs to encourage property owners in high-risk areas to relocate or limit future development.
- Clustering new development in areas considered to have a low vulnerability to sea-level rise.
- Creating additional buffers and setbacks for new construction to minimize risks to people and property and to protect coastal resources such as natural habitat and recreational areas (see strategy 4c).

Critical coastal and ocean habitats and recreational areas should be protected and maintained to the extent feasible. The state should identify priority conservation areas and recommend lands that should be considered for acquisition and preservation, especially vulnerable shoreline areas containing critical habitat or opportunities for habitat creation (strategy 1c). Future sea-level rise estimates should be considered during restoration efforts (i.e., grading levels for wetland restorations), and natural shoreline enhancements (e.g., species such as native oysters, eelgrass) should be designed to promote sedimentation and protect against shoreline erosion.

Adaptation Strategies and Actions

The Coastal Adaptation Working Group has identified the following priorities in addressing climate adaptation for California state agencies. The near-term actions referenced below are those actions that have been identified and which can be initiated or completed by 2010, if, in some cases, related statutory or regulatory changes are made. The long-term actions include those that will require support from that state and collaboration with multiple state agencies or that require significant legal or regulatory changes.

Strategy 1: Establish State Policy to Avoid Future Hazards and Protect Critical Habitat.

Near -Term Actions:

a. **Hazard Avoidance Policy** – State agencies should consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding or erosion due to climate change.
The most risk-averse approach for minimizing the adverse effects of sea level rise and storm activities is to carefully consider new development within areas vulnerable to inundation and erosion, and to consider prohibiting development of undeveloped, vulnerable shoreline areas containing critical habitat or opportunities for habitat creation. State agencies should generally not plan, develop, or build any new significant structure in a place where that structure will require significant protection from sea-level rise, storm surges, or coastal erosion during the expected life of the structure. However, vulnerable shoreline areas containing existing development or proposed for new development that has or will have regionally significant economic, cultural, or social value may have to be protected, and in-fill development in these areas should be closely scrutinized. State agencies should incorporate this policy into their decisions, and other levels of government are also encouraged to do so. Some state agencies already base decisions on hazard avoidance, for example Coastal Act provisions require that new development in the coastal zone be designed to minimize risks from current and future hazards, which would include

risks from expected sea-level rise, the Act restricts new development in hazardous areas, especially if it would require the construction of a protective device.

b. **Innovative Designs** – If agencies do plan, permit, develop or build any new structures in hazard zones, agencies should employ or encourage innovative engineering and design solutions so that the structures are resilient to potential flood or erosion events or can be easily relocated or removed to allow for progressive adaptation to sea level rise, flooding, and erosion.

c. **Habitat Protection** – The state should identify priority conservation areas and recommend lands that should be considered for acquisition and preservation. The state should consider prohibiting projects that would place development in undeveloped areas already containing critical habitat, and those containing opportunities for tidal wetland restoration, habitat migration, or buffer zones. The strategy should likewise encourage projects that protect critical habitats, fish, wildlife and other aquatic organisms and connections between coastal habitats. The state should pursue activities that can increase natural resiliency, such as restoring tidal wetlands, living shoreline, and related habitats; managing sediment for marsh accretion and natural flood protection; and maintaining upland buffer areas around tidal wetlands. For these priory conservation areas, impacts from nearby development should be minimized, such as secondary impacts from impaired water quality or hard protection devices.

Long -Term Actions:

d. **Coordinate Policy Implementation** – State agencies should use outreach and incentive programs to promote hazard avoidance policies and sound management decisions for coastal habitat protection and development to all levels of government.

Strategy 2: Provide Statewide Guidance for Protecting Existing Critical Ecosystems, Existing Coastal Development, and Future Investments

Significant and valuable development has been built along the California coast for over a century. Some of that development is currently threatened by sea-level rise or will be threatened in the near future. Similarly, the coastal zone is home to many threatened or endangered species and sensitive habitats. We must acknowledge that the high financial, ecological, social and cultural costs of protecting everything may prove to be impossible; in the long run, protection of everything may be both futile and environmentally destructive. Decision guidance strategies should frame cost-benefit analyses so that all public and private costs and benefits are appropriately considered.

Near -Term Actions:

a. **Establish Decision Guidance** – The OPC in close coordination with other state resource agencies should develop a statewide framework that can be used by state and local agencies as guidance in preparation of adaptation plans. This guidance should discuss current regulatory and legal frameworks and whether changes are necessary to pursue this approach to adaptation. In addition the OPC should incorporate this new guidance within existing decision-making processes as much as possible and tailor it, when necessary, to specific regional approaches (see strategy 4c)..

It should consider three key questions for helping to design and locate proposed or existing structures that may be threatened by sea-level rise:

1. Is the existing or proposed structure either necessary for the health, safety, or welfare of an entire region, or is it located within a hazard area for which protection will be provided because of surrounding high-value development?
2. Is it infeasible to relocate an existing structure or site a new structure outside the hazard area and still provide this health, safety, or welfare function?

3. Will relocating an existing or proposed structure provide habitat protection or recreational opportunities that may be otherwise lost if that structure is built or is protected along the coast?

Additional questions that should be considered in the preparation of the framework include:

- Is there a feasible "soft" protection solution (i.e., can a barrier beach or wetland be used instead of a seawall)?
- Will the protection approach, retrofit, or new design:
  - i. Be necessary to protect an existing structure threatened by erosion?
  - ii. Allow continuation of important natural processes, such as littoral drift, and avoid any impacts to neighboring habitats or structures?
  - iii. Result in the loss of state tidelands or beaches?
  - iv. Provide a long-term solution to the threats caused by sea-level rise?
  - v. Be resilient over a range of sea-level rise possibilities?
  - vi. Provide broad protection to existing developed areas?
  - vii. Protect structures of high cultural or social value?
  - viii. Provide for a natural shoreline (i.e., can seawalls be designed to include habitat)?
  - ix. Be coordinated with proposed actions for other infrastructure in the same flood hazard area?
  - x. Cost less than the value of the structure to be protected?
  - xi. Provide mitigation for adverse impacts that cannot be avoided?

Long -Term Actions:

b. **Pilot Studies** – Develop pilot studies in cooperation with specific cities/state agencies that will examine the efficacy and utility of the framework highlighted above.

Strategy 3: State Agencies Should Prepare Sea-Level Rise and Climate Adaptation Plans

Near -Term Actions:

a. **Adaptation Planning** – By September 2010 state agencies responsible for the management and regulation of resources and infrastructure subject to potential sea-level rise should prepare agency-specific adaptation plans, guidance, and criteria, as appropriate. Agencies with overlapping jurisdictions in the coastal zone will coordinate when drafting these plans to reduce or eliminate conflicting approaches.
   - i. The Coastal Commission, the San Francisco Bay Conservation and Development Commission, the state and Regional Water Quality Control Boards, California State Parks, and the State Lands Commission should continue to develop adaptation strategies that can be implemented through their existing planning and regulatory programs.
   - ii. The Coastal Conservancy, the Ocean Protection Council, and the Wildlife Conservation Board should continue to develop criteria to guide their financial decisions and ensure that projects are designed to consider a range of climate change scenarios.
   - iii. The California Department of Transportation, State Parks, the Department of Water Resources, the Department of Fish and Game, the State Lands Commission, and other state agencies that own land and facilities along the coast should develop policies to guide them in land-use projects and the development of infrastructure in vulnerable areas in the future.
   - iv. The aforementioned agencies should:
     a. Consider requiring applicants to address how sea-level rise will affect their project, include design features that will ensure that the project objectives are feasible and that the project will not be rendered unusable or inoperable over its lifespan, that critical habitat is protected, and that public access is provided, where appropriate.

b. Prepare climate strategies, indicators, and thresholds that respond to changing ocean temperatures, air temperatures, predator-prey interactions, and ocean acidification. These strategies should include alternative management strategies that could be employed, such as alternative fisheries management approaches dependent upon temperature regimes, alternative marine protected areas for stressed species, or changes to aquaculture and fishing practices under lower pH conditions.
c. Identify areas where their jurisdiction and authority should be clarified or extended to ensure effective management and regulation of resources and infrastructure subject to potential sea-level rise.

v. The Department of Insurance should develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas.

Long -Term Actions:

b. **Adaptation Plan Updates** – State agencies should regularly update, modify, and refine these adaptation guidance documents and plans based on new information and lessons learned from previous implementation actions.

Strategy 4: Support Regional and Local Planning for Addressing Sea-Level Rise Impacts

Near -Term Actions:

a. **Public Outreach** – The Ocean Protection Council (OPC) in close coordination with other state ocean resource agencies should (beginning in 2010) conduct public meetings within coastal communities to examine adaptive strategies available to state and local agencies to prepare for potential sea-level rise impacts. Strategies, tools, and information will be compiled and made publically available for use by local governments when updating their local and general plans.

b. **Funding Mechanisms** – The OPC should collaborate with state agencies to identify potential funding sources (i.e., AB32 or an amendment to Prop 218) for state agencies and local governments to undertake revisions to local plans.

c. **Regional Coordination** – The state should work with local governments and existing regional organizations, such as the Los Angeles Regional Collaborative for Climate Action and Sustainability, associations of local governments, or SB 375 regional planning teams, to provide for regional adaptation planning. The state should continue to conduct, synthesize, and disseminate regionally relevant research and information with this purpose in mind.

Shoreline and land use planning should be informed by regional and sub-regional level considerations. Shoreline dynamics must be understood within the context of discrete littoral cells and other natural systems. In addition, geography, development patterns, and tectonic forces differ a great deal regionally; and the success of alternatives to respond to the challenges of sea level rise and coastal hazards will depend, in large part, on these regional differences. In addition, numerous strategies when implemented may have consequences for neighboring habitats or communities, and coastal communities should have the ability to jointly plan for impacts to the full region to reduce mutually unbeneficial approaches. Developing regional information and understanding regional consequences of various adaptation options will be useful to location governments as they update individual local coastal plans or general plans within a region.

d. **Local Government Guidance** – All relevant state agencies should collaborate with local jurisdictions to encourage them to consider the following strategies when updating plans:
    i. **Setbacks** – Mandatory construction setbacks can be imposed to prohibit construction and significant redevelopment in areas that will likely be impacted by sea-level rise within the life of the structure.
    ii. **Additional Buffer Areas** – Additional buffer areas can be established in some places to protect important cultural and natural resource assets.
    iii. **Clustered Coastal Development** – Coastal development can be concentrated in areas of low vulnerability and may reduce carbon emissions from transportation.
    iv. **Rebuilding Restrictions** – Rebuilding can be restricted when structures are damaged by sea-level rise and coastal storms.
    v. **New Development Techniques** – Building codes can be amended to require that coastal development incorporate features that are resilient to sea-level rise (e.g., require that development begin on the second floor).
    vi. **Relocation Incentives** – Federal, state and local funding or tax incentives to relocate out of hazard areas.
    vii. **Rolling Easements** – Policies and funding to facilitate easements to a) relocate developments further inland, b) remove development as hazards encroach into developed areas, or c) facilitate landward movement of coastal ecosystems subject to dislocation by sea-level rise and other climate change impacts.
    viii. **Engineering Solutions** – New engineering approaches will need to be applied to ports, marinas and other infrastructure that must be located on the shoreline to maintain their function as the sea level rises.

    The Governor's Office of Planning and Research will provide a guidance document in 2009 to address state land use planning.

e. **Amend Local Coastal Plans and General Plans to Address Climate Change Adaptation:** By 2011, or within one year after development of the tools or guidance necessary to support such amendments and if funding is secured, all coastal jurisdictions, in coordination with the Coastal Commission, should begin to develop amended LCPs that include climate change impacts; and local jurisdictions around San Francisco Bay should begin to update their general plans, in coordination with BCDC.

Strategy 5: Complete a Statewide Sea-Level Rise Vulnerability Assessment Every Five Years

Long -Term Actions:

a. **Vulnerability Assessment** – In coordination with all relevant state agencies, OPC should produce a coastal and ocean vulnerability assessment every five years that consolidates and builds upon existing efforts by the California Energy Commission and other agencies. Each new assessment will discuss the most recent knowledge about climate impacts to ocean and coastal resources, inventory coastal natural and man-made assets, and assess what is at risk (including an economic valuation). The data from these assessments should be periodically incorporated into state agency adaptation plan updates (discussed above, 3b).

Strategy 6: Support Essential Data Collection and Information Sharing

Research and data are needed to perform and update vulnerability assessments. Agencies should work in cooperation with federal partners to seek funding for the collection of essential data. The state should continue to establish baseline climate change data and common modeling assumptions so that planning actions in the different agencies are based on common information to the greatest extent possible.

Near -Term Actions:

a. **High-Resolution Mapping** – The state, in cooperation with federal partners, should immediately fund the collection of high-resolution topography and bathymetry mapping (i.e., LiDAR) to provide elevation information needed as a baseline for monitoring change, for the modeling of flood hazards, and to help identify and document habitats and ecosystems.

b. **Tidal Datum** – Monitoring on tidal datums should be maintained and expanded, including establishing additional tide gage stations. Tidal datums are used to measure local water levels and can project how global sea-level rise will be experienced at the local scale. These data are needed to determine the mean high tide and other reference points used in regulatory and legal settings.

c. **Ecosystem Research** – Research should be conducted on potential changes to ocean and coastal ecosystems, and species ranges, which are already changing - resulting in divergence in breeding and feeding behavior. Understanding ecosystem changes will be essential to future management decisions related to fisheries, species protection, and restoration projects.

d. **Coastal and Wetland Process Studies** – Research should be conducted to understand and model coastal, estuarine, and wetland circulation and sediment distribution and transport. This information is essential to successful wetland and beach maintenance, restoration, and nourishment projects.

Long -Term Actions:

e. **Decision Support** – The OPC should work with state ocean resource agencies and other appropriate partners (such as academia and nongovernmental organizations) to help provide the necessary data and tools to state and local agencies for decision support to protect development and habitat from sea-level rise.

VII. WATER MANAGEMENT

Introduction

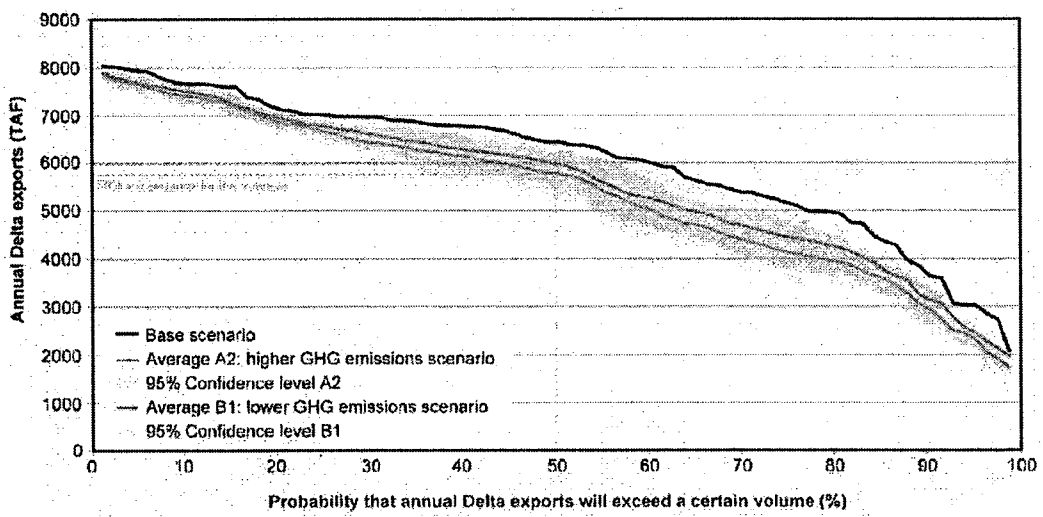
Water is the lifeblood of California's natural and human systems. For more than 200 years, California water and flood management systems have provided the foundation for the state's economic vitality, providing water supply, sanitation, electricity, recreation, and flood protection. However, the climate patterns that these systems were based upon are different now and may continue to change at an accelerated pace. These changes collectively result in significant uncertainty and peril to water supplies and quality, ecosystems, and flood protection.

Nearly 75 percent of California's available water supply originates in the northern third of the state (north of Sacramento), mainly from water stored in the Sierra Nevada snowpack. At the same time, 80 percent of the demand occurs in the southern two-thirds of the state.[1] California has been able to bridge the geographic distance between water supply and demand by building one of the most complex water storage and transport systems in the world to convey large quantities of water throughout the state.

However, drought conditions are likely to become more frequent and persistent over the 21st century due to climate change. Today, the effects of hydrologic droughts are increasingly being exacerbated by additional regulatory requirements to protect listed fish species, especially regarding water diversion from the Bay-Delta. For example, the hydrologic severity of California's present three-year drought is not remarkable in comparison to past three-year droughts, but drought impacts in the Delta export area are such that a statewide drought emergency has been proclaimed for the first time in California.

Population growth expected over the next few decades will lead to additional demand. Even without higher air temperatures and changing precipitation patterns over the next few decades, California's water supply problems would already be challenging. A portfolio of measures implemented at the local and regional level will be needed to meet these growing challenges.

Figure 13: *Using mid-century climate projections to support water resources decision making in California (Source: Chung, et al 2009)*



Future Climate Change Impacts to Water Management

The state's water supply system already faces challenges to provide water for California's growing population. Climate change is expected to exacerbate these challenges through increased temperatures and possible changes in precipitation patterns. The trends of the last century – especially increases in hydrologic variability – will likely intensify in this century. We can expect to experience more frequent and larger floods and deeper droughts. Rising sea level will threaten the Delta water conveyance system and increase salinity in near-coastal groundwater supplies. Planning for and adapting to these simultaneous changes, particularly their impacts on public safety and long-term water supply reliability, will be among the most significant challenges facing water and flood managers this century.

WATER MANAGEMENT IMPACTS DUE TO WARMING

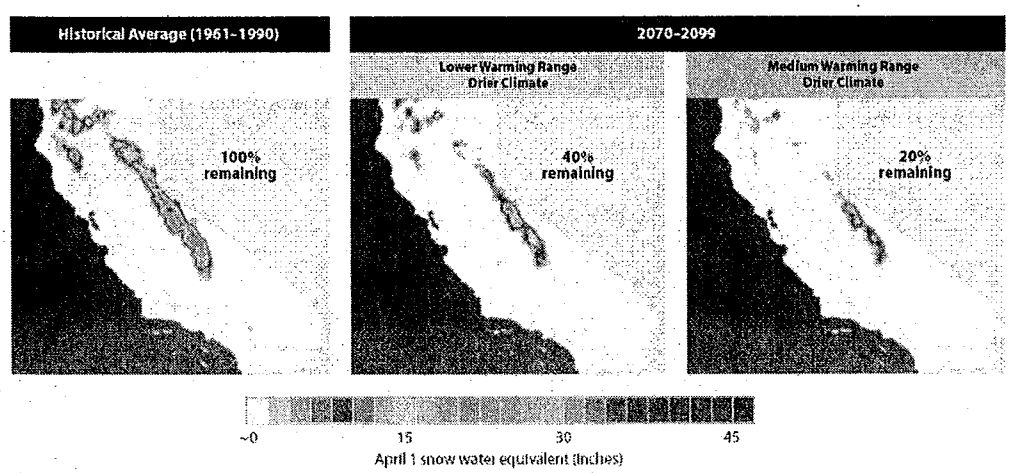
- Reduced Water Supply from the Sierra Snowpack
- Changes in Water Quality
- Increased Evapotranspiration Rates from Plants, Soils and Open Water Surfaces
- Moisture Deficits in Non-irrigated Agriculture, Landscaped Areas and Natural Systems
- Increased Irrigation Needs
- Increased Agricultural Water Demands Due to a Longer Growing Season.
- Increased Urban Water Use, at Possible Expense of Agriculture Water.

A. Increased Temperature and Extreme Events

Increasing average temperatures may have several impacts on water supply and demand, affecting California's farms, municipalities, and ecosystems.

First, increasing winter and early spring temperatures will cause earlier melting of the Sierra Nevada snowpack – the most important seasonal surface reservoir of water in California. Historically this snowpack has released about 15 million acre-feet slowly over the warming spring and summer months (one acre-foot provides the annual water needs of one to two families).[2] California's water storage and conveyance infrastructure gathers this melting snow in the spring and delivers it for use during the drier summer and fall months. This same infrastructure is also used for flood control in the winter and early spring by keeping lower reservoir levels. With earlier snowmelt and heavy winter/spring rains possibly coinciding, difficult tradeoffs may need to be made between water storage and flood protection.

Figure 14: *California historical and projected decrease in April snowpack, 1961-2099 (Source: Cayan et al 2006).*



Increased underground storage of surface waters and increased groundwater withdrawal may potentially be used to ensure that future water supplies meet growing demands. However, groundwater balances in California are generally not well documented, with many aquifers contaminated, necessitating further study to assess the more widespread feasibility of groundwater storage.

In addition, climate change may make preservation and restoration of habitat more difficult. The ecological requirements of cold-water fishes provide an example. Climate change may warm rivers and streams, with less water available for ecosystem flow and temperature needs in spring and summer. In many low- and middle-elevation streams today, summer temperatures often approach the upper tolerance limits for salmon and trout; higher air and water temperatures will exacerbate this problem. Thus, climate change might require dedication of more water, especially cold water stored behind reservoirs, to simply maintain existing fish habitat. Climate change is also expected to raise sea level. As this happens, the brackish and fresh aquatic habitats of the Sacramento-San Joaquin estuary that are critical to many at-risk species will shift upstream and inland. Growing urbanization on the eastern edge of the Delta will limit opportunities to acquire or restore lands that would provide suitable habitat. Threatened and endangered species could be increasingly squeezed between the inland sea and the encroaching cities. Higher water temperatures also can accelerate biological and chemical processes that increase growth of algae and microorganisms, thereby creating an additional demand for oxygen in the water.[3]

Higher temperatures – especially in the summer growing season – increase evapotranspiration rates from plants, soils and open water surfaces. In a study conducted for the 2008 California climate impacts assessment, net evaporation from reservoirs was projected to increase by 37 percent in a warmer-drier climate, but only by 15 percent in a warmer-only scenario, reducing available supplies accordingly.[4]

While higher temperatures increase the water demand and use by plants, soil moisture decreases and reservoirs and/or groundwater reserves are reduced. Non-irrigated agriculture and landscaped areas, as well as natural systems, will suffer moisture deficits if natural water supplies are limited, and the risk of wildfires will increase. Elsewhere, irrigation will need to be increased if crop losses are to be avoided.[5] During extreme heat events livestock will require more water for drinking and cooling.

Finally, higher average temperatures extending over longer periods of the year will lengthen the growing season, thereby increasing the amount of water needed for non-irrigated plant growth, environmental water needs, and for the irrigation of crops and landscaped areas.[6] A recent study on water demand in California estimated agricultural and urban water demands under both a warmer-only and a warmer-drier climate change scenario using the CALVIN (California Value Integrated Network) model – a statewide model of the economic and engineering aspects of California's interconnected water supply system. Using these scenarios, the study found that agricultural water use would decrease by nearly 15 percent (4,070 thousand acre feet [TAF]/year) between 2020 and 2050 as urban demand increases and overall supply decreases by 7 percent.[7] Even assuming the implementation of water conservation and water efficiency measures to partially compensate for the expected reduction in supply, urban water demand is expected to increase by more than 10 percent (1,606 TAF/year) between 2020 and 2050.[8] The study also concluded that the agricultural sector is more vulnerable to water shortages than the urban sector; thus, water supplies to agriculture may be 20 percent below demand targets under the warmer-only climate scenario and 23 percent below demand under the warmer-drier scenario.[9]

B. Precipitation Changes and Extreme Events

Climate change can potentially alter California's historical precipitation patterns. While the state is expected to retain its Mediterranean pattern of dry summers and wet winters, along with significant year-to-year variability in total precipitation, some projections of the future involve worrisome changes for the state's water supplies. Global climate models vary considerably in projecting precipitation patterns into the future. For planning purposes, eleven of the twelve simulations selected for the 2008 California Climate Change Impacts Assessment deliberately project a future marginally to considerably drier by mid-century, while only one simulation projects a slightly wetter future. In addition to the warming trend and the snowline moving higher, scientists expect that a growing proportion of winter precipitation to fall as rain instead of as snow, significantly reducing snow accumulation on April 1 (an important date in the hydrological calendar).[10]

WATER MANAGEMENT IMPACTS DUE TO SEA-LEVEL RISE

Increased Stress on Sacramento-San Joaquin Delta Levees

Saltwater Intrusion into Estuaries, Bays, and Coastal Groundwater:

- Change Water Quality
- Transform Ecosystems
- Reduce Freshwater Supplies

The expected reduction in the Sierra snowpack is particularly troublesome for California water supplies, as it essentially functions as California's largest surface water reservoir. The state's agriculture, industrial and municipal users, and a wide variety of ecosystem functions, depend heavily on the stored water being released in the early dry months of the year.

WATER MANAGEMENT IMPACTS DUE TO PRECIPITATION CHANGES

- Possible Precipitation Decreases - From 12-35 Percent Compared to Historical Annual Averages
- More Winter Precipitation Falling as Rain Instead of Snow
- Intense Rainfall Events - More Frequent and/or More Extensive Flooding
- Droughts - More Frequent and Persistent
- Possible Decreasing Water Quality:
  - Longer Low-flow Conditions
  - Higher Water Temperatures
  - Higher Contaminant Concentrations

Existing storage and conveyance facilities have been built and operated based on historical patterns of rain and snowfall. Over the last century, the average early spring snowpack runoff has decreased by about 10 percent, a loss of 1.5 million acre-feet of water. Using historical data in conjunction with climate and hydrologic models, the Department of Water Resources projects that the Sierra Nevada snowpack may be further reduced from its mid-20th century average by 25 to 40 percent by 2050.[11]

Water supplies originating from outside of the state are also important. Rising temperatures and drier conditions have led to projections of decreasing volumes of water in another one of California's water sources, the Colorado River basin. Studies underway by the Western Water Assessment of the University of Colorado are seeking to reconcile the wide range of estimates in possible decreases – from -6 percent to -50 percent - in Colorado River flow by mid-century or later.[12] In late 2007, the Secretary of the Interior signed an historic Record of Decision for *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* that allows for more efficient operation of the reservoir system to reduce the potential frequency and magnitude of shortages. Through 2025, the period covered in the interim guidelines, the estimated risk of shortage to California is very small, thanks to the large volume of storage in the river basin, the high elevation of the runoff generating region of the upper basin, and the relative seniority of California water rights. Estimating the risk of shortages beyond that date is complicated by the uncertainties of future reservoir operations strategies and the disparate projections of runoff impacts.[13]

Figure 15: *View of Lake Oroville in 2005 (left) and November 2008 (right)*



Finally, California's hydroelectricity production relies on predictable water reserves. In 2007, nearly 12 percent of California's electricity was produced from large hydroelectric power plants, presently the state's largest source of renewable energy.[14] With snow falling at higher elevations, creating less snowpack, and melting earlier in the year less water is available for this source of power generation when it is most needed, during the warmer summer months. When several dry years create drought conditions, reservoir levels can be reduced to levels lower than those required for hydroelectric power generation.[15]

Extreme Rainfall and Flooding

California's current water systems are designed and operated to strike a balance between water storage for the dry months and flood protection during the winter and spring, when heavy rainstorms, runoff, and snowmelt can cause downstream flooding. While some climate models predict an overall drying of California's climate, at the same time there are also continued risks from intense rainfall events that can generate more frequent and/or more extensive runoff and flooding.[16] Additionally, periodic larger than historical floods are expected to occur, especially in the southern parts of the Sierra Nevada, where a transition from snow to more rainfall will occur.[17]

Flood peaks can increase erosion rates that results in greater sediment loads and turbidity while runoff from streets and farms can increase concentrations of pollutants.[18] Changes in temperature and precipitation could alter existing fresh water systems and an overall reduced availability of water for fish and wildlife. An increase in floods may amplify movement of pollutants and contaminants into previously pristine areas. Temperature and precipitation changes will affect a variety of aquatic species and may result in loss and degradation of sensitive aquatic ecosystems and potentially increase invasive species challenges. In addition, these changes will affect groundwater recharge and over drafting as well as hydropower and hatchery project operations, fish passage issues, and water diversion projects. Changes in composition and structure from precipitation and flow changes for riparian communities and conflicts over allocation of surface water could result in increased management conflicts between people and wildlife and will require communication and collaboration among managers.

C. Sea-Level Rise

The higher mean water levels from sea-level rise can exacerbate existing factors that threaten critical portions of the Sacramento and San Joaquin Delta levee system. This system extends over more than 700,000 acres and consists of a myriad of small natural and man-made channels bounded by levees to protect land and key infrastructure from floods.[19] If levees fail, water from San Francisco Bay would inundate agricultural land and some communities, damage infrastructure, affect ecosystems, enter California's freshwater supply, and change water quality.

Warmer storms and snowmelt may coincide and produce higher winter runoff from the watersheds, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, they increase the probability of Delta levee failures, breaking a critical link between water supply in the north and water users in the southern portions of the state.

Additionally, a drop in summer stream flows could affect the Sacramento-San Joaquin Delta water supply and ecosystems, both directly through low-flow conditions and higher stream water temperatures, and indirectly as saltwater intrudes further upstream from the Pacific Ocean. An increase in the penetration of seawater into the Delta will thus further degrade drinking and agricultural water quality and alter ecosystem conditions.[20] Holding back this salinity intrusion will require more freshwater releases from upstream reservoirs to maintain fresh water levels for municipal, industrial and agricultural uses, which in turn will further increase pressure on already scarce water resources.

D. Risks for Water Management

Higher temperatures, changes in precipitation patterns and sea-level rise all combine to exacerbate California's existing water supply challenges. Expected population growth alone would make it more difficult to meet growing water demands. With climate change the state's water crisis will worsen, overall increasing the risk of water shortages and flooding. To summarize the changing risks that California's water supply will face from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The resulting risk profile for California's water supply can be characterized as follows:

- Higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher, resulting in less snowpack to supply water to California users. In addition, a growing proportion of winter precipitation will fall as rain instead of as snow. Snow accumulation on April 1 will be significantly reduced, and snowmelt will run off earlier, leaving less water stored for the dry months.
- By mid-century, most climate simulations used by the 2009 CAT report project marginally to considerably drier conditions in California. Water supplies originating from outside of the state (e.g., the Colorado River Basin and the Klamath River Basin) are also decreasing.
- Intense rainfall events, periodically ones with larger than historical runoff, will continue to affect California with more frequent and/or more extensive flooding.
- Droughts are likely to become more frequent and persistent in the 21st century.
- Streams may experience longer low-flow conditions with higher temperatures and higher concentrations of contaminants.
- Higher temperatures – especially in the summer and over a longer growing season – increase evapotranspiration rates from plants, soils and open water surfaces, including water reservoirs.
- Non-irrigated agriculture and landscaped areas, as well as natural systems will suffer moisture deficits if natural water supplies are limited, and irrigation will need to be increased if crop losses are to be avoided. Even with conservation and efficiency measures, urban water use is expected to increase.

- Storms and snowmelt may coincide and produce higher winter runoff from the landward side, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, they increase the probability of levee failures in the Sacramento-San Joaquin Delta.
- Saltwater intrusion into estuaries, bays, and coastal groundwater resources will diminish water quality, transform ecosystems and reduce freshwater supplies.

Water Management Adaptation Strategies

Introduction

Concerns over the availability, quality, and distribution of water are not new to California, but these concerns are growing and solutions are becoming more complex as water managers navigate competing interests and regulations to reliably provide quality water to farms, businesses, and homes, while also protecting the environment and complying with legal and regulatory requirements. Water adaptation strategies are primarily driven by the possibility of reduced future water supplies and increased flood threat brought about by climate change. While we are unlikely to know the full scope of climate change for many decades, we do know enough now to begin taking action strategically to adapt California's water management systems.

The Department of Water Resources (DWR), in collaboration with the State Water Resources Control Board, other state agencies, and numerous stakeholders, has initiated a number of projects to begin climate change adaptation planning for the water sector. For instance, the recent incorporation of climate change impacts into the California Water Plan Update is an essential step in ensuring that all future decisions regarding water resources management address climate change. As part of the Update, in October 2009 DWR released the U.S.'s first state-level climate change adaptation strategy for water resources, and the first adaptation strategy for any sector in California. Entitled *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water,* the report details how climate change is already affecting the state's water supplies and sets forth ten adaptation strategies to help avoid or reduce climate change impacts to water resources. Because of the large role of local and regional water management, central to these adaptation efforts will be the full implementation of Integrated Regional Water Management (IRWM) plans, which address regionally appropriate management practices that incorporate climate change adaptation. These plans will evaluate and provide a comprehensive, economical and sustainable water use strategy at the watershed level for California.

North Coast Integrated Regional Water Management Plan (NCIRWMP):

Stakeholders on the North Coast are incorporating climate change into the NCIRWMP in many ways, including evaluating options for carbon sequestration, GHG emission reduction via large scale alternative energy generation and by reducing the risk of catastrophic wildfire, incorporating adaptation into local planning, water infrastructure and watershed restoration activities, and educating the public regarding the need for climate adaptation. In particular, there are substantial opportunities to incorporate climate adaptation into the NCIRWMP framework, many of which address multiple objectives of the IRWM program such as flood and stormwater management, water conservation, local planning, floodplain and habitat enhancement, and water supply reliability.

Another key adaptation approach is to aggressively increase water use efficiency. Implementing this approach will require the adoption of urban best management practices and other measures. Agricultural entities will be encouraged to apply Efficient Water Management Practices (EWMPs) to reduce water demand and improve the quality of drainage and return flows. In regions where recycled water may represent a relatively energy efficient and drought-proof water management strategy, local water agencies will be encouraged to adopt policies that promote the use of recycled water for appropriate, cost-effective uses while still protecting public health. However, not all water use efficiency activities are

equally effective responses to climate change. For example, efficiencies that reduce evaporative (e.g., landscape and crop evapotranspiration), other consumptive uses, and flows to saline sinks (e.g., the ocean) are the most effective.

Statewide, adaptation strategies aim to fundamentally improve water and flood management systems and enhance and sustain ecosystems. Reliable water supplies and resilient flood protection depend upon ecosystem sustainability. Building adaptive capacity for both public safety and ecosystems requires that water and flood management projects maintain and enhance biological diversity and natural ecosystem processes. Water supply and flood management systems are significantly more sustainable and economical over time when they preserve, enhance and restore ecosystem functions, thereby creating integrated systems that suffer less damage from, and recover more quickly after, severe natural disruptions. By reducing existing, non-climate stressors on the environment, ecosystems will have more capacity to adapt to new stressors and uncertainties brought by climate change. Flood management will be improved by increased coordination among existing water and flood management systems. Ecosystem enhancement will include actions to restore previous connections between rivers and their historical floodplains, creating seasonal aquatic habitats and facilitating the growth of native riparian forests.

A strategy for improving management and decision-making capacity focuses on planning for and adapting to sea-level rise. This will require the establishment of an interim range of sea-level rise projections for short-term planning purposes for local, regional, and statewide projects and activities. A scientific panel of the National Research Council (NRC) will provide expert guidance regarding official long-range sea-level rise estimates and their application to specific California planning issues. The DWR, in collaboration with other state agencies and under guidance from the NRC, will develop long-range sea-level rise scenarios and response strategies for the *California Water Plan Update 2013*.

As climate change continues to unfold in the coming decades, institutions, along with infrastructure, may need to also adapt, which may require reconsidering existing agency missions, policies, regulations, and other responsibilities, as well as changes to existing resources legislation. The California Water Plan Update is one example of where such adaptation has already occurred.

Adaptation Strategies and Actions

Climate change is already affecting California's water resources as evidenced by changes in snowpack, river flows and sea levels. Impacts and vulnerability will vary by region, as will the resources available to respond to climate change, necessitating regional solutions to adaptation rather than an easily administered but comparably ineffective "one-size-fits-all" approaches. An array of adaptive water management strategies must be implemented to better address the risks and uncertainties of changing climate patterns. Fortunately, as one water stakeholder has observed, California has far more knowledge, expertise, and financial capacity to adapt its water management systems to climate change than our society had in the 1850's, when an east-coast American society abruptly found itself in a Mediterranean climate upon settlement in the West. The strategies listed below are from *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water* and the California Water Plan Update; they are cross-referenced with other sectors for contextual efficacy:[21]

Strategy 1: Provide Sustainable Funding for Statewide and Integrated Regional Water Management

Long-Term Actions:

a. **Financing Mechanisms** – A formal assessment of state and local financing mechanisms should be conducted by the state Legislature in order to provide a continuous and stable source of revenue to sustain proposed climate resiliency programs. Activities include regional water

planning, inspection, maintenance, repair, and rehabilitation of flood management facilities, observational networks and water-related climate change adaptation research.

Strategy 2: Fully Develop the Potential of Integrated Regional Water Management

Near-Term Actions:

a. **Integrated Water Management Plans (IRWM)** – By 2011, all IRWM plans should identify strategies that can improve the coordination of local groundwater storage and banking with local surface storage along with other water supplies including recycled municipal water, surface runoff, flood flows, urban runoff, storm water, imported water, water transfers and desalinated groundwater and seawater.

b. **Adaptation Component** – By 2011, all IRWM plans should include specific elements for climate change adaptation.

Strategy 3: Aggressively Increase Water Use Efficiency

Near-Term Actions:

a. **Statewide Reduction in Water Use** – As directed by Governor Schwarzenegger and reinforced through legislation, Department of Water Resources (DWR) in collaboration with the Water Boards, the California Energy Commission, the California Public Utilities Commission, the California Department of Public Health (CDPH), and other agencies will implement strategies to achieve a statewide 20 percent reduction in per capita water use by 2020.

b. **Water Efficiency** – Agricultural entities should apply all feasible Efficient Water Management Practices (EWMPs) to reduce water demand and improve the quality of drainage and return flows, and report on implementation in their water management plans.

c. **Energy Efficiency** – Recycled water is a drought-proof water management strategy that may also be an energy efficient option in some regions.

d. **Water Conservation** – The State Water Resources Control Board (SWRCB) and the California Public Utilities Commission may impose water conservation measures in permitting and other proceedings to ensure water conservation efforts. It is recommended that the Legislature authorize and fund new incentive-based programs to promote the mainstream adoption of aggressive water conservation by urban and agricultural water systems and their users.

Strategy 4: Practice and Promote Integrated Flood Management

Near-Term Actions:

a. **Flood Management Improvements** – To reduce flood peaks, reduce sedimentation, temporarily store floodwaters, recharge aquifers and restore environmental flows, flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.

b. **System Reoperation Task Force** – The improved performance of existing water infrastructure cannot be achieved by any single agency, and will require the explicit cooperation of many. Moreover, system-wide operational coordination and cooperation must be streamlined to respond to extreme events that may result from climate change. Successful system re-operation will also

require that the benefits of such actions are evident to federal and local partners. To achieve these goals, the State will establish a System Re-operation Task Force comprised of state personnel, federal agency representatives, and appropriate stakeholders.

c. **Support Decision Making** – To successfully meet the challenges posed by climate change, the federal-state Joint Operations Center (JOC) capacity should be expanded to improve tools and observations that better support decision-making for individual events, seasonal and inter-annual operations and water transfers. The JOC should be enhanced to further improve communications and coordination during emergencies such as floods and droughts.

d. **Central Valley Flood Protection Plan** – By January 1, 2012, DWR will collaboratively develop a Central Valley Flood Protection Plan that includes actions to improve integrated flood management and consider the potential impacts of climate change.

e. **Emergency Flood Preparedness** – All at-risk communities should develop, adopt, practice and regularly evaluate formal flood emergency preparedness, response, evacuation and recovery plans.

f. **Land Use Policies** – Local governments should implement land use policies that decrease flood risk.

Strategy 5: Enhance and Sustain Ecosystems

Long-Term and Near-Term Actions:

a. **Species Migration and Movement Corridors** – Water management systems should protect and reestablish contiguous habitat and migration and movement corridors for plant and animal species related to rivers and riparian or wetland ecosystems. IRWM and regional flood management plans should incorporate corridor connectivity and restoration of native aquatic and terrestrial habitats to support increased biodiversity and resilience for adapting to a changing climate.

b. **Floodplain Corridors** – Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains. Setback levees and bypasses help to retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Carbon sequestration within large, vegetated floodplain corridors may also assist the state in meeting GHG emissions reductions mandated by AB 32.

c. **Anadromous Fish** – The state should work with dam owners and operators, federal resource management agencies, and other stakeholders to evaluate opportunities to introduce or reintroduce anadromous fish to upper watersheds. Reestablishing anadromous fish, such as salmon, upstream of dams may provide flexibility in providing cold water conditions downstream, and thereby help inform system reoperation. Candidate watersheds should have sufficient habitat to support spawning and rearing of self-sustaining populations.

d. **Tidal Wetlands as Buffers** – The state should identify and strategically prioritize for protection lands at the boundaries of the San Francisco Bay and Sacramento-San Joaquin Delta that will provide the habitat range for tidal wetlands to adapt to sea-level rise. Such lands help maintain estuarine ecosystem functions and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level rise and storm surges.

e. **Reversal of Delta Island Subsidence** – The state should prioritize and expand Delta island subsidence reversal and land accretion projects to create equilibrium between land and estuary elevations along select Delta fringes and islands. Sediment-soil accretion is a cost-effective, natural process that can help sustain the Delta ecosystem and protect Delta communities from inundation.

f. **Upper Watershed Services** – The state should consider actions to protect, enhance and restore upper watershed forests and meadow systems that act as natural water and snow storage. This measure not only improves water supply reliability and protects water quality, but also safeguards significant high elevation habitats and migratory corridors.

Strategy 6: Expand Water Storage and Conjunctive Management of Surface and Groundwater Resources

Near-Term Actions:

a. **Expand Water Storage** – California should expand its available water storage for both surface and groundwater supplies. Funding for this is included in the proposed 2010 Water bond.

b. **Surface Storage Feasibility Studies** – DWR will incorporate climate change considerations as it works with the U.S. Bureau of Reclamation (Reclamation) and local agencies to complete surface storage feasibility studies.

c. **Conjunctive Use Management Plans** – State, federal, and local agencies should develop conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage.

d. **Groundwater Management Plans** – Local agencies will be encouraged to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of their IRWM plans. In addition, recently passed legislation requires that local agencies monitor the elevation of their groundwater basins.

e. **Local Ordinances** – Cities and counties will be encouraged to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

Strategy 7: Fix Delta Water Supply, Quality and Ecosystem Conditions

Near-Term Actions:

a. **Delta Adaptation Planning** – Recently passed legislation establishes the framework to achieve the co-equal goals of providing a more reliable water supply to California and enhancing the Delta ecosystem. It encourages the incorporation of adaptive responses to climate change in the development of the Bay-Delta Conservation Plan and other Delta-related efforts.

b. **Sustainable Delta Goals** – The Safe, Clean and Reliable Drinking Water Supply Act of 2010 is an $11.14 billion general obligation bond proposal that would provide funding for California's aging water infrastructure and for projects and programs to address the co-equal goals as well as statewide water projects and programs. It includes funding for drought relief, water supply reliability, Delta sustainability, statewide water system improvements, conservation and watershed protection, groundwater protection and water quality, and water recycling and conservation.

Strategy 8: Preserve, Upgrade and Increase Monitoring, Data Analysis and Management

Long-Term Actions:

a. **Climate Monitoring** – Critical for the projection of future water supply, climate change detection and consistent monitoring of critical variables such as temperature, precipitation, evapotranspiration, wind, snow level, vegetative cover, soil moisture and stream flow will be expanded at high elevations and wilderness areas to observe and track changes in the rain and snow transition zone.

b. **Atmospheric Observations** – To better project future rain and snow patterns on a regional scale, atmospheric observations are needed to define and understand the mechanisms underlying atmospheric processes that lead to California's seasonal and geographic distribution of precipitation.

c. **Water Use Feasibility Study** – The accurate measurement of water use can facilitate better water planning and management. By 2009, DWR, the state and regional Water Boards, the Department of Public Health, and the California Bay-Delta Authority will complete a feasibility study for a water use measurement database and reporting system.

d. **Water Use Accountability** – Recently passed legislation improves accounting of the location and amounts of water diverted from the Delta.

Strategy 9: Plan for and Adapt to Sea-Level Rise

Long-Term Actions:

a. **Sea-Level Rise Projections** – The state will establish an interim range of sea-level rise projections for short-term planning purposes for local, regional and statewide projects and activities.

b. **National Research Council study** –The Resources Agency, in coordination with DWR and other state agencies will convene and support a scientific panel from the National Research Council (NRC) to provide expert guidance regarding long-range sea-level rise estimates and their application to specific California planning issues.

c. **California Water Plan Update** – Based upon guidance from the NRC, DWR, in collaboration with other state agencies will develop long-range sea-level rise scenarios and response strategies to be included in the California Water Plan Update 2013.

Strategy 10: Identify and Fund Focused Climate Change Impacts and Adaptation Research and Analysis

Long-Term Actions:

a. **Research Planning and Partnerships** – In association with research institutions such as the Regional Integrated Sciences and Assessment centers, Lawrence Livermore and Berkeley National Laboratories, and the University of California, state agencies will identify research needs that provide guidance on activities to reduce California's vulnerability to climate change. The state will also explore partnerships with the federal government, other western states, and research institutions on climate change adaptation.

b. **Sensitivity Analysis** – The state's water supply and flood management agencies will perform a sensitivity analysis of preliminary planning studies, along with risk-based analyses for more advanced planning studies. For flooding, sensitivity and risk-based analyses an appropriate risk tolerance and planning horizon for each individual situation is under consideration. Selection of climate change scenarios for these analyses can be guided by recommendations of the Governor's Climate Action Team.

c. **Pilot Projects** – The sponsorship of science-based pilot projects for watershed adaptation research is needed to address climate change adaptation for water management and ecosystems. Funding for pilot projects should only be granted in those regions that have adopted IRWM plans that meet DWR's plan standards and have broad stakeholder support.

d. **California Water Plan Update** – Every five years DWR will provide revised estimates of changes to sea level, droughts, and flooding that can be expected over the following 25 years, this will be included in future versions of the California Water Plan Update.

VIII. AGRICULTURE

Introduction

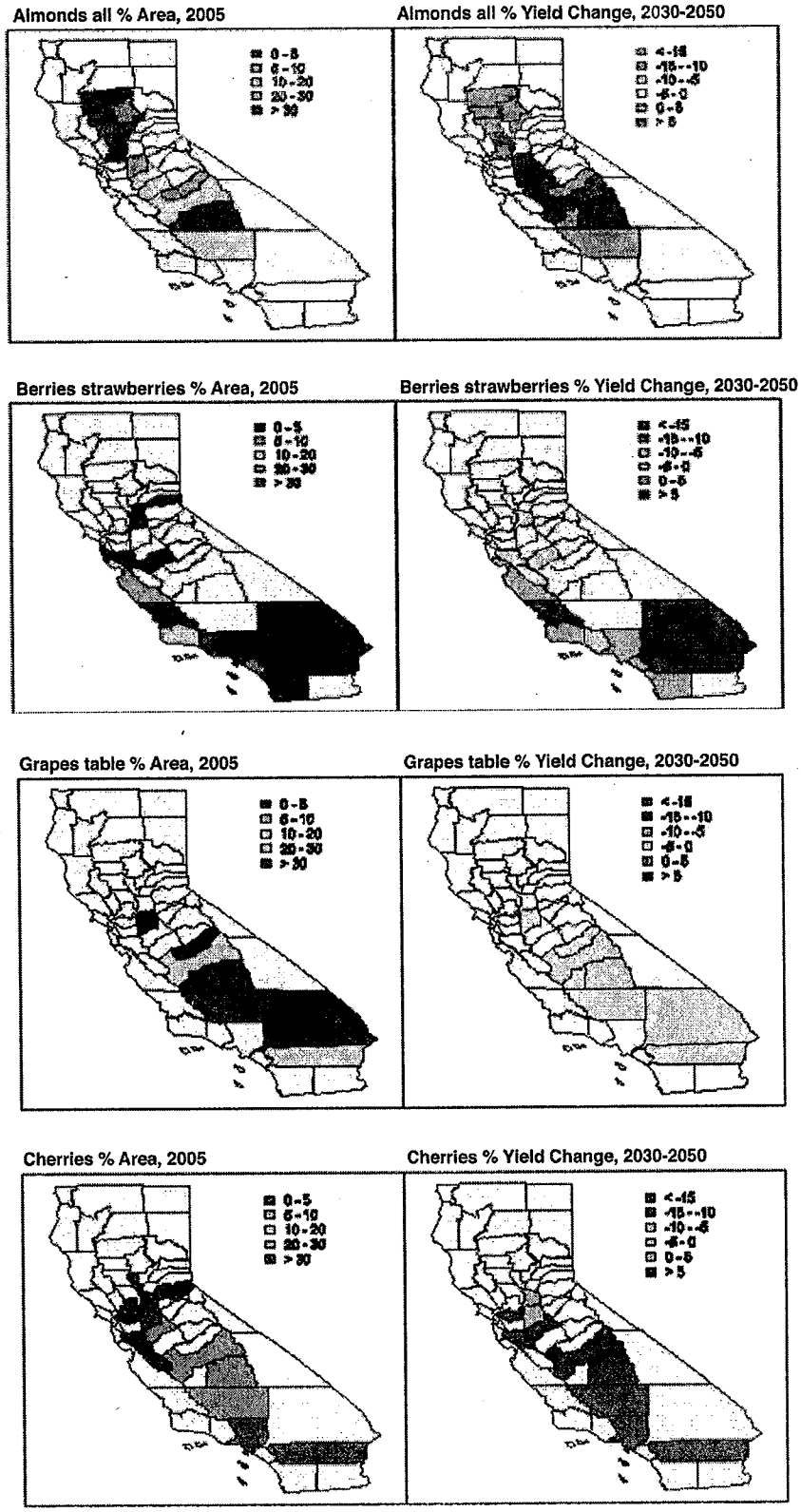
"Conservation is ethically sound. It is rooted in our love of the land, our respect for the rights of others, and our devotion to the rule of law." -Lyndon Baines Johnson

California has been the most productive agricultural state in the union for more than 50 years.[1] From 1974 to 2004, the value of California's agricultural commodity gross cash receipts more than quadrupled while the total acreage devoted to agriculture declined by 15 percent. This growth in production gross sales value is due largely to technological improvements in crop production and more intensive use of farmland, including the shift to higher value crops. Today, with tens of thousands of family farms and ranches, California agriculture produces more than $37 billion in farm gate revenue.[2] California has become the nation's leading producer of nearly 80 different crop and livestock commodities. In fact, the state supplies more than half of all domestic fruit and vegetables and is responsible for more than 90 percent of the nation's production of almonds, apricots, raisin grapes, olives, pistachios and walnuts.

The diversity and size of California's agricultural sector creates unique opportunities and challenges with regard to climate change. Climate change alters both average and extreme temperatures and precipitation patterns, which in turn influence crop yields, pest and weed ranges and introduction, and the length of the growing season. Extreme events, such as heat waves, floods, and droughts, may be among the most challenging impacts of climate change for agriculture since they can lead to large losses in crop yields and livestock productivity. Since California plays a critical role in feeding not only state residents, but those of the U.S. and other countries, these large production declines and losses would translate to not only food shortages but financial and economic shifts that could disrupt local, regional, and national commodities systems. In the Delta region, saltwater intrusion from sea level rise may make production of certain crops increasingly challenging. Traditional water delivery systems may face challenges due to generally drier conditions and the reduction of the Sierra snowpack concurrent with urban demand increases.

Understanding the implications of climate change on the agricultural sector and the world's food supply not only underscores the importance of California's leadership in reducing GHG emissions, but can also provide invaluable guidance to growers and policymakers on how to prepare for and adapt to changes that may occur.

Figure 16: *California perennial crops in a changing climate*



Current % of crop area in each county (left) and average projected changes in county yields (right) for four perennial crops. Yield changes are expressed as percentage difference between average yields in 2030–2050 and those in 1995–2005

Future Climate Change Impacts to Agriculture

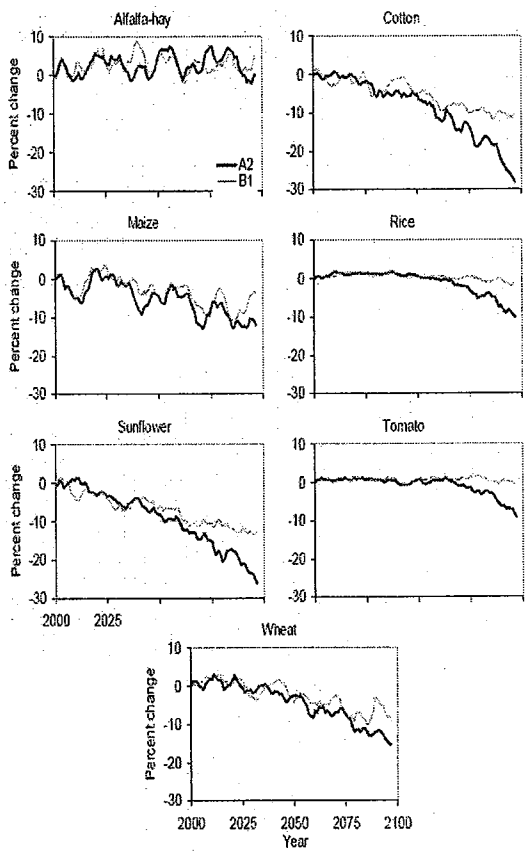
A. Increased Temperature and Extreme Events

California's agriculture could be severely affected by the warming projected by the latest climate change models.[3] Some crop yields may increase with warming, while others may decrease. According to these models, many of today's top annual field crops such as wheat, cotton, maize, sunflower, and rice show declining yields later in the century due to rising temperatures (see Figure 17).[4]

Conversely, the production of high-quality wine grapes is expected to benefit from a warmer climate because of a longer growing season and more favorable growing conditions in the short-term. At some point, however, the magnitude of the warming may become too large for certain grape varieties.

Agriculture may benefit from higher levels of atmospheric CO_2 (which functions as a fertilizer and increases the efficiency of the plants' water use) as well as from the lengthening of the growing season as freezing temperatures may become less common over the course of the 21st century. Yet these temperature changes not only affect desirable crops, but also undesirable pests. Weeds and other invasive species are likely to migrate north due to temperature increases, while disease and pest pressures will increase with earlier spring arrival and warmer winters. In addition, crop-pollinator timing can also be affected by climate change, leading to a need for modifications in crop production.

Figure 17: *Modeled crop yields by 2100, shown in 25-year increments (2000, 2025, 2050, 2075, 2100)*



PREDICTED AGRICULTURAL IMPACTS OF WARMING

- Crop Yield Changes
- Changes in Crop Types and Cultivars
- New Weed Invasions/Expanded Ranges of Existing Weeds
- New Disease & Pest Invasions/Expanded Ranges of Existing Diseases & Pests
- Flooding and Crop Pollination Changes
- Heat Waves and Stress
  - Loss of Crop Quality and Yields
  - Increased Vulnerability to Pests
  - Increased Animal Vulnerability to Disease
  - Increased Mortality of Animals
  - Less Production from Animals

Higher average temperatures can cause increases in mortality and/or decreases in productivity of livestock, leading to decreases in meat, egg, and dairy production and reproductive success of cattle.[5] Greater proliferation and survival of pathogens and pests will affect both crops and livestock.[6]

Temperature and precipitation changes can also disrupt the critical link between agriculture and biodiversity. In California a large number of wildlife species are dependent on privately owned agricultural lands for habitat and a reliable food source. As temperature and precipitation patterns change it is likely that there will be a shift in the intensity and location of agriculture that could impact fish and wildlife resources. Agricultural lands can provide significant habitat and connectivity between protected reserves, but can also compete with fish and wildlife for resources that may become limited due to climate change. Predictions of higher proportion of precipitation in the form of rain with concomitant loss of snow pack suggests more frequent summer droughts, thereby creating conflicts between beneficial uses of water. Further impact to fish and wildlife may result from the management of pests and pathogens that may proliferate within agricultural settings with warming temperatures.

Reduction of Chill Hours

While many crops benefit from the increase in average temperatures and the lengthening of the growing season, not all do. Some of California's most valuable crops, such as fruits, wine grapes, and nuts, require a certain number of chill hours in the winter. Chill hours are the number of hours below a certain temperature that a plant requires for dormancy before springtime growth. The temperature threshold and duration of dormancy needed are species-dependent, yet without the required period in dormancy, blooming, the setting of fruit, fruit quality, and therefore crop yields are negatively affected.[7]

The number of winter chill hours has already declined since 1950 with the greatest rates of change occurring in the Bay Delta region and the mid-Sacramento Valley. Grapes and almonds, which are grown in these regions, may need to be replaced with new cultivars that require fewer chill hours or alternative crops that do not require as many winter chill hours in order to avoid substantial losses.

For many high-value crops, a reduction of chill hours could be harmful. In one study, researchers examined the effects of climate change on the 20 most valuable perennial crops grown in California. They found that cherries, the 18th most valuable perennial crop in the state, are likely to be the most negatively affected by warming in coming decades. This finding is likely related to a loss of chilling hours. A second robust finding of the study was that almonds, the most valuable perennial crop in California and the source of the world's supply, will be harmed by increasing February temperatures. None of the crops studied showed any clear benefits from projected warming.[8]

Changing Temperature Extremes

Understanding how climate change affects the occurrence of temperature extremes is crucial for California's agriculture. The costliest acute event to California's agriculture in recent years was the freeze of December 1998. Various crops, including oranges, lemons, olives and cotton, experienced major losses. The second costliest individual event was the heat wave of July 2006, which was especially damaging to the livestock industry.[9]

In recent decades, cold extremes have already become less frequent, and are projected to become even less frequent across the state in the future.[10] Heat waves, by contrast, are very likely to become more frequent due to climate change.[11,12] Climate scenarios using the higher emissions scenario suggest that heat waves similar in length and intensity to the one experienced in July 2006 may become as frequent as once a year in many parts of California by the end of the century.[13]

The heat stress caused by extremely high temperatures can increase livestock vulnerability to disease, infection, and mortality; and can decrease livestock production. For crops, heat stress can lead to losses in quality and yields; and can increase plant vulnerability to pests. Extreme heat can also indirectly affect irrigated agriculture by generating short-term disruptions of the water supply, as well as increased water needs due to higher rates of water loss from evapotranspiration.[14]

B. Precipitation Changes and Extreme Events

Most climate change projections show a general drying trend over California, resulting in reduced water deliveries from a decreasing Sierra Nevada snowpack. This would lead to a water supply and supply reliability risk for agriculture, with more competition among all water users. A decrease in water supply reliability will direct crop selection to crops, such as row/field crops, that are not dependent on a steady long-term supply of water. Also, with less reliability, comes greater risk, which affects the availability of operating credit from lending institutions. One study found that under any projected climate scenario, agriculture would consistently be most vulnerable to water shortages. Researchers also estimated that annual costs of approximately $200 million would be incurred by agriculture if water availability was more than 20 percent lower than demand. [15]

Droughts and legal constraints on water delivery have in some years led to losses in excess of $1 billion annually to Central Valley agriculture, translating to tens of thousands of lost jobs, and a reduction in world food supply. Thus, short of significant adaptations, water supply reductions and intermittent disruptions will adversely affect agricultural crop yields. One modeling study combining future crop yield predictions with future water supply stresses indicated notable declines in overall crop acreage and production by 2050.[16] This potential scenario is of particular concern because of the protected demand on food supply attributable to population growth world wide.

Non-irrigated lands, despite their lack of dependence on water delivery systems, can also be impacted by altered precipitation patterns. For example, low or infrequent rainfall results in less forage on California rangelands, which can result in lower livestock productivity and increased soil erosion and water quality degradation.

Agricultural impacts can differ geographically under Delta water system shortages. For example, water shortages may be more acutely felt in the western San Joaquin Valley and Tulare Basin.[17] With projected climate change the San Joaquin Valley is projected to have potentially greater irrigation demand and evapotranspiration than the Sacramento Valley, leading to more risk for agriculture in the southern Central Valley counties by the end of the century.[18] Some of these shortages may be managed by changes in technology and agricultural practices. For example, if additional water conservation measures and new technology becomes available in the next few decades in San Diego County, agricultural demand for water could actually decrease, shrinking from 13 percent of total county demand in 2005 to six percent in 2030.[19] However, the prospects of achieving this level of efficiency increases without a reduction in acres or crop yields are improbable especially in light of the very high level of water efficiency that is currently being employed in other parts of the state.

AGRICULTURE- PREDICTED IMPACTS OF PRECIPITATION HANGES

- Loss of Water Supply and Reliability
- Loss of Food Security as Water Supply Diminishes, is Less Reliable
- Loss of Irrigated Lands, Crop Production and Food Security
- Lack of Water for Agriculture and Livestock
- Drier Conditions May Affect Agricultural Crop Yields
- Increased Fire Risk to Rangeland
- Dry Steep Terrain - Increased soil erosion and sedimentation from Agricultural Lands
- Changes in Pests, Diseases and Invasive Species
- Changes in ozone and air quality - likely adverse affects on crop production

Drought can produce severe lack of water for crops and livestock, increase the risk of fire on rangeland, and ultimately reduce food security. Historically, irrigation has helped to minimize the impact of droughts, but climate projections suggest that long-lasting droughts may become more common under the higher emissions scenario later in the 21st century. Such severe decreases in water availability may well limit the types and amounts of crops grown in California.[20]

The ultimate impact of changing water supplies will depend on the degree to which farmers switch to crops and livestock that are better adapted to the new climate conditions as well as to potentially lower water supplies, market value changes in crops and livestock, and usage of water efficiency and conservation measures. According to DWR, most new water that derives from conservation will come from urban water use efficiency; most readily-adopted agricultural water conservation measures have already been implemented.[21] The gains in water use efficiency by agriculture over the past forty years was documented in a recent preliminary draft paper, which documented a doubling in inflation-adjusted dollars of agricultural gross revenue between 1967 and 2007, while during the same period total crop applied water fell by 14 percent.[22]

AGRICULTURE
IMPACTS OF SEA LEVEL RISE

- Saltwater Intrusion onto Coastal Farmland Soils
- Seawater Flooding of Low-lying Farmland
- Increases in Soil, Surface Water, and Ground Water Salinity
- Increased Upstream Flooding

Heavy Rainfall and Flooding Events

The agricultural sector is also challenged in wet conditions. For example, some farmlands in or near floodplains could be inundated when winter and spring rainfall combine with rapid snow melt (due to higher temperatures over the Sierras) and generate larger runoff than streams and soils can absorb.[23]

Flooding during the planting season is known to be particularly damaging for crops. A study of the impacts of extreme events on California agriculture, using disaster and insurance loss data over the years 1993-2007, showed that excess moisture related to heavy rainfall events and subsequent flooding led to the greatest overall economic losses during these years.[24] Specifically, heavy rainfall in the spring and winter months accounted for the 3rd, 4th and 5th costliest individual extreme events. While the number of storms is not expected to increase in the future, heavy rainfall events will continue to play a significant role in California's future climate. Especially in the Delta region, increases in winter flooding can be expected due to the coincidence of rainfall events and earlier runoff with higher sea levels. This may necessitate additional levee maintenance to protect farmland.

C. Sea Level Rise

Sea level rise impacts include saltwater intrusion onto farmlands and an increased risk of coastal flooding of low-land agriculture. Both will raise soil salinity to a point which most crops currently grown are not adapted. Increases in surface and groundwater salinity, as well as decreases in irrigation water quality near the coast, will negatively impact coastal agriculture.

Sea level rise impacts may also constrain farmers' abilities to adapt to changing water supplies and temperatures as some management practices, irrigation methods, and crop switching may not be possible in areas near sea level increases. Livestock operations and croplands may need to be relocated onto more productive lands. Investments in technology, plant breeding and cropping system research will help minimize some of the projected climate change-related agricultural impacts.[25]

D. Risks for Agriculture

To summarize the changing risks that California's agricultural sector may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The emerging risk profile for the agricultural sector can be characterized as follows:

- Climate change is likely to alter:
    - Precipitation amounts and patterns
    - Average as well as maximums and minimum temperatures, resulting in growing season lengthening and chilling hours reductions
    - Pest and weed ranges

  The resulting critical changes in water availability, temperatures, sea level rise and extreme events will all affect crop and livestock productivity which in turn will have a direct impact on domestic and international food supply.
- Extreme events may be among the greatest challenges, as they can lead to large losses of crops, impose stress on livestock, and be most difficult to manage.
- Perennial crops such as grapes, fruits, and nuts will experience varying risks, with moderate warming potentially benefiting some crops such as table grapes and almonds, but mostly negatively impacting other perennial crops, such as cherries.
- Yields of some annual crops such as cotton, maize, sunflower, and wheat are expected to slightly decrease by mid-century, while rice and tomato yields remain more or less unchanged. By the end of the century there is a growing risk of declining yields of all examined crops except alfalfa; that risk is significantly higher under the higher emissions scenario.
- Livestock is particularly at risk from heat extremes, which can lead to increased risk of mortality, lower productivity, and lower reproductive success.
- Sea level rise and increased winter run-off together with meltwater will increase low-land flooding risks. Sea level rise together with higher moisture loss from soil and water table drawdown will increase the risk of high salinity in coastal soils, thereby negatively impacting salt-sensitive crops.
- Disruptions in temperature and precipitation patterns can disrupt the link between agriculture and biodiversity.
- Hydrologic changes will decrease agricultural water supply reliability and thus diminish food security.
- Hydrologic changes will increase both threat and risk of crop and soil damaging flood on agricultural lands.

Agriculture Adaptation Strategies

Introduction

The state agencies that participated in the Climate Adaptation Working Groups (California Department of Food and Agriculture and California Department of Conservation) developed the following strategies and shall be responsible for and will spearhead strategy implementation. California's family farms and ranches play a large role in the state's economy, and rural culture; as a result, climate change will have countless impacts on the cultivation of crops and livestock. In addition, California agricultural productivity is of strategic importance to the state and nation, as a major producer of the nation's food supply. California's family farms and ranches have been successful in large part due to their ingenuity and capacity to adapt from year to year and over the long haul to changing growing conditions, such as pests and disease, labor availability, weather and market demands. To adapt to changes in temperature and precipitation, a number of approaches are proposed or in development to assist in increasing the diversity of California's agricultural commodities, thereby fostering resilience within the industry. The identification and development of crops and animals found to be resistant or better suited to the myriad of climate change variables is central when planning for adaptation and will ultimately support California farmers and preserve their ongoing operations.

Local Government Example:

Yolo County is completing the update of its general plan. The update places a strong emphasis on responding to climate change, including policies to help agriculture adapt. Among the policies are those that aim to keep as much agricultural land free from the constraints of urbanization, thus broadening the landscape flexibility for adaptation; protect water supplies through such measures as protecting groundwater recharge basins and supporting improvements in water use efficiencies; assist farmers to anticipate and respond to opportunities and adversities resulting from climate change; promote practices that sequester carbon long-term to help growers qualify for carbon credits; support the production and use of agricultural bio-fuels for economic sustainability; and, promote local market outlets to reduce transportation energy costs.

Increased research into development of crops or cultivars which exhibit an increased tolerance to heat waves, high average temperatures, drought, pests and disease should be encouraged. Strategies are also being developed that support the research of crop rotations that maximize efficient water usage. Continued improvements in irrigation systems will further the reliability of water supplies through water conservation. Management practices that address adaptive flood control will also serve to benefit existing levees and adjacent floodplains; while incentives will allow for the cultivation of floodplain compatible crops introduced in the areas prone to regular flooding.

To protect against agricultural weeds, pests and diseases, additional investments should be made in the detection, prevention and eradication of invasive species that originate from outside of the state or have relocated from other regions within the state. Further research is needed in the development of best management practices that enable adaptation, or can help predict and respond to the spreading of weeds, pests, and disease. Resilience to harmful pests and associated diseases may be optimized by providing growers with the most favorable management techniques possible, ones that will harmonize with planting, thinning, and harvest timing.

In concert with adaptation, mitigation protocols favor low carbon emission strategies such as renewable energy production on farms, and the development of a carbon and carbon equivalent credit mechanism that can be utilized in concert with food and fiber production in the future. Research is also needed to develop low-carbon, non-petroleum based crop protection tools.

Agriculture is part of the existing environment and to ensure that agriculture has room to adapt to a warming climate by moving onto lands in cooler climates further north or in higher altitudes, local general plans will need to zone for and protect such lands for future agricultural growth. Such zoning changes need to be coordinated with design and connectivity of landscape preserves for biodiversity conservation (see Biodiversity and Habitat chapter) and should contain right to farm protections to help ensure agricultural viability. Incorporating climate change model results in general plan updates that recognize the value of these lands will need to be encouraged through strategies that provide information as well as incentives to local governments.

Adaptation Strategies and Actions:

California's agricultural sector plays a large role in the state's economy and culture and is thus vital to sustain. California's family farms and ranches fulfill a key role by providing for one of the fundamental needs of society: a safe, secure, and affordable food supply. Moreover, export commodities produced by California's agriculture sector feed consumers across the nation, and around the globe. This enhances the critical nature of the relationship between food security and the agricultural impacts of climate change. To adapt to the expected changes described earlier in this chapter, the sector has a wide range of options. Those which are consistent with the activities of DOC (Department of Conservation) and CDFA (California Department of Food and Agriculture) include, but are not limited to the following:

Strategy 1 - Water Supply and Conservation Support

Near Term Actions:

a. **Water Conservation** - Continue to enhance water conservation activities at the farm and district level by initiating incentives, distributing information and introducing other strategies that encourage the development of diverse farm and irrigation district water sources.

   i. **California Irrigation Management Information System** - Expand the collection and dissemination of local weather information for irrigation planning and expand the California Irrigation Management Information System (CIMIS).

   ii. **Mobile Irrigation Labs** - Increase support for water stewardship practices either through expanding the role of mobile irrigation labs or through other services provided by Resource Conservation Districts, Water or Irrigation Districts, and Cooperative Extension services.

   iii. **California Agricultural Water Management** - Support expansion and development of voluntary district-level water conservation plans for all agricultural water districts; and encourage the implementation of approved district conservation plan actions (e.g., tailwater return ponds).

   iv. **Collaboration & Partnerships** - DOC will collaborate with the USDA Natural Resources Conservation Service, DWR, CEC, and CDFA to prioritize and expand technical and financial cost-share assistance programs (e.g., water stewardship practices, farm conservation planning, water use efficiency, micro-irrigation, low energy precision application drip systems, and land-leveling) for growers.

   v. **Energy Efficient Water Recycling** - Invest in new uses for saline drainage water, using renewable solar and on-farm bio-fuels energy sources to treat saline water. This is partially mitigation, but should focus on re-use of saline drainage on more salt tolerant crops, or to expand supplies through treatment.

   vi. **Water Incentives** – Incentivize water pricing systems that reward conservation, accounting for regional differences in growing conditions, crops, and other agronomic needs. Create incentives and streamline regulatory requirements for agricultural water users to make more water available for other beneficial uses through voluntary water transfers.

vii. **Urban Conservation Programs** - Invest in urban water conservation programs that result in increased local sources of agricultural irrigation water available for future use.

viii. **Water and Energy use Efficiency on Farms** - DOC shall implement statewide expansion of the Watershed programs which support adaptive management through watershed stewardship and project implementation grant awards, including practices that increase water and energy use efficiency on farms.

ix. **Dry Farming** – Dry farming in higher rainfall coastal regions has traditionally produced high quality crops, such as wine grapes and apples. Through water conservation funding, develop incentives and marketing to support appropriate coastal zone dry farming recognizing that there will be a likely reduction in crop yields and/ or reliability of harvests and in turn available local food supplies.

b. **Floodplain Easements** - Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance. These actions will also enhance economic sustainability and protect urban residents from flooding, provide improved shallow water and seasonal wetland habitat, improved fish passage and nursery conditions, while protecting agricultural lands for the continued production of food and fiber.

Long Term Actions:

c. **Drought Tolerant Research** - Support research and development for more drought-tolerant cultivars, crop rotations, and crop mixtures.

d. **Improve Water Reliability** - Initiate reliability of irrigation water delivery to facilitate farm and district-scale crop and farm management to better adapt to climate change.

i. **Water Projects** - Continue to improve the coordination of the State Water Project, Central Valley Project, and Colorado River Project operation.

ii. **Water Conveyance** - Improve state and regional water conveyance systems to move more wet-year flows to off-stream and groundwater storage and to facilitate intra-regional water transfers.

iii. **Increase Storage Capacity** - Expand and improve the use of existing surface and groundwater storage capacity while developing new surface and groundwater storage. On-farm ponds and increased soil moisture storage are additional ways to provide operational flexibility and short term storage capacity.

iv. **Integrated Regional Water Management Planning** - Increase regional reliance of water supplies through continued support for integrated regional water management planning.

v. **Increase Recycled Water Use** - Consistent with state policy, supplement existing agricultural water supplies by encouraging the increased agricultural use of recycled urban water.

e. **Reduce Flood Impacts** - Initiate actions to reduce the harmful effects on agricultural lands from increased flooding likely from more intense storms and sea level rise.

i. **Levee Improvements** - Improve levees to protect the state's most productive farmland and reduce damage to investments, such as agricultural infrastructure and irrigation systems (e.g., land leveling and irrigation ditches, etc).

ii. **Enhance Water Capture** - Promote measures that rainfall capture by improving groundwater infiltration and soil retention/capture.

f. **Develop Severe Drought Response Strategies** – Support research and development of emergency response plans for agriculture in severe drought.

g. **Support research on practices to promote soil water-holding capacity--** California Department of Food and Agriculture, the University of California Cooperative Extension, and other interested entities should continue to support new and existing research on farm management practices that result in increased soil water retention, thus reducing irrigation needs and runoff. Research on these agricultural practices include, but are not limited to, cover cropping, conservation tillage, increasing the use of renewable inputs, increasing the carbon content of agricultural lands, improving soil fertility, and reducing evapotranspiration. These endeavors should be inclusive of conventional, organic, and other food production systems and shall do so with a focus on meeting a growing global food demand.

Strategy 2 – Preventing, Preparing for, and Responding to Agricultural Invaders, Pests, and Diseases

The California Invasive Species Council (CISC) will coordinate invasive species response for the State. The CISC mission is to provide policy level direction and planning for mitigating harmful invasive species infestations throughout the state and for preventing the introduction of others that may be potentially harmful; and to foster coordinated, streamlined approaches that support initiatives for the prevention and control of invasive species, avoiding program duplication by building upon the core competencies of member organizations. The CISC is chaired by Secretary of CDFA and vice-chaired by Secretary of CNRA. Also serving on the council will be Secretary of California's Environmental Protection Agency; Secretary of Business, Transportation and Housing Agency; Secretary of California Health and Human Services Agency; and Secretary of California Emergency Management Agency.

Near Term Actions:

a. **Inspection Stations** – Increase vigilance and develop a long-term funding strategy at the state's port-of-entry inspection stations to prevent entry of new diseases, pests and weeds.

b. **Statewide Detection** - Increase the effectiveness of statewide detection system in order to detect newly introduced pest species.

c. **Risk Analysis of Potential Invasives** – CDFA, UC Cooperative Extension, and CEMA should collaborate in developing risk analysis of foreign plant and animal pests that could invade California, to aid in better preventing introductions and better preparing for emergency eradication responses.

d. **Pollinator Technical and Financial Assistance** - Provide technical and financial assistance and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e. seedless crop varieties).

e. **Information Distribution** - Provide information to the agricultural community to enable growers to modify farm management practices and adapt to new pests and diseases.

Long Term Actions:

f. **Prevention and Detection** - Invest in the prevention, detection and eradication of noxious invaders due to climate change that come from outside California, and native California species that move into new regions of California.

    i. **Collaboration and Information Sharing** - Increase interstate and statewide cooperation in the sharing of databases, modeling, detection, warning systems and eradication.

ii. **Field Experiments** - Initiate field experiments for climate gradients that represent the range of future climates (e.g., landscape surveys) providing data on predictors, potential invasions and expansions of pests, weeds and diseases.

iii. **Identify Risks** - Identify pests and pathogens that may potentially place California at risk. Conduct analysis of previously developed scenarios from regions with similar climatic conditions.

g. **Sustained Research and Extension** - Invest in research and development of control strategies and chemicals that add to the toolbox of Integrated Pest Management in anticipation of climate change. Distribute research results through University of California Cooperative Extension programs.

i. **Adaptive Strategies** - Support research into management strategies that assist grower adaptation to increased pest and disease pressures, such as changes in planting, thinning and harvesting timing, planting of crop mixtures, and crop diversification practices.

ii. **Resiliency Development** - Safeguard farm and regional crops and livestock against uncertain pests and disease exposure by developing more resilient cultivars and breeds (i.e., develop more stone fruit varieties with fewer chill hours required for good harvests); develop inter-cropping and soil enhancing practices which improve plant, field, and landscape scale resilience. Develop practices that improve resilience of field and landscape, through research, development, and support of diverse crop and livestock populations.

iii. **Disease and Pest Resistance** – Support research and development on the identification of plant cultivars and livestock breeds that are resistant to predicted disease and pest pressures. Reduce dependence on off-farm inputs through continued research, development, and support of Integrated Pest Management practices.

iv. **Bee Colony Collapse** - Support research on the causes of bee colony collapse and the effects of climate change and adaptation strategies on healthy native and non-native pollinator populations.

v. **Modeling** - Support research on impacts of climate change that improves our understanding through the development of better scientific models on temperature and precipitation patterns to predict the spread of disease, noxious weeds and pests.

Strategy 3 - Land Use Planning Practices

Near Term Actions:

a. **Policy Integration** – CDFA, in collaboration with the Strategic Growth Council and other agencies, should provide guidance for cities and counties to help develop and adopt sustainable agriculture[iii] policies, particularly in conjunction with smart growth planning initiatives.

i. **Protection of Farmland** - Under the leadership of the DOC, ensure the continuation of the Land Conservation Act (1965) and the California Land Conservancy Program, as well as other local and state agency programs to permanently protect farmland. Use the Land

[iii] Per the 1990 "Farm Bill," sustainable agricultural policies consist of an integrated system of plant and animal production practices having a site-specific application that will, over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole.

Conservation Act in combination with the Farmland Mapping and Monitoring Program and the California Farmland Conservancy Program to identify and secure lands that offer future productivity potential against climate impacts (e.g., lacustrine and alluvial soils at higher elevations, or northern climates.)

ii. **Adaptable Farmlands** – Encourage the conservation of the most productive and adaptable farmland by supporting land conservation programs and smart growth (e.g., urban growth boundaries, in-fill, redirection and redevelopment of existing urban areas).

iii. **Community Land Use** – CDFA will encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture.

iv. **Local and Regional Markets** – Encourage and support the development of local and regional markets allowing smaller farms a niche to coexist on smaller parcels in near-urban environments. DOC Farmland Conservancy Program, utilizing data from the DOC Farmland Mapping and Monitoring Program, has developed a prototype foodshed map, starting with San Francisco, in response to the cities' local food initiative. Such foodshed mapping products can facilitate sound regional planning to optimize farmland conservation.

v. **Mapping Collaboration** - Develop and employ methods to update existing soil classification maps based on climate change scenarios in collaboration with the Natural Resources Conservation Service.

b. **Wetland Easements** – Pursuant to DWR Water Plan 2009, continue purchase of wetland easements on marginal, flood-prone, agricultural lands to diversify grower income and buffer productive lands from flood events and improve the environmental services provided by these lands. These efforts may include DWR, DFG, NRCS (Natural Resource Conservation Service), WCB (Wildlife Conservation Board) or other funding sources and incentivize private investment in the establishment and preservation of wetlands.

Long Term Actions: - The near term actions, as they are comprehensive, are expected to continue long term. Additional long term land use actions for consideration include the following:

c. **Farm Carbon Sequestration** - CDFA and the Resources Agency will work with the Climate Action Team and the Air Resources Board to identify opportunities to include farm carbon sequestration as an offset credit. Examples include promotion of offset credits for GHG emissions trading that includes the carbon sequestration by soils and other GHG reduction measures, as well as supporting research and development of protocols for agricultural practices that can potentially reduce GHG emissions. CDFA shall have a major role in developing the mechanisms for offset credits.

i. **Credits and Offsets** - Promote the integration of carbon offset markets with environmental market credits (i.e., water quality and wildlife habitat improvements) to reduce greenhouse gases, and improve the economic and environmental sustainability of agricultural operations.

Strategy 4 – Promote Working Landscapes with Ecosystem Services to Improve Agrobiodiversity

Near Term Actions:

a. **Technical Assistance and Outreach** - Use new and existing technical and financial assistance programs, and informational outreach where appropriate to increase the diversification of the agricultural region from field to landscape scales. For example, inter-cropping with rotations, cover cropping, hedgerows, riparian restoration and wetlands can provide grower opportunities for diversification of income from carbon sequestration and other environmental services credits; create opportunities for pest predator and pollinator habitat; and enhance resilience against climate change.

b. **Bio-Energy** – The University of California Cooperative Extension (UCCE), along with the California Energy Commission (Energy Commission) and the California Department of Food and Agriculture (CDFA) should encourage the development of sustainable agricultural feedstocks for bio-energy that use marginal land and avoid competing with both plant and animal food production.

Long Term Actions:

c. **Climate Adapted Crops and Crop Mixtures** - Support identification, research, development, and breeding of crop varieties, cultivars, and mixes of crops capable of adapting to expected climate change (e.g. with respect to changes in temperature, precipitation, pest and disease resistance, air quality, salt tolerance and drought tolerance) in order to assist growers in the selection of crop and livestock most likely to succeed.

d. **Crop Diversification** – The University of California, in partnership with the Energy Commission and the CDFA should support the identification, agronomic and economic analysis of multiple crop types and second-generation (cellulosic) energy crops for use by growers to diversify their production options, improve their ability to adapt to climate change, and create long-term opportunities for recycled water reuse.

e. **Economic Evaluation of Systems that Enhance Ecosystem Services** – The University of California, in partnership with the Energy Commission, CDFA, and other agencies, should support the identification of new or evolving markets for systems that fulfill consumer demand for reduced "foodprint" agricultural products: methods that enhance, enrich, or regenerate soil; require reduced farm inputs; or reduce energy consumption or feedstock and product transportation needs (including conventional and organic farming); opportunities to fulfill consumer demand for agro-tourism; and other emerging consumer driven markets. Research on agronomic and economic efficiency of these new systems will support their continued adoption and expansion, where appropriate. .

Strategy 5 - Farm and Land Management Initiatives

Near Term Actions:

a. **Permit Streamlining** – The State Environmental Protection Agency (CalEPA) and CDFA will promote and facilitate permit streamlining coordination of dairy digester technologies and other initiatives (regulatory and voluntary) that have a net benefit to food supply, climate change, and the environment. CalEPA, CDFA, and other state agencies should promote technical and financial assistance for regional and on-farm sources of renewable energy and encourage the economic and environmental sustainability of California farms, dairies and rural lands.

Long Term Actions:

b. **Technical Assistance & Funding** - Complement federal financial and technical assistance such as those offered by the NRCS for farmers under the co-leadership of the Department of Conservation (DOC) and the CDFA to collaboratively encourage improved farm management practices involving tillage, rotations, manure management, fallowing, use of cover crops, inter-cropping, multi-cropping, and fertilizer-use efficiency, which result in net environmental benefits including reduction of soil erosion, increased soil fertility, water-holding capacity, and reduced on and off-site contamination of water resources.

c. **Grower Outreach** – State agencies should partner with existing information networks such as UCCE, RCDS, etc to provide information on the benefits of crop management (e.g., manipulation of planting, thinning and harvesting dates, crop mixtures, crop diversification from within-field to landscape scale, etc.) in order to adapt to climate change impacts resulting in the increase of crop pests and disease, as well as increases in temperature and changes in precipitation.

d. **High-Carbon Crop Cultivation** – State agencies should incentivize the use of crop options, encourage economic sustainability and the development of carbon credit protocols for the cultivation of woody plants in appropriate natural areas (e.g., riparian forests, hedgerows and windbreaks.) These endeavors shall be mindful of any potential reduction in food supply.

e. **Research** - State agencies should continue to invest in research and development to determine nitrous oxide generation from soil, irrigation, carbon and nitrogen input from various sources and application methods. Such research should explore relative benefits of organic and inorganic sources of nitrogen, with the aim of reducing the need for off-farm sources of nitrogen. Identify peer-reviewed scientific research that supports industry-wide practices that will reduce greenhouse gases. Develop protocols where appropriate and feasible that provide incentives to growers (e.g., GHG credits) to improve fertilizer and manure delivery technology, or reduce the need for off-farm sources of nitrogen fertilizer inputs.

Strategy 6 – Building and Sustaining Institutional Support

Near and Long Term Actions:

a. **Information Clearinghouse** - Establish information clearinghouse(s) for growers that provide information and guidance on adaptive management of crops and cultivars, air quality, precipitation, pests and diseases, climate change scenarios, annual planning, disease and pest invasions, control strategies, water conservation technology, technical and financial assistance, crop failure insurance and general information pertinent to climate change adaptation.

IX. FORESTRY

Introduction

Forestlands and rangelands occupy over 80 percent of California's 100 million acres. Forests and woodlands, which cover about 31 million acres, have at least 10 percent tree canopy and include coniferous and hardwood habitats. About half of this area consists of timberland, land capable of growing 20 cubic feet of wood per acre annually. The most recent timber yield data shows that over 1.6 billion board feet of timber, valued at about $474 million dollars, was harvested from private and public timberlands in 2007. Rangelands are native or naturalized grasslands, shrublands, deserts and open woodlands which have primarily been used for livestock grazing. They cover about 47 million acres of California's wildlands. For the purposes of this chapter, climate impact discussion and adaptation strategies focus mostly on ecosystems supporting tree cover, i.e., forests and oak woodlands (hardwood range). In addition to traditional economic uses of these working landscapes, California's forests and rangelands provide important environmental and economic benefits such as watershed protection, carbon sequestration and storage, biomass for energy production, recreation, and wildlife habitat for wildlife.

Climate change in California forests may affect tree survival and growth, forest composition, forest health and productivity, and will likely increase the intensity of ecosystem disturbances from wildfire, insects and pathogens. Population growth and land use change may create additional stresses that increase vulnerability to impacts from climate change. The interaction of these forces may reduce or change the range of ecosystem goods and services available for wildlife and watersheds, citizens, communities, and businesses.

Future Climate Impacts to Forest and Rangeland Resources

A. Increased Temperature and Extreme Events

Temperature rise affects plant species behavior, including seed production, seedling establishment, growth and vigor. It also reduces moisture availability for plants, threatens seedling and plant survival, increases the risk of wildfire, and is likely to enhance the survival and spread of insects and possibly pathogens. These effects could change the survival, distribution and composition of rangeland and forest habitats. A recent analysis of tree mortality information collected over the last five decades in the Western United States, including older established Sierran forests, determined that trees have been dying at a faster rate in recent decades as a result of increasing regional temperatures and climate change.[1]

With warmer temperatures, tree species in California may respond by migrating both northward and to higher altitudes.[2] Recent research concluded that upslope movement of pine forests and oak woodland conversions to grassland have already occurred due to climate change.[3] As the rate of climate change increases some tree species may not be able to adapt to changed conditions. Species with currently restricted ranges will probably be most vulnerable, while species with broader climate tolerances may be able to adapt more easily. Alpine forests and associated plant species are particularly vulnerable, because they have little room to expand. Ecologists also no longer assume that plant communities will migrate intact, so forest and range communities may change in species composition as they move.

The scenarios reviewed for the 2009 Scenarios Assessment show – inconclusively at this time –potential increases and decreases in forest productivity due to temperature and climate change.[4] Other researchers modeled interactions of temperature, wildfire, CO_2, and other climate effects. The results have predicted declines in conifer forests, oak woodlands, savanna and chaparral, but increases in hardwood forests and grasslands.[5]

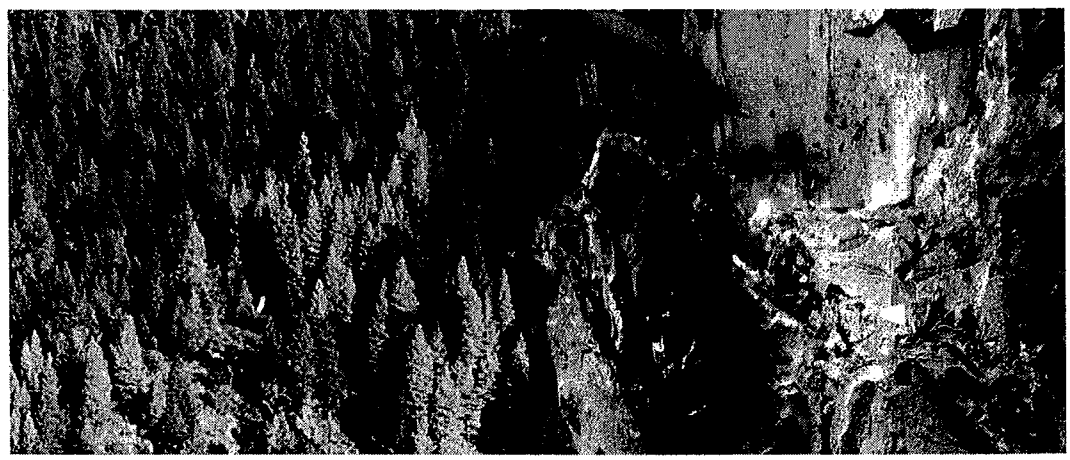
Other studies have predicted that in areas where water availability is adequate for growth, warmer average temperatures will potentially extend the growing season and allow forests to expand. A wetter climate model predicted that woody biomass would increase over the next century, while a drier climate model predicted a decrease in woody biomass.[6] A study modelling ponderosa pine plantation growth showed 9 to 28 percent increases in tree volume by the end of the century, primarily due to higher temperatures.[7] Ponderosa pine is an important commercial species, thus climate change could be economically beneficial in some areas.

Higher daily and seasonal temperatures will affect insect pest and disease life cycles and processes as winters become milder. Pests such as the mountain pine beetle have already expanded their range and have increased overall fecundity due to warmer average temperatures (Figures 18 and 19).[8] A 2 °F increase in annual average temperature allows mountain pine beetle to complete its life cycle in one year versus two.[9]

FORESTRY IMPACTS DUE TO WARMING

- Enhanced and/or Decreased Forest Productivity
- Tree Mortality
- Species Migration Barriers
- Invasive Species Increases
- Changes in Natural Community Structure
- Spread of Diseases & Insects
- Reduction in Ecosystem Goods and Services

Figures 18 and 19: *Bark Beetle damage- forest mortality has increased in recent decades as tree-damaging pests expand their range with warmer temperatures*



Many invasive plant, insect and disease species are successful at colonizing new areas precisely because they have a broad tolerance of physical conditions. As such, warmer average temperatures may make California rangelands and forests more hospitable for species that are new to the area. This could compound the loss of California's native species, increase costs for removal of invasive species, and potentially bring new species of commercial value to California's timberlands. Temperature rise also reduces moisture availability for vegetation. Warmer, shorter winters result in earlier snowmelt and spring runoff, which can mean longer dry periods in the summer months and reduced moisture for plant use. These factors have also been implicated in earlier and longer fire seasons.[10] Some models suggest that these snowpack losses are likely to occur more quickly in milder climates and at lower elevations; while slower losses are predicted at higher elevations.[11]

B. Precipitation Changes and Extreme Events

Climate change may affect precipitation and hydrology, which are critical drivers in forest and range ecosystems, in several ways. Recent winters have been warmer and snowmelt has begun earlier.[12] In addition, a greater percentage of precipitation is already falling, and will continue to fall, in the form of rain rather than snow.[13] Less snowpack and the temporal changes in snowmelt and spring runoff can lead to longer dry periods in summer months, reducing available moisture for forest plants. Moisture deficits may, however, be somewhat offset by increases of atmospheric carbon dioxide which generally cause plants to increase their water use efficiency.[14] Earlier snowmelt will also affect wildlife behavior, and this could affect forests. For example, the early emergence of denning bears could result in greater localized tree damage, tree stress and lower forest health.

While the results of precipitation models vary, recent models lean toward predictions of a drier future for California.[15] Declines in precipitation and drier cycles will increase the risk of drought. The effects of a prolonged drought on forests will depend on the species present, their life stages, soil texture and depth, and the duration and severity of the drought.[16]

A lack of consistently available moisture can impact forest health, although some regions and forest types will be impacted more than others. For example, declines in precipitation may have significant impact on those inland forests that are drier as compared to coastal forests which receive moisture through coastal fog. Climate change may, however, also result in decreased fog regimes.[17]

In the short-term, forest trees will respond to increased drought by limiting growth and reducing water use. While adult trees, with their deeper root system and stored nutrients and carbohydrates, will be able to survive short-term droughts, new seedlings and saplings may be unable to establish. Under prolonged drought conditions trees and shrubs may weaken and become more susceptible to pests, disease and wildfires, and some plant communities may be more vulnerable to invasive species. Reforestation success may be improved by management practices that use more drought tolerant species or genotypes, by changes in stocking, and other silvicultural practices.

Climate change may result in other precipitation extremes. While total average annual rainfall may decrease only slightly, rainfall is predicted to occur in fewer, more intense precipitation events. More intense weather events may result in high runoff and flooding, which can cause soil erosion and landslides. These events can impact watersheds, habitats, structures and public safety, integrity of road systems and other infrastructure and forest site productivity. Effects can be devastating when they follow wildfires that denude and destabilized slopes, as seen in "fire/flood" sequences in southern California.

Forestry Impacts due to Precipitation Changes

- Longer Dry Periods and Moisture Deficits
- Potential for Increased Growth from CO_2
- Competitive Species Interaction
- Increased Flooding & Runoff - Increases Erosion and Nutrient Loss
- Drought Conditions
  - Limits Seedling and Sapling Growth
  - Increase Wildfire Risk
  - Economic Losses

Wildfires

Fire History and the Ecological role of fire in California

Wildfires are an intrinsic part of California's forest and rangeland ecosystems. Our native habitats have evolved with and adapted to periodic wildfire disturbance. Plants species have developed mechanisms or characteristics for resisting fire damage or for reproducing or re-establishing quickly after certain kinds of fire. Fire regimes differ by region and ecosystem due to differences in weather, topography, vegetation type and stand characteristics, which affect the timing, frequency, and behavior of wildfires. Plant communities may be well adapted to some fire regimes, but not to others. For example, species such as lodgepole, Coulter, knobcone and Bishop pines have cones that release seed in response to heat and fires; thus the vegetation is adapted to moderate to high severity fires, even though fire kills individual trees. Vegetation such as ponderosa pine forest and oak woodlands, on the other hand, evolved with and benefit from frequent but relatively low intensity understory fires that remove competing vegetation without damaging trees; seed dispersal is not dependent on fire, so large, high severity fires that result in extensive tree mortality can damage these types. The table below describes fire regimes for some California plant communities (adapted from Keeley et. al, 2009, Table 1, p25, incorporated with permission from the author)[18].

Fire return interval (years)	Fire spread driven by	Fire intensity	Fire effects	Ecosystem examples
1-35	Surface and other low understory fuels	Heavy understory and fuel consumption	Low to moderate fuel overstory mortality	Ponderosa pine, pine oak savanna
1-35	Mostly surface fuels	Low to moderate	Aboveground biomass killed, most fuels consumed	Grassland, low scrub
35-100	Surface and canopy fuels	Mixed high and low	High understory mortality and fuel consumption, thinning of overstory	Western mixed-conifer forest
35-100	Mostly canopy fuels	High	Aboveground biomass killed, high fuel consumption	Chaparral, boreal forest, sagebrush
>200	Mostly canopy fuels	High	Aboveground biomass killed, high fuel consumption	Lodgepole pine forest, subalpine forest

Fire activity in California has undergone many changes over time. Prehistoric fire activity (before 1800) is estimated to have annually burned 1.8 million or more hectares (3.5 million acres) of California's wildlands, excluding deserts[19]. European settlement brought livestock grazing and introduced nonnative annual grasses, both of which altered fire regimes. Gold rush settlement resulted in disturbances, ignitions and large fires in Sierran forests and woodlands. Fire suppression was instituted in the twentieth century, significantly reducing total acres burned in California wildlands and producing longer fire return intervals in many habitats.

Fire exclusion has resulted in white fir expansion downslope into ponderosa pine habitats, the expansion of juniper and pinyon stands in sage scrub communities on the east side of the Sierra and Cascades, and decreased giant Sequoia regeneration and encroachment into Sequoia groves by other conifer species[20].

Fire frequencies have increased, however, in Southern California chaparral and coastal scrub vegetation (Keeley et al., 2009). This is due to dramatic increases in human ignitions, coupled with the invasion of exotic annual grasses that act as "flashy" fuels. Scrub species are being replaced by even more annual grasses as a consequence of these shortened fire return intervals, resulting in complete vegetation type conversions in some areas and the loss of critical habitat values.

Predicted Effects of Climate Change on Wildfire

Increased wildfire has been identified as one of the most potentially significant climate change impacts to forested ecosystems. Climate change research predicts increased numbers and acres of wildfire. Wildfire occurrence statewide could increase from 57 percent to 169 percent by 2085 under the A2 (higher) emissions scenario and by more than 100 percent in most northern California forests[21]. Fire severity is also predicted to increase as a result of more frequent severe fire weather.[22]

The wildfire season already appears to be starting sooner, lasting longer, and increasing in intensity.[23] Burned wildland acreage has increased in the last several decades[24]. Over 48 million acres, or nearly half of the state, is at a high to extreme level of fire threat.[25]

Climate change will greatly influence the size, severity, duration, and frequency of fires. Rising temperatures will produce drier fuel conditions and increase moisture stress, likely impacting forest health and increasing susceptibility to pathogens and insects. These stressors, in turn, will further increase fire hazard. Fuel buildup from years of fire suppression and past management practices, in concert with changing climate, can contribute to increasing fire hazards, threatening life and property, air quality, watersheds and water quality, terrestrial and aquatic habitats, recreation and tourism, timber resources and other goods and services.

Increases in the frequency and intensity of wildfires will make forests more susceptible to vegetation conversions from trees to brush or grasslands.[26] In order for trees to reestablish after wildfires, patches of living trees must be left to provide seeds for the recruitment of new seedlings. As wildfires increase in size, they can result in "stand replacing" burns that are too big for natural regeneration. More frequent fires may also result in vegetation conversion by repeatedly killing regeneration.

Increased frequency of fires in southern California interior and coastal chaparral ecosystems will aggravate already damaged habitats, replacing brush species with annual grasses until there's no brushy fuel left to burn. Vegetation conversions of chaparral and forest vegetation will impact biodiversity, habitats, watershed conditions, timber resources and other goods and services.

On rangelands, climate change induced wildfire increases are predicted to increase grassland acreage, while decreasing brush and oak woodlands.[27] Wildfires may increase invasion by annual and brush nonnative species, which are generally less palatable to livestock and wildlife than native grass and brush species. Annual grasses also increase fire risk and hazard by producing "flashy fuels" that ignite easily and carry fire quickly across the landscape.

Larger and more frequent wildfires will impact California's economy by increasing fire suppression and emergency response costs, damages to homes and structures, interagency post-fire recovery costs, and damage to timber, water supplies, recreation use and tourism. The California Department of Forestry and Fire Protection (Cal/Fire) spent over $500 million on fire suppression during fiscal year 2007/2008. As climate change continues these costs are expected to increase.

Fire Management

Management options for adapting to the threat of increased fires must address public health, public safety and ecosystem protection. Fire protection measures, including suppression, prevention and building codes, can reduce the occurrence, extent and damage of wildfires. Fuel reduction by manual, mechanical and prescribed burning can reduce the size and severity of wildfires. Vegetation and wildfire

management may be used to reestablish conditions that support historic or more ecologically beneficial and socially acceptable fire regimes. In significantly altered ecosystems and developed areas, this may take many steps and treatments.

In ecosystems where fuel loads have increased under fire suppression, such as northern California forests, proper fuel management, strategically placed, can effectively reduce hazard and risk and help restore vegetation conditions that are more resistant to wildfire damage. Fuel reduction also mitigates climate change by reducing GHG wildfire emissions and providing biomass for energy production as a fossil fuel alternative. Fuels management to restore more fire resistant forest conditions can be accomplished through prescribed fire, manual and mechanical treatments, or a combination of methods.

Over 200,000 acres of fuel management is conducted annually by federal and state agencies with natural resource protection responsibilities (i.e., US Forest Service, BLM (Bureau of Land Management), BIA (Bureau of Indian Affairs), NPS (National Park Service), NFW (National Fish and Wildlife Foundation), CAL FIRE, DPR (Department of Parks and Recreation)). The USFS conducts fuel management and forest health improvement on about 100,000 acres of their lands per year.[28] Prescribed fire is used on about 40 percent of the area and mechanical or other treatments on 60 percent. CAL FIRE has been treating about 16,500 acres per year on private lands (about 10,000 acres through prescribed burning and 6,500 with manual and mechanical treatments).[29] Federal grants are also been provided for community fire hazard reduction through the California Fire Safe Council. These efforts typically treat only a fraction of the area now at risk for high intensity fire.

Based on the area of ecosystems that historically supported frequent low-severity fire regimes, the potential need for prescribed burning or other treatments that restore fire resistant ecosystem conditions may be estimated at over a million acres per year. While prescribed burning treatments can be less expensive to conduct, in many cases reintroduction of fire is not prudent until heavy understory and ladder fuel hazards have been treated through alternative means (e.g., mechanical treatments). Additional research, monitoring and information sharing on the effectiveness of all treatments to re-establish desired conditions for supporting wildland fire will also be very important.

Public health and safety concerns must also be taken into consideration. Air quality impacts, concerns about fire escapes and potential harm to people and property can also impact the feasibility and costs of using prescribed fire. (See the Biodiversity and Habitat chapter for more discussion of ecological concerns.)

C. Sea-Level Rise

Sea-level rise poses minimal threats to forest stands. The convergence of sea-level rise and storm surges may, however, damage road systems in low lying forested areas right along the coast. This will impact residential access, timber management, recreation, and tourism uses of the landscape.

D. Risks for Forestry

The changing risks faced by California's forestry sector have been qualitatively assessed and the projected consequences for California's forests and woodlands are characterized as follows:

- The most significant climate change risk facing California is associated with an increase in wildfire activity. Warmer weather, reduced snowpack and earlier snowmelt can be expected to increase fuel hazards and ignition risks. It can also increase plant moisture stress and insect populations, both of which impact forest health and reduce forest resilience to wildfires. An increase in wildfire intensity and extent will increase public safety risks, property damage, fire suppression and emergency response costs to government, watershed and water quality impacts, vegetation conversions and habitat fragmentation.

- Climate change may dramatically change forested and range landscapes, resulting in expansions of some forest and woodland types, contraction of others, and conversions to brush and grassland habitats. These will affect biodiversity and may impact habitat availability, quality and connectivity. It may also affect economic uses, such as timber harvest, though net interactions of growth, wildfire, lumber markets and other effects are hard to predict.

- Temperature rise may enhance and expand insect populations, resulting in increased mortality. This would impact timber resources and reduce habitat quality for some species. It also increases fuel hazards and the likelihood for more intense, stand replacing fires that impact timber resources, fragment habitats, threaten life and property and damage watersheds.

- Climate change may result in increased establishment of non-native species, particularly in rangelands where invasive species are already a problem. These species may be able to exploit temperature or precipitation changes, or to quickly occupy areas denuded by fire, insect mortality or other climate change effects on the vegetation.

Forestry Adaptation Strategies

Introduction

The state agency that participated in the Climate Adaptation Working Group (CAL FIRE) developed the following strategies and shall be responsible for and will spearhead strategy implementation for the state. Developing a successful comprehensive forestry adaptation strategy will, however, require working across agencies and with public and private landowners. Collaboration among federal and state resource protection agencies, landowning agencies, industry and non-industrial forest landowners, and other stakeholders is essential. The U.S. Forest Service, which owns over 13 million acres of forests and woodlands, will be an important partner in this effort.

Recent research has focused on the nature of successful adaptation strategies for minimizing the threats to forests resulting from climate change. Following the findings of some researchers, adaptation can be thought of in terms of three broad strategy constructs, from which a variety of specific actions can follow.[30] Resistance refers to either forestalling or protecting key areas from harm, and is generally considered a near-term strategy to highlight high-vulnerability/high-value resources and to target actions that defend those resources against change. An example would be a particularly sensitive habitat that fires are expected to destroy. The resistance adaptation would be to put in place fire prevention and hazard reduction projects to reduce the risk from future wildfires by making fire in the habitat area less likely.

Resilience strategies emphasize transforming currently vulnerable systems into less vulnerable ones, much like how preventative health care is designed to mitigate future medical problems. This is a more mid-term level approach that requires systematic understanding of how fires impact key assets, and how the fire environment can be modified to reduce damage. The classic example is treating high hazard mixed-confer forests through fuel modifications to make future fires in low-severity systems low severity events, rather than the high severity events that might be expected under current fuel conditions. This approach has the added benefit of also being a climate change mitigation strategy in that it promotes carbon sequestration and limits CO_2 flux from future wildfires.

Finally, a Response strategy refers to pushing system effects in a beneficial way, and is typically viewed as a long-term strategy, in that ecological response is required to be conducted through successional time. As such, this strategy does not avoid change, it accommodates it.

Treatments in this strategy would try to mimic or expand on natural adaptive processes that allow natural systems to respond to changing environmental conditions as all systems have developed

over ecological time. Thus, treatments designed to improve dispersal, colonization, migration, etc. all can be viewed as promoting response. By encouraging gradual adaptation to a changing climate, the idea is to avoid rapid and often catastrophic conversions that might otherwise occur.

Adaptation Strategies and Actions

Assessment and planning

While forests inherently contain the ability to adapt to a changing climate, rapid climate change may result in significant disruptions of existing forest and range habitat structure and the goods and services we receive from them. Management actions, therefore, should enhance the resiliency of existing forests where possible, and facilitate the establishment of future stands that are more tolerant or able to exploit future climate conditions. Planning should include short and long term strategies, monitoring for unanticipated climate effects and for effectiveness of adaptation strategies, and flexibility to manage adaptively and make adjustments as we go.

CAL FIRE will continue to refine its understanding of wildland vulnerability to climate change. The Fire and Resource Assessment Program (FRAP) is updating a chapter on climate change in its Forest and Rangeland Resources Assessment. The climate change chapter will incorporate information on Fire Hazard Severity Zone mapping, recent revisions to CAL FIRE's Vegetation Management Program EIR, and climate research conducted by FRAP personnel. The assessment, which will be finished in 2010, will inform climate policy development, strategic planning, and implementation of the AB 32 Scoping Plan's Sustainable Forests target by the Board of Forestry and Fire Protection (BOF).

In order to meet the threat of increasing wildfires, CAL FIRE will focus adaptation activities on pre-fire management and fire suppression. It will work with the BOF to revise the State Fire Plan by January 2010. The plan will consider policies and programs for defensible space (fuels treatments and fire safe development standards), land use planning (timberland conversions, development projects, and fire protection responsibility), ignition resistant building standards, fire suppression deployment based on hazard/risk rating, and restoration and rehabilitation. By 2009, CAL FIRE will also have made recommendations for Very High Fire Hazard Severity Zone classification of over 200 cities in Local Responsibility Areas, which can be used to implement adaptation activities for increasing fuel reduction and improving structural resistance to wildfire. CAL FIRE will also encourage local entities to reduce fire risks and hazards and to enhance disaster readiness planning for escape routes and evacuation.

Fire Hazard Reduction and Fire Suppression

CAL FIRE has several programs that support vegetation management and fuel hazard reduction activities (mechanical treatments and prescribed burning). These can be used to increase forest health and resilience to climate impacts. Although state funding for the Proposition 40 Sierra Nevada Fuels Reduction Program expires this year, CAL FIRE is anticipating a $13.5 million-dollar, one-time federal fuels management grant and is actively pursuing other potential funding sources.

In recent years, both state and federal fuel reduction priorities have focused on the wildland urban interface (WUI), the area where at-risk forests and rangelands meet structure and human development. The WUI's proximity to communities makes mechanical treatments often more acceptable than prescribed fire, due to concerns about fire escape, life and property damage, and smoke impacts. In 2001, federal agencies and the Western Governors' Association approved "A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment," a 10-year strategy to improve fire suppression, prevention, fuels reduction and recovery, and to restore fire adapted ecosystems through collaboration among states, federal agencies and stakeholders. The plan includes the use of prescribed fire, mechanical treatments and wildland fire use, and seeks to reduce barriers to treatments through policies and incentives. [31]

Biomass utilization can help offset the cost of vegetation management and fuels reduction activities to reduce fire risk and create healthier, more resilient forests. In addition to promoting healthy forests and defensible communities, biomass utilization of these materials reduces landfill waste, provides net air quality benefits over open slash burning, and contributes to economic and job development. Sustainable biomass utilization for energy production will reduce GHG emissions because emissions are carbon neutral. CAL FIRE will work with the California Energy Commission, the Air Resources Board, stakeholder organizations and the research community to develop definitions, practices and policies that ensure forest biomass utilization is sustainable and to enhance its use for environmental benefits. CAL FIRE is developing a plan for a small demonstration biomass-to-electricity plant in Mendocino County which will be completed by December 2010. It is also working with the California Biomass Collaborative (CBC) and the California Energy Commission to inventory available forest biomass and to evaluate the potential for "Biomass Management Zones" (report due December 2009).

Ignition resistant building construction is also critical to reducing fire hazard and risk to life and property in wildland-urban interface (WUI) fires. These conflagrations, though not necessarily large (e.g., 1991 Oakland Tunnel Fire, at 1,600 acres), can overwhelm fire suppression and result in 80 to 90 percent destruction of ignited buildings. The State Fire Marshal has begun a revision of the California Building Code Chapter 7A, "Materials and Construction Methods for Exterior Wildfire Exposure" to develop more comprehensive hazard mitigation measures. The revision will be completed January 2010.

CAL FIRE has already increased fire suppression readiness to meet changing climate conditions. A year round fire season was established and staffed in southern California, and recommendations from the Governor's Blue Ribbon Commission are being implemented to replace aging fire engines and to provide a higher level of firefighter safety. Emerging remote sensing technologies are being tested on major fires to provide real time planning tools to incident commanders and fire managers, and new air tanker platforms, including the DC-10, are being evaluated for large and remote fires. Recent Governor Executive Orders have also provided increased staffing, additional aircraft availability and other support for periods of critical fuel and weather conditions.

Reforestation, Urban Forestry and Forestland Conservation

Adaptive approaches to forest regeneration can increase resilience in the short and long-term by adjusting silvicultural practices to establish forests that are more tolerant of future climate conditions. This includes planting genetically appropriate species that will be better adapted to changed climate conditions than the genotypes currently on site. CAL FIRE's L.A. Moran Reforestation Center seedbank catalogues and stores approximately 42,000 pounds of primarily native conifer seeds which are available for replanting forest stands after fires, insect or disease outbreaks, or other catastrophic events. Its greenhouse facilities have capacity for up to 400,000 container seedlings per year, but have gone unused for seven years due to inadequate funding. CAL FIRE's Magalia Reforestation Center has the capacity to produce up to 2.5 million bare-root seedlings and 40-50,000 container seedlings per year. These facilities could be brought back on line relatively quickly and inexpensively if funds for operating and staffing were provided.

Urban forestry has a significant role in adaptation to rising temperature and precipitation runoff events. Increased street tree cover provides shade relief to pedestrians and other residents, absorbs pollutants including ozone and CO_2 which may increase with climate change, and reduces stormwater pollution and flooding. A ten percent increase in vegetation cover can reduce ambient temperatures by 1 to 2 degrees. Urban forests also provide significant co-benefits, reducing habitat fragmentation and mitigating GHG emissions through sequestration and by reducing energy use for buildings. CAL FIRE urban forestry activities, funded through state bonds authorized under Propositions 40 and 84, help plant trees and support local agencies and non-profits in planning, implementing and monitoring urban forestry programs. CAL FIRE helped develop urban forestry carbon protocols to provide incentives for increased urban forest development, and will continue to work with local and federal agencies, private and non-profit sector to expand and enhance urban forests.

Development pressures on forestlands are increasing due to declining profitability from timber management and demand for rural subdivisions and vineyards. Forestland conversion fragments forested ecosystems, reducing forest health and capacity for carbon sequestration, degrading and eliminating wildlife habitat and isolating populations of forest species, increasing wildfire risk, and complicating wildland fire suppression efforts. CAL FIRE is proposing revisions to the CEQA guidelines to incorporate more protection for forestland and will work with the Board of Forestry and Fire Protection over the next 18 months to improve review and permitting for forest, timberland and Timberland Production Zone (TPZ) conversions.

Strategies and Actions

The following list of strategies and actions by the Department of Fire and Forestry (CAL FIRE) elaborates on the discussion above and identifies additional activities for addressing climate adaptation. The strategies include both near term actions - those recommendations that have been identified, proposed, initiated, or can be completed by 2010. The long term actions identified include those recommendations that will require additional collaborative efforts with multiple state agencies, as well as sustainable funding and long-term state support.

Strategy 1: Incorporate Existing Climate Information into Policy Development and Program Planning.

Near-Term Actions:

a. **Comprehensive Program Integration** – Integrate climate risk information into existing CAL FIRE program planning to address forest and range adaptation. CAL FIRE program managers should identify key climate effects or uncertainties that may affect implementation of a broad range of programs including: Forestry Assistance, State Forests, Forest Practices Regulations, Fire Protection, Fire Prevention, Unit Fire Plans, and Capital Outlay.

b. **Identify and Engage Stakeholders** – CAL FIRE will fully engage Forest Sector and cross-sector stakeholders in identifying key impact and adaptation concerns and questions as they relate to agency responsibilities and services. [e.g., U.S. Forest Service (USFS), Bureau of Land Management (BLM), National Park Service, National Marine Fisheries Service, U.S. Fish and Wildlife Service, State Department of Fish and Game (DFG), State Parks, regional air boards, regional water quality boards and other state agencies, local governments, private landowners, community groups and Non-Government Organizations (NGO)].

c. **Forest and Rangeland Resource Assessment** – CAL FIRE is required by statute to periodically assess the condition and availability of the state's forest and rangeland natural resources. The update will expand upon the previous climate change chapter to inform the Board of Forestry and Fire Protection's (BOF) climate policy, strategic plan and climate change actions. The draft plan will be developed, reviewed by the public, and considered for BOF approval by the end of 2009, and finalized in 2010.

d. **Timber harvest planning under the Forest Practices Act** - Provide guidance for project proponents and CAL FIRE staff to address climate impacts and adaptation actions within existing maximum sustained timber yield production plans required by the California Forest Practices Act.

Long-Term Actions:

e. **Build Institutional Capacity** - Update policies and CAL FIRE Handbook and activity guidelines.

Strategy 2: Improve Institutional Capacity for Data Development and Analysis, Assess Climate Effects and Forest Vulnerabilities, and Recommend Strategic and Tactical Responses.

Near-Term Actions:

a. **Vulnerability & Risk Assessment** – CAL FIRE will conduct strategic risk analyses and vulnerability assessments to identify and prioritize planning and tactical actions to address adaptation needs. Included in this is the deliberate development of quantitative risk modeling of fire impacts on key assets and resources in a spatially explicit framework. A major portion of this work involves projecting future fire probabilities and future vegetation/fuel conditions across the state.

b. **Policy Actions** – Begin to develop policy, management and funding recommendations for actions by Board of Forestry and Fire Protection, CAL FIRE, other agencies (including USFS) and private sector to increase resilience of forest lands and resources.

Long-Term Actions:

c. **Improve Data and Modeling Capabilities** – Fill major data gaps for strategic planning and assessment by CAL FIRE and other programs.

d. **Improve Scientific Knowledge Base** – CAL FIRE programs, such as the Fire and Resource Assessment Program, will work with Scripps, UC, USFS, Energy Commission and others to refine climate models for CAL FIRE Fire Protection and Resource Management Programs. CAL FIRE's Demonstration State Forest Program will also work with the USFS Pacific Southwest Research Station, the University of California and other landowners to establish research reserves, studies and demonstrations across geographic and elevation gradients that inform climate change forest management and protection needs.

Strategy 3 - Actions to Address Climate Vulnerabilities (Sector Preparedness Action Plan)

Near-Term Actions:

a. **Management of Forest and Range Lands for Resilience** – In cooperation with federal, state and local agencies, CAL FIRE plans to reduce the vulnerability of forests to disturbances from climate change impacts. Specific actions include:

   i. **Expand Landowner Assistance and Technology Transfer** – CAL FIRE's Forest Improvement Program will work with the US Forest Service, University of California Extension, Resource Conservation Districts (RCDs), Natural Resource Conservation Service and others to prevent and minimize catastrophic wildfire and restore fire resistant conditions in fire adapted vegetation types through mechanical and prescribed fire treatments, and to assist with post-fire recovery.

   ii. **Review Regulatory Framework** – The Board of Forestry and CAL FIRE's Forest Practices, Fire Protection and State Fire Marshal programs will review and consider the need for regulatory and related improvements, incentives for private investments, and revisions to CAL FIRE Handbook.

   iii. **Support Urban Forestry** – Funded through Propositions 40 and 84, CAL FIRE's Urban Forestry Program will continue to assist local entities with tree planting and urban forest management. This will help protect and expand urban forests that serve to buffer the impacts of local wildland forests, and provide sequestration, watershed, water quality and habitat co-benefits.

b. **Department Established as "Trustee" Agency in CEQA** – CAL FIRE will work with Board of Forestry to consider establishment of CAL FIRE as a Trustee agency in CEQA will provide assurance that new projects and development provide mitigation that is consistent with adaptation goals, including fire safety and forestland conservation and maintenance.

Long-Term Actions:

c. **Reduce Fire Risk, Hazards and Emissions** – CAL FIRE will work with state agencies such as Fish and Game, Parks and Recreation, Sierra Nevada Conservancy, Tahoe Conservancy and Dept. of Water Resources, with landowners and local government, and with federal agencies, including USFS and others, to identify high value and high risk natural resource areas (e.g., habitats and corridors, watersheds, parks, timberlands) and to increase fuels management and restore fire resistant forest conditions where appropriate through mechanical and prescribed fire fuel treatments.

d. **Support Restoration Activities** – CFIP and Nurseries will work with state agencies such as DFG and DPR, USFS, landowners, and others to develop technical assistance and guidance materials.

e. **Seedbank and Nursery Support** – CAL FIRE will work with the USFS and private sector to improve long-term seedbanks and nurseries in order to secure genetically appropriate varieties for future plantings and to preserve genetic legacies.

f. **Rangeland Adaptation** – CAL FIRE will cooperate with the Board of Forestry and Fire Protection and its Range Management Advisory Committee, state agencies, the University, and the private sector to promote research on carbon cycling benefits and rangeland management climate benefits.

g. **Promote Adaptation in Land Use, Public Safety and Economic Infrastructure** – Promote an active response by communities and other institutions to improve land use planning and implementation to reduce conversion and wildfire risks. Specific actions needed include:

   i. **Determine Regional Readiness to Respond to Disasters** – CAL FIRE's Fire Protection Program should work with governmental agencies and others to examine the climate impacts resulting from more frequent extreme natural events such as floods and wildfire and the ability of regional or statewide resources to respond.

   ii. **Improve Local Land Use Planning Support** – CAL FIRE's Fire Protection Program and State Fire Marshal (SFM) will work with local agencies and groups to decrease risk and hazards and increase public safety options, including revision of California Building Code Chapter 7A, "Materials and Construction Methods for Exterior Wildfire Exposure" to develop more comprehensive hazard mitigation measures.

   iii. **Factor Climate Change into Planning for Fire Protection Services** – CAL FIRE will encourage other state agencies, cities, counties, special districts and community-based non-profits such as Fire Safe Councils to develop local fire management plans that explicitly evaluate climate change impacts as part of the planning process. Fire management plans should identify risks, vulnerabilities, and preventative measures to cope with climate change.

   iv. **Minimize Impacts of Development** – CAL FIRE will work with other agencies to incorporate adaptation concerns into environmental review and permitting (e.g., timberland conversion, County General Plans, subdivision development review and individual development projects for forest impacts, wildfire hazard mitigation and structural fire resistance).

   v. **Improve Utilization of Forest Carbon Stocks** –CAL FIRE and Board of Forestry and Fire Protection will work with state agencies, industry, the Legislature and others to

ensure adequate infrastructure for biomass utilization and traditional wood products. CAL FIRE will also work with the California Energy Commission, the Air Resources Board, federal agencies, stakeholder organizations and academia to develop definitions, practices and policies that ensure that forest biomass utilization is sustainable.

vi. **Improve Opportunities for Rangeland Management Adaptation** – CAL FIRE will cooperate with the Board of Forestry and Fire Protection, the Range Management Advisory Committee, and the Dept. of Food and Agriculture to support private sector efforts to identify economic opportunities for climate adaptation, including invasive weed control, fire hazard reduction, watershed restoration and livestock management.

vii. **Post-Fire Vegetation Management** - The Department will strengthen efforts following large damaging fires to guide and invest in vegetation management to change conditions under which the next fire will burn, including encouraging the establishment of new populations of native species that may be favored by climate change. Smaller investments of resources are needed to manage vegetation following a fire than when applied to dense pre-fire vegetation.

h. **Identify Investment Options and Other Strategies to Address Climate Adaptation** – The state, CAL FIRE and the Board of Forestry and Fire Protection will initiate efforts to build public support for long term investments in public and private forestlands and develop a robust set of options to address adaptation needs for the protection of forest and range land resources.

Near-Term Actions:

i. **Explore Cross Agency and Sector Synergies** – The state, though the Climate Action Team and the California Natural Resources Agency should promote coordination among state planning processes, grant and assistance programs, and management activities on climate actions with high co-benefits. CAL FIRE will collaborate with other agencies on their adaptation strategies and with programs that increase forest resilience (e.g., with ARB to explore funding opportunities from cap and trade markets for activities with both mitigation and adaptation benefits; with WCB on Prop 84 forest conservation; with DWR, DFG, and the California Department of Conservation (DOC) to implement upper watershed protection and riparian reforestation; with DFG to identify, protect and improve the resilience of critical habitats at wildfire risk; with Energy Commission and others on Renewable Portfolio Standard (RPS) implementation to increase funding for fuels reduction; with OPR on CEQA and land use planning tools; with the Department of Public Health and ARB to address fire and smoke issues; with DOC and Dept of Food and Agriculture to consider rangeland issues; with local governments, CalTrans and others to consider development effects on fire risks; working with Strategic Growth Council on urban greening; and with Sierra Nevada Conservancy Prop 84 fuels reduction and forest restoration).

ii. **Demonstration Project** – CAL FIRE will develop a biomass-to-electricity plant at Mendocino County Conservation Camp to demonstrate the value of small power plants. Planning and funding commitments will be completed by December 2010.

iii. **Maintain Current Wood Product Utilization Capacity** – The Board of Forestry and Fire Protection and CAL FIRE will work with other agencies and the private sector as appropriate to encourage policies and strategies that help maintain utilization infrastructure (sawmills, pulp mills, veneer plants, etc.) and that encourage modernization of existing facilities or development of new facilities.

iv. **Provide Regulatory Certainty** – The Board of Forestry and Fire Protection and CAL FIRE will consider the need for additional incentives, or the removal of disincentives, to encourage landowners to actively manage their lands for adaptation, e.g., cap and trade markets, protocols and RPS implementation.

Long-Term Actions:

v. **Adequately Fund Programs** – Consider development of stable funding sources such as carbon fees, Carbon Trust, and public goods charges.

vi. **Encourage Market Development** – The Board of Forestry and Fire Protection is collaborating with the U.S. Forest Service to encourage investment in bio-energy facilities. The Board will consider the role of biomass utilization in the California Fire Plan revision by January, 2010.

Strategy 4 - Implement Priority Research Agenda

CAL FIRE will work with California Energy Commission's PIER Program (Climate Action Team), Air Resources Board, University of California and other research entities to identify and fill knowledge gaps related to climate adaptation and evaluate the most effective strategies. Potential research options include:

Long-Term Actions:

a. **Fill research gaps, including, but not restricted to, the following topics:**

i. Urban Forests and Climate Change: Comprehensive Cost and Benefit Analysis

ii. Predictive Tree Biomass Model Evaluation and Improvement

iii. Wildfire GHG Emission Analysis: Standardized Estimation Methodologies

iv. Life-Cycle Characterization of Forest Carbon Pools and Wood Products in California

v. Forest Landowner Profile Development: Current and Projected Forest Conditions and Landowner Participation in Programs and Markets

vi. Improved Forest Research and Management Tools: Climate Smart Forest Projections and Risk Assessments for Pests and Fire

vii. Forest Bioenergy and Biofuel GHG Profile Characterization

viii. Climate Change and Forests Research and Monitoring Infrastructure Development: Joint Strategic Planning

ix. Quantification of managed fire versus wild fire GHG emissions in California forests.

x. Risk and prevention analysis of catastrophic tree mortality in California forests and woodlands from parasitic and exotic insects and disease.

xi. A comprehensive monitoring and adaptive management program to quantify the effects on climate change and the effectiveness of adaptation strategies.

xii. Improved analysis of timberland conversion trends and effects.

xiii. Economic analysis of cross sector effects of investments, e.g. looking at feed-in tariff for biomass based electricity on the cost of fire suppression.

Strategy 5 - Implement Forest Health Monitoring in an Adaptive Management Context

Monitoring programs for detecting climate change, effects on vegetation and management results are needed to support adaptation planning and management. CAL FIRE will work with the California Natural Resources Agency and others to determine and implement key monitoring needs, including forest health trends, land use and management change, and effectiveness of adaptation actions.

Long Term Actions:

a. **Define Indicators** – Development of ecosystem and other climate related indicators that show or measure trends.

b. **Establish Monitoring Criteria** – Establish a network of long term monitoring plots that are implemented across both longitudinal and elevation gradients to detect climate change impacts

c. **Continue and Expand Pest Detection** – Support existing programs that can provide early detection of insects, disease, and drought in forest and range lands.

d. **Establish Adaptive Management Criteria** – Identify feedback process to inform and, as necessary, adjust policy, strategies, and regulatory approaches.

e. **Monitor Changes in Land Use** – Acres of growth and loss of forest cover as well as resulting carbon stock effects.

f. **Interagency Cooperation** – Collaborate with other state agencies to leverage limited monitoring resources.

X. Transportation and Energy Infrastructure

Introduction

California's economy and population relies on one of the most extensive and costly infrastructure systems in the world. This includes thousands of miles of roads, highways and railroads, nearly 200 large water reservoirs of varying capacity, miles of canals, the second largest hydropower production in the United States, over 12 of the nation's largest oil reservoirs, hundreds of airports, thousands of bridges, and sea ports that deal in over $200 billion in trade a year. Without this infrastructure, the state would not function as the eighth largest economy in the world.

California's infrastructure was developed to accommodate its highly variable climatic conditions, but it is frequently disrupted by natural disasters such as earthquakes, storms, and floods. Future climate change can directly and indirectly exacerbate these disasters, and add new ones, to California's infrastructure resulting in increased maintenance and repair expenditures, disrupting economic activity, interrupting critical lifelines, and ultimately reducing the overall quality of life for Californians.

To date, there are very few studies providing thorough, comprehensive economic or physical assessments of where California is most vulnerable from future climate change when, and from what specific climate change impacts. More are needed. However, several recent studies shine light on the potential scale of the economic and social impacts from climate change. One recent study from the Pacific Institute estimates that a 1.4 meter sea-level rise over the next century will "put 480,000 people at risk of [what is considered today] a 100 year flood" which would become a common event and cost $100 billion to replace flooded property assuming current levels of development. Another study by researchers at UC Merced and RAND Corporation estimated that by the next 15 to 20 years the cost of wildfires to residential properties could escalate to more than two billion dollars a year and to more than $10 billion a year by the end of this century.[1] Finally, a study by Next10 and U.C. Berkeley estimates that over $2.5 trillion of the state's real estate assets (of $4 trillion) are "at risk from extreme weather events, sea-level rise, and wildfires, with a projected annual price tag of $300 million to $3.9 billion."

In this chapter, *infrastructure* refers largely to transportation and energy-related infrastructure. Other chapters address water and coastal infrastructure strategies and impacts. Future climate adaptation strategy efforts will require a broader look at all infrastructure across California including the private sector and federal and local jurisdictions.

Future Climate Change Impacts to Infrastructure

The most significant climate impacts to California's infrastructure are predicted to be from higher temperatures and extreme weather events across the state, reduced and shifting precipitation patterns in Northern California, and sea-level rise. Higher air temperatures are expected to increase the demand for electricity in the Central Valley and Southern California, especially during hotter summer months, reducing energy production and transmission efficiency while increasing the risk of outages. Potential reductions on precipitation levels could significantly reduce hydropower production which currently accounts for up to 20 percent of the state's electricity supply. Heavy precipitation and increased runoff during winter months are likely to increase the incidence of floods damaging housing, transportation, wastewater, and energy infrastructure. The largest projected damages will come from sea-level rise threatening large portions of California's coastal transportation, housing, and energy-related infrastructure.

A. Increased Temperature and Extreme Events

Temperature changes will have direct impacts on energy production, use and distribution and on transportation infrastructure. Average temperature changes are expected to increase energy demands in summer and decrease them in winter. However, with temperatures expected to increase more in summer than in winter in California, wintertime heating demand reduction is likely to be far outweighed by summertime demand increases.[2] Over the past few decades, California's per capita electricity consumption has remained relatively steady due in large part to cost-effective building and appliance efficiency standards and other energy efficiency programs.[3] The *total* consumption, however, has increased substantially along with California's rapidly growing population.

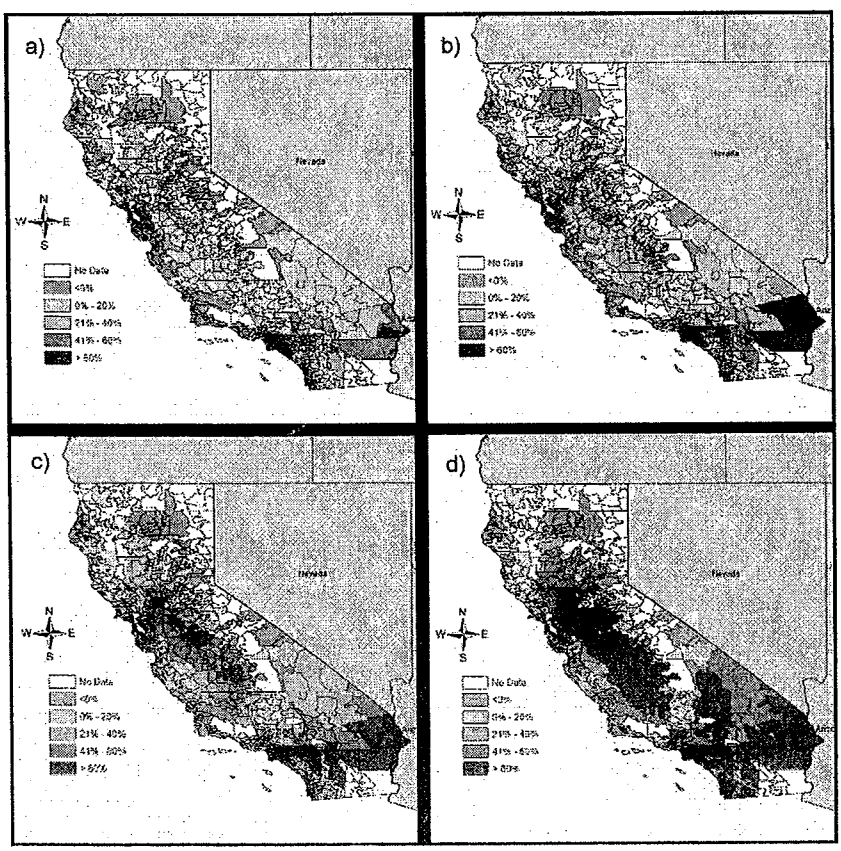
Coupled with future population growth, the projected rise in ambient temperatures will increase energy demand for cooling, especially in the Central Valley region where temperatures are predicted to significantly increase.[4] A 2003 study analyzed data for several California cities and found that although previous studies indicate a response rate of two to four percent in electricity use for each degree Celsius increase in ambient temperatures, "long-term climate change will also impact electricity consumption through corresponding increases in the market saturation of air conditioning".[5] A more recent study showed that while California's total domestic electricity demand in the residential sector will most likely increase by a few percent in the next three decades, it could increase more than 60 percent by the end of the 21st century in certain areas, depending upon emissions scenarios.[6] These increases are beyond what is expected from population growth alone.

In a nationwide review of the available research literature, researchers examined how climate change might affect energy consumption in the United States. Their answer is consistent with California Energy Commission projections and other regional

POTENTIAL INFRASTRUCTURE IMPACTS DUE TO WARMING

- Higher Average Temperatures Affect Energy Production, Transmission and Demand
  - Increase in Cooling Demands
  - Decrease in Water Availability for Hydropower Generation
  - Risk of Increased Brown-Outs and Black-Outs
  - Transmission Efficiencies are Impacted in Hot Weather
- Temperature Extremes
  - Increase of Road and Railroad Track Buckling
  - Decrease in Transportation Safety and Higher Costs

Figure 20: *Projected increase in household electricity consumption (from 1980–1999 simulated consumption) (a) 2020–2039, (b) 2040–2059, (c) 2060–2079, and (d) 2080–2099 (Source: Aroonruengsawat and Auffhammer, 2009)*



research relevant to California: "The research evidence is relatively clear that climate warming will mean reductions in total U.S. heating requirements and increases in total cooling requirements for buildings. These changes will vary by region and by season, but they will affect household and business energy costs and their demands on energy supply institutions. In general, the changes imply increased demands for electricity, which supplies virtually all cooling energy services but only some heating services".[7]

Higher temperatures also decrease the efficiency of fossil fuel-burning power plants and energy transmission lines, thus requiring either increased production or improvements in the efficiency of power generation and transmission.[8]

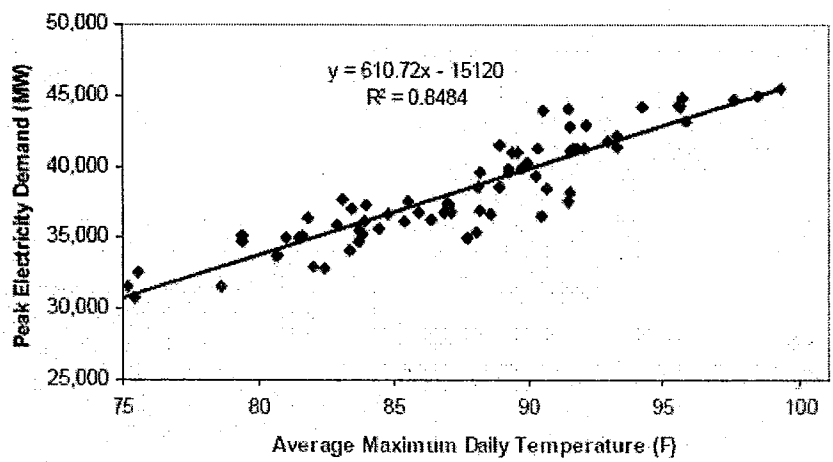
Extreme heat events could cause significant impacts to the energy and transportation sectors. A recent study on extreme heat events and energy demand in California concluded that by 2070-2099 extreme heat events under the IPCC's highest emissions scenario (A1fi) are 20 to 30 percent higher than under the lower scenario (B1) due to temperature differences. The study concluded extreme heat days could double in inland cities like Sacramento and quadruple in coastal cities such as San Diego. Regarding energy supplies, the researchers found California has a 17 percent probability of facing electricity deficits during high-temperature (top 10 percent of historic temperatures) summer electricity demand periods, assuming constant technology and population growth.[9] However, this negative effect could be averted or at least minimized adding more electricity generating units.

POTENTIAL INFRASTRUCTURE IMPACTS DUE TO PRECIPITATION CHANGES

- Climate Changes - Decrease of Hydropower Generation
- Shrinking Snowpack - Affects High Elevation Hydropower Systems with Less Storage Capacity
- Lower River Flows - Requires Increase Release of Water
  - Causing Spills and
  - Reducing Water in Dry Months
- Winter Storms and High Runoff Snowmelt - Results in Flooding and Damage to Transmission Lines
- Extreme Rainfall and Flooding - Causes Wastewater System Overload and Damage to Culverts, Canals and Treatment Facilities
- Increased Flood Damage of Transportation Infrastructure
- More Drought, Fires and Intense Rainfal - Results in Landslides and Disrupt Roadways and Rail Lines

Higher temperatures and heat waves will impact peak electricity demand in California. Figure 21 illustrates how peak temperatures correlate with state electricity load during a peak summer day[10].

Figure 21: *Peak electricity demand June- September 2004*



Temperature

extremes are also relevant to the transportation sector. It is expected less extreme cold days will reduce frost heave and road damage,[11] but extreme hot days (including prolonged periods of very hot days), are likely to become more frequent, increasing the risk of buckling of highways and railroad tracks and premature deterioration or failure of transportation infrastructure (Figure 22).[12]

Figure 22: *Trains can derail due to extreme heat warping railroad tracks.*



B. Precipitation Changes and Extreme Events

Fluctuations, and possible total reductions, in California's precipitation patterns will impact several key energy and transportation infrastructure components; primarily hydropower production and all manufacturing and processing operations requiring large volumes of readily available water. In addition, roads, tunnels, airport runways and railroad tracks are likely to be affected by changes in precipitation patterns.

In the energy sector, changes in hydrological patterns will affect the reliability of the region's hydropower generation, which accounts for 12 to 20 percent of the state's total annual electricity generation. A warmer and drier future climate could reduce hydroelectric generation by 19 percent, whereas a wetter future climate could increase hydroelectric generation by 5 percent.[13] Of the 12 climate projections used in the 2008 California Climate Impacts Assessment, only one simulation produced slightly wetter conditions by 2050, and none did so for the end of the century (see Water chapter).
Hydropower production is a significant contributor of energy for electricity suppliers Pacific Gas and Electric Company (PG&E) and the Sacramento Municipal Utility District (SMUD) among many others. SMUD is particularly vulnerable, as hydropower can account for up to 50 percent of its annual power generation.[14]

The economic impact of climate change due to the loss in hydropower generation and the increase in electricity demand during late spring and summer is estimated to be approximately $2.7 billion annually in a lower-warming scenario and $6.3 billion annually in a high-warming scenario, with roughly $21 billion in energy assets at risk.[15]

The extent to which climate change will actually affect hydropower generation in California depends both on how precipitation patterns and the amount of warming in different regions end up changing reservoir storage and the flexibility of the systems. Hydropower generation capacity in high-elevation systems peaks in the summer, whereas capacity in lower-elevation systems peaks in winter.[16]

A decreasing Sierra Nevada snowpack (due to a higher snowline and increased temperatures, making more precipitation fall as rain rather than as snow) will also reduce the amount of water available for hydropower generation during late spring and summer when energy demand is higher. The shrinking snowpack will particularly affect high-elevation hydropower systems (higher than 1,000 feet above sea level) that have less storage capacity. This type of system accounts for half of the state's hydropower generation and relies on melting snowpack for operations.[17] In addition, more winter precipitation falling as rain instead of snow will result in extreme flows that will require reservoir operators to release more water, causing undesired spills and retaining less water for the dry months.[18]

Winter storm activities, especially if coinciding with earlier snowmelt and high runoff, can cause flooding which, in turn, can cause damage to transmission lines and lead to power outages. Further research is needed in this area to determine the overall vulnerability of the power grid in coastal and delta areas subject to increased flooding in addition to what recommendations should be implemented.

Lower-elevation hydropower units such as the Central Valley Project (CVP) and the State Water Project (SWP) are expected to generate less power under current climate scenarios, but also require less electricity to pump water to Central and Southern California. When the SWP and CVP power supply and power consumption estimates are combined, the water projects require more energy to operate than they generate. By the end of the century, the amount of supplemental power that the combined projects will need decreases by 500-600 GWh/yr.[19] Both could see reductions in energy production of three percent by mid-century and 6 percent by end of the century.[20]

Changes in precipitation patterns can also be expected to affect other types of infrastructure. For example, sewers and wastewater treatment facilities could see growing strains as climate change proceeds. Expected changes in precipitation patterns include a continued risk of intense rainfall events and associated flooding, with the occasional greater-than-historical flooding events. Such extreme rainfall events and flooding can cause overloading of wastewater systems, as well as physical damage to culverts, canals, and water treatment facilities.

Researchers and the California Department of Transportation also expect increased damage of transportation infrastructure as a result of flooding of tunnels, coastal highways, runways, and railways, and associated business interruptions. The combination of a generally drier climate in the future, which will increase the chance of drought and wildfires, and the occasional extreme downpour, is likely to cause more mud- and landslides which can disrupt major roadways and rail lines. The related debris impacts are historically well known to California, but if they become more frequent, will create greater costs for the state and require more frequent repair.[21]

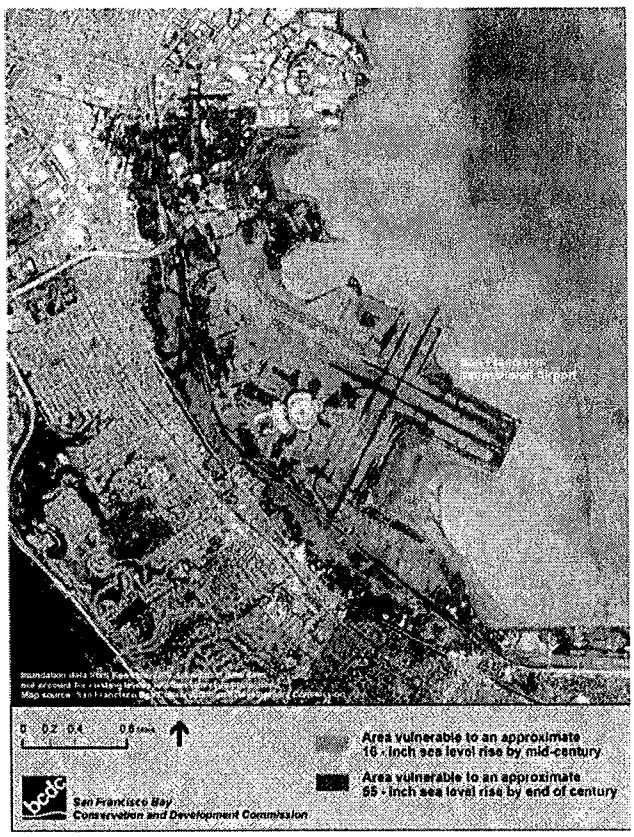
C. Sea-Level Rise and Extreme Events

Accelerating sea-level rise is likely to cause some of the greatest impacts on California's infrastructure, including vital lines of coastal transportation, possibly some of the power plants located along the coast, a densely developed urban landscape, wastewater treatment facilities, ports, airports, and any other lifelines.

Port infrastructure and airports located near sea level are particularly vulnerable. The San Francisco Bay area for example, is home to three major airports – San Francisco, Oakland, and San Jose – which are all near sea level (Figure 23). Unless these exposed assets are raised and/or protected by seawalls, they will be inundated and will experience increasing flooding as storm surges reach higher and farther inland. Similarly vulnerable are California's seaports, which account for 40 percent of total U.S. shipping volume[22] and have extensive docking facilities at risk. The total value of at-risk air and seaport

infrastructure is estimated to total in the multi-billions of dollars.[23] Furthermore, a substantial amount of ground transportation infrastructure, including 2,500 miles of roads and railroads, is projected to be at growing risk from storm-related coastal flooding, elevated due to accelerated sea-level rise.[24] This infrastructure is vital to the residents of California as they commute to work and school, is needed for the movement of commercial freight and thus is integral to the functioning of the overall state economy.

Figure 23: *Projected sea level rise around San Francisco Airport (SFO). (Source: San Francisco Bay Conservation and Development Commission)*



The economic cost associated with the required alteration, fortification, or relocation of existing infrastructure is likely to be substantial. One example is the proposal by the California Department of Transportation to move three miles of Highway 1 in Big Sur as far as 475 feet inland in order to protect against expected cliff erosion underneath the current stretch of highway.[25] Other infrastructure components that may require modifications include raising bridges to ensure marine vessel clearance, fortification of petroleum facilities with ocean exposure, and gravity-assisted outfalls of wastewater discharge.[26]

Certain types of infrastructure may also be at risk from indirect impacts of climate change and coastal inundation, such as the potential for sea water backflow to impair coastal water sanitation drainage systems during flood events,[27] or the collapse of cliffs, due to increased erosion, that underlie housing developments, roadways, and sewers placed on coastal bluffs. Further, substantial sea-level rise may necessitate entirely new drainage systems in low-lying cities with drainage that is pump-driven rather than gravity-driven.[28]

The extent of needed upgrades to existing infrastructure and the construction of new protective infrastructure will also be influenced by the scope of climate change-induced damage to *natural* coastal protective barriers, i.e., the degree of erosion of beaches, cliffs, and wetlands.[29] Additionally, studies find that protective infrastructure in particular areas may be at risk of heightened dual-sided stress as the incidence and intensity of both of sea-based and land-based waters increasingly act upon these barriers. The Bay-Delta levee system, for example, is exposed to increases in the intensity and coincidence of river flooding-related forces combined with increased sea-level rise-related bayside stress.[30]

As discussed in the Ocean and Coastal Resources chapter, California has already begun to protect its low-lying developments from the sea with construction of many miles of levees, sea walls, bluff-protective structures, and other hard structures. Hardening of the coastline, however, is restricted by coastal law to older structures and to certain emergency situations where essential structures or infrastructure is at risk from immediate loss. However, as sea level continues to rise at a faster pace and coastal storms become more intense due to higher storm surges, existing fortifications will be increasingly inadequate. Not only will existing barriers need to be raised, but new, previously not at-risk sections of coastal and bay-side lands and ecosystems will become at risk.[31] Moreover, both new and old infrastructure will likely require more frequent and costly maintenance should the intensity and duration of water and wind forces increase as projected.

One study conducted for the 2009 California Impacts Assessment found that about $100 billion in structures, contents, and infrastructure along the California coast and San Francisco Bay and Delta may be at risk of storm-related inundation by 2100 due to projected increases in mean sea level. This estimate may be conservative as population growth, development and any contribution to sea level from Greenland and West Antarctic ice sheet melting have not been included (see Chapter 3 on sea-level rise projections).[32] Nearly 300,000 acres of Bay-Delta lands are already below sea level, sit upon continuously subsiding land and rely upon an aging levee system that was built upon soft peat soils.[33] Furthermore, the amount of at-risk development in the Bay area, without accounting for any future development, could more than double from current levels by 2100.[34]

Costs associated with constructing the necessary fortifications of natural barriers and new protective infrastructures are likely to be substantial. A 2008 study estimating the cost of coastal protection structures necessary to safeguard *existing* development against rising sea levels found that 1,070 miles of new or upgraded protective levees and seawalls will be needed by 2100 to protect the Bay and open coastline against inundation under a scenario of ~5 feet (1.4 meter) sea-level rise.[35] Such coastal protection could conservatively involve a capital cost of over $14 billion and will require ongoing maintenance, which may add an additional annual cost of 10 percent of the capital cost.[36] These estimated costs, however, do not consider potential ecological impacts and unintended consequences or armoring coastal areas and legal restrictions for such actions. Therefore, actual adaptation costs could be much higher. The study also found that the burden of construction costs will be disproportionate along California's coast, as Southern California will need the greatest investment, with 20 percent of the capital investment required in Los Angeles County alone.[37] It would be necessary to fortify existing protective infrastructure by 0.1-0.2 feet per year for the next few decades in order to merely keep pace with rising waters and to maintain the same relative risk of flood-related inundation those lands have had in recent years.[38]

POTENTIAL INFRASTRUCTURE IMPACTS DUE TO SEA-LEVEL RISE

- Seaside Airports - Vulnerable to Storm-related Inundation
- Seaports and Docks - Inundation and Flooding (Impedes Business)
- Roads and Railroads - Risk of Storms and Coastal Flooding
- Sea-Level Rise and Coastal Surges Requires Increased Fortifications.
- Economic Costs of Fortifications or Relocation is Considerable
- Sea Water - Floods Can Damage Coastal Water Sanitation Systems Requiring Costly Upgrades
- Sea-Level Rise and river Flooding will Impact Bay-Delta Levee System

D. Changing Risks for Infrastructure

To summarize the changing risks that California's transportation and energy infrastructure may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The resulting risk profile for California's infrastructure can be characterized as follows:

- Higher average temperatures and higher summer peaks will greatly affect energy production, distribution (transmission), and demand with increased cooling demand likely to far outpace reductions in heating demand in the winter.

- Higher temperatures, together with a drying climate and less snowpack, will decrease the amount of water available for hydropower generation, especially high-elevation systems. In addition, transmission of electricity is less efficient during hotter periods, leading to electricity deficits especially during peak demand times. The risk of outages is likely to increase.

- Temperature extremes can increase the risk of road and railroad tracks buckling, decreasing transportation safety and creating higher maintenance costs.

- More winter precipitation falling as rain instead of snow will result in extreme flows that will require reservoir operators to release more water, causing undesired spills and retaining less water for the dry months.
- Winter storms, especially if coinciding with earlier snowmelt and high runoff, can cause flooding and damage to transmission lines, overloading and damage of wastewater treatment facilities, as well as physical damage to culverts, canals, tunnels, coastal highways, runways, and railways, and associated business interruptions.
- More drought, fires and intense rainfall events will produce more mud- and landslides which can disrupt major roadways and rail lines.
- Sea-level rise is likely to cause the greatest impacts on California's infrastructure, including more frequent storm-related flooding of airports, seaports, roads, and railways in floodplains due to higher sea levels.
- As sea level rises at a faster pace and coastal storm surges increase, existing fortifications will be increasingly inadequate and need to be raised, and areas previously not at-risk will become at risk.
- The economic cost associated with the required alteration, fortification, or relocation of existing infrastructure is likely to be in the tens of billions.
- Sea water backflow will impair coastal water sanitation drainage systems during flood events, requiring costly upgrades and alterations.
- The Bay-Delta levee system, for example, is exposed to increases in the intensity and coincidence of river flooding-related forces combined with increased sea-level rise-related bayside stress.

Infrastructure Adaptation Strategies

Introduction

The state agencies that participated in the Climate Adaptation Working Group (California Energy Commission and California Department of Transportation) developed the following strategies and are responsible for and will spearhead strategy implementation. Climate is already changing in California and its impacts are going to be felt in all sectors of the state's economy. The impacts of climate change on infrastructure will vary at the local level, but it is certain they will be widespread and costly in human and economic terms, and will require significant changes in the planning, design, construction, operation, and maintenance of California's infrastructure. Infrastructure adaptation strategies developed thus far pertain to two aspects of development: transportation and energy.

Transportation routes and infrastructure will be dramatically affected by sea-level rise. Therefore, adaptation strategies focus on this effect of climate change. Adaptation plans will be developed for the long-term with estimations of future growth, demand, and vulnerability issues. A 50-year planning horizon will be used to parallel the time period of current model predictions. Predicted sea-level rise and storm surges will be guarded against by increasing the elevation of streets, bridges, and rail lines, while some at-risk sections of roads and rail lines will be relocated farther inland. Flood zones will be re-mapped to account for different sea-level rise projections. As a result of these updated maps, areas may be identified that will need to be returned to a natural state.

Energy infrastructure will be tested by higher temperatures and intense storm events. Adaptation strategies reflect the "loading order," a state energy policy which calls for meeting new electricity needs first with energy efficiency and demand response; second, with new generation from renewable energy

and distributed generation resources; and third, with clean fossil-fueled generation and transmission infrastructure improvements.. These programs will promote the use of more efficient air conditioning equipment and lighting systems. They will work to increase the level of insulation (ceiling, floor and walls) and window glazing used in new and existing homes. The planting of trees will be used to shade homes and buildings, and the use of roof materials that reflect the heat to reduce the "heat island effect" will be promoted in new construction. Energy strategies such as smart grid technologies also aim to improve the ability of the electricity system to respond to peak demands. Additionally, they will implement modern techniques for the integrated management of water reservoirs in Northern California to improve their management, and include information regarding changing hydrological patterns in that management.

Encouraging the development of distributed and centralized renewable resources will also help the state meet increased energy demand due to climate change. Opportunities to expand renewable distributed generation resources include increased use of solar, biomass (including biomass that is currently being landfilled), and biogas from wastewater treatment plants. Further development of centralized renewable resources is also needed to help meet expected energy demand due to climate change and care will be needed to ensure that associated transmission is developed in the least environmentally sensitive areas. Renewable development needs to be advanced throughout California, including on state, federal, and tribal lands. Further work is needed to assess the impacts of climate change on existing and planned energy infrastructure and to identify the most vulnerable communities.

In addition, the Energy Commission and other responsible planning authorities should assess potential impacts of climate change on species and habitat needs, including movement patterns, when developing natural community conservation plans and other mitigation measures for new power plants.

The impacts of climate change on California's infrastructure are varied and far-reaching. Infrastructure adaptations to climate change will be costly, but it will be more expensive if the state does not begin planning and adapting before the predicted changes alter the physical landscape. California's infrastructure is the conduit through which economic activity flows. The production and movement of goods and services relies on existing infrastructure. Disruption of these deliveries will be detrimental to California's economy. Protection of infrastructure will help ensure California's future as a leading economic player.

Adaptation Strategies and Actions

The California Energy Commission (Energy Commission) and the California Department of Transportation (CalTrans) have identified the following priorities in addressing climate adaptation for California state agencies. The near term actions referenced below are those actions that have been identified and which can be initiated or completed by 2010. The long term actions include those recommended actions that will require support from that state, and collaboration with multiple state agencies.

Climate is already changing in California and its impacts are going to be felt in all sectors of the state's economy. The impacts of climate change on infrastructure will vary at the local level, but it is certain they will be widespread and costly in human and economic terms, and will require significant changes in the planning, design, construction, operation, and maintenance of California's infrastructure. Infrastructure adaptation strategies developed thus far pertain to two aspects of development: energy and transportation.

Strategy 1 – ENERGY: Increase Energy Efficiency Efforts in Climate Vulnerable Areas

Near -Term and Long-Term Actions:

a. **Meet the Energy Efficiency Goals Outlined in AB32 Scoping Plan** – The Air Resources Board's (ARB) Scoping Plan has identified 26.3 $MMTCO_2e$ that will be reduced by 2020 through increased use of building and appliance efficiency standards, increased combined heat and power generation and through increased solar water heating improvements (AB1470). Ensuring these measures are met, while increasing these efforts over time, will help ease projected energy demand increases and possible supply disruptions from climate change.

b. **Facilitate Access to Local, Decentralized Renewable Resources** – The Energy Commission should consider policies and incentives to maximize and to encourage de-centralized (local and near demand) generation and on-site renewable energy generation systems where feasible and appropriate. This deployment of additional renewable generation would reduce GHG emissions and help meet the expected increase in electrical demand due to climate change.

Strategy 2 – ENERGY: Assess environmental impacts from climate change in siting and re-licensing of new energy facilities.

Near -Term and Long-Term Actions:

a. **Assess Power Plants Vulnerable to Climate Impacts, and Recommend Reasonable Adaptation Measures** – The Energy Commission will assess GHG impacts for power plant siting cases through its Integrated Energy Policy Report, and consider the potential impact of sea-level rise, temperature increases, precipitation changes and extreme events, where relevant.

b. **Encourage Expansion of Renewable Energy Resources** – The Energy Commission should assess long-term benefits of renewable energy generation in reducing GHG emissions that also provide environmental co-benefits. The state shall encourage additional development of the most suitable and efficient renewable technologies to maximize the amount of electrical generation from renewable sources. The Energy Commission and DFG should encourage renewable energy generation in the least sensitive environmental areas to maintain natural habitats and healthy forests that will further buffer the environmental impacts of climate change.

c. **Assess the Impacts of Climate Change on Energy Infrastructure** – Use the Energy Commission's PIER regional climate modeling and related study efforts to assess the potential impacts of climate change on energy infrastructure from sea-level rise, precipitation, and temperature changes and other impacts. The Energy Commission will determine additional actions on its siting and planning programs based on this work.

d. **Identify the Most Vulnerable Communities** – Develop an energy-use "hot-spot" map to identify areas in the state where increases in temperature, population, and energy-use will make communities most vulnerable to climate change impacts. The Energy Commission will include in this analysis how the lowest-income communities in hot spot areas will be impacted. Also, assess impacts of climate change on tribal lands and ability of tribes to adapt to changing conditions.

Strategy 3 – ENERGY: Develop Hydropower Decision-Support Tools to Better Assess and Manage Climate Change Variability

Near -Term and Long-Term Actions:

a. **Expand Scientific Climate Research** – The Energy Commission and the DWR will continue to support and develop enhancements and demonstration of modern decision support systems for the management of existing major water reservoirs in California to adapt to current levels of climate variability and increase our resilience to increased levels of climate variability and change in the future.

b. **Public Interest Energy Research** – The Energy Commission's PIER program will sponsor research on climate change factors influencing hydropower generation – for example, how hydropower generation would be affected by requirements to release additional water to attenuate increased water temperatures in rivers and streams for environmental purposes.

c. **Develop Partnerships** –Partner with hydropower generators particularly vulnerable to climate change to identify how public-private partnerships could reduce long-term risks to hydropower generation.

Strategy 4 – ENERGY: Identify how state renewable energy goals could be impacted from future climate impacts.

Near -Term and Long-Term Actions:

a. **Assess Climate Impacts on Energy** – The Energy Commission's PIER program will research how climate change impacts could influence the goals of AB32, AB118, and EO S-13-08 goals. For example, climate change will influence wind speeds and patterns, temperature density, etc. that will affect power levels from wind turbines, photovoltaics, etc. In addition, biomass feedstocks could be reduced due to decreased water levels and increased wildfire. It is unclear how this will impact long-term projections for meeting our 2020 and 2050 renewable energy goals.

The near term actions referenced below are those actions that have been identified and which can be initiated by 2010, subject to availability of necessary information to ensure credibility of the analysis and authority of the information, and will require collaboration with multiple state, regional and local agencies as well as adequate funding. The climate impact data serving as the basis of these actions will stem from ongoing research undertaken by the PIER program, and centralized through the CAT. The long term actions include those recommended actions that will require support from the state and collaboration with multiple state, regional, and local agencies.

Strategy 5 – TRANSPORTATION: Develop a detailed climate vulnerability assessment and adaptation plan for California's transportation infrastructure.

Near -Term and Long-Term Actions:

a. **Vulnerability and Adaptation Planning** – BTH (Business, Transportation and Housing Agency) and CALTRANS will develop a climate vulnerability plan that will assess how California's transportation infrastructure facilities are vulnerable to future climate impacts, assess climate adaptation options, prioritize for implementation, and select adaptation strategies to adopt in coordination with stakeholders. This plan will be coordinated with an updated climate mitigation plan that will act as BTH's and Caltrans' overall transportation climate policy.

i. Develop a transportation use "hot-spot" map – Caltrans will research and identify transportation "hot spots", using updated NAS and other appropriate study efforts, to identify across the state where the mixture of climate change impacts, population increases, and transportation demand increases will make communities most vulnerable to climate change impacts. Caltrans will include in this analysis how the lowest-income communities in hot spot areas will be impacted.

b. **Economic Impacts Assessment** – Complete an overall economic assessment for projected climate impacts on the state's transportation system and other related infrastructure along transportation corridors as appropriate under a "do nothing" scenario and under climate policy scenarios identified by BTH/Caltrans.

   i. Prepare a list of transportation adaptation strategies or measures based on the "hot spot" map and prepare an economic assessment and cost-benefit analysis for these strategies vs. a do nothing scenario.

Strategy 6 – TRANSPORTATION: Incorporate climate change vulnerability assessment planning tools, policies, and strategies into existing transportation and investment decisions.

Near -Term and Long-Term Actions:

a. **Integrate Mitigation and Adaptation System-wide** –Caltrans will develop and incorporate climate change mitigation and adaptation policies and strategies throughout state strategic, system and regional planning efforts. These will be included in key phases of the following planning and project development phases when appropriate:

   i. Strategic Planning (Governor's Strategic Growth Plan and California Transportation Plan)

   ii. System Planning (i.e., District System Management Plan, Inter-regional Strategic Plan, Corridor System Management Plan, and Transportation Concept Report)

   iii. Regional Transportation Planning (Regional Transportation Plan Guidelines and Regional Blueprint Planning)

   iv. Project planning (Project Development Procedures Manual, Project Initiation Document, Project Report, Design and engineering standards, Environmental Guidelines)

   v. Programming (State Transportation Improvement Program, State Highway Operations and Protection Program, California Transportation Commission State Transportation Improvement Program Guidelines)

Strategy 7 – TRANSPORTATION: Develop transportation design and engineering standards to minimize climate change risks to vulnerable transportation infrastructure.

Near-Term and Long Term Actions:

a. **Transportation Infrastructure Assessment** - Caltrans will assess existing transportation design standards as to their adequacy to withstand climate forces from sea level rise and extreme weather events beyond those considered.

b. **Buffer Zone Guidelines** - Develop guidelines to establish buffer areas and set backs to avoid risks to structures within projected "high" future sea level rise or flooding inundation zones.

c. **Stormwater Quality** - Assess how climate changes could alter size and design requirements for stormwater quality BMP's.

Strategy 8 – TRANSPORTATION: Incorporate climate change impact considerations into disaster preparedness planning for all transportation modes.

Near -Term and Long Term Actions:

a. **Emergency Preparedness** – CALTRANS provides significant emergency preparedness abilities for all transportation modes across the state. The transportation system is sensitive to rapid increases in precipitation, storm severity, wave run-up and other extreme weather events. CALTRANS will assess the type of climate-induced impact information necessary to respond to district emergencies. Results will be incorporated into existing operations management plans.

b. **Decision Support** – CALTRANS will identify how climate impact information can be integrated into existing Intelligent Transportation Systems and Transportation Management Center operations.

Appendix A: Acknowledgements

This Strategy was prepared by the California Natural Resources Agency. Tony Brunello led the overall strategy development, and Kurt Malchow managed the completion of the overall report for CNRA. This document was made possible by the hard work of numerous contributors. Below is a list of State agencies, organizations, individuals and events that directly provided input to this Strategy.

Climate Adaptation Working Group:

- Public Health
- Biodiversity and Habitat
- Oceans and Coastal Resources
- Water Management
- Agriculture
- Forestry
- Transportation and Energy Infrastructure

Climate Action Team

State Agencies:

Governor's Office of Planning and Research
California Coastal Commission
California Coastal Conservancy
California Environmental Protection Agency
California Ocean Science Trust
Bay Conservation and Development Commission
Business, Transportation and Housing Agency
Department of Food and Agriculture
California Energy Commission
California Department of Conservation
California Department of Forestry and Fire Protection (CalFIRE)
California Department of Fish and Game
California Department of Parks and Recreation
California Department of Public Health
California Department of Transportation
California Department of Water Resources
NOAA Coastal Services Center
Ocean Protection Council
State Lands Commission
State Water Resources Control Board

Organizations and individuals:

Science Applications International Corporation:

- Steven Messner
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- Jette Findsen
- Michael Mondshine

Suzanne Moser, Independent consultant

ICLEI, Local Governments for Sustainability

Sara S. Moore, UC Berkeley Goldman School of Public Policy

Science and Policy Review Panel:

- Jay Lund, University of California, Davis
- Gary Rynearson, Green Diamond Resource Co.
- Max Moritz, University of California, Berkeley
- Louise Bedsworth, Public Policy Institute of California
- Steven Schneider, Stanford University
- Gary Griggs, University of California, Santa Cruz
- Greg San Martin, Pacific Gas and Electric Co.
- Guido Franco, California Energy Commission
- Louise Jackson, University of California, Davis
- Michael Mastrandrea, Stanford University
- Samuel Johnson, U.S. Geological Survey
- Dan Cayan, Scripps Institute of Oceanography

Public Meetings:

Stakeholder meetings on draft sector strategies: September – December, 2008
Sacramento public stakeholder meeting on CAS Discussion Draft: August 13, 2009
Los Angeles public stakeholder meeting on CAS Discussion Draft: August 31, 2009

Appendix B: Governor's Executive Order

EXECUTIVE ORDER S-13-08
by the Governor of the State of California

WHEREAS climate change in California during the next century is expected to shift precipitation patterns, accelerate sea level rise and increase temperatures, thereby posing a serious threat to California's economy, to the health and welfare of its population and to its natural resources; and

WHEREAS California is a leader in mitigating and reducing its greenhouse gas emissions with the 2006 Global Warming Solutions Act (Assembly Bill 32), the Low Carbon Fuel Standard (Executive Order S-01-07), the 2008 Senate Bill 375 and the Renewable Portfolio Standard; and

WHEREAS these efforts, coupled with others around the world, will slow, but not stop all long-term climate impacts to California; and

WHEREAS California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science; and

WHEREAS there is a need for statewide consistency in planning for sea level rise; and

WHEREAS California's water supply and coastal resources, including valuable natural habitat areas, are particularly vulnerable to sea level rise over the next century and could suffer devastating consequences if adaptive measures are not taken; and

WHEREAS the country's longest continuously operating gauge of sea level, at Fort Point in San Francisco Bay, recorded a seven-inch rise in sea level over the 20th century thereby demonstrating the vulnerability of infrastructure and resources within the Bay; and

WHEREAS global sea level rise for the next century is projected to rise faster than historical levels with the Intergovernmental Panel on Climate Change predicting that global sea levels will rise by between seven to 23 inches this century and some experts predicting even higher rises; and

WHEREAS while climate models predicting global sea level rise are generally understood and improving, less information is available for sea level rise projections specific to California that accounts for California's topography, coastal erosion rates, varying land subsidence levels and tidal variations; and

WHEREAS billions of dollars in state funding for infrastructure and resource management projects are currently being encumbered in areas that are potentially vulnerable to future sea level rise; and

WHEREAS safety, maintenance and operational efforts on existing infrastructure projects are critical to public safety and the economy of the state; and

WHEREAS the longer that California delays planning and adapting to sea level rise the more expensive and difficult adaptation will be; and

WHEREAS the California Resources Agency is a member of the California Climate Action Team and is leading efforts to develop and implement policy solutions related to climate change adaptation regarding current and projected effects of climate change; and

WHEREAS the Department of Water Resources (DWR) is responsible for managing the state's water resources to benefit the people of California, and to protect, restore and enhance the natural and human environments; and

WHEREAS California's coastal management agencies such as the California Coastal Commission, the California Ocean Protection Council (OPC) and California State Parks are charged with managing and protecting the ocean and coastal resources of the state; and

WHEREAS the California Energy Commission's (CEC) Public Interest Energy Research Program has funded research on climate change since 2001 including funding the development of preliminary sea level rise projections for the San Francisco Bay area by the Scripps Institution of Oceanography/University of California at San Diego.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power vested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. The California Resources Agency, in cooperation with DWR, CEC, California's coastal management agencies, and the OPC, shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate, within 60 days after the signing of this Order, an independent sea level rise science and policy committee made up of state, national and international experts.

2. By March 31, 2009, the OPC, DWR and the CEC, in coordination with other state agencies, shall hold a public workshop to gather policy-relevant information specific to California for use in preparing the Sea Level Rise Assessment Report and to raise state awareness of sea level rise impacts.

3. The California Resources Agency shall request that the final Sea Level Rise Assessment Report be completed as soon as possible but no later than December 1, 2010. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California.

4. The OPC shall work with DWR, the CEC, California's coastal management agencies and the State Water Resources Control Board to conduct a review of the NAS assessment every two years or as necessary.

5. I direct that, prior to release of the final Sea Level Rise Assessment Report from the NAS, all state agencies within my administration that are planning construction projects in areas vulnerable to future sea level rise shall, for the purposes of planning, consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. However, all projects that have filed a Notice of Preparation, and/or are programmed for construction funding the next five years, or are routine maintenance projects as of the date of this Order may, but are not required to, account for these planning guidelines. Sea level rise estimates should also be used in conjunction with appropriate local information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

6. The Business, Transportation, and Housing Agency shall work with the California Resources Agency and the Governor's Office of Planning and Research (OPR) to prepare a report within 90 days of release of this Order to assess vulnerability of transportation systems to sea level rise that will include provisions for investment critical to safety, maintenance and operational improvements of the system and economy of the state.

7. By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by CEC's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts.

8. By May 30, 2009, OPR, in cooperation with the California Resources Agency, shall provide state land-use planning guidance related to sea level rise and other climate change impacts.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 14th day of November 2008.

ARNOLD SCHWARZENEGGER
Governor of California

Appendix C: Glossary

Key Climate Change Adaptation Concepts and Terms

The following terms were collected from the *Intergovernmental Panel on Climate Change Third Assessment Report* (2001), unless otherwise noted.

Adaptation – Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Adaptation Assessment – The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.

Adaptation Benefits – The avoided damages (measured in monetary terms or otherwise) or the accrued benefits following the adoption and implementation of adaptation measures.

Adaptation Costs – Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs and unavoidable negative side effects.

Adaptive Capacity – The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.[3]

Adaptation Policy Framework – is a structural process for developing adaptation strategies, policies, and measures to enhance and ensure human development in the face of climate change, including climate variability. It consists of five basic components: assessing current vulnerability, characterizing future climate risks, developing an adaptation strategy, scoping and designing individual adaptation projects to implement the strategy, monitoring results, adjustments, and continuing the adaptation process.[4]

Baseline/Reference – The baseline (or reference) is any datum against which change is measured. It might be a "current baseline," in which case it represents observable, present-day conditions. It might also be a "future baseline", which is a projected future set of conditions excluding the driving factor of interest (e.g., how would a sector evolve without climate warming). It is critical to be aware of what change is measured against which baseline to ensure proper interpretation. Alternative interpretations of the reference conditions can give rise to multiple baselines.[6]

Climate Change – Climate change refers to any long-term change in average climate conditions in a place or region, whether due to natural causes or as a result of human activity.

(Climate) Impacts Assessment – The practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

(Climate Change) Impacts – Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Climate Variability – Climate variability refers to variations in the mean state of the climate and other statistics (such as standard deviations, the occurrence of extremes, etc.) on all temporal and spatial scales beyond that of individual weather events.

Co-benefits – The benefits of policies that are implemented for various reasons at the same time—including climate change mitigation—acknowledging that most policies designed to address greenhouse gas mitigation also have other, often at least equally important, rationales (e.g., related to objectives of development, sustainability, and equity).

Impact – An effect of climate change on the structure or function of a system.[2]

Integrated Assessment – A method of analysis that combines results and models from the physical, biological, economic, and social sciences, and the interactions between these components, in a consistent framework to evaluate the status and the consequences of environmental change and the policy responses to it.

Mitigation – A human intervention to reduce the sources or improve the uptake (sinks) of greenhouse gases.

No-regrets policy – A policy that would generate net social benefits whether or not there is climate change.

Policies and Measures – Usually addressed together, respond to the need for climate adaptation in distinct, but sometimes overlapping ways. Policies, generally speaking, refer to objectives, together with the means of implementation. Measures can be individual interventions or they consist of packages of related measures.[4]

Potential Impacts – All impacts that may occur given a projected change in climate, without considering adaptation.

Residual Impacts –The impacts of climate change that would occur after adaptation.

Resilience – The ability of a system to absorb some amount of change, including shocks from extreme events, bounce back and recover from them, and, if necessary, transform itself in order to continue to be able to function and provide essential services and amenities that it has evolved or been designed to provide.*

*It is important to note that resilience, as the term applies to ecosystems, is being used as a way to measure a systems ability to recover from stress or disturbance without undergoing a fundamental change in process or structure with the recognition that climate change will likely not allow for the return to a pre-existing equilibrium as the definition of resilience implies[7].

Risk (climate-related) – is the possibility of interaction of physically defined hazards with the exposed systems. Risk is commonly considered to be the combination of the likelihood of an event and its consequences – i.e., risk equals the probability of climate hazard occurring multiplied the consequences a given system may experience.[4]

Sensitivity – The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).

System – A human population or ecosystem; or a group of natural resources, species, infrastructure, or other assets.

Vulnerability – In the most general sense, a susceptibility to harm or change. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity.

Vulnerability Assessment – A practice that identifies who and what is exposed and sensitive to change and how able a given system is to cope with extremes and change. A vulnerability assessment considers the factors that expose and make people or the environment susceptible to harm and accesses to natural and financial resources available to cope and adapt, including the ability to self-protect, external coping mechanisms, support networks, and so on.[5]

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Appendix D: Acronyms

Acronyms used in the California Climate Adaptation Strategy

ACE - Areas of Conservation Emphasis (defined by the Department of Fish and Game)

ARB - Air Resources Board

BLM - Bureau of Land Management

BIA - Bureau of Indian Affairs

BMPs - Best Management Practices

BOF - Board of Forestry and Fire Protection

BTH - Business, Transportation and Housing Agency

CalEMA - California Emergency Management Agency

Cal/EPA - California Environmental Protection Agency

Cal/Fire, CAL FIRE - California Department of Forestry and Fire Protection

Cal-REDIE - California Reportable Disease Information Exchange

CalTrans - California Department of Transportation

CALVIN - California Value Integrated Network

CAS - California Climate Adaptation Strategy

CAT - Climate Action Team

CAWGS - Climate Adaptation Working Groups

CBC - California Biomass Collaborative

CCAPA - California Chapter of the American Planning Association CCVA- California Climate Vulnerability Assessment

CCVA - California Climate Vulnerability Assessment

CDFA - California Department of Food and Agriculture

CDPH - California Department of Public Health

CEC - California Energy Commission

CERES - California Environmental Resources Evaluation System

CEQA - California Environmental Quality Act

CFIP - California Forest Improvement Program

CIMIS - California Irrigation Management Information System

CISC - California Invasive Species Council

CNRA - California Natural Resources Agency

COGs - Councils of Government

CSMP - Corridor System Management Plan

CTC STIP guidelines - California Transportation Commission State Transportation Improvement Program guidelines

CVP - Central Valley Project

DFG - Department of Fish and Game

DOC - Department of Conservation

DPR - Department of Parks and Recreation

DSMP - District System Management Plan

DWR - Department of Water Resources

EIR - Environmental Impact Report

ENSO - El Niño Southern Oscillation

EO - Executive Order

EPA - Environmental Protection Agency

EWMPs - Efficient Water Management Practices

FEMA - Federal Emergency Management Agency

FRAP - Fire and Resource Assessment Program

GHG - Green House Gases

ICLEI - Local Governments for Sustainability

IPCC - Intergovernmental Panel on Climate Change

IRWM - Integrated Regional Water Management

ITSP - Interregional Transportation Strategic Plan

JOC - Joint Operations Center

LCP - Local Coastal Plan

MPOs - Metropolitan Planning Organizations

NAS - National Academy of Science

NFIP - National Flood Insurance Program

NFW - National Fish and Wildlife Foundation

NGO - Non-Governmental Organizations

NPS - National Park Service

NRC - National Research Council

NRCS - Natural Resource Conservation Service

OPC - Ocean Protection Council

OPR - Governor's Office of Planning and Research

PDPM - Project Development Procedures Manual

PID - Project Initiation Document

PIER - Public Interest Environmental Research Program (run through the California Energy Commission)

PR - Project Report

RCD - Resource Conservation District

RPS - Renewable Portfolio Standard

SEMS - Standardized Emergency Management System

SFM - State Fire Marshall

SG - Strategic Growth Council

SHOPP - State Highway Operations and Protection Program

SMUD - Sacramento Municipal Utility District

STIP - State Transportation Improvement Program

SWRCB - State Water Resources Control Board

SWP - State Water Project

TCR - Transportation Concept Report

TNC - The Nature Conservancy

TPZ - Timberland Production Zone, UC- University of California

UCCE - University of California Cooperative Extension

USDA - United States Department of Agriculture

USFS - United States Forest Service

USGS - United States Geological Survey

WCB - Wildlife Conservation Board

WebCMR - Web Portal for the Confidential Morbidity Report

WIC - Women, Infants, and Children Nutrition Program

WNV - West Nile Virus

WUI - Wildland Urban Interface

APPENDIX E: TABLE OF SHORT TERM CLIMATE ADAPTATION STRATEGIES

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Cross-Sector	Strategy 1) Promote Comprehensive State Agency Adaptation Planning	a. Establish a framework for promoting collaboration within and among state agencies to implement climate change adaptation strategies. Three different levels of coordination will be established to promote comprehensive state adaptation planning. First, individual agencies are responsible for implementing the short-term climate adaptation strategies identified in this report. Second, the CNRA will be responsible for monitoring overall progress on implementing adaptation measures in this report and to develop cross-sector strategies. Finally, the CAT will monitor progress on climate adaptation measures through the CNRA and will coordinate state integration of mitigation and adaptation measures within the CAT working groups. b. Develop a Climate Adaptation Advisory Panel (CAAP) made up of world class science, business and government leaders to recommend improved opportunities for collaboration across state government on climate adaptation. The CAAP will also identify climate adaptation strategies outside the scope of California's climate adaptation strategy that identify near term priority strategies that will reduce California's vulnerability to climate change in the shortest time at the lowest long-term cost.	CNRA, CAT
Cross-Sector	Strategy 2) Integrate Land Use Planning and Climate Adaptation Planning	a. Revise Section 15126.2 of the CEQA guidelines to direct lead agencies to evaluate the impacts of locating development in areas susceptible to hazardous conditions, including hazards potentially exacerbated by climate change. b. Incorporate climate adaptation considerations into the Strategic Growth Council and Sustainable Community Strategy processes to ensure incentives are provided to communities that are most vulnerable and are preparing for climate change impacts.	CNRA, CAT

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Cross-Sector	Strategy 3) Improve Emergency Preparedness and Response Capacity for Climate Change Impacts	a. CNRA will coordinate with OPR, Cal EMA, CEC, and Cal Poly SLO to update the State Emergency Plan, the State Hazard Mitigation Plan (SHMP), and to strengthen consideration of climate impacts to hazard assessment planning, implementation priorities, and emergency response. This effort will be directly linked with the Climate Change Center vulnerability report identified in Strategy 5 and the Climate Change Advisory Panel identified in Strategy one of this Chapter.	CNRA, CAT, participating agencies
Cross-Sector	Strategy 4) Expand California's Climate Change Research and Science Programs and Expand Public Outreach of Research to Policy-Makers and General Public	a. The State Climate Action Team Research Group will develop a strategic plan by September 2010 that will identify: priority state climate adaptation research and monitoring needs; proposed resources and timeframes to implement the plan; and potential for research co-funding and collaboration with local, state, and national agencies, universities and other research institutions. The CAT Sub-Group should develop a comprehensive research project catalog and continue to biannually publish key state sponsored climate research on the California Climate Change web-portal. b. Develop a California Climate Vulnerability Assessment (CCVA) to ensure the best available science informs climate adaptation decision making. State agencies will work through the CNRA to develop the state's first CCVA focused on sharing information, providing opportunities for public discussion on climate risk research and policies, and developing cross-sector strategies. The development of a CCVA will include public outreach to prioritize risk reduction strategies and will be completed by January 1, 2011 (depending on contracting and funding this study by January 1, 2010). The final CCVA will allow policy-makers the ability to develop a more systematic approach to funding risk reduction efforts. Every effort will be paid to identify and assist those communities expected to be most at risk from future climate change.	CNRA, CAT

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
		c. Develop the "CalAdapt" web-based portal that uses Google Earth to show state supported research (and other research) in a way most relevant and useful to policy-makers and local communities as a public outreach tool for the California climate adaptation strategy. The tool will show basic climate impact information at a scale that allows local communities to develop their own climate adaptation strategies based on this information. CNRA will coordinate with CEC and the State Chief Information Officer to develop the CalAdapt Tool and outreach in a way that ensures the portal will be used and developed over time and integrated with other state programs.	
Public Health	Strategy 1: Promote Community Resilience to Reduce Vulnerability to Climate Change.	a. Promote Healthy Built Environments –CDPH should continue working in collaboration with local health departments, community based organizations (CBOs), and other state and local planning and transportation agencies to improve community planning and design to promote healthy living, and to balance integration of social, economic and environmental concerns. CDPH should identify mechanisms to institutionalize the consideration of health in local and regional land use and transportation decision-making in, for example, local general plans, regional transportation plans, or CEQA guidelines, and through the use of Health Impact. CDPH should develop guidelines for health impact assessment, for use by local health departments and other agencies.	CDPH
Public Health	Strategy 1 (cont'd)	b. Identify and reduce health vulnerabilities -- CDPH should provide tools for use by local health departments, other agencies, and CBOs to identify and reduce climate-related health vulnerabilities For example, community wide assessments could identify the homes occupied by disabled persons and seniors, assess the safety, energy and water use efficiency of these homes, and modify or retrofit homes, for example weatherproofing, energy efficient appliances, and shade cover. Identification of urban heat islands could lead to targeted efforts to increase shading and reduce heat-reflecting pavement through, for example, expansion of parks and community gardens. Increased efforts to reduce air pollution in "toxic hot spots" would also decrease vulnerability to the health effects of increased air pollution with rising temperatures.	CDPH

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Public Health	Strategy 1 (cont'd)	c. Food Security and Quality– CDPH should work in partnership with USDA, CDFA, and CDSS to maintain commitment to healthy foods and nutrition programs that improve access to healthy foods in low-income communities DPH should partner with Local Health Departments and CBOs to promote healthy sustainable local food systems through working for consideration of healthy food access in agricultural, land use, and other policies (e.g., zoning to allow farmers markets, incentives for farm to school/business/consumer, community and school gardens, and strong state support for programs such as Women, Infants and Children (WIC), SNAP-Ed, etc). CDPH should partner with CDFA and local health and environmental agencies to enhance capacity for surveillance and response for food-borne illness outbreaks.	CDPH
Public Health	Strategy 2: Educate, Empower and Engage California Citizens, Organizations and Businesses to Take Actions to Reduce Individual and Community Vulnerability to Climate Changes through Mitigation and Adaptation.	a. Educational Outreach Campaign – Incorporate climate change and public health messages into existing education and media outreach efforts. Develop diverse educational materials for diverse populations (e.g., vulnerable communities, school-age children, business, and labor) that focus on the health impacts of climate change. Conduct focused outreach to clinicians and the health sector about the health impacts of climate change, actions the health sector can take to mitigate and adapt to climate change, and prevention and management of climate-related illnesses (e.g., heat illness). Utilize existing resources to disseminate climate-related health information (e.g., bepreparedcalifornia.ca.gov., public health advisories).	CDPH
Public Health	Strategy 2 (cont'd)	b. Specific Outreach to Vulnerable Populations – Identify dissemination networks (e.g., CBOs, local government, philanthropic organizations) that can reach vulnerable populations (e.g., outdoor workers and their employers, residents in urban heat islands, asthmatics, immigrants with literacy/language needs) and provide them with information on what they need to know about the risks of climate change, and what they can do to address them, both individually and at the community and state levels.	CDPH

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Public Health	Strategy 3: Identify and Promote Mitigation and Adaptation Strategies with Public Health Co-benefits.	a. Identify and prioritize strategies with co-benefits – CDPH should identify public health and climate change mitigation and adaptation strategies that offer health and climate co-benefits; strategies with co-benefits should be prioritized. For example, community design ("smart growth") that promotes walking and bicycling to increase physical activity and decrease motor vehicle greenhouse gas and toxic pollutants. When possible, adaptation strategies that increase health risks and/or greenhouse gas emissions should be avoided. (e.g. promoting air conditioner use without changes in electricity production reliance on fossil fuel combustion). Strive to institutionalize the inclusion of public health considerations in all applicable climate change policies.	CDPH
Public Health	Strategy 4: Establish, Improve and Maintain Mechanisms for Robust Rapid Surveillance of Environmental Conditions, Climate-related Illness, Vulnerabilities, Protective factors and Adaptive Capacities.	a. Monitor Outcomes at state and local level – CDPH should work with local health departments and the health care services sector to increase capacity to monitor the climate related deaths and illnesses associated with heat-related and other events, as well as other climate related illnesses, environmental risks, vulnerabilities, protective factors, and adaptive capacities. Maintain operation of the California Environmental Health Tracking Program, and incorporate the climate health indicators recommended by the Council of State and Territorial Epidemiologists.	CDPH
Public Health	Strategy 4 (cont'd)	b. Environmental Contaminant Biomonitoring – CDPH and Cal/EPA (California Environmental Protection Agency) should encourage the development of the existing California Environmental Contaminant Biomonitoring Program to determine the level of contaminants in California residents to help reduce baseline illness and increase community resiliency.	CDPH
Public Health	Strategy 4 (cont'd)	c. Water Accessibility Information – Maintain and upgrade the existing Safe Drinking Water Information System, which provides information about public water systems and their violations of EPA's drinking water regulations regarding maximum contaminant levels, treatment techniques, and monitoring and reporting requirements, in order to ensure safe and reliable public water resources.	CDPH
Public Health	Strategy 4 (cont'd)	d. Heat Warning Systems – Work with the CDPH Emergency Preparedness Office EPO, CalEMA, and local health and emergency response agencies to develop heat warning systems for regions of the State that have not yet adopted them. These systems should be coupled with existing heat emergency	CDPH

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
		response plans.	
Public Health	Strategy 5: Improve Public Health Preparedness and Emergency Response	a. Preparedness Response – CDPH and local health departments should refine existing emergency preparedness plans and conduct exercises to augment preparedness for events likely to increase with climate change (e.g., heat waves, wildfires, floods), and should develop plans for anticipated impacts such as sea level rise, saline intrusion into drinking water, etc. Public health agencies should also be prepared for the more frequent occurrence of severe heat events in geographic areas where they have previously been very rare (e.g., coastal areas). Fomally request the Centers for Disease Control and Prevention to incorporate climate change response and preparedness as an acceptable use of federal funds for public health preparedness.	CDPH
Public Health	Strategy 6: Work in Partnership with Multiple Agencies (e.g., Environmental, Agricultural, Transportation, and Education at Local, State and Federal levels, as well as Business, Labor, Schools and Community-based Organizations).	a. Institutional Capacity – CDPH should work with appropriate state and local agencies to expand training and education to build capacity to respond appropriately to the public health risks of climate change. Institutional capacity needs should be addressed in local health departments, health and social services providers, and mental health agencies (e.g. for post-disaster recovery).	CDPH
Public Health	Strategy 7: Conduct Research to Enable Enhanced Promotion and Protection of Human Health in Light of Climate Change.	a. Vulnerability Assessments – CDPH should conduct detailed vulnerability assessments for all the leading climate-change health outcomes (e.g., heat morbidity, valley fever, flooding, wild fires) utilizing locally scaled-down emergency and environmental shift scenarios, including assessments of impacts on vulnerable populations and cumulative impacts, and risk and resilience factors.	CDPH

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Public Health	Strategy 7 (cont'd)	b. Research collaboration – CDPH should encourage the California Energy Commission PIER program to devote more substantial attention to a public health research agenda. CDPH should develop a closer working relationship with the University of California and other universities and NGO's involved with climate change analysis and impacts, and provide greater input to federal agencies conducting climate change research to increase funding and focus on public health impacts.	CDPH
Public Health	Strategy 8: Implement Policy Changes at Local, Regional and National Levels.	a. Policy Collaboration - Work with stakeholders to develop federal and state policies to implement adaptation strategies that reduce public health risks related to climate change.	CDPH
Public Health	Strategy 8 (cont'd)	b. Occupational Safety Standards – Advise and revise occupational health and safety standards to identify occupations at risk due to climate change.	CDPH
Public Health	Strategy 9: Identify, Develop and Maintain Adequate Funding for Implementation of Public Health Climate Adaptation Strategy.	a. Funding Mechanisms – Develop a comprehensive funding strategy for public health adaptation strategies that utilize a broad range of funding strategies including fees, taxes and grants. Funds should be allocated to both statewide and local efforts, and specifically to local health departments.	CDPH
Biodiversity & Habitat	Strategy 1: Establish a System of Sustainable Habitat Reserves	Organization of Collaborating Entities – Initiate the development of a working structure that would include a facilitator and key entities (including a scientific panel) that will work together to identify a statewide reserve system and provide scientific expertise. Participants should be from the major land management and acquisition entities around the state, and federal and multi-organizational partnerships including but not be limited to the State Department of Fish and Game, State Parks, State Coastal Conservancy, the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, US Geological Survey, Bureau of Land Management, academia including the University of California Natural Reserve System, representatives of working landscapes, and the Nature Conservancy and other conservation partners. In addition, multi-organizational partnerships provide important opportunities to engage and help achieve goals including the USGS Global Change Science Strategy, USFWS Climate Change Strategic Plan, and the Bay Area Ecosystem Climate Change Coalition.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 1 (cont'd)	a. Team activities and associated deliverables shall incorporate an open and transparent process that encourages stakeholder participation.	

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Biodiversity & Habitat	Strategy 1 (cont'd)	i. Incorporate Latest Science – Participants identified in strategy 1a should establish policies, priorities, and actions based upon the best available science and incorporate new scientific information into adaptive strategies (iterative approach) when available. Give research priority to monitoring keystone species, selected species, species interactions and the influence of abiotic ecosystem components on species adaptation or movement relative to reserves and unprotected lands.. In addition pursue opportunities to centralize database management and increase information sharing.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 1 (cont'd)	ii. Incentives for Private Conservation – Participants identified in strategy 1a should provide, where feasible, incentives for the conservation of private lands and working landscapes (including the creation and maintenance of habitat on private lands) and prioritize those at greatest risk.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 1 (cont'd)	b. Best use of California's Wildlife Action Plan (Action Plan) – The Action Plan is already proving to be an important blueprint for how the Department of Fish and Game will address future and current climate change challenges and will play a significant role in identifying a course of action.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 1 (cont'd)	c. Setting Priorities for Conservation – The Department of Fish and Game's Areas of Conservation Emphasis (ACE) mapping effort involved a statewide prioritization of areas considered to be of highest conservation value. The ACE effort is still in its preliminary mapping phase but is intended as a tool to directly support efforts to create a system of priority sustainable habitat reserves across California. The ACE mapping effort will to the extent practical incorporate climate change projections and vulnerabilities. In addition, the ACE can be used in conjunction with other mapping efforts to identify areas overlooked within biological subregions to ensure representative examples of every ecotype have been accounted for. This effort will also help identify linkages and corridors that will help aid species movement and migration. The Department of Fish and Game is committed to continuing coordination with our conservation partners as the final ACE maps are developed and informing all levels of government to better build collaboration and focus resources to the highest priorities. Additional conservation priorities will include consideration of California State Parks reports identifying Key and Representation Parklands and Key Watersheds. These areas have been found to be the most significant habitat areas that are linked to other large	DFG, CA State Parks

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
		blocks of protected habitat. TNC's priority conservation areas should be included in the overall review of conservation strategies in all ecoregions.	
Biodiversity & Habitat	Strategy 2: Management of Watersheds, Habitat, and Vulnerable Species	a. Integrate Climate Change into Field Management – Each land managing entity in the state should commit to reviewing and modifying current land and resource management objectives and practices to reduce environmental stressors and improve watershed conditions and ecosystem services on major holdings.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 2 (cont'd)	b. California Wildlife Action Plan (Action Plan) – Local, regional, and state wide land use and conservation plans should incorporate important regional actions to improve habitat and animal populations identified in the Action Plan. These actions should be considered priorities for implementation of stewardship efforts.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 2 (cont'd)	c. Use and Improve Existing Conservation Efforts – Department of Fish and Game's Natural Communities Conservation Program, Areas of Conservation Emphasis and mitigation banking should be continually supported as effective methods of identifying and protecting priority habitat areas. With appropriate resources these programs could use dynamic habitat-based models to improve identification of conservation areas.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 2 (cont'd)	d. Field Restoration and Improved Protection – Managers of conservation lands, including working landscapes, should continue restoration and other land stewardship practices. State and federal agencies should seek resources and expertise that will help them expand capacity to reduce environmental stressors, improve watershed conditions and restore ecosystem services on priority lands	DFG, CA State Parks, participating agencies

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Biodiversity & Habitat	Strategy 2 (cont'd)	e. Restore Aquatic Habitat – With appropriate resources prioritize conservation and management actions on aquatic systems (including but not limited to associated floodplains, riparian zones, springs, and marshes) for monitoring and restoration efforts that will reduce stress on species resulting from events associated with climate change (i.e., increased sedimentation from flooding events).	DFG, CA State Parks
Biodiversity & Habitat	Strategy 3 - Regulatory Requirements	a. CEQA Review/Wildlife – The Departments within the Natural Resources Agency will continue to use the California Environmental Quality Act (CEQA) process to address the climate change impacts from projects on wildlife, including cumulative impacts.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 3 (cont'd)	b. CEQA Review/Department Guidance – The Department of Fish and Game will initiate the development of internal guidance for staff to help address climate adaptation and to ensure climate change impacts are appropriately addressed in CEQA documents.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 5 - Education and Outreach	a. Public Outreach – Given climate change and its associated impacts a commitment to ongoing public communication and outreach is essential, and should articulate the role of organizations in the protection of biodiversity.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 5 (cont'd)	b. Citizen Scientists - In order to pursue efforts to engage the public, build support to reduce impacts and support adaptation and mitigation strategies, citizen scientists should be engaged to help collect important information including but not limited to phenology observations, stream monitoring, and weather data. This will result in data collected across many locations with limited costs.	DFG, CA State Parks, stakeholders
Biodiversity & Habitat	Strategy 5 (cont'd)	c. Public Interpretation and Classroom Education – A public education campaign on interpretation and climate change, developed by California State Parks includes ten priority components, and will help the 85 million visitors each year understand climate change. Elementary schools will be offered three programs that teach climate change, given the availability of funding. The Department of Fish and Game should pursue similar outreach and education initiatives to inform the public regarding the effects of climate change on natural environments and species. In addition, the State should provide materials to the extensive environmental education community of California.	DFG, CA State Parks

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Biodiversity & Habitat	Strategy 6 – Implementation of Adaptation Strategies	a. Policy Development – All state agencies should review existing policies, criteria, and directives to initiate adaptation measures in response to climate change impacts.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 6 (cont'd)	b. Capacity and Continuity – In order to accomplish and maintain actions associated with the adaptation strategies, new funding sources should be identified to support new full time permanent civil servant positions that are dedicated to climate change adaptation.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 6 (cont'd)	c. Success Measurements – Establish quantifiable and qualitative near-term targets, mid-term and long-term milestones to measure success.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 6 (cont'd)	d. Implementation Timing – The Natural Resources Agency should convene a group of stakeholders and state agency staff to identify sustainable funding for climate change adaptation, prioritize recommendations and opportunities for securing funding.	CNRA, CAT, DFG, CA State Parks
Biodiversity & Habitat	Strategy 6 (cont'd)	e. Adaptive Management – Adaptive management is a key element of implementing effective conservation programs especially in light of the uncertainties associated with climate change related impacts on natural resources. The State should establish a clear process to identify priority species and systems for adaptation management projects as a short-term action and include an adaptive management response. A statewide knowledge base should be pulled together as soon as possible with the assistance of the scientific community to support the State's efforts to employ an adaptive management framework.	DFG, CA State Parks
Biodiversity & Habitat	Strategy 6 (cont'd)	f. Cross Sector Cooperation – Interagency cooperation and collaboration are critical to the implementation and long term success of the strategies particularly in regards to the overlap between biodiversity and habitat concerns and all other sectors of this report. In addition, this same spirit of collaboration needs to be extended to other partners and stakeholders that can provide the data, research, and support to help achieve these goals.	DFG, CA State Parks, participating agencies

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Oceans and Coastal Resources	Strategy 1: Establish State Policy to Avoid Future Hazards and Protect Critical Habitat.	a. Hazard Avoidance Policy – State agencies should consider project alternatives that avoid significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from flooding or erosion due to climate change. The most risk-averse approach for minimizing the adverse effects of sea level rise and storm activities is to carefully consider new development within areas vulnerable to inundation and erosion, and to consider prohibiting development of undeveloped, vulnerable shoreline areas containing critical habitat or opportunities for habitat creation. State agencies should generally not plan, develop, or build any new significant structure in a place where that structure will require significant protection from sea-level rise, storm surges, or coastal erosion during the expected life of the structure. However, vulnerable shoreline areas containing existing development or proposed for new development that has or will have regionally significant economic, cultural, or social value may have to be protected, and in-fill development in these areas should be closely scrutinized. State agencies should incorporate this policy into their decisions, and other levels of government are also encouraged to do so. Some state agencies already base decisions on hazard avoidance, for example Coastal Act provisions require that new development in the coastal zone be designed to minimize risks from current and future hazards, which would include risks from expected sea-level rise, The Act restricts new development in hazardous areas, especially if it would require the construction of a protective device.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 1 (cont'd)	b. Innovative Designs – If agencies do plan, permit, develop or build any new structures in hazard zones, agencies should employ or encourage innovative engineering and design solutions so that the structures are resilient to potential flood or erosion events or can be easily relocated or removed to allow for progressive adaptation to sea level rise, flooding, and erosion.	Coastal Adaptation Working Group

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Oceans and Coastal Resources	Strategy 1 (cont'd)	c. Habitat Protection – The state should identify priority conservation areas and recommend lands that should be considered for acquisition and preservation. The state should consider prohibiting projects that would place development in undeveloped areas already containing critical habitat, and those containing opportunities for tidal wetland restoration, habitat migration, or buffer zones. The strategy should likewise encourage projects that protect critical habitats, fish, wildlife and other aquatic organisms and connections between coastal habitats. The state should pursue activities that can increase natural resiliency, such as restoring tidal wetlands, living shoreline, and related habitats; managing sediment for marsh accretion and natural flood protection; and maintaining upland buffer areas around tidal wetlands. For these priory conservation areas, impacts from nearby development should be minimized, such as secondary impacts from impaired water quality or hard protection devices.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 2: Provide Statewide Guidance for Protecting Existing Critical Ecosystems, Existing Coastal Development, and Future Investments	a. Establish Decision Guidance – The OPC in close coordination with other state resource agencies should develop a statewide framework that can be used by state and local agencies as guidance in preparation of adaptation plans. This guidance should discuss current regulatory and legal frameworks and whether changes are necessary to pursue this approach to adaptation. In addition the OPC should incorporate this new guidance within existing decision-making processes as much as possible and tailor it, when necessary, to specific regional approaches (see strategy 4c).	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3: State Agencies Should Prepare Sea-Level Rise and Climate Adaptation Plans	a. Adaptation Planning – By September 2010 state agencies responsible for the management and regulation of resources and infrastructure subject to potential sea-level rise should prepare agency-specific adaptation plans, guidance, and criteria, as appropriate. Agencies with overlapping jurisdictions in the coastal zone will coordinate when drafting these plans to reduce or eliminate conflicting approaches.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3 (cont'd)	i. The Coastal Commission, the San Francisco Bay Conservation and Development Commission, the state and Regional Water Quality Control Boards, California State Parks, and the State Lands Commission should continue to develop adaptation strategies that can be implemented through their existing planning and regulatory programs.	Coastal Adaptation Working Group

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Oceans and Coastal Resources	Strategy 3 (cont'd)	ii. The Coastal Conservancy, the Ocean Protection Council, and the Wildlife Conservation Board should continue to develop criteria to guide their financial decisions and ensure that projects are designed to consider a range of climate change scenarios.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3 (cont'd)	iii. The California Department of Transportation, State Parks, the Department of Water Resources, the Department of Fish and Game, the State Lands Commission, and other state agencies that own land and facilities along the coast should develop policies to guide them in land-use projects and the development of infrastructure in vulnerable areas in the future.	Coastal Adaptation Working Group
		iv. The aforementioned agencies should:	
Oceans and Coastal Resources	Strategy 3 (cont'd)	a. Consider requiring applicants to address how sea-level rise will affect their project, include design features that will ensure that the project objectives are feasible and that the project will not be rendered unusable or inoperable over its lifespan, that critical habitat is protected, and that public access is provided, where appropriate.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3 (cont'd)	b. Prepare climate strategies, indicators, and thresholds that respond to changing ocean temperatures, air temperatures, predator-prey interactions, and ocean acidification. These strategies should include alternative management strategies that could be employed, such as alternative fisheries management approaches dependent upon temperature regimes, alternative marine protected areas for stressed species, or changes to aquaculture and fishing practices under lower pH conditions.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3 (cont'd)	c. Identify areas where their jurisdiction and authority should be clarified or extended to ensure effective management and regulation of resources and infrastructure subject to potential sea-level rise.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 3 (cont'd)	v. The Department of Insurance should develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 4: Support Regional and Local Planning for Addressing Sea-Level Rise Impacts	a. Public Outreach – The Ocean Protection Council (OPC) in close coordination with other state ocean resource agencies should (beginning in 2010) conduct public meetings within coastal communities to examine adaptive strategies available to state and local agencies to prepare for potential sea-level rise impacts. Strategies, tools, and information will be compiled and made publically available for use by local governments when updating their local and general plans.	Coastal Adaptation Working Group

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Oceans and Coastal Resources	Strategy 4 (cont'd)	b. Funding Mechanisms – The OPC should collaborate with state agencies to identify potential funding sources (i.e., AB32 or an amendment to Prop 218) for state agencies and local governments to undertake revisions to local plans.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 4 (cont'd)	c. Regional Coordination – The state should work with local governments and existing regional organizations, such as the Los Angeles Regional Collaborative for Climate Action and Sustainability, associations of local governments, or SB 375 regional planning teams, to provide for regional adaptation planning. The state should continue to conduct, synthesize, and disseminate regionally relevant research and information with this purpose in mind.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 4 (cont'd)	d. Local Government Guidance – All relevant state agencies should collaborate with local jurisdictions to encourage them to consider the following strategies when updating plans regarding setbacks, additional buffer areas, clustered coastal development, rebuilding restrictions, new development techniques, relocation incentives, rolling easements, and engineering solutions. The Governor's Office of Planning and Research will provide a guidance document in 2009 to address state land use planning.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 4 (cont'd)	e. Amend Local Coastal Plans and General Plans to Address Climate Change Adaptation: By 2011, or within one year after development of the tools or guidance necessary to support such amendments and if funding is secured, all coastal jurisdictions, in coordination with the Coastal Commission, should begin to develop amended LCPs that include climate change impacts; and local jurisdictions around San Francisco Bay should begin to update their general plans, in coordination with BCDC.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 5:	Complete a Statewide Sea-Level Rise Vulnerability Assessment Every Five Years	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 6: Support Essential Data Collection and Information Sharing	a. High-Resolution Mapping – The state, in cooperation with federal partners, should immediately fund the collection of high-resolution topography and bathymetry mapping (i.e., LiDAR) to provide elevation information needed as a baseline for monitoring change, for the modeling of flood hazards, and to help identify and document habitats and ecosystems.	Coastal Adaptation Working Group

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Oceans and Coastal Resources	Strategy 6 (cont'd)	b. Tidal Datum – Monitoring on tidal datums should be maintained and expanded, including establishing additional tide gage stations. Tidal datums are used to measure local water levels and can project how global sea-level rise will be experienced at the local scale. These data are needed to determine the mean high tide and other reference points used in regulatory and legal settings.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 6 (cont'd)	c. Ecosystem Research – Research should be conducted on potential changes to ocean and coastal ecosystems, and species ranges, which are already changing - resulting in divergence in breeding and feeding behavior. Understanding ecosystem changes will be essential to future management decisions related to fisheries, species protection, and restoration projects.	Coastal Adaptation Working Group
Oceans and Coastal Resources	Strategy 6 (cont'd)	d. Coastal and Wetland Process Studies – Research should be conducted to understand and model coastal, estuarine, and wetland circulation and sediment distribution and transport. This information is essential to successful wetland and beach maintenance, restoration, and nourishment projects.	Coastal Adaptation Working Group
Water	Strategy 1: Provide Sustainable Funding for Statewide and Integrated Regional Water Management		DWR
Water	Strategy 2: Fully Develop the Potential of Integrated Regional Water Management	a. Integrated Water Management Plans (IRWM) – By 2011, all IRWM plans should identify strategies that can improve the coordination of local groundwater storage and banking with local surface storage along with other water supplies including recycled municipal water, surface runoff, flood flows, urban runoff, storm water, imported water, water transfers and desalinated groundwater and seawater.	DWR
Water	Strategy 2 (cont'd)	b. Adaptation Component – By 2011, all IRWM plans should include specific elements for climate change adaptation.	DWR
Water	Strategy 3: Aggressively Increase Water Use Efficiency	a. Statewide Reduction in Water Use – As directed by Governor Schwarzenegger and reinforced through legislation, Department of Water Resources (DWR) in collaboration with the Water Boards, the California Energy Commission, the California Public Utilities Commission, the California Department of Public Health (CDPH), and other agencies will implement strategies to achieve a statewide 20 percent reduction in per capita water use by 2020.	DWR

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Water	Strategy 3 (cont'd)	b. Water Efficiency – Agricultural entities should apply all feasible Efficient Water Management Practices (EWMPs) to reduce water demand and improve the quality of drainage and return flows, and report on implementation in their water management plans.	DWR
Water	Strategy 3 (cont'd)	c. Energy Efficiency – Recycled water is a drought-proof water management strategy that may also be an energy efficient option in some regions.	DWR
Water	Strategy 3 (cont'd)	d. Water Conservation – The State Water Resources Control Board (SWRCB) and the California Public Utilities Commission may impose water conservation measures in permitting and other proceedings to ensure water conservation efforts. It is recommended that the Legislature authorize and fund new incentive-based programs to promote the mainstream adoption of aggressive water conservation by urban and agricultural water systems and their users.	DWR
Water	Strategy 4: Practice and Promote Integrated Flood Management	a. Flood Management Improvements – To reduce flood peaks, reduce sedimentation, temporarily store floodwaters, recharge aquifers and restore environmental flows, flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.	DWR
Water	Strategy 4 (cont'd)	b. System Reoperation Task Force – The improved performance of existing water infrastructure cannot be achieved by any single agency, and will require the explicit cooperation of many. Moreover, system-wide operational coordination and cooperation must be streamlined to respond to extreme events that may result from climate change. Successful system re-operation will also require that the benefits of such actions are evident to federal and local partners. To achieve these goals, the State will establish a System Re-operation Task Force comprised of state personnel, federal agency representatives, and appropriate stakeholders.	DWR
Water	Strategy 4 (cont'd)	c. Support Decision Making – To successfully meet the challenges posed by climate change, the federal-state Joint Operations Center (JOC) capacity should be expanded to improve tools and observations that better support decision-making for individual events, seasonal and inter-annual operations and water transfers. The JOC should be enhanced to further improve communications and coordination during emergencies such as floods and droughts.	DWR

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Water	Strategy 4 (cont'd)	d. Central Valley Flood Protection Plan – By January 1, 2012, DWR will collaboratively develop a Central Valley Flood Protection Plan that includes actions to improve integrated flood management and consider the potential impacts of climate change.	DWR
Water	Strategy 4 (cont'd)	e. Emergency Flood Preparedness – All at-risk communities should develop, adopt, practice and regularly evaluate formal flood emergency preparedness, response, evacuation and recovery plans.	DWR
Water	Strategy 4 (cont'd)	f. Land Use Policies – Local governments should implement land use policies that decrease flood risk.	DWR
Water	Strategy 5: Enhance and Sustain Ecosystems	a. Species Migration and Movement Corridors – Water management systems should protect and reestablish contiguous habitat and migration and movement corridors for plant and animal species related to rivers and riparian or wetland ecosystems. IRWM and regional flood management plans should incorporate corridor connectivity and restoration of native aquatic and terrestrial habitats to support increased biodiversity and resilience for adapting to a changing climate.	DWR
Water	Strategy 5 (cont'd)	b. Floodplain Corridors – Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains. Setback levees and bypasses help to retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Carbon sequestration within large, vegetated floodplain corridors may also assist the state in meeting GHG emissions reductions mandated by AB 32.	DWR
Water	Strategy 5 (cont'd)	c. Anadromous Fish – The state should work with dam owners and operators, federal resource management agencies, and other stakeholders to evaluate opportunities to introduce or reintroduce anadromous fish to upper watersheds. Reestablishing anadromous fish, such as salmon, upstream of dams may provide flexibility in providing cold water conditions downstream, and thereby help inform system reoperation. Candidate watersheds should have sufficient habitat to support spawning and rearing of self-sustaining populations.	DWR, participating agencies, stakeholders

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Water	Strategy 5 (cont'd)	d. Tidal Wetlands as Buffers – The state should identify and strategically prioritize for protection lands at the boundaries of the San Francisco Bay and Sacramento-San Joaquin Delta that will provide the habitat range for tidal wetlands to adapt to sea-level rise. Such lands help maintain estuarine ecosystem functions and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level rise and storm surges.	DWR, participating agencies
Water	Strategy 5 (cont'd)	e. Reversal of Delta Island Subsidence – The state should prioritize and expand Delta island subsidence reversal and land accretion projects to create equilibrium between land and estuary elevations along select Delta fringes and islands. Sediment-soil accretion is a cost-effective, natural process that can help sustain the Delta ecosystem and protect Delta communities from inundation.	DWR
Water	Strategy 5 (cont'd)	f. Upper Watershed Services – The state should consider actions to protect, enhance and restore upper watershed forests and meadow systems that act as natural water and snow storage. This measure not only improves water supply reliability and protects water quality, but also safeguards significant high elevation habitats and migratory corridors.	DWR
Water	Strategy 6: Expand Water Storage and Conjunctive Management of Surface and Groundwater Resources	a. Expand Water Storage – California should expand its available water storage for both surface and groundwater supplies. Funding for this is included in the proposed 2010 Water bond.	DWR
Water	Strategy 6 (cont'd)	b. Surface Storage Feasibility Studies – DWR will incorporate climate change considerations as it works with the U.S. Bureau of Reclamation (Reclamation) and local agencies to complete surface storage feasibility studies.	DWR
Water	Strategy 6 (cont'd)	c. Conjunctive Use Management Plans – State, federal, and local agencies should develop conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage.	DWR, participating agencies
Water	Strategy 6 (cont'd)	d. Groundwater Management Plans – Local agencies will be encouraged to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of their IRWM plans.	DWR
Water	Strategy 6 (cont'd)	e. Local Ordinances – Cities and counties will be encouraged to adopt local ordinances that protect the natural functioning of groundwater recharge areas.	DWR

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Water	Strategy 7: Fix Delta Water Supply, Quality and Ecosystem Conditions	a. Delta Adaptation Planning – Recently passed legislation establishes the framework to achieve the co-equal goals of providing a more reliable water supply to California and enhancing the Delta ecosystem. It encourages the incorporation of adaptive responses to climate change in the development of the Bay-Delta Conservation Plan and other Delta-related efforts.	DWR
Water	Strategy 7 (cont'd)	b. Sustainable Delta Goals – The Safe, Clean and Reliable Drinking Water Supply Act of 2010 is an $11.14 billion general obligation bond proposal that would provide funding for California's aging water infrastructure and for projects and programs to address the co-equal goals as well as statewide water projects and programs. It includes funding for drought relief, water supply reliability, Delta sustainability, statewide water system improvements, conservation and watershed protection, groundwater protection and water quality, and water recycling and conservation.	DWR
Water	Strategy 8: Preserve, Upgrade and Increase Monitoring, Data Analysis and Management		DWR
Water	Strategy 9: Plan for and Adapt to Sea-Level Rise		DWR
Water	Strategy 10: Identify and Fund Focused Climate Change Impacts and Adaptation Research and Analysis		DWR
Agriculture	Strategy 1 - Water Supply and Conservation Support	a. Water Conservation - Continue to enhance water conservation activities at the farm and district level by initiating incentives, distributing information and introducing other strategies that encourage the development of diverse farm and irrigation district water sources.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	i. California Irrigation Management Information System - Expand the collection and dissemination of local weather information for irrigation planning and expand the California Irrigation Management Information System (CIMIS).	CDFA, DOC

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Agriculture	Strategy 1 (cont'd)	ii. Mobile Irrigation Labs - Increase support for water stewardship practices either through expanding the role of mobile irrigation labs or through other services provided by Resource Conservation Districts, Water or Irrigation Districts, and Cooperative Extension services.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	iii. California Agricultural Water Management - Support expansion and development of voluntary district-level water conservation plans for all agricultural water districts; and encourage the implementation of approved district conservation plan actions (e.g., tailwater return ponds).	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	iv. Collaboration & Partnerships - DOC will collaborate with the USDA Natural Resources Conservation Service, DWR, CEC, and CDFA to prioritize and expand technical and financial cost-share assistance programs (e.g., water stewardship practices, farm conservation planning, water use efficiency, micro-irrigation, low energy precision application drip systems, and land-leveling) for growers.	CDFA, DOC, participating agencies
Agriculture	Strategy 1 (cont'd)	v. Energy Efficient Water Recycling - Invest in new uses for saline drainage water, using renewable solar and on-farm bio-fuels energy sources to treat saline water. This is partially mitigation, but should focus on re-use of saline drainage on more salt tolerant crops or to expand supplies through treatment.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	vi. Water Incentives – Incentivize water pricing systems that reward conservation, accounting for regional differences in growing conditions, crops, and other agronomic needs. Create incentives and streamline regulatory requirements for agricultural water users to make more water available for other beneficial uses through voluntary water transfers.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	vii. Urban Conservation Programs - Invest in urban water conservation programs that result in increased local sources of agricultural irrigation water available for future use.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	viii. Water and energy use efficiency on farms - DOC shall implement statewide expansion of the Watershed programs which support adaptive management through watershed stewardship and project implementation grant awards, including practices that increase water and energy use efficiency on farms.	CDFA, DOC

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Agriculture	Strategy 1 (cont'd)	ix. Dry Farming – Dry farming in higher rainfall coastal regions has traditionally produced high quality crops, such as wine grapes and apples. Through water conservation funding, develop incentives and marketing to support appropriate coastal zone dry farming recognizing that there will be a likely reduction in crop yields and in turn available local food supplies.	CDFA, DOC
Agriculture	Strategy 1 (cont'd)	b. Floodplain Easements - Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance. These actions will also enhance economic sustainability and protect urban residents from flooding, provide improved shallow water and seasonal wetland habitat, improved fish passage and nursery conditions, while protecting agricultural lands for the continued production of food and fiber.	CDFA, DOC
Agriculture	Strategy 2 – Preventing, Preparing for, and Responding to Agricultural Invaders, Pests, and Diseases	a. Inspection Stations – Increase vigilance and develop a long-term funding strategy at the state's port-of-entry inspection stations to prevent entry of new diseases, pests and weeds.	CDFA, DOC
Agriculture	Strategy 2 (cont'd)	b. Statewide Detection - Increase the effectiveness of statewide detection system in order to detect newly introduced pest species.	CDFA, DOC
Agriculture	Strategy 2 (cont'd)	c. Risk Analysis of Potential Invasives – CDFA, UC Cooperative Extension, and CEMA should collaborate in developing risk analysis of foreign plant and animal pests that could invade California, to aid in better preventing introductions and better preparing for emergency eradication responses.	CDFA, DOC, participating agencies
Agriculture	Strategy 2 (cont'd)	d. Pollinator Technical and Financial Assistance - Provide technical and financial assistance and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e. seedless crop varieties).	CDFA, DOC
Agriculture	Strategy 2 (cont'd)	e. Information Distribution - Provide information to the agricultural community to enable growers to modify farm management practices and adapt to new pests and diseases.	CDFA, DOC
Agriculture	Strategy 3 - Land Use Planning Practices	a. Policy Integration – CDFA, in collaboration with the Strategic Growth Council and other agencies, should provide guidance for cities and counties to help develop and adopt sustainable agriculture policies, particularly in conjunction with smart growth planning initiatives.	CDFA, DOC

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Agriculture	Strategy 3 (cont'd)	i. Protection of Farmland - Under the leadership of the DOC, ensure the continuation of the Land Conservation Act (1965) and the California Land Conservancy Program, as well as other local and state agency programs to permanently protect farmland. Use the Land Conservation Act in combination with the Farmland Mapping and Monitoring Program and the California Farmland Conservancy Program to identify and secure lands that offer future productivity potential against climate impacts (e.g., lacustrine and alluvial soils at higher elevations, or northern climates.)	CDFA, DOC
Agriculture	Strategy 3 (cont'd)	ii. Adaptable Farmlands – Encourage the conservation of the most productive and adaptable farmland by supporting land conservation programs and smart growth (e.g., urban growth boundaries, in-fill, redirection and redevelopment of existing urban areas).	CDFA, DOC
Agriculture	Strategy 3 (cont'd)	iii. Community Land Use – CDFA will encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture.	CDFA, DOC
Agriculture	Strategy 3 (cont'd)	iv. Local and Regional Markets – Encourage and support the development of local and regional markets allowing smaller farms a niche to coexist on smaller parcels in near-urban environments. DOC Farmland Conservancy Program, utilizing data from the DOC Farmland Mapping and Monitoring Program, has developed a prototype foodshed map, starting with San Francisco, in response to the cities' local food initiative. Such foodshed mapping products can facilitate sound regional planning to optimize farmland conservation.	CDFA, DOC
Agriculture	Strategy 3 (cont'd)	v. Mapping Collaboration - Develop and employ methods to update existing soil classification maps based on climate change scenarios in collaboration with the Natural Resources Conservation Service.	CDFA, DOC
Agriculture	Strategy 3 (cont'd)	b. Wetland Easements – Pursuant to DWR Water Plan 2009, continue purchase of wetland easements on marginal, flood-prone, agricultural lands to diversify grower income and buffer productive lands from flood events and improve the environmental services provided by these lands. These efforts may include DWR, DFG, NRCS (Natural Resource Conservation Service), WCB (Wildlife Conservation Board) or other funding sources and incentivize private investment in the establishment and preservation of wetlands.	CDFA, DOC, participating agencies

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Agriculture	Strategy 4 – Promote Working Landscapes with Ecosystem Services to Improve Agrobiodiversity	a. Technical Assistance and Outreach - Use new and existing technical and financial assistance programs, and informational outreach where appropriate to increase the diversification of the agricultural region from field to landscape scales. For example, inter-cropping with rotations, cover cropping, hedgerows, riparian restoration and wetlands can provide grower opportunities for diversification of income from carbon sequestration and other environmental services credits; create opportunities for pest predator and pollinator habitat; and enhance resilience against climate change.	CDFA, DOC
Agriculture	Strategy 4 (cont'd)	b. Bio-Energy – The University of California Cooperative Extension (UCCE), along with the California Energy Commission (Energy Commission) and the California Department of Food and Agriculture (CDFA) should encourage the development of sustainable agricultural feedstocks for bio-energy that use marginal land and avoid competing with both plant and animal food production.	CDFA, DOC, participating agencies
Agriculture	Strategy 5 - Farm and Land Management Initiatives	a. Permit Streamlining – The State Environmental Protection Agency (CalEPA) and CDFA will promote and facilitate permit streamlining coordination of dairy digester technologies and other initiatives (regulatory and voluntary) that have a net benefit to food supply, climate change, and the environment. CalEPA, CDFA, and other state agencies should promote technical and financial assistance for regional and on-farm sources of renewable energy and encourage the economic and environmental sustainability of California farms, dairies and rural lands.	Cal EPA, CDFA, DOC, participating agencies
Agriculture	Strategy 6 – Building and Sustaining Institutional Support	a. Information Clearinghouse - Establish information clearinghouse(s) for growers that provide information and guidance on adaptive management of crops and cultivars, air quality, precipitation, pests and diseases, climate change scenarios, annual planning, disease and pest invasions, control strategies, water conservation technology, technical and financial assistance, crop failure insurance and general information pertinent to climate change adaptation.	CDFA, DOC
Forestry	Strategy 1: Incorporate Existing Climate Information into Policy Development and Program Planning.	a. Comprehensive Program Integration – Integrate climate risk information into existing CAL FIRE program planning to address forest and range adaptation. CAL FIRE program managers should identify key climate effects or uncertainties that may affect implementation of a broad range of programs including: Forestry Assistance, State Forests, Forest Practices Regulations, Fire Protection, Fire Prevention, Unit Fire Plans, and Capital Outlay.	CAL FIRE

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Forestry	Strategy 1 (cont'd)	b. Identify and Engage Stakeholders – CAL FIRE will fully engage Forest Sector and cross-sector stakeholders in identifying key impact and adaptation concerns and questions as they relate to agency responsibilities and services. [e.g., U.S. Forest Service (USFS), Bureau of Land Management (BLM), National Park Service, National Marine Fisheries Service, U.S. Fish and Wildlife Service, State Department of Fish and Game (DFG), State Parks, regional air boards, regional water quality boards and other state agencies, local governments, private landowners, community groups and Non-Government Organizations (NGO)].	CAL FIRE, participating agencies
Forestry	Strategy 1 (cont'd)	c. Forest and Rangeland Resource Assessment – CAL FIRE is required by statute to periodically assess the condition and availability of the state's forest and rangeland natural resources. The update will expand upon the previous climate change chapter to inform the Board of Forestry and Fire Protection's (BOF) climate policy, strategic plan and climate change actions. The draft plan will be developed, reviewed by the public, and considered for BOF approval by the end of 2009, and finalized in 2010.	CAL FIRE
Forestry	Strategy 1 (cont'd)	d. Timber harvest planning under the Forest Practices Act - Provide guidance for project proponents and CAL FIRE staff to address climate impacts and adaptation actions within existing maximum sustained timber yield production plans required by the California Forest Practices Act.	CAL FIRE
Forestry	Strategy 2: Improve Institutional Capacity for Data Development and Analysis, Assess Climate Effects and Forest Vulnerabilities, and Recommend Strategic and Tactical Responses.	a. Vulnerability & Risk Assessment – CAL FIRE will conduct strategic risk analyses and vulnerability assessments to identify and prioritize planning and tactical actions to address adaptation needs. Included in this is the deliberate development of quantitative risk modeling of fire impacts on key assets and resources in a spatially explicit framework. A major portion of this work involves projecting future fire probabilities and future vegetation/fuel conditions across the state.	CAL FIRE
Forestry	Strategy 2 (cont'd)	b. Policy Actions – Begin to develop policy, management and funding recommendations for actions by Board of Forestry and Fire Protection, CAL FIRE, other agencies (including USFS) and private sector to increase resilience of forest lands and resources.	CAL FIRE

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Forestry	Strategy 3 - Actions to Address Climate Vulnerabilities (Sector Preparedness Action Plan)	a. Management of Forest and Range Lands for Resilience – In cooperation with federal, state and local agencies, CAL FIRE plans to reduce the vulnerability of forests to disturbances from climate change impacts. Specific actions include:	CAL FIRE
Forestry	Strategy 3 (cont'd)	i. Expand Landowner Assistance and Technology Transfer – CAL FIRE's Forest Improvement Program will work with the US Forest Service, University of California Extension, Resource Conservation Districts (RCDs), Natural Resource Conservation Service and others to prevent and minimize catastrophic wildfire and restore fire resistant conditions in fire adapted vegetation types through mechanical and prescribed fire treatments, and to assist with post-fire recovery.	CAL FIRE, participating agencies
Forestry	Strategy 3 (cont'd)	ii. Review Regulatory Framework – The Board of Forestry and CAL FIRE's Forest Practices, Fire Protection and State Fire Marshal programs will review and consider the need for regulatory and related improvements, incentives for private investments, and revisions to CAL FIRE Handbook.	CAL FIRE
Forestry	Strategy 3 (cont'd)	iii. Support Urban Forestry – Funded through Propositions 40 and 84, CAL FIRE's Urban Forestry Program will continue to assist local entities with tree planting and urban forest management. This will help protect and expand urban forests that serve to buffer the impacts of local wildland forests, and provide sequestration, watershed, water quality and habitat co-benefits.	CAL FIRE
Forestry	Strategy 3 (cont'd)	b. Department established as "Trustee" agency in CEQA – CAL FIRE will work with Board of Forestry to consider establishment of CAL FIRE as a Trustee agency in CEQA will provide assurance that new projects and development provide mitigation that is consistent with adaptation goals, including fire safety and forestland conservation and maintenance.	CAL FIRE

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Forestry	Strategy 3 (cont'd)	i. Explore Cross Agency and Sector Synergies – The state, though the Climate Action Team and the California Natural Resources Agency should promote coordination among state planning processes, grant and assistance programs, and management activities on climate actions with high co-benefits. CAL FIRE will collaborate with other agencies on their adaptation strategies and with programs that increase forest resilience (e.g., with ARB to explore funding opportunities from cap and trade markets for activities with both mitigation and adaptation benefits; with WCB on Prop 84 forest conservation; with DWR, DFG, and the California Department of Conservation (DOC) to implement upper watershed protection and riparian reforestation; with DFG to identify, protect and improve the resilience of critical habitats at wildfire risk; with Energy Commission and others on Renewable Portfolio Standard (RPS) implementation to increase funding for fuels reduction; with OPR on CEQA and land use planning tools; with the Department of Public Health and ARB to address fire and smoke issues; with DOC and Dept of Food and Agriculture to consider rangeland issues; with local governments, CalTrans and others to consider development effects on fire risks; working with Strategic Growth Council on urban greening; and with Sierra Nevada Conservancy Prop 84 fuels reduction and forest restoration).	CAL FIRE
Forestry	Strategy 3 (cont'd)	ii. Demonstration Project – CAL FIRE will develop a biomass-to-electricity plant at Mendocino County Conservation Camp to demonstrate the value of small power plants. Planning and funding commitments will be completed by December 2010.	CAL FIRE
Forestry	Strategy 3 (cont'd)	iii. Maintain Current Wood Product Utilization Capacity – The Board of Forestry and Fire Protection and CAL FIRE will work with other agencies and the private sector as appropriate to encourage policies and strategies that help maintain utilization infrastructure (sawmills, pulp mills, veneer plants, etc.) and that encourage modernization of existing facilities or development of new facilities.	CAL FIRE
Forestry	Strategy 3 (cont'd)	iv. Provide Regulatory Certainty – The Board of Forestry and Fire Protection and CAL FIRE will consider the need for additional incentives, or the removal of disincentives, to encourage landowners to actively manage their lands for adaptation, e.g., cap and trade markets, protocols and RPS implementation.	CAL FIRE
Forestry	Strategy 4 - Implement Priority Research Agenda		CAL FIRE

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Forestry	Strategy 5 - Implement Forest Health Monitoring in an Adaptive Management Context		CAL FIRE
Infra-structure	Strategy 1 – ENERGY: Increase Energy Efficiency Efforts in Climate Vulnerable Areas	a. Meet the Energy Efficiency Goals Outlined in AB32 Scoping Plan – The Air Resources Board's (ARB) Scoping Plan has identified 26.3 MMTCO$_2$e that will be reduced by 2020 through increased use of building and appliance efficiency standards, increased combined heat and power generation and through increased solar water heating improvements (AB1470). Ensuring these measures are met, while increasing these efforts over time, will help ease projected energy demand increases and possible supply disruptions from climate change.	CEC
Infra-structure	Strategy 1 (cont'd)	b. Facilitate Access to Local, Decentralized Renewable Resources – The Energy Commission should consider policies and incentives to maximize and to encourage de-centralized (local and near demand) generation and on-site renewable energy generation systems where feasible and appropriate. This deployment of additional renewable generation would reduce GHG emissions and help meet the expected increase in electrical demand due to climate change.	CEC
Infra-structure	Strategy 2 – ENERGY: Assess environmental impacts from climate change in siting and re-licensing of new energy facilities.	a. Assess Power Plants Vulnerable to Climate Impacts, and Recommend Reasonable Adaptation Measures – The Energy Commission will assess GHG impacts for power plant siting cases through its Integrated Energy Policy Report, and consider the potential impact of sea-level rise, temperature increases, precipitation changes and extreme events, where relevant.	CEC
Infra-structure	Strategy 2 (cont'd)	b. Encourage Expansion of Renewable Energy Resources – The Energy Commission should assess long-term benefits of renewable energy generation in reducing GHG emissions that also provide environmental co-benefits. The state shall encourage additional development of the most suitable and efficient renewable technologies to maximize the amount of electrical generation from renewable sources. The Energy Commission and DFG should encourage renewable energy generation in the least sensitive environmental areas to maintain natural habitats and healthy forests that will further buffer the environmental impacts of climate change.	CEC/DFG

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Infra-structure	Strategy 2 (cont'd)	c. Assess the Impacts of Climate Change on Energy Infrastructure – Use the Energy Commission's PIER regional climate modeling and related study efforts to assess the potential impacts of climate change on energy infrastructure from sea-level rise, precipitation, and temperature changes and other impacts. The Energy Commission will determine additional actions on its siting and planning programs based on this work.	CEC
Infra-structure	Strategy 2 (cont'd)	d. Identify the Most Vulnerable Communities – Develop an energy-use "hot-spot" map to identify areas in the state where increases in temperature, population, and energy-use will make communities most vulnerable to climate change impacts. The Energy Commission will include in this analysis how the lowest-income communities in hot spot areas will be impacted. Also, assess impacts of climate change on tribal lands and ability of tribes to adapt to changing conditions.	CEC
Infra-structure	Strategy 3 – ENERGY: Develop Hydropower Decision-Support Tools to Better Assess and Manage Climate Change Variability	a. Expand Scientific Climate Research – The Energy Commission and the DWR will continue to support and develop enhancements and demonstration of modern decision support systems for the management of existing major water reservoirs in California to adapt to current levels of climate variability and increase our resilience to increased levels of climate variability and change in the future.	CEC/DWR
Infra-structure	Strategy 3 (cont'd)	b. Public Interest Energy Research – The Energy Commission's PIER program will sponsor research on climate change factors influencing hydropower generation – for example, how hydropower generation would be affected by requirements to release additional water to attenuate increased water temperatures in rivers and streams for environmental purposes.	CEC
Infra-structure	Strategy 3 (cont'd)	c. Develop Partnerships –Partner with hydropower generators particularly vulnerable to climate change to identify how public-private partnerships could reduce long-term risks to hydropower generation.	CEC, participating agencies
Infra-structure	Strategy 4 – ENERGY: Identify how state renewable energy goals could be impacted from future climate impacts.	a. Assess Climate Impacts on Energy – The Energy Commission's PIER program will research how climate change impacts could influence the goals of AB32, AB118, and EO S-13-08 goals. For example, climate change will influence wind speeds and patterns, temperature density, etc. that will affect power levels from wind turbines, photovoltaics, etc. In addition, biomass feedstocks could be reduced due to decreased water levels and increased wildfire. It is unclear how this will impact long-term projections for meeting our 2020 and 2050 renewable energy goals.	CEC

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Infra-structure	Strategy 5 – TRANSPORTATION: Develop a detailed climate vulnerability assessment and adaptation plan for California's transportation infrastructure.	a. Vulnerability and Adaptation Planning – BTH (Business, Transportation and Housing Agency) and CALTRANS will develop a climate vulnerability plan that will assess how California's transportation infrastructure facilities are vulnerable to future climate impacts, assess climate adaptation options, prioritize for implementation, and select adaptation strategies to adopt in coordination with stakeholders. This plan will be coordinated with an updated climate mitigation plan that will act as BTH's and Caltrans' overall transportation climate policy	CalTrans/BTH
Infra-structure	Strategy 5 (cont'd)	i. Develop a transportation use "hot-spot" map – Caltrans will research and identify transportation "hot spots", using updated NAS and other appropriate study efforts, to identify across the state where the mixture of climate change impacts, population increases, and transportation demand increases will make communities most vulnerable to climate change impacts. Caltrans will include in this analysis how the lowest-income communities in hot spot areas will be impacted.	CalTrans
Infra-structure	Strategy 5 (cont'd)	b. Economic Impacts Assessment – Complete an overall economic assessment for projected climate impacts on the state's infrastructure under a "do nothing" scenario and under climate policy scenarios identified by BTH/Caltrans.	CalTrans/BTH
Infra-structure	Strategy 5 (cont'd)	i. Prepare a list of transportation adaptation strategies or measures based on the "hot spot" map and prepare an economic assessment and cost-benefit analysis for these strategies vs. a do nothing scenario.	CalTrans
Infra-structure	Strategy 6 – TRANS-PORTATION: Incorporate climate change vulnerability assessment planning tools, policies, and strategies into existing transportation and investment decisions.	a. Integrate Mitigation and Adaptation System-wide – Caltrans will develop and incorporate climate change mitigation and adaptation policies and strategies throughout state strategic, system and regional planning efforts. These will be included in key phases of the following planning and project development phases when appropriate:	CalTrans
Infra-structure	Strategy 6 (cont'd)	i. Strategic Planning (Governor's Strategic Growth Plan and California Transportation Plan)	CalTrans
Infra-structure	Strategy 6 (cont'd)	ii. System Planning (i.e., District System Management Plan, Inter-regional Strategic Plan, Corridor System Management Plan, and Transportation Concept Report)	CalTrans

Adaptation Sectors	Strategy	Short-term strategies to complete by November 2010	Responsible Agencies
Infra-structure	Strategy 6 (cont'd)	iii. Regional Transportation Planning (Regional Transportation Plan Guidelines and Regional Blueprint Planning)	CalTrans
Infra-structure	Strategy 6 (cont'd)	iv. Project planning (Project Development Procedures Manual, Project Initiation Document, Project Report, Environmental Guidelines)	CalTrans
Infra-structure	Strategy 6 (cont'd)	v. Programming (State Transportation Improvement Program, State Highway Operations and Protection Program, California Transportation Commission State Transportation Improvement Program Guidelines)	CalTrans
Infra-structure	Strategy 7 – TRANS-PORTATION: Develop transportation design and engineering standards to minimize climate change risks to vulnerable transportation infrastructure.	a. Transportation infrastructure assessment - Caltrans will assess existing transportation design standards as to their adequacy to withstand climate forces from sea level rise and extreme weather events beyond those considered.	CalTrans
Infra-structure	Strategy 7 (cont'd)	b. Buffer zone guidelines - Develop guidelines to establish buffer areas and set backs to avoid risks to structures within projected "high" future sea level rise or flooding inundation zones.	CalTrans
Infra-structure	Strategy 7 (cont'd)	c. Stormwater quality - Assess how climate changes could alter size and design requirements for stormwater quality BMP's.	CalTrans
Infra-structure	Strategy 8 – TRANS-PORTATION: Incorporate climate change impact considerations into disaster preparedness planning for all transportation modes.	a. Emergency Preparedness – CALTRANS provides significant emergency preparedness abilities for all transportation modes across the state. The transportation system is sensitive to rapid increases in precipitation, storm severity, wave run-up and other extreme weather events. CALTRANS will assess the type of climate-induced impact information necessary to respond to district emergencies. Results will be incorporated into existing operations management plans.	CalTrans
Infra-structure	Strategy 8 (cont'd)	b. Decision Support – CALTRANS will identify how climate impact information can be integrated into existing Intelligent Transportation Systems and Transportation Management Center operations.	CalTrans

REFERENCES

Part I- Planning for Climate Change

[1] See, for example, the following publications:

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Figure 22: Photo courtesy of CALTRANS.

Figure 23: San Francisco Bay Conservation and Development Commission, Shoreline Areas Vulnerable to Seal Level Rise, Central Bay West Shore index map, 16 and 55-inch sea level rise scenarios. www.bcdc.ca.gov/planning/climate_change/maps/16-55/cbay_west.pdf

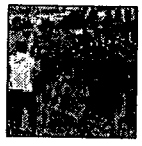

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Eroding cliff prompts Pacifica evacuation

Justin Berton,Henry K. Lee, Chronicle Staff Writers
Friday, December 18, 2009





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(12-17) 14:37 PST PACIFICA -- The owners of a seaside Pacifica apartment building that was evacuated Thursday had been applying for emergency permits to build a rock barrier at the base of an eroding bluff, but nature and high tides beat them to the punch.

Delfarid Fanine, co-owner of the 12-unit building at 330 Esplanade Drive, said the owners told tenants weeks ago that they were hoping to prevent the bluff from vanishing from under the apartments.

"Unfortunately, it all happened before anyone expected," Fanine said. "It's nature. No one can beat nature."

According to city officials and workers at the apartments, as much as 40 feet of land has disappeared at the property in the past year. Early Thursday, the bluff starting falling away in alarmingly large chunks, and city officials red-tagged the apartments.

The 20 or so tenants were told just before 11 a.m. that they had only minutes to leave, prompting a mad dash to save whatever they could. One resident flung belongings from a second-story window.

Then, a few minutes later, city officials decided the tenants could safely remove possessions until 3 p.m. Mattresses, couches, chairs and random items such as fishing poles and reading lamps lined the sidewalk.

Randall Nelson, the building manager who has lived there for 14 years, said he was upset about leaving. But he also said he understood when he moved in that along with the picturesque view came the possibility that the cliff wouldn't sit still.

"We live here because we love the ocean," Nelson said, "but nothing lasts forever."

Pacifica residents have long dealt with the challenges of living on the seaside bluffs.

In 1998, seven homes on Esplanade Drive were demolished after El Niño-powered storms ate away at the cliff upon which they stood.

Nearly all the shoreline in Pacifica is soft, compacted sand, according to the U.S. Geological Survey. The weak soil, the direct attack of waves and the saturation from rainwater make the area especially susceptible to erosion.

The apartments were built in 1961. The bluff has been eroding for some time, but in the past two years the situation has grown much worse, officials said.

Tony Fortunato, a superintendent with Engineered Soil Repairs, estimated that the cliff had receded as much as 15 feet in recent days because of unusually high tides.

"They had a lot more real estate last year," Fortunato said. "A lot of it is in the ocean now."

He said his company will try to save the building in the coming days by using cranes to lower boulders into the cliff's base to create a rock wall, known as riprap.

Owners of buildings on either side of the apartment building inserted similar barriers last year. The cliffs there have withstood the recent high tides.

Fanine said her company applied for permits from the California Coastal Commission at the same time last year, but delays held up the work.

Amanda O'Connell, who moved into the apartments four months ago, said she received a letter from the owners last month that a barrier would be completed by Christmas and they would have nothing to worry about.

"Guess they didn't make it," O'Connell said while packing a car. She wasn't sure where she was going to live.

Paul Wells, 47, moved in less than a month ago from Redwood City.

"I pretty much got entirely unpacked, just in time to be told it was time to start packing again," Wells said. "Of course I'm frustrated. I'm still in some degree of shock. I know that once the shock wears off, I'm going to feel a lot more anger."

E-mail the writers at jberton@sfchronicle.com and hlee@sfchronicle.com.

http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2009/12/18/BA601B5QLH.DTL

This article appeared on page **C - 1** of the San Francisco Chronicle

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Tuesday, December 8, 2009

We need a way to cross Highway 1 safely in Moss Beach and Montara

Letter posted by Sabrina Brennan (http://coastsider.com/index.php/member/1980/) on Dec 8, 2009 at 02:57 pm in Real Estate (http://coastsider.com/index.php/site/C12/) Top stories (http://coastsider.com/index.php/site/C16/)
31 comments • Print (http://coastsider.com/index.php/site/print/4052/) • Share on Mail, Facebook, Twitter... (http://www.addtoany.com/share_save?linkname=Optional&linkurl=http%3A%2F%2Fcoastsider.com)

On Thursday, December 3rd at 5:15pm, a 12-year-old boy was struck by a vehicle while riding his bike across Highway 1 near the Moss Beach Sheriff's substation.

The sheriff's office reported that the boy was conscious and breathing, both legs were severely injured. The boy was transported to Stanford Medical Center for treatment.

The sheriff's substation has no further information at this time.

I hope the MCC will form a task force and work with Caltrans and the County to resolve this problem ASAP. I don't want any more kids severely injured or killed while crossing Highway 1. What are we waiting for? The situation is totally unacceptable and has been extremely dangerous for years. Traffic is increasing on the Coastside and Caltrans and the County are doing nothing to deal with the risk to pedestrians and cyclists.

Comments

Comment 1 (http://coastsider.com/index.php/site/news/4052/#8147) by Barry Parr (http://coastsider.com/index.php/member/1/) on Dec 8 at 3:28pm • All my comments (http://coastsider.com/index.php/site/member_comments/1) •



(http://coastsider.com/index.php/member/1/)

Highway 1 separates nearly all of Montara and Moss Beach from the ocean, and there is no safe way to cross it.

I appreciate the attention that the county and Caltrans have paid to walking and biking trails, as well as safe intersections in El Granada, but our need is urgent.

Without a safe crossing, we're isolated from the rest of the Coastside and forced to use cars when we'd rather walk or bike.

I've crossed the road in Moss Beach. It's frightening. Biking from Montara requires using the narrowest, most deadly curve on the Coastside. Or the even deadlier Sunshine Valley Road.

Comment 2 (http://coastsider.com/index.php/site/news/4052/#8149) by Ginny McShane (http://coastsider.com/index.php/member/2017/) on Dec 8 at 4:47pm • All my comments (http://coastsider.com/index.php/site/member_comments/2017) •

I heard about this accident and I fully agree with the previous posters. The accident was terrible! I would like to join a committee to look into this safety issue. I can be reached at: **ginny@coastside.net** (mailto:ginny@coastside.net) .

My prayers go out to the child and family.

Ginny McShane

Comment 3 (http://coastsider.com/index.php/site/news/4052/#8150) by Jim Sullivan (http://coastsider.com/index.php/member/1039/) on Dec 9 at 7:31am • All my comments (http://coastsider.com/index.php/site/member_comments/1039) •

Perhaps some pedestrian-cyclist activated blinking yellow in pavement crosswalk lights, like the ones used in front of SF City hall on Polk st would enhance safety. These could be installed a multiple locations for convenient access within this stretch of highway.
I ride my bicycle on Sunshine Valley Rd 1-2x a week up from Etheldore, and cars do drive fast, but the drivers seem , on the whole , to be very courteous and give plenty of room as they pass(fwiw).

My Thoughts are with the youngster who is injured,and pray for his recovery.

Comment 4 (http://coastsider.com/index.php/site/news/4052/#8151) by Barbara Kossy (http://coastsider.com/index.php/member/1266/) on Dec 9 at 5:58pm • All my comments (http://coastsider.com/index.php/site/member_comments/1266) •

Right now the speed limit is 50 mph in Moss Beach. Hwy. 1 in Montara has a speed limit of 45 mph. Perhaps a start would be to get the speed limit in MB to 45, and then enforce it.

Comment 5 (http://coastsider.com/index.php/site/news/4052/#8152) by Kevin J. Lansing (http://coastsider.com/index.php/member/116/) on Dec 10 at 1:11am • All my comments (http://coastsider.com/index.php/site/member_comments/116) •

Building a safe crossing at large expense in one place on Hwy 1 is not going to stop people from trying to cross unsafely and unwisely at some other place which happens to be more convenient to their own destination along Hwy 1.

Comment 6 (http://coastsider.com/index.php/site/news/4052/#8153) by Jennifer Castner (http://coastsider.com/index.php/member/1057/) on Dec 10 at 7:09am • All my comments (http://coastsider.com/index.php/site/member_comments/1057) •

Yes, some people will continue to cross in other places, but I bet that many, many people will take advantage of a safe crossing. Isn't that better than nothing at all?

Coastside Adult Day Health Center
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645 Correas Street . Half Moon Bay, CA 94019 . (650) 726-5067

Coastsider

Half Moon Bay Review

Print Page

Highway 1 re-opened after Moss Beach accident

By Greg Thomas
[greg@hmbreview.com]
Published/Last Modified on Thursday, December 3, 2009 6:49 PM PST

CHP officials have reopened Highway 1 at Moss Beach to traffic in both directions.

Around 5:20 p.m., a 12-year-old boy was hit by a vehicle while riding a bike across Highway 1 at Moss Beach, completely closing down the roadway to all traffic.
He was severely injured in both legs, but is conscious and breathing, according to a Sheriff's Office spokesman. The victim has been transported to Stanford Medical Center for treatment.

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GOLDEN GATE REGIONAL CENTER

POLICY GUIDELINES

JULY 17, 2007

Regional Center Purpose (mission):

"The purpose of the statutory scheme is twofold: to prevent or minimize the institutionalization of developmentally disabled persons and their dislocation from family and community (WIC §4501, 4509, 4685), and to enable them to approximate the pattern of everyday living of non-disabled persons of the same age and to lead more independent and productive lives in the community (WIC §4501, 4750-4751)."

The desired outcome for individuals with developmental disabilities in adopting the above mission is to: 1) Decrease use of institutions, 2) Increase inclusion and integration, 3) Increase individual development in independence and productivity, and 4) Protect basic health and well-being.

As a value-based organization, Golden Gate Regional Center needs to have at its core principles, strategies and policies that reflect those values. The common values are set forth in the Lanterman Developmental Services Act and are reinforced through performance goals of the Department of Developmental Services and carried out in the day-to-day practices of the regional center.

The following pages outline proposed policies that will guide the work and direction of Golden Gate Regional Center over the next few years. To be true to the purpose of the policies, they will need to be flexible and dynamic changing as the needs of individuals change. While the format of the policies may not be of a traditional model, it reflects the language and form hopefully that will be understood by those interested in a dynamic system responsive to the needs of constituents.

LIVING SERVICES – BOARD POLICY	PRACTICES TO CREATE LIVING SERVICES
Residential options created for individuals with developmental disabilities will promote living arrangements in which these individuals may have their unique needs met, in the least-restrictive setting, which is most similar to those in which persons without disabilities reside. Separating home ownership and delivery of services will be explored first and will take priority in development of new residential resources. Priority is given to develop housing that is permanently established for GGRC clients. Reference: WIC § 4418.25 – 4418.3, 4685, 4685.1, 4689, 4510, Olmstead Decision, Americans with Disabilities Act, DDS Strategic Plan.	• Clients and families will be presented with all possible living options that are appropriate to meet their needs and are located in their home community. • Clients will be given the choice to live in their own home with support. • Institutional settings will be considered only after all other options have been explored. • Group living arrangements will be three clients or less unless an exception is granted. • Clients will have the opportunity to have their own bedroom. • Development of resources to maintain children in the family home will take priority over out-of-home residential placement. • When family circumstances require a child to be placed outside the family home, the child will live as near to the family as possible and the possibility of reunification will be explored. • Families will be able to keep their children at home with supports such as respite and behavior consultation (Client Choice).

Approved by the Board of Directors, July 17, 2007.

INDIVIDUALIZED SERVICES – BOARD POLICY	PRACTICES TO CREATE INDIVIDUALIZED SERVICES
Clients will be offered a range of services and supports from which to choose. All supports and services will: - be individualized, - assist clients to be more productive, - be accountable to the people served, - include a mechanism to assure client satisfaction, - be effective in assisting clients with meeting their stated life goals, - be most similar to supporting life activities of people without disabilities, - provide a holistic approach to physical, mental and behavioral health, and - be available in integrated settings. Reference: WIC §4648 (a) (2)(5)(7), 4648(d), 4648.1, 4651, 4680, 4688, 4690, 4691, 4418.1, 4511, 4640.6(g), 4750,Americans with Disabilities Act, Vocational Rehabilitation Act of 1974, Individuals with Disabilities Education Act, DDS Strategic Plan	• Services offering integrated opportunities (offering services to those with and without disabilities) will be explored first. • All day programs will develop an employment component consistent with the abilities of clients they serve. • All day programs will ensure that training includes components on individual client need as well as overall professional development. • All clients will be given the opportunity to become independent in travel through training. • Private transportation will not be funded if the team determines that the consumer is able to travel independently. • Customized employment will support micro-enterprise business development services as an option. • Clients will be able to work in jobs of their choice where they can earn a competitive wage and receive benefits. • Clients will have access to information regarding all resources that will help them achieve their goals through a variety of means, including the GGRC website and a resource center. • Clients will be able to socialize and recreate in the same way as those without disabilities.

Approved by the Board of Directors, July 17, 2007.

QUALITY SERVICES – BOARD POLICY	PRACTICES TO CREATE QUALITY SERVICES
All services delivered by GGRC will be of the highest quality consistent with defined expectations and measurable outcomes for clients which demonstrate continuous improvement. All service providers and GGRC will conduct a regular quality review of their services. GGRC will continually research best practices and provide for innovation. Supports will be provided to assure excellence in leadership throughout the service system. Reference: WIC § 4418.1, 4511, 4640.6(g), 4648 (a)(2)(5)(7), 4648 (d), 4648.1, 4651, 4680, 4688, 4690, 4691, 4750, DDS Strategic Plan	• All programs will have a self-evaluation of the quality of services as part of their GGRC quality review. • GGRC will have a review process for its service delivery including the self-evaluations and audits by service providers. • Quality reviews will involve stakeholders including clients, families, service providers, Area Board, Department of Developmental Services, and other interested parties. • Training will be provided to strengthen all parts of the system. • GGRC will consider new service models, seek input from staff and the community, and have a continuous review of operational systems to ensure that there is both efficiency and quality. • GGRC Board of Directors will represent the diverseness of the community. • Training will be provided to clients to ensure skill development for Board participation within the regional center and community groups.

Approved by the Board of Directors, July 17, 2007.

FUNDING FOR SERVICES – BOARD POLICY	PRACTICES TO CREATE FUNDING FOR SERVICES
GGRC will demonstrate good stewardship of public funds and will provide quality services to the full extent that funding is provided by the state. GGRC funding policies and guidelines will be readily accessible to the people served and to the public. Reference: WIC § 4620.2, 4622, 4629, 4633, 4638, 4639, DDS Strategic Plan	• When quality and other client concerns are equal and there is a difference in rate, the least expensive program will be preferred. • Programs with negotiated rates will be reviewed in consideration of the total budgetary obligations of GGRC to preserve overall services to GGRC clients. • GGRC will have a balanced budget at the end of a fiscal year. • Required audits will be completed on a timely basis. • Feedback from the community on funding policies will be sought via surveys, website and public forums. • GGRC will make its funding policies and guidelines accessible to clients and families through the GGRC website, Board meeting discussions, and public forums.

CLIENT CHOICE – BOARD POLICY	PRACTICES TO CREATE CLIENT CHOICE
Clients and families will be provided information to assist them in understanding the principles of public policies in areas such as creating opportunities for independence. Client and family choice will be the guiding principle in decision making. Clients and families will be offered all appropriate options of services. Clients and families will be able to participate in self-determination consistent with State regulation. Clients' rights will be honored. Adult clients will lead their Individual Program Planning process as they are able to do so. Family members will lead the Individual Family Service Plan process for their children. Cultural, language and personal lifestyle needs will be given priority consideration in providing service. Reference: WIC § 4501, 4511, 4512 (h), 4620.1, 4640.7, 4646, 4646.5 (a), DDS Strategic Plan	• Clients will be encouraged to participate in self-advocacy efforts. • Training will be provided to ensure awareness of clients' rights. • Clients and families will be involved in new-staff orientation for GGRC and service providers. • GGRC will increase communication of information through newsletters and the website. • Clients and families will have internet access. When not available in the home setting, GGRC will provide opportunity for access. • Client choice will take into consideration the wishes of the parents if a client is a minor or the wishes of a conservator if the client is an adult. • Families will be encouraged to keep their children at home with supports such as respite and behavior consultation (Living Services).

Approved by the Board of Directors, July 17, 2007.

Abuse and Neglect of Adults with Developmental Disabilities:

A Public Health Priority for the State of California

A report of:
Protection and Advocacy, Inc.
State Council on Developmental Disabilities
USC University Affiliated Program
The Tarjan Center for Developmental Disabilities, UCLA

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Abuse and Neglect of Adults with Developmental Disabilities:

A Public Health Priority for the State of California

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Foreword

This report is the product of a collaboration of the four agencies in California authorized under the Developmental Disabilities Assistance and Bill of Rights Act (2000) (DD Act). 42 U.S.C. §§ 15001 et seq.

1. **Protection and Advocacy, Inc.**

2. **State Council on Developmental Disabilities**

3. **California's University Centers for Excellence in Developmental Disabilities Education, Research and Service:**

   - University of Southern California University Affiliated Program, and
   - the Tarjan Center for Developmental Disabilities at the University of California Los Angeles

While each agency has a specific mandate and designated activities under the DD Act, they are jointly responsible for quality assurance activities, which involve (1) monitoring; (2) training; and (3) and other activities to assure the appropriate coordination and integration of services, to ensure that individuals with developmental disabilities will not experience abuse, neglect, sexual or financial exploitation, or violation of legal or human rights, and will not be subject to the inappropriate use of restraints or seclusion. See 42 U.S.C. § 15002(23). This joint responsibility is the catalyst for this report.

Many individuals with disabilities are victims of abuse, neglect, and criminal activity. Due to the breadth and complexity of issues underlying this topic, we have deliberately narrowed the focus of this report to:

1. **Individuals with developmental disabilities as defined by California's Lanterman Act[1];**

2. **Victims of physical abuse, sexual abuse, and/or violence[2];**

---

[1] Under state law, a developmental disability refers to a disability which originates before an individual attains age 18, continues, or can be expected to continue, indefinitely, and constitutes a substantial disability for that individual; includes mental retardation, cerebral palsy, epilepsy and autism, or disabling conditions found to be closely related to mental retardation or to require treatment similar to that required for individuals with mental retardation. Welf. & Inst. Code § 4512(a).

[2] This report does not encompass regulatory and policy issues particular to (a) financial abuse, (b) illegal use of medication to restrain and control individuals, and (c) child abuse.

3. **Adults (individuals with developmental disabilities over the age of 18), not children.**

The content of this report and its recommendations were derived from literature review, analyses of existing statutes and regulations for a variety of systems, and interviews with knowledgeable individuals within the existing systems. Experts interviewed were from the developmental disability, advocacy, and criminal justice systems. They included staff of the Department of Developmental Services (Information Services and Residential Services), regional centers, Organization of Area Boards, Office of Clients Rights Advocacy, Department of Mental Health Crime Victims with Disabilities Initiative (California Health and Human Services Agency), Crime Victims with Disabilities pilot programs (at Easter Seals Superior County, Ventura County District Attorney's Office, and the USC UAP), the Arc California, State Long-Term Care Ombudsman's office, Adult Protective Services, Child Protective Services, law enforcement, and Los Angeles County Mental Health Court 95.

A preliminary draft was distributed to representatives of developmental services and the criminal justice system, specifically: Department of Developmental Services Office of Human Rights and Advocacy Services; Department of Mental Health Crime Victims with Disabilities Initiative; Child and Youth Services, Governor's Office Criminal Justice Planning; the Association of Regional Center Agencies; and the Organization of Area Boards. All members of the State Council on Developmental Disabilities were invited to submit written comments to the final draft. Written comments were submitted by the California Association of State Hospital Parent Councils for the Retarded (CASH-PCR), the Department of Aging, the Department of Developmental Services, and the Department of Social Services. The authors considered each written comment and included all content that contributed to the factual accuracy of the report and was relevant to the general subject matter.

The audience for this report is the California Legislature and other public policymakers, as we believe this report raises such broad issues of systems inadequacy that remedies must be of a broad and sweeping nature. We expect that this report will also be of interest to individuals with disabilities, family members, state agency executive and administrative staff, executive and front-line staff of regional centers and their provider network, executive and front-line staff of law enforcement and the criminal justice system (including prosecutors, judges, and victim/witness assistance programs), and mental health and other related professionals mandated to serve Californians with developmental disabilities.

It should be noted that this report's recommendations present remedies for problems identified. Our recommendations were not influenced by potential cost; instead, we proposed a set of changes likely to eliminate the barriers identified in this report. Our intent is to urge the development of a system which protects Californians with developmental disabilities from abuse and neglect and holds their abusers accountable for their action. While it would be imprudent to ignore cost when systems are established, policymakers are best positioned to consider these issues when making decisions that affect the lives of California citizens with developmental disabilities.

Pseudonyms have been used throughout this report for all the names of individuals described in the case examples.

Executive Summary

This report describes the nature and extent of abuse and neglect perpetrated against people with developmental disabilities and identifies systemic issues that underlie the increased risk for victimization of this population. Three major findings are presented and discussed.

1. **Abuse and neglect of people with developmental disabilities is a public health problem because Californians with developmental disabilities are likely to be:**

   - victimized at a much higher rate (4-10 times more frequently) than other citizens;
   - at higher risk for re-victimization;
   - frequently severely abused and for longer periods of time;
   - most frequently victimized in their residences by persons they know and who may be responsible for their services and supports; and
   - inadequately educated and supported to recognize, resist, and seek alternatives to abusive situations.

2. **The current system of protections is inadequate for victims with developmental disabilities because it:**

   - results in the underreporting of abuse, neglect, and victimization in this population;
   - fails to collect reliable, valid data concerning the scope of the problem;
   - is complex and confusing to victims and mandated reporters; and
   - is generally unsuccessful in prosecuting perpetrators.

3. **Many individuals within the abuse response and criminal justice systems lack training and expertise working with people with developmental disabilities.**

These findings create an obligation for the Legislature to address significant reform. Eight recommendations are made:

1. **Eliminating abuse and neglect of people with developmental disabilities must be made a public health priority in California.**

2. **The Legislature must designate a lead agency with authority and responsibility to coordinate system reform.**

3. **An integrated data collection must be implemented to document the incidence of abuse and neglect and track the outcomes of criminal investigations and prosecutions.**

4. **Regional centers must have an increased and uniform role in coordinating the response and services provided victims.**

5. **Incidents of abuse and neglect in long-term care facilities must be investigated by law enforcement or Adult Protective Services, not the long-term care Ombudsman.**

6. **Victims with developmental disabilities must be provided new protections from perpetrators.**

7. **The Department of Developmental Services must continue to implement the Department of Justice recommendations regarding the law enforcement division of developmental centers.**

8. **All agencies involved in the abuse response system must receive mandatory training regarding working with individuals with developmental disabilities.**

Chapter 1: The Nature and Extent of Physical and Sexual Abuse Involving Individuals with Developmental Disabilities

A. Frequency and Severity of the Problem

Although violent crime has declined in the United States over the past several years, people with developmental disabilities remain at disproportionately high risk for violent victimization, abuse and neglect (Petersilia et al., 2001). While the scientific evidence continues to be limited, international studies from Canada, Australia, Great Britain, and the United States have documented high rates of violence and abuse affecting people with disabilities (Ibid.). Experts conservatively estimate that people with disabilities are at least four times more likely to be victimized than people without disabilities (Sobsey, 1994; Toronto Star, 1990). Individuals with an intellectual impairment are at the highest risk of victimization (c.f., Sobsey & Doe, 1991).

Some studies estimate that close to 80% of women with developmental disabilities have been sexually assaulted at some point in their lives (Sorensen, 2002; Lumley and Miltenberger, 1997). Other studies have found the rate for sexual assault was anywhere between 2-10 times higher for people with disabilities when compared to people without disabilities (Wilson & Brewer, 1992; Baladerian, 1991; Muccigrosso, 1991; Westat Inc, 1993).

Similar findings have been documented from studies of Californians with disabilities. Hard (1986) found that, of 95 adult Californians with developmental disabilities surveyed, 83% of the women and 32% of the men had been sexually assaulted. A later study of San Francisco Bay area residents with mild mental retardation found that nearly 80% of the women and 54% of the men had been sexually abused at least once (Stromsness, 1993). While many feel that living in the community carries inherent risks, it is notable that some studies have found that crime rates are higher for victims with disabilities in institutions, group homes and other segregated facilities (Sobsey & Mansell, 1990; Roeher Inst., 1994).

Adding to these alarming incidence rates, studies show that people with disabilities are more likely to experience more severe abuse, experience abuse for a longer duration, be victims of multiple episodes, and be victims of a larger number of perpetrators (Schaller & Fieberg, 1998; Sobsey & Doe, 1991; Young et al., 1997).

The authors are aware that some of the above data must be interpreted cautiously. Accurate estimates regarding the incidence of abuse or neglect of persons with developmental disabilities specifically are difficult to obtain. Consequently, some

research referenced in this report comes from studies of individuals with a broad range of disabilities. Much of the research on victimization of people with disabilities does not delineate specific sub-populations. Public records of violence against individuals usually do not indicate whether or not the victim has a disability, let alone a developmental disability (Curry et al., 2001). Reliable studies focusing specifically on Californians with developmental disabilities who have been victims of physical or sexual abuse are small in number. Furthermore, there is no coordinated system to collect data on and track outcomes of victims with disabilities from the initial allegation, to the initial report, to prosecution and finally to conviction. However, most experts agree that research findings involving other groups of people with disabilities should be viewed as under-estimates for persons with developmental disabilities.

B. Underreporting and Lower Rates of Prosecution and Conviction

Contributing to the gravity of this problem, most crimes against people with developmental disabilities tend to go unreported (Sorensen, 2002). Wilson & Brewer (1992) found that 71% of crimes against people with severe mental retardation go unreported. Again disputing beliefs about the safety of congregate settings, Powers, Mooney, & Nunno (1990) suggested that 80-85% of criminal abuse of residents in institutions never reach the proper authorities.

Research findings document excessively low rates of prosecution and conviction of crimes against people with disabilities. One study found that 65% of sexual assault cases reported to police were not prosecuted when the victim had a disability (Sobsey & Varnhaggen, 1991). A more recent survey in Boston found that only 5% of serious crimes against people with disabilities were prosecuted compared to 70% for similar crimes against people without disabilities (Boston Globe, 2001). A study of sexual assaults of people with intellectual disabilities in Britain found that police investigated only 21% of cases reported and only 9 % were referred by police for prosecution. Just two cases (less that 1%) proceeded to court with only one resulting in conviction. (Brown & Stein, 1997).

C. Factors Contributing to the Problem

1. Victim Factors

A number of studies suggest that people with disabilities have different profiles for victimization and abuse than the non-disabled population (c.f., Petersilia et al., 2001; Sobsey & Varnhagen, 1991). These include: (1) cognitive deficits which may make it difficult for the victim to recognize unlawful activity and/or their

Vulnerable Man Repeatedly Abused

Vic Palmer was an 18-year-old man with Down's Syndrome. He was non-verbal but understood his native language and English. Vic was able to communicate using gestures, signs, and pointing to pictures. In March 2000, Vic arrived at school from his group home with a black eye. No inquiries were made or abuse reports filed. A week later, Vic appeared at school with bruises on his chin (concealed with make-up) and scratches on his back and chest. The school reported the injuries to Adult Protective Services (APS) and the regional center, but returned Vic to his group home. A week passed before APS investigated. They did not attempt to interview Vic or ask the regional center to assist with the interview. APS concluded that the abuse could not be substantiated. The regional center did not receive APS's report until three months after Vic's death.

Over a month later, Vic's father contacted the regional center about new bruises on Vic's face and to express concern about how staff at the group home were treating his son. Vic remained at the group home. Four days later he was rushed to the local hospital where he died. According to the coroner, Vic had been severely beaten, sustaining multiple traumatic injuries to the base of his skull and to his abdomen, including traumatic lacerations of his liver. Investigators suspect that the perpetrator was a staff member at the group home, but the investigation has been closed without any arrests.

rights to safety and protection; (2) dependence on others to assist with activities of daily living and personal care; (3) presence of communication or physical impairments which limit their ability to verbally or physically defend against a perpetrator and disclose abuse (Sobsey & Varnhagen, 1991); (4) lack of training in sex education; (5) lack of experience and socialization which encourages compliance rather than self-advocacy (Lumley & Miltenberger, 1997; Sobsey, 1994; Tharinger et al., 1990); and (6) fear of retribution from the perpetrator if they do report or fear that they will have to move from their home as a solution to the abuse incident.

Some persons with developmental disabilities must rely on others to recognize that they are being abused and to take appropriate action to notify investigators from responsible agencies. Yet few family members, friends, and providers are adequately trained to recognize signs of abuse in individuals with developmental disabilities and to assist victims to access the criminal justice and/or social service system.

Even if they want to report or stop the abuse, some individuals may not be able to formulate and execute a plan of response, some

may not be able to physically escape from an abusive environment, and some may not be able to travel to a police station to file a report. In addition, for those individuals who want to report, the presence of an array of communication difficulties frequently leads to frustration when officers taking the report cannot understand the victim.

2. Assailants

Regardless of the type of disability or whether the abuse is emotional, physical, or sexual, people who provide care and support to individuals with disabilities are often the same people who victimize them – people the victims know and trust (Petersilia et al., 2001; Nosek et al, 1997; Marchetti & McCartney, 1990). It is estimated that risk of abuse increases by 78% due to the vulnerability of people with developmental disabilities and their need for personal assistance services (c.f., Sobsey and Doe, 1991; Young et al., 1997; Curry & Powers, 1999). In a survey of individuals with disabilities who had been abused, 96% of the cases involved perpetrators who were known to their victim (Sobsey and Doe, 1991). The largest group of offenders (44%) were individuals who had a relationship with the victim specifically because of their disability (27.7% disability service providers, 5.4% specialized transportation, 4.3% specialized foster parents and 6.5% other

Sexual Encounter with Care Giver

Lisa Russell was a 47-year-old woman with cerebral palsy and mild mental retardation living in a large residential facility. Miguel Chase, a certified nurse assistant (CNA) at the facility enticed Ms. Russell to a remote area of the campus and had a sexual encounter with her. Although she went with Chase willingly, Ms. Russell later said she had anticipated the rendezvous would involve "making out" but not sexual intercourse.

The following morning Ms. Russell reported the encounter and administrators quickly interviewed her. She was not provided with an advocate or other support during the interview. They asked leading and compound questions, including questions that led Ms. Russell to state that the encounter was consensual. The answers to these questions were later relied upon by law enforcement investigators. The facility did not report the sexual encounter as dependent adult abuse.

Chase was fired, lost his CNA certificate, but was never prosecuted. As a result of that sexual encounter, Ms. Russell was infected with cytomegalovirus and died less than six weeks later.

disabled individuals). Mansell et al. (1992) similarly found that 26% of perpetrators were paid care givers providing services related to the victim's disability and 11% were other service providers.

Homes and other residences are the most common setting for abuse (Sobsey, 1994; Furey, 1994; Turk & Brown, 1992). One study found that 58% of the offenses took place in the homes of either the victim (48%) or the perpetrator (10%) (Turk and Brown, 1992). As individuals with developmental disabilities have access to a wider array of living arrangements[3], states must ensure that systems are in place to prevent abuse not only in congregate facilities, but also in the community.

3. Disincentives for Program Administrators and Staff

The current system inadvertently creates disincentives for program administrators and staff to report incidents involving individuals with developmental disabilities. Non-abusing staff of care facilities may fear reprisals or retribution from their administrators or their peers (*The Edmonton Journal*, 1990; Sorenson, 2002). Administrators may fear negative publicity, questions about their competence, damage to their careers, or loss of licenses for their facilities (Sorenson, 2002). Experts have reported that the negative consequences of publicity about a crime or abuse in a facility can be severe to that institution. Consequently, facilities and/or their managers may ignore or minimize abuse or neglect allegations.

4. Lack of Training, Experience, and Socialized Compliance

Other authors have noted that individuals with disabilities may have a specific vulnerability to abuse due to compliance training and a desire to "fit in" and be liked (Sobsey, 1994; Tharinger et al., 1990). These vulnerabilities are highlighted in a study by Conte, Wolfe, and Smith (1989), who interviewed a group of child abuse perpetrators who had successfully completed treatment. They found that perpetrators seek out children who are friendly, compliant and unlikely to disclose abuse. Compliance training has been implicated in abuse cases with adults, when care givers are the perpetrators (Tharinger et al., 1990). Such compliance is further reinforced by a dependence on care givers and the relatively powerless relationship which exists between individuals with disabilities and their service providers.

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[3] With a national movement supporting personal choice, many individuals with developmental disabilities are choosing to live in small community settings. Between 1982 and 1997, the number of persons with mental retardation or developmental disabilities living in settings of 3 or fewer persons rose 427%. Nationally, the average daily population of large state MR/DD facilities decreased by 56.1% from 1980 to 1997. (Prouty and Lakin, 1998).

People with mental retardation and other cognitive or intellectual impairments may not realize that they can refuse unwanted sexual contact (Reynolds, n.d.). Lumley & Miltenberger (1997) suggest that because persons with mental retardation often do not receive formal sex education, they may have limited knowledge and ability to fully consent to sexual activity and to protect themselves from potentially abusive situations. Some individuals in today's society believe individuals with disabilities are asexual and thus do not need sexual education (Sobsey, 1994). To the contrary, it has been found that individuals with disabilities typically exhibit normal sexual development and desires (Tharinger, et al., 1990). When sex education is not provided, an individual with a disability will be less likely to identify and/or respond assertively to inappropriate touching or behaviors, thereby contributing to the perception by others that this may be consensual sexual activity (Lumley & Miltenberger, 1997; Tharinger et al., 1990).

D. Personal Choice Versus Safety

When discussing the broad arena of abuse and neglect involving people with disabilities, a dynamic tension between personal choice and personal safety surfaces. Simply stated, this tension refers to the inherent conflict between the dignity of risk associated with increased self-direction and the competing inclination to provide protections for vulnerable individuals, which can negate personal choice and self-determination. While an appropriate discussion of this tension is not possible in this report, federal and state law are clear that the appropriate response of society and systems responsible for protecting citizens with disabilities must not unduly suppress choice and self-direction. 42 U.S.C. § 15002(23); Welf. & Inst. Code §§ 4646.7 (a)(1) & 4646.5(a)(2).

Chapter 2: Current System of Protections for Victims of Abuse and Neglect with Developmental Disabilities

California's system for responding to allegations of abuse and neglect involving people with developmental disabilities is governed by multiple sets of statutes and regulations. See Table 1. Each addresses a different component, from the initial response and investigation, to safeguarding the victim, to the tertiary action by licensing entities of facilities and/or individual perpetrators. For a licensed care facility, this means the same abuse or neglect allegation must be reported to several different entities. While this system attempts to provide for comprehensive protections for vulnerable populations, it is cumbersome and confusing to victims and reporters of abuse or neglect. What constitutes a reportable event varies. Reporters who meet their obligations under one statute may not meet their obligations under another statute. A report to one entity under one mandate does not automatically prompt a report to another entity under a different mandate. This leads to incomplete reporting and, ultimately, inadequate investigation and response.

A. Elder Abuse and Dependent Adult Civil Protection Act

The Elder Abuse and Dependent Adult Civil Protection Act (the Abuse Reporting Act) is the most victim and consumer-focused of the various abuse and neglect laws and regulations. California enacted the Abuse Reporting Act to protect vulnerable persons[4] by requiring individuals providing care and services for elders and dependent adults in health facilities and in the community to report instances of abuse and neglect. Welf. & Inst. Code §§ 15600 et seq. Although abuse allegations may be reported by anyone having knowledge of the incident, the Abuse Reporting Act requires certain individuals (mandated reporters) to report known or suspected abuse or neglect of dependent adults and elders. Any person who has responsibility for the care or custody of a dependent adult is a mandated reporter. They are required to report incidents that reasonably appear to be abuse or neglect of dependent adults and elders, whether directly observed by, reported to, or based upon knowledge of the reporter. Reportable incidents include physical abuse, abandonment, isolation, financial abuse, and neglect. Welf. & Inst. Code § 15630(b)(1). Mandated reporters have no duty to conduct an investigation before

[4] Vulnerable persons include: elderly (any person 65 years of age or older) and dependent adults (any person, between the ages of 18 and 64 years, who has physical or mental limitations that restrict his or her ability to carry out normal activities or to protect his or her rights, including but not limited to, persons who have physical or developmental disabilities or whose physical or mental abilities have diminished with age). Welf. & Inst. Code §§ 15610.23 and 15610.27.

Table 1: Agencies receiving and investigating reports of abuse or neglect involving adults with disabilities

	Pursuant to the Abuse Reporting Act				*Pursuant to California Regulations*		
	Law Enforcement	**Investigations in Dev. Ctrs.**	**APS**	**Long-Term Care Ombudsman**	**Regional Center**	**Community Care Licensing**	**DHS Licensing & Certification**
Oversight	Local Police or Sheriff's Department	Dept. of Developmental Services	Dept. of Social Services	Dept. of Aging	Dept. of Developmental Services	Dept. of Social Services	Dept. of Health Services
Statutory Authority	WIC §§15600 *et seq.*	WIC §§15600 *et seq.*	WIC §§15600 *et seq.*	WIC §§9700, *et seq.*; 42 U.S.C. § 3058(i)	Cal. Code of Regs. tit. 17	Cal. Code of Regs. tit. 22	Cal. Code of Regs. tit. 22
Targeted Population: Age	All ages	All ages	65 years or older; dependent adults age 18-64	60 or older	All ages	All ages	All ages
Disability	All persons	Residents of developmental centers	Elderly; Individuals with mental or physical impairments that restrict ability to complete ADLs	Elderly; Dependent adults	Developmental disabilities: autism, epilepsy, cerebral palsy, MR, conditions closely related to MR	Residents of community or non-medical facilities	Residents of healthcare facilities
Location	Anywhere	Developmental Center	Community Setting	Long-term Care Facility	Anywhere	Licensed Community Facility	Licensed Healthcare Facilities

making the required report. Welf. & Inst. Code § 15630(b)(2)(B). The Abuse Reporting Act also designates specific penalties for mandated reporters who fail to report. Welf. & Inst. Code § 15630(h).

Mandated reporters must notify specific agencies which conduct an investigation. If abuse occurs in a long-term care facility[5], the report must be made to either the local long-term care Ombudsman (Ombudsman) or local law enforcement agency. If the abuse occurs in a state developmental center, the report must be made to the Department of Developmental Services (DDS) investigators or to the local law enforcement agency. Abuse occurring anywhere else is reported to Adult Protective Services (APS) or local law enforcement. Welf. & Inst. Code §15630(b).

The following are descriptions of the initial investigative entities notified by mandated reporters. While these primary investigators have the general goal of protecting the dependent adult from abuse, they approach allegations of abuse from different perspectives, pursuant to their agency's mandate. No direction is offered to a mandated reporter about how to select which entity is notified. However, the determination about who is notified has significant ramifications as to the quality and timeliness of the investigation.

1. Local Law Enforcement

No matter where an incident takes place, the local municipal police department and/or county sheriff's department may respond. Yet, many reports never reach law enforcement even though the incident may involve a crime.[6] Law enforcement agencies investigate crimes and present the evidence from those investigations to the District Attorney's office. An investigation by law enforcement is crucial to prosecuting predators. The District Attorney's office decides whether to file charges for prosecution.

Law enforcement is often not the first investigator to respond to incidents of abuse or neglect in facilities. By law, if it is likely a crime has been committed, law enforcement must be contacted to investigate. However, law enforcement reports receiving relatively few abuse or neglect allegations involving victims with developmental disabilities (in contrast to the number of reports involving elderly

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[5] These do not include state developmental centers.

[6] Crimes upon a dependent adult include infliction of bodily harm, death, physical pain and/or mental suffering of any dependent adult; placing a dependent adult in a situation in which his/her person or health is endangered; theft or embezzlement with respect to property of a dependent adult; and false imprisonment of the dependent adult. Penal Code § 368.

victims), and the vast majority of these are reported by staff of small community-based facilities where consumers live. Self-reports by consumers living in the community are rare.

2. Investigations in Developmental Centers

Incidents of suspected abuse or neglect at developmental centers are documented by facility staff and reported to law enforcement personnel employed by DDS [7] (stationed at the developmental centers) for investigation. Developmental center law enforcement investigates both administrative (i.e. employment or personnel) and criminal matters. Akin to community law enforcement, developmental center law enforcement personnel are the primary investigators of criminal activity and evidence collected may be forwarded directly to the District's Attorney's office for consideration of prosecution. Because the process of notifying developmental center law enforcement personnel of an incident varies from one developmental center to another, the quality and timeliness of investigations also varies. DDS does not consistently notify local law enforcement agencies of abuse. Local law enforcement rarely takes the lead on investigations at developmental centers.

In May of 2000, Senator Wesley Chesbro, Chair of the California Senate Select Committee on Developmental Disabilities and Mental Health, requested that Bill Lockyer, Attorney General State of California, authorize an investigation by the Department of Justice (DOJ) into the quality of police and investigative activities at the state developmental centers. That investigation was completed and a report with findings and recommendations was issued in March 2002. In August of 2001, in response to chaptered legislation[8], developmental centers began implementing new procedures in abuse reporting. The procedures include reporting all resident deaths and serious injuries of unknown origin to the local law enforcement agency in the community and providing annual written training materials to all employees regarding mandatory reporting requirements.

3. Adult Protective Services (APS)

APS constitutes the essential safety net for vulnerable adult populations living in the community, including the prompt investigation of all situations involving elders (age 65 or older) and dependent adults (18-64 year olds with physical or

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[7] The law enforcement division of each developmental center employs hospital peace officers and special investigators to keep the peace, prevent crime, investigate offenses on developmental center property, and protect residents, employees, visitors, and facility property. DDS requires that law enforcement services be available 24 hours a day in each developmental center.

[8] Assem. Bill No 430 (2001-2002 Reg. Sess.); Welf. & Inst. Code § 4427.5.

mental impairments) who are reported to be endangered (LA4Seniors.com). APS focuses on the victim's current and future safety. Reports of suspected or alleged abuse are recorded by mandated reporters on a *Report of Suspected Dependent Adult/Elder Abuse* form. (California Department of Social Services, 2000). APS social workers visit alleged victims to determine whether they are in danger. If the individual is in imminent danger, APS can remove the individual from his or her residence or place of harm. Otherwise, they try to eliminate or reduce the endangerment by providing necessary services, including follow-up and monitoring.

APS cannot investigate an incident without the victim's consent unless it involves a possible penal code violation. Welf. & Inst. Code § 15636(a). APS must report their investigation to law enforcement and request an investigation if the alleged perpetrator is to be prosecuted.

4. Long-Term Care Ombudsman

The Office of the State Long-Term Care Ombudsman was established by the California Department of Aging (CDA) pursuant to the federal Older Americans Act and the state Older Californians Act. 42 U.S.C. §§ 3001 et seq.; Welf. & Inst. Code §§ 9000 et seq. Its mission is to advocate for the dignity, quality of life, and quality of care for all residents in long-term care facilities. The federal Administration on Aging, which administers the Ombudsman program, has indicated that it is their long-standing policy that the Ombudsmen may serve individuals with disabilities who are living in long-term care facilities. 42 U.S.C. §3058g(a)(3). This includes persons with developmental disabilities under age 60.

Ombudsmen, who are mostly unpaid volunteers, serve as advocates for adult residents of long-term care facilities, investigating complaints and monitoring conditions and care in these facilities. Pursuant to State law, they also investigate allegations of abuse and neglect. Welf. & Inst. § 156050(a). Reports of suspected or alleged abuse are recorded on the same reporting form utilized by APS. When an Ombudsman receives a report, he or she is mandated to investigate the complaint to determine the validity of the report and refer it to the appropriate agency for further action as necessary. 42 U.S.C. § 3058g(a)(3); Welf. & Inst. Code §§ 9720(a) and 15650(f). With victim consent, the Ombudsman refers cases of abuse to APS or law enforcement for assistance. Welf. & Inst. § 15640(d). The Ombudsmen are mandated to refer cases of serious neglect to the appropriate licensing authority (e.g. Department of Health Services) and the Bureau of Medi-Cal Fraud and Elder Abuse. *Id.*

B. Title 17 – Special Incident Reports Regarding Regional Center Clients

While the Abuse Reporting Act places duties to report upon individuals, the California Code of Regulations place reporting duties on facilities providing services, including housing for persons with developmental disabilities. DDS requires the reporting of special incidents by facilities vendorized[9] by the local regional centers. Cal. Code Regs. tit. 17 §54327(b). This special incident reporting system establishes a process for DDS and regional centers to monitor the health and safety of consumers in the community and to ensure quality services and supports are provided to individuals with developmental disabilities.

A special incident includes:

1. reasonable suspected abuse or exploitation, including physical, sexual, fiduciary, emotional/mental abuse, or physical and/or chemical restraint;

2. reasonable suspected neglect, including failure to provide medical care, to prevent malnutrition or dehydration, to protect from health and safety hazards, to assist with personal hygiene, or the provision of food, clothing, or shelter;

3. the death of any consumer;

4. cases in which a consumer is the victim of a crime;

5. cases in which a consumer is missing and the vendor or long-term health care facility has filed a missing persons report with law enforcement;

6. unplanned or unscheduled hospitalization, serious bodily injury, or accident; or

7. unusual occurrences reportable to Department of Social Services (DSS) or Department of Health Services (DHS).

Id.

[9] Vendors are facilities, programs or service providers authorized and funded by the local regional center to provide services to people with developmental disabilities.

A comparison of the Abuse Reporting Act with these regulations reveals that there are variations in the definition of abuse and neglect. This means some incidents are reportable under the Abuse Reporting Act but are not considered special incidents requiring reporting to the regional center and vice versa. For example, isolation is considered abuse pursuant to the Abuse Reporting Act while it is not considered a special incident. Welf. & Inst. Code § 15610.43; Cal. Code Regs. tit. 17 § 54327(b). And conversely, Title 17 regulations include physical and chemical restraint in the definition of abuse while the Abuse Reporting Act has no comparable regulation. *Id.*

The regulations further outline the required elements of the report, which differ in form and content from the requirements under the Abuse Reporting Act. Each regional center has its own special incident reporting form for vendors to record reportable incidents. While there is some variability in the forms across regional centers, special incident reports prepared by regional centers are submitted electronically via DDS' Electronic Data Reporting System using a standard reporting field.

Upon receipt of a special incident report, regional centers review the report and decide what action is necessary. Title 17 mandates that regional centers make appropriate and timely referrals to authorized investigative entities. Cal. Code Regs. tit. 17 § 54327.1(b)(16). Regional centers also track any action taken by other entities, including the vendor, law enforcement, APS and licensing agencies. *Id.* The regional center forwards information about the special incident to DDS. DDS may require the regional center to follow up and submit additional information.

Each regional center is required to establish a Risk Management, Assessment and Planning Committee to ensure accurate and timely handling of special incidents. These committees review special incident reports to identify trends and unusual patterns. Cal. Code Regs. tit. 17, § 54327.2(b). DDS has contracted with the Columbus Organization to analyze the special incident reports for trends, conduct focused reviews, and develop prevention strategies. This analysis and statewide data on special incident reports are not publicly available.

C. Title 22 – Facility Reports to Licensing

Many facilities must also report incidents of abuse or neglect to their respective licensing agencies. For example, abuse occurring in an Adult Residential Facility, a long-term care facility, is reported to both the Ombudsman and Community Care Licensing (CCL). Typically facilities are required to report all unusual

occurrences which threaten the welfare, safety, or health of clients. Other reportable events include the death of a resident, incidents which threaten the physical and emotional health or safety of a resident, any suspected physical or psychological abuse of a resident, and any injury to a resident requiring medical treatment. Cal. Code Regs. tit. 22, §80061(b)(1). According to the Department of Social Services (DSS), there are two specific forms available to licensees for reporting, one for "unusual incidents/injuries" and the other for deaths. These forms have spaces to indicate other agencies or individuals notified. (Department of Social Services, electronic mail, May 30, 2003).[10] The regulations do not specify who must report, and not all regulations specify what incidents must be reported and when.

Licensing may conduct its own investigation of an incident of abuse or neglect to determine if the facility violated any regulations. Violations may include failure of a facility to report an incident of abuse. If a regulatory violation is substantiated, the licensing agency may penalize the facility, issuing deficiencies or citations or suspending or revoking a facility's license.

[10] Written comments to the final draft of this report received from the Department of Social Services.

Chapter 3: Problems with the Current System

A. Current reporting laws lead to inconsistent outcomes and inadequate protections for victims with developmental disabilities.

While intended to provide efficient reporting of incidents of abuse and neglect and to protect and support victims with developmental disabilities, the current set of rules and regulations is circuitous when implemented. One incident of abuse or neglect must be reported to different and independent entities, each with distinct reporting requirements. Incidents reportable under one set of regulations may not be considered a reportable event under other regulations.

Mandated reporters decide who to report an incident to and in what order. This initial choice determines the timeliness and quality of the initial investigation. Reports of crimes can be misdirected to a variety of administrative agencies, and either never referred to law enforcement or referred too late to prevent contamination of evidence, thus frustrating equal justice.

The system must ensure that when abuse, neglect and/or a crime involving a person with a developmental disability is suspected, the appropriate agencies are notified without delay. This is necessary to provide for immediate protection of the victim and a thorough, timely and competent investigation. Currently, when a report is made to an agency lacking jurisdiction, the abuse report is not taken and the caller is told to contact the appropriate agency. This creates a delay, at best, and ultimately discourages some from reporting.

Investigating agencies inconsistently share information about an investigation after initial notification. Because there is no designated entity with authority to oversee compliance with cross-reporting between investigating agencies or entities when it is required, there are limited assurances that cross-reporting is consistent and appropriate. Cross-reporting and systemic oversight of reporting would ensure all required agencies are notified promptly of incidents and responses to incidents involving this vulnerable population.

B. Mandated reporters in the disability service system are not uniformly aware of their reporting obligations.

Not all mandated reporters are fully aware of their multiple reporting obligations for many reasons. First, many facilities or agencies have an internal system of reporting suspected abuse or neglect that circumvents and may replace mandated reporting requirements. For example, a facility, by policy, may require a nurse to

report suspected abuse or neglect via an internal incident report without contacting the appropriate investigative agency directly. This internal report moves through the facility's administrative channels before the appropriate investigative agency is contacted, leading to unnecessary delays in reporting and investigation. These policies mislead the mandated reporter about the satisfaction of their reporting duty.

Another example of internal systems of reporting relates to reports made by vendors to the regional center. Regional center vendors (who are mandated reporters) have an obligation to also report incidents to the service coordinator of the regional center. However, many vendors believe they have met their reporting obligations when they report to the regional center. Furthermore, the inconsistency in definitions of reportable events between the Abuse Reporting Act and special incidents pursuant to Title 17 only further confuses mandatory reporters about their reporting obligations. These various policies and practices mislead personnel about their mandated reporting duties.

Internal Reporting of Abuse

One caller to Protection & Advocacy, Inc. described an incident where a direct care provider at a large intermediate care facility threatened a resident with a cigarette lighter, in order to "persuade" the resident to take a shower. The victim sustained no physical injury but undoubtedly sustained emotional trauma, as did two peer witnesses. The care giver was fired but her whereabouts are unknown. As she was an unlicensed care provider, there are no safeguards warning future victims of her history of abuse.

According to the caller, this incident of abuse was handled internally without reporting to or involving outside investigators or the regional center. In fact, direct care staff at this facility were instructed to report all special incidents internally only, to the supervisors within the facility.

Existing mandated reporting training materials tend to focus on the elderly, misleading viewers about their reporting mandate for abuse or neglect involving victims with developmental disabilities. A recent example is the training videotape and curriculum about the reporting of elder and dependent adult abuse developed and distributed by the California Attorney General's Office, Department of Justice (DOJ) (Department of Justice, 2002). This training program, targeted at mandated reporters in long-term care, community care, and residential care facilities, reviews their reporting obligations pursuant to the Abuse Reporting Act. However, the

tape focuses almost entirely on elderly residents. The phrase "dependent adult" is used only once during the video tape, whereas the terms "older adult" or "elderly" are used throughout. The tape contains a number of vignettes or case examples of abuse and neglect but none portrays a victim with a developmental disability under 65 years of age. Ultimately, the tape misleads the audience to only report abuse or neglect involving elderly victims and overlook their reporting obligations when the victim has a developmental disability. According to DSS, the DOJ has agreed to revise the video when funding is available. (Department of Social Services, electronic mail, May 30, 2003). However it is unclear when funding will be available.

C. Many investigators lack expertise in conducting abuse and neglect investigations involving victims with developmental disabilities.

Under current law, at least six entities may investigate reports of abuse and neglect involving people with developmental disabilities: law enforcement, special investigators at developmental centers, APS, the Ombudsman, regional centers, and licensing agencies (for facilities and licensed care providers). The skill of investigators in these separate systems varies considerably, with many lacking sufficient training in interviewing victims with developmental disabilities. This causes inconsistent outcomes and unequal protection for victims with developmental disabilities, including failure to collect critical information from the victim about the incident and perpetrator, inappropriate assessments regarding the credibility of the victim, and ultimately, very few prosecutions of alleged perpetrators.

In addition, many first responders to a scene, other than law enforcement, may not receive relevant training in recognizing possible criminal conduct and identifying and preserving a potential crime scene and/or criminal evidence. Consequently, evidence of a crime may be contaminated or completely elude untrained investigators. It is notable that very few situations involving potential victims from the general population permit potential criminal conduct to be investigated initially by administrative agencies, as is the case with victims with developmental disabilities. This represents a separate and unequal system of justice for crime victims with developmental disabilities.

1. Law Enforcement

Law enforcement has the most experience conducting investigations. While law enforcement is the designated agency to investigate crimes, the Abuse Reporting Act permits an election about which agency is contacted initially when the victim

is a person with a disability. Many law enforcement departments describe receiving very few reports about crimes against people with developmental disabilities. In one large urban county, officers and detectives report that approximately 20% of their calls under the Abuse Reporting act involve people with disabilities (as compared with the elderly) and, of those calls, the majority involve allegations occurring in facilities, not in the community. This failing is important because law enforcement is the most appropriate entity to conduct investigations of criminal acts of abuse or neglect if the intent is to prosecute perpetrators.

Officers have minimal training in working with people with developmental disabilities. In the police academy, law enforcement officers are given a 6-hour course regarding people with mental and developmental disabilities. The bulk of their training specifically addresses intervening with persons with psychiatric disabilities in crisis in the community. Beyond this, officers are not required to receive any mandatory refresher instruction regarding this unique population of victims.[11] Victims with developmental disabilities express frustration in the response by law enforcement to their reports of abuse or neglect. Many say they did not report later crimes because of the poor response they received by law enforcement to a prior incident.

2. Special Investigators in Developmental Centers

The hiring criteria and training requirements of special investigators at developmental centers are below that required by most law enforcement agencies. While most community police officers must graduate from a 6-month program at the police academy, investigators at developmental centers are only required to complete a 40-hour basic course in arrest, search and seizure. Completion of this training program is not a minimum job qualification but rather required within the first 90-days of employment. Although more training is expected within the first year of hire[12], there is no structured program to track compliance with initial training requirements or target continuing education needs to increase job proficiency of developmental center law enforcement personnel.

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[11] In 2001, an eight hour advanced officer training course, entitled, *Police Response to People with Mental Illness or Developmental Disabilities*, was developed by the California Commission on Peace Officer Standards and Training (POST) in consultation with community, local and state organizations and agencies with expertise in the area of mental illness and developmental disabilities, along with consumer and family advocacy groups.

[12] Investigators at developmental centers not possessing a POST certification as a peace officer are required to complete a POST course regarding arrest, search and seizure, and firearms training. Within the first year of employment, officers are further required to attend the *Specialized Investigators' Basic Course*, a 591 hour program regarding criminal investigations.

Developmental center law enforcement investigates both administrative (i.e. employment or personnel) and criminal matters. Allegations of abuse or neglect may implicate both administrative and criminal issues, but these investigations are rarely separated. This potentially jeopardizes the integrity of the criminal investigation by inadvertently compromising the admissibility of evidence obtained without the necessary admonishments or chain of custody safeguards.

A March 2002 investigation by the DOJ of the law enforcement program at the developmental centers found that officers' continuing professional training is insufficient, particularly specialized instruction in investigating abuse, sexual assault, and crime scene preservation and evidence collection (Department of Justice, 2002). Since release of the DOJ report, DDS has worked to implement an infrastructure to support accomplishing many of the recommendations, including hiring more experienced law enforcement officers for the Office of Protective Services at DDS headquarters. DDS acknowledges that many issues remain, including those related to officer training, recruitment and retention, and the separation of administrative and criminal investigations.

Incomplete Reporting of Abuse

Chuck Waters was a 29-year-old resident living in a state developmental center. In January 2001, Mr. Waters became agitated, destroying property and attempting to push and strike staff. Two staff members grabbed Mr. Waters' arms. He resisted, turning and pulling against the staffs' hold. Two other staff were summoned and Mr. Waters was taken to the floor in a prone containment. During the containment, a "pop" sound was heard. A subsequent x-ray revealed that Mr. Waters had sustained a spiral fracture of his arm.

Staff notified the Senior Special Investigator who conducted a thorough and timely investigation. He found that staff had used an improper restraint technique which caused the fracture. Three of the four staff members involved in the restraint were not currently certified in restraint procedures.

The developmental center never reported the incident to the licensing agency (DHS) as required. DHS learned of the incident coincidently during their licensure survey but did not conduct a separate investigation. No deficiency or citation was issued by DHS for the injury or the facility's failure to report the incident.

3. Adult Protective Services

APS uses social workers to conduct investigations with the focus on endangerment of the victim. The experience of APS investigators in working with people with developmental disabilities varies. Interviews with key APS staff suggest that they lack expertise in working with people with developmental disabilities and frequently refer cases involving an individual with a developmental disability to regional centers. Some offices employ outside experts or consultants to provide training and consultation. Others work with the regional center to assess a particular situation and provide assistance.

4. Long-Term Care Ombudsman

Initially, Ombudsmen receive 36 hours of in-class mandatory training; the majority of the training focuses on elder issues and the dynamics of aging, and pertains primarily to issues other than conducting abuse and neglect investigations, such as the Ombudsman's role and responsibilities, effective communication and interviewing techniques, residents' rights, and the long-term care setting. After classroom training is complete, the CDA reports Ombudsmen participate in an internship with an "experienced" Ombudsman before resolving complaints and investigating abuse allegations on their own. The length of the internship varies, depending on the needs of the trainee. Certified Ombudsmen must also complete 12 hours of continuing education annually. (Department of Aging, personal communication, May 16, 2003).

Three areas of concern arise around the Ombudsman's role in investigations of abuse or neglect allegations. First, Ombudsmen respond to a broad range of issues and relatively few of their cases involve allegations of abuse. The Office of the Long-Term Care Ombudsman reports that less than 15 %of complaints received in 2002 involved allegations of abuse or neglect.[13] On average, Ombudsmen work only 20 hours per month with some working a more reduced schedule. (Department of Aging, personal communication, August 11, 2003). APS personnel, who respond to abuse allegations in the community, generally work full-time, with the majority of their caseload involving abuse or neglect.

Second, because of limited training and experience in working with individuals with developmental disabilities, some Ombudsmen may not be able to readily identify or verify abuse reports. In spite of recent changes in training curricula

[13] In the year 2002, a total of 34, 000 complaints were received Five thousand (5000) involved complaints of abuse or neglect. (Department of Aging, personal communication, July 10, 2003).

Opposing Outcomes to One Abuse Allegation: Who was the Victim?

Dan Casey is a 30-year-old man with developmental and psychiatric disabilities and was living temporarily in a crisis facility. He has limited verbal abilities. One morning facility staff insisted on using the client restroom adjacent to Mr. Casey's bedroom, in violation of facility policy. Mr. Casey became angry and an altercation ensued between Mr. Casey and three facility staff. Mr. Casey alleged that staff struck him repeatedly with a heating grate, threw him down, and kicked him. He sustained multiple injuries, including bruises to his face and torso and parallel lacerations to his abdomen consistent with injuries from a heating grate. Facility staff claim that Mr. Casey's injuries were sustained as they attempted to restrain him. The facility terminated all three employees.

Law enforcement conducted an investigation, including an interview of Mr. Casey, the alleged perpetrators, and two staff members not present at the time of the altercation. Police concluded that Mr. Casey was the perpetrator and misdemeanor assault charges were filed against him.

CCL also conducted an investigation. They determined Mr. Casey to be the victim of abuse and cited the facility for failing to provide for the care and safety of Mr. Casey. CCL prohibited the three employees involved in the incident from working in a CCL licensed facility.

incorporating how to investigate cases of abuse of persons with developmental disabilities, the CDA acknowledges that additional training is needed. (Department of Aging, personal communication, July 10, 2003).

Finally, according to the CDA, the Ombudsman investigates cases of suspected abuse of residents in long-term care facilities, including persons with developmental disabilities under age 60, and refers cases to the appropriate licensing authority for further action. (Department of Aging, personal communication, May 16, 2003). [14] However, other reliable sources report that, in some cases, the Ombudsman does not investigate abuse or neglect allegations involving persons with developmental disabilities and these are referred directly to DDS, who, in turn, refer the investigation to the regional center. If this circumstance is correct, this may create an unnecessary delay in response.

[14] Written comments to the final draft of this report received from the Department of Aging.

5. Licensing Agencies (Community Care Licensing, DHS, Provider Licensing Boards)

Licensing bodies are mandated to investigate whether facilities violate regulations. As a result, their investigation focuses on the facility's culpability in and response to the underlying incident. Investigations conducted by licensing bodies are not directly related to protection of the individual victim but may result in new safeguards for remaining residents.

There is considerable variability in the quality and timeliness of investigations and the training of individual investigators in working with victims with developmental disabilities.[15] For example, CCL Program Investigators have peace officer status and are responsible for the investigations of high priority complaints such as abuse. (Department of Social Services, electronic mail, May 30, 2003). Investigators from other licensing bodies do not have similar peace officer status.

If the alleged perpetrator is a licensed care giver, an investigation may also be conducted by their licensing board, if notified. The variability and lack of training described elsewhere is also reported with these investigators.

6. Regional Centers and DDS

While regional centers and DDS have no duty to investigate, regional center caseworkers reportedly investigate referrals from the Ombudsman and monitor the status of investigations conducted by other entities, including those listed above. Regional center staff receive periodic training on investigating alleged regulatory violations but many lack specific expertise in conducting abuse investigations.

7. District Attorneys and Judges

Prosecutors typically do not receive any special training in working with people with disabilities (Ventura County District Attorney's Office, personal communication, July 11, 2002). It is incumbent upon the prosecutor to utilize all resources available to prosecute their case, including petitioning the judge for

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[15] According to DSS, training on investigation of adult/elder abuse complaints is currently being provided to all CCL analysts and managers with adult and elderly residential caseloads. This training includes components that provide interviewing and investigation techniques that are specific to clients with developmental disabilities. CCL analysts with caseloads serving clients with developmental disabilities are also required to attend an initial 24-hours of core training on the needs and characteristics of persons with developmental disabilities followed by annual 24-hour advanced training courses. Some of the topics covered include interviewing skills, communication systems, active-listening and recognizing indicators of abuse. (Department of Social Services, electronic mail, May 30, 2003).

Rape Victim Denied Equal Justice

Leslie Vales is a 26-year-old woman living independently. As Ms. Vales was going to her sheltered workshop, a male stranger approached her at the bus stop. The perpetrator grabbed her and dragged her across the street into some bushes. He allegedly raped her twice and then sodomized her. After the assault, Ms. Vales got up, quickly dressed herself, and ran to catch her bus.

When she arrived at her workshop, Ms. Vales immediately reported the rape to staff. A sexual assault examination showed evidence of trauma, including leaves and sticks inside her vagina. Based upon a description of the assailant and location information provided by Ms. Vales, law enforcement quickly apprehended the perpetrator. He confessed to having sex with her.

At trial, many of the prosecutor's requests for accommodations were denied. Evidence of Ms. Vales' disability (IQ of 59), which would help jurors understand its impact on her testimony, was excluded. Evidence that she was a dependent adult could have extended the perpetrator's sentence, if convicted. The defense attorney asked leading, compound, and complex questions and used complicated medical terms.

Ultimately, Ms. Vales gave seemingly inconsistent answers. In the end, the jury was unable to reach a verdict and the perpetrator was not convicted.

special accommodations and evidence code adjustments that are needed to assist the victim or witness with a developmental disability. Yet, not all prosecutors or judges understand and pursue the accommodations necessary for an individual with a cognitive impairment. All personnel in the criminal justice system should understand the needs of victims and witnesses with disabilities and the related accommodations needed to provide them equal access to the criminal justice system.

There have been some advances in recent years regarding the inadequate protections and treatment of individuals with disabilities who have been victims of crime by the criminal justice system. While these programs attempt to address some of the gaps identified in this report, they are frequently short-lived due to temporary funding and not uniformly available throughout the state.

D. California has no coordinated database that documents the extent and severity of abuse, neglect, and victimization of people with developmental disabilities.

There are no statistics publicly available regarding the incidence of crime, abuse, and neglect of individuals with developmental disabilities and the system's response. Existing agency data collection systems do not use common data elements so they are not compatible and cannot be merged or compared to track the response. It is difficult to tract an initial report through the criminal justice system to arrest, prosecution and conviction and there is no aggregate information publicly available.

DDS and regional centers keep records on the occurrence and response to special incidents. These data could help to approximate the incidence of abuse, neglect, and response to crimes involving people with developmental disabilities. Currently these data are only utilized for internal monitoring, including statewide data analysis and monitoring by an independent contractor (the Columbus Organization) for DDS, and are not available for public scrutiny.

APS collects statewide data on incidents involving elders or dependent adults. This information is publicly available but does not specify type of disability. As the Ombudsman may not investigate allegations involving persons with developmental disabilities, the data complied by this agency does not offer sufficient information regarding the victimization of this population.

Law enforcement reporting records do not specifically indicate if an individual has a disability, unless the report is related to "domestic violence" or covered by the Abuse Reporting Act. As with APS, data collected by law enforcement pursuant to the Abuse Reporting Act does not delineate type of disability. It only indicates that the criteria for a dependent adult had been met. There is no mechanism by which incidents investigated by law enforcement are tracked through the criminal justice system.

Agencies, policymakers and advocates cannot calculate the rate of prosecutions and convictions for perpetrators of crimes against victims with developmental disabilities accurately. This hampers the ability to direct reform efforts targeting deficiencies in the criminal justice system and evaluate the effectiveness of new programs.

Chapter 4: Findings and Recommendations

Finding I

Abuse and neglect of people with developmental disabilities is a serious public policy issue warranting the highest level of attention.

The literature indicates that abuse and neglect of people with developmental disabilities is a pervasive problem nationwide, and California likely mirrors the national problem. Individuals with disabilities are victims of abuse and neglect more frequently than the general population. Individuals with cognitive impairments (e.g. persons with developmental disabilities) are at greatest risk. Yet the abuse response system has failed to implement a program that properly prioritizes this public health problem. It has failed to accurately document the scope of the issue or to develop sufficient initiatives that decrease the frequency of occurrence and increase protections to victims.

There is no reliable statewide system in California that documents the frequency of abuse or neglect of individuals with developmental disabilities. Each entity in the abuse response system has a singular data collection system. Much of the data gathered fails to distinguish victims by type of disability and is not shared with other entities in related systems. With so many players (DDS, regional centers, APS, law enforcement, Ombudsman), any individual agency's data likely portrays only a portion of the picture of abuse and neglect of individuals with developmental disabilities.

Without accurate, specific, publicly available data, there is no means of quantifying the extent of the problem, isolating specific gaps in the abuse response system, or ensuring that individuals and entities have fulfilled their obligations. Even more importantly, there is little incentive to fund programs because the extent of the problem has not been determined. Furthermore, the outcome of new programs or reform initiatives can not easily be measured.

To date, no single agency is championing the issue and coordinating reform efforts. No single agency has emerged to take responsibility for documenting and tracking individual incidents of abuse and ensuring that victims receive necessary services and protections. While the California Health and Human Services (HHS) Secretary, Grantland Johnson, put forth extensive efforts to positively impact this

critical problem through the Crime Victims with Disabilities Initiative (CVDI)[16], its authority and sustainability was limited by statutory and budget constraints. By statute, HHS has jurisdiction over a select group of state departments, which does not include criminal justice or judicial entities. Due to a severe state budget crisis, the State was unable to continue the CVDI. Without a designated office assuming responsibility for this issue and tracking incidents through the abuse response system, abuse and neglect of individuals with developmental disabilities is likely to continue.

Recommendation 1: Eliminating abuse and neglect of people with developmental disabilities must be made a public health priority in California.

The incidence of abuse and neglect of individuals with developmental disabilities is significant. These victims are members of a vulnerable population less able or equipped to defend themselves. Most are victimized by the very individuals identified to care for them. Inattention by state agencies and the Legislature has allowed this issue to linger too long. The complexity of the system and related deficiencies demands sweeping statewide systemic reform. What constitutes the appropriate response of society and systems working with citizens with developmental disabilities, without unduly suppressing choice and self-direction, is the ultimate challenge for system change. Reform must become a top priority for the Governor, lawmakers, the criminal justice system, and the agencies responsible for providing services and supports to persons with developmental disabilities.

Recommendation 2: The Legislature must designate a lead agency with authority and responsibility to coordinate system reform.

Given the extent of the issues identified, the Legislature must designate one agency with the authority and responsibility for coordinating reform measures. This agency must possess sufficient authority to assure a coordinated system of services that will significantly reduce the risk of victimization and unequal access to justice for victims. Regular contact and input from agencies, statewide associations, and advocacy groups must be solicited and considered. Annually, this agency must submit a report to the Legislature including, but not limited to, data about incidents

[16] For a complete overview of this initiative see Appendix B Recent Advances, page 39.

of abuse against people with developmental disabilities and the response from DDS, law enforcement, APS, and the Ombudsman until their role in the abuse response system ceases (see Recommendation 5).

Recommendation 3: An integrated data collection system must be implemented to:

- **document the incidence of abuse and neglect; and**
- **track the outcomes of criminal investigations and prosecutions.**

Data from California's criminal justice and developmental disabilities systems do not provide a clear picture of the incidence of abuse, neglect, and victimization of people with developmental disabilities. Without accurate data there is no mechanism to:

- monitor the severity of the problem,
- identify areas of significant need for immediate and sustained intervention,
- guide the systematic development of services and supports, which will ultimately lead to environments which do not put people with developmental disabilities at excessive risk for harm, and
- evaluate the outcomes of interventions and institutional reform.

A uniform statewide data collection system must be developed which will address these issues. Such a system must have the following characteristics:

- All reporting forms (used by law enforcement, APS, DDS, CCL, etc.) must have a field which identifies whether the victim has a disability and should utilize uniform terms and definitions related to the presence and type of disability.
- Outcome data on crimes reported must be collected documenting the results of investigations, prosecution, and judicial determinations.
- Data from parallel systems which are involved when a victim has a developmental disability (regional centers, APS, law enforcement, CCL) must be relational (i.e., the database is built so that data related to individual victims from all systems involved can be integrated).

- Appropriate protections must be put into place to protect the identity of victims.
- Analyses of data in aggregate form must be reported and available for public scrutiny.

Finding II
The current system of protections is inadequate for victims with developmental disabilities.

The current abuse reporting and response system involves a multitude of regulatory and investigative agencies, each addressing a different component. A single allegation may involve notifying a minimum of four agencies, each with a separate focus and with little interagency collaboration or cooperation in practice. Frequently, the investigator varies depending on where the individual lives (e.g., law enforcement or APS for community residents; Ombudsmen for residents of long-term care facilities; developmental center investigators for residents of developmental centers), leading to variation in investigative practices and stimulus to investigate. In addition, communication between and among agencies is not well-coordinated.

Reporters with good intentions may inadvertently fail to report allegations to each agency, thinking they have met their mandated reporting requirement at the first report. While there have been efforts to provide better training to mandated reporters, most efforts frequently emphasize reporting obligations for cases of elder abuse or neglect, with less attention given to reporting duties for incidents involving individuals with developmental disabilities.

There is no one entity accountable for the appropriate investigation of all incidents involving people with developmental disabilities. Consequently, incidents are under-reported and perpetrators may escape punishment, free to repeat acts of violence and other criminal activity. People with developmental disabilities are less safe than the general citizenry.

Even when identified, perpetrators are poorly tracked by the system. Currently, several licensing bodies oversee the various professionals, paraprofessionals, and technicians that work with people with disabilities in the community, at home, and in hospitals and developmental centers. Each licensing body has a procedure by which consumers or providers may check the status of an individual care giver's license. In some systems care giver information is accessible only by social

Care Givers' Prior History of Abuse

Jeanne Swain was a 22-year-old non-verbal woman with autism. She was living in a small licensed adult residential facility. Ms. Swain was found by care staff seated in a bathtub full of scalding hot water. She sustained 2nd and 3rd degree burns over 30 % of her body. Staff were unable to explain how she got into the bath unsupervised or why the water was so hot. Ms. Swain died several weeks later of complications from her burns.

Investigations revealed that 16 of the 18 employees employed by the home in the previous year had criminal records. A child abuse allegation had been substantiated two months earlier against the staff member on duty at the time Ms. Swain sustained her lethal burns.

security number and not individual name, frustrating public access. But many complain investigations lag for months with the individual still eligible to work. This allows perpetrators opportunities to continue to victimize individuals under their care. Ultimately, the system is only as good as the current status of its database. Newspaper accounts allege that the California Medical Board's records are inadequately maintained (San Francisco Chronicle, 2002). The 2002 review of over 60 widely reported verdicts and arbitration awards against doctors revealed that one third were missing from the agency's public database.

Perhaps, the most comprehensive background check requirement is that mandated for all community care facilities licensed by the DSS. According to DSS, the background check is not a point in time clearance because DSS continuously receives subsequent information from the DOJ on all individuals for which a background check is requested (until the DOJ is notified otherwise). This means that if a person who is currently working in any community care facility is subsequently arrested or convicted, the DOJ notifies DSS. DSS does not verify criminal background clearance during annual visits because DSS is confident that they are aware of all subsequent criminal activity. Similarly, DSS permits an individual to request that his or her clearance from one facility be transferred to another licensed facility when they change employment rather than requiring a pre-employment check by the new facility. Though DSS processes the clearance transfers and maintains records of individual's criminal histories, providers are required to maintain copies of clearances, transfer approvals and criminal record exemptions in the individual's file at the facility. (Department of Social Services, electronic mail, May 30, 2003).

Only individuals who have been arrested or convicted are entered into the system. As has been noted throughout this report, most perpetrators accused of crimes are never formally reported to law enforcement. The accusation is often handled administratively, typically resulting in the termination of the employee. As a result, many perpetrators move to other facilities to continue predator activity. The current system must eliminate administrative handling of accusations of abuse and criminal activity, assure the full implementation of existing policies where they exist and ensure pre-employment criminal background checks are required of all care-providers regardless of setting.

Recommendation 4: Regional centers must have an increased and uniform role in coordinating the response and services provided victims.

Given the complexity of the reporting system, it is imperative that a single agency ensure that all necessary entities are contacted and fulfill their individual duties. Regional centers are uniquely positioned to play a pivotal role in ensuring a timely and thorough response by all entities to allegations of abuse and neglect of individuals with developmental disabilities. This is evidenced by the regional center's dual role in service procurement and service coordination. As part of their responsibilities related to service procurement, regional centers are charged with monitoring the quality of service provided by their community vendors, including the vendor's response to a special incident. The regional center's role in service coordination goes beyond the coordination of specialized developmental services. It includes all community services afforded to the general public regardless of disability, commonly referred to as generic services.

The regional center's role must be expanded to ensure that entities in the abuse response system are notified and complete their associated duties. For example, if a vendor notifies the regional center of an incident of suspected abuse, the regional center can ensure that law enforcement is notified and conducts a thorough and timely investigation. The regional center can offer assistance to law enforcement when interviewing the victim and can caution them not to rely solely upon the statements of facility staff. They can also ensure that the vendor receives follow-up training and is compliant with their mandated reporting obligation. Vendors who fail to protect clients adequately or consistently fail to comply with their reporting duties would enter into a plan of correction with their regional center, agreeing that no referrals can be made to the vendor until all terms in the agreement are met.

Since regional centers are already required to have expertise in criminal justice and forensics, this person should also be responsible for meeting this recommendation. Over time, this individual will cultivate relationships with other entities and increase the efficiency of the system's response. He or she will be able to identify trends - successes and inadequacies in the abuse response and criminal justice systems. Future victims will benefit from this accumulation of experience. Regional centers can also implement proactive initiatives to improve the system and better serve the needs of their consumers.

Following an incident of abuse or neglect, regional centers can work with victims in a variety of ways. In addition to crisis intervention and coordination of victims' assistance services, the regional center can take a preventive approach. This should include training in abuse prevention and providing adequate support to consumers. While this training should make very clear that the individual is not to be blamed for becoming a victim of a crime, it should also discuss an individual's responsibility associated with personal choice and the potential to improve choices for desired outcomes. Regional centers may identify an array of housing options that allow individuals in unsafe situations to move easily and comfortably to another community-based setting, without the threat of institutionalization as the only alternative to tolerating abuse. Merging this model of prevention services seamlessly with crisis intervention and victims' assistance services will likely reduce the vulnerability of individuals with developmental disabilities and increase the responsiveness of entities within the abuse response system.

Recommendation 5: Incidents of abuse or neglect in long-term care facilities must be investigated by law enforcement or APS, not the long-term care Ombudsman.

Methods and systems for investigating abuse or neglect should not vary depending upon where the victim lives. These options should be changed to require reporting to APS or local law enforcement *only*. By assigning to APS and law enforcement the role of investigating abuse or neglect, the system is simplified and residents with developmental disabilities in long-term care facilities are better protected.

Ombudsmen provide a valuable service to all residents of long-term care facilities. They monitor conditions and care in the facility and respond to a wide spectrum of resident complaints. As previously discussed, the Ombudsmen are primarily unpaid volunteers who work limited hours. Currently their training, experience and the focus of their work does not provide them with the level of expertise and

skill in identifying and investigating abuse allegations comparable to APS or law enforcement. The Ombudsman's training and experience is focused primarily on issues of the elderly with very little existing training involving conducting abuse and neglect investigations involving victims with developmental disabilities. The Ombudsman's role in investigating complaints involving residents with developmental disabilities should cease.

However, given the Ombudsmen's continuing presence and advocacy role in long-term care facilities, they should receive additional and on-going instruction in identifying abuse, neglect, and criminal activity which will facilitate appropriate reporting to APS and local law enforcement for investigation. This training should also prepare them with skills to assure crime scene preservation which is critical to potential successful prosecution of perpetrators.

Recommendation 6: Victims with developmental disabilities must be provided new protections from perpetrators.

The balance between protecting victims' rights and the rights of alleged perpetrators must be carefully considered. However, when individuals are vulnerable and at exceptional risk or victimization, enhanced systems to respond to all allegations of abuse and criminal activity must be established and enforced. Without such a system, perpetrators will continue to escape prosecution, background checks will not be useful, and serial perpetrators will continue to prey on people with disabilities. Such enhancements require a number of changes in the current system.

Legislators must direct the lead agency to explore the following issues and potential solutions. The lead agency must (1) eliminate the internal handling of accusations of abuse and criminal activity by facility administration; (2) develop a system to periodically review employee terminations to determine if termination was due to potential allegations of abuse or criminal activity, (3) consider solutions to employer disincentives to report a thorough employee work history upon inquiry by a potential new employer; (4) establish a system which ensures consistent recording and monitoring of the arrest and/or conviction of perpetrators (including but not limited to new fingerprint clearance for all newly employed care providers) and easy access of this information by future employers; (5) assure that all consumers have access to training and assistance in checking with local authorities to verify criminal record clearance for services such as supported living,

independent living, or in-home supportive services and; (6) assure that the cost for background checks should not be a deterrent to obtaining this information.

Recommendation 7: The Department of Developmental Services must continue to implement the Department of Justice recommendations regarding the law enforcement division of developmental centers.

Allegations and incidents of abuse and neglect occurring in developmental centers are documented by facility staff and referred to law enforcement personnel employed at the centers. Inadequacies of this system are being addressed currently in response to recommendations made by the DOJ. DDS must continue to focus resources to the remaining issues. These include separating of criminal and administrative investigations, ensuring that criminal investigations take precedence, expanding the number of personnel in the law enforcement division, implementing standard procedures for the investigation of incidents, and reporting them to outside agencies, including local law enforcement. In addition, the basic training and continuing education of Senior Special Investigators must more closely proximate that of other peace officers. Finally, the qualifications of investigators hired must be raised to approach standards required by local law enforcement.

Finding III
Individuals within the abuse response and criminal justice systems lack training and expertise in working with people with developmental disabilities.

Investigators and individuals within the criminal justice system are generally inadequately trained in working with individuals with developmental disabilities. Victims, family members and advocates report lapses in the criminal justice system when investigators lack skills in communicating with and providing accommodations to individuals with developmental disabilities. APS and law enforcement do not receive adequate initial and periodic retraining regarding how to work with this unique and vulnerable population. Law enforcement officers only receive limited training in the academy and it focuses primarily on individuals with psychiatric disabilities. Ombudsmen receive minimal training regarding working with individuals with developmental disabilities. This results in

investigations of variable quality with inconsistent outcomes, ultimately leading to inadequate protection of victims with developmental disabilities and low rates of prosecution of alleged perpetrators.

Encounters with the criminal justice system can be baffling and intimidating to people with cognitive impairments. Investigators and prosecutors may see victims with developmental disabilities as poor historians. The veracity of victims is often questioned. This leads to inadequate investigation, including failure to consider the testimony of victims sufficiently. Less egregious acts or acts where the mental capacity of the victim is considered a factor are often not reported to or aggressively investigated by law enforcement.

Family Claims Law Enforcement Bias

Casey family members (see vignette on p.21) report that the investigation conducted by law enforcement was inadequate and biased against their son. They claim that officers assumed that Mr. Casey was the assailant, not facility staff, because he exited the home holding the weapon (a heating grate). Law enforcement allegedly disregarded Mr. Casey's explanation that he was holding the grate to show officers the weapon used to inflict his injuries. Law enforcement recorded a detailed and lengthy statement regarding the altercation given by the manager of the facility who was not present at the time and did not witness the altercation between Mr. Casey and three staff.

Investigators tend to rely upon information provided by facility staff and neglect to gather or sufficiently value necessary information from the victim or other witnesses with disabilities. Often facility staff have a conflict of interest in acknowledging that the incident occurred. Furthermore, the perpetrator is often a care giver and a member of the facility's staff.

Some prosecutors are reluctant to prosecute cases because of unfamiliarity with persons with developmental disabilities and the challenges posed by bringing such a case. Many judges have limited understanding about the needs of these victims and may narrow the application of courtroom accommodations to physical disabilities without similar consideration of cognitive disabilities. The result is failure by the criminal justice system to provide equal protection to victims with developmental disabilities and to offer them the same protections and response as victims of the general population.

Recommendation 8: All agencies involved in the abuse response system must receive mandatory training regarding working with individuals with developmental disabilities.

Law enforcement must be required to periodically and regularly complete the California Commission on Peace Officers Standards and Training (POST) eight-hour advanced officer training course, entitled, *Police Response to People with Mental Illness or Developmental Disabilities*. Similarly, there must be periodic training provided to local prosecutors and judicial personnel specifically regarding crimes against persons with disabilities, including requesting and providing necessary accommodations. APS and licensing agencies (for facilities and licensed care providers) should develop and implement a similar training component regarding conducting investigations involving victims with developmental disabilities.

Appendix A Definitions

There are a number of laws and regulations pertaining to the reporting and investigation of abuse and neglect allegations, primarily the Elder Abuse and Dependent Adult Civil Protection Act (the Abuse Reporting Act) and the California Penal Code. Each offers slightly differing definitions, which, in itself, presents problems because a specific incident may constitute a reportable event leading to different system responses depending on the governing regulations for the system responding.

Physical abuse, defined by reference to the California Penal Code, is any act involving assault, battery, assault with a deadly weapon or force likely to produce great bodily injury, and sexual assault including sexual battery, rape, incest, sodomy, and oral copulation. Welf. & Inst. Code § 15610.63. Citing the vulnerability of the victim to understand or report criminal conduct or to testify in court proceedings on their own behalf, the Legislature specified that certain acts of abuse or neglect of dependent adults rises to the level of criminal behavior, punishable with a fine and/or imprisonment. Penal Code § 368(b)(1). Sanctions include imprisonment for up to one year, or a fine of up to six thousand dollars ($6,000), or both a fine and imprisonment. *Id.* Additional terms in state prison are added if the victim suffers great bodily harm from the offense. Penal Code § 368(b)(2). Circumstances not likely to produce great bodily harm or death but resulting in unjustifiable physical pain or mental suffering are considered misdemeanors. Penal Code § 368(c).

The Welfare and Institutions Code which regulates services for individuals with developmental disabilities, defines physical abuse as unreasonable physical constraint, prolonged or continual deprivation of food or water and the use of physical or chemical restraint or psychotropic medication for punishment, for a period of time beyond or for any purpose not authorized by the ordering physician. Welf. & Inst. Code § 15610.63.

Neglect is defined as the negligent failure of any person having the care or custody of a dependent adult to exercise that degree of care that a reasonable person in a like position would exercise and specifically includes failure to:

1. **assist with personal hygiene;**

2. **provide food, shelter, and clothing;**

3. **provide medical care for physical and mental health needs;**

4. protect from health and safety hazards; or

5. prevent malnutrition or dehydration.

Welf. & Inst. Code § 15610.57.

Appendix B Recent Advances

Efforts over the last several years to raise the awareness of the abuse response and criminal justice systems of the inadequacies of protections and treatment of people with disabilities have yielded some advances in the training of personnel. However, current budget issues have jeopardized some of these programs.

The State Council on Developmental Disabilities funded "Striving for Justice – Enhancing Services for Crime Victims with Developmental Disabilities", a statewide multidisciplinary conference organized by the Ventura County DA's Office. The conference, attended by more 150 law enforcement personnel, prosecutors, care providers, consumers and families, and others, was well-received. This DA's Office also developed a local law enforcement protocol to assist officers who encounter victims of crime, witnesses, and defendants with developmental disabilities. The California Attorney General's Office developed "Crime Victims with Disabilities, a Prosecutor's Guide to the California Statutes" which made its public debut at the conference and serves as an excellent companion resource to the training received and will benefit California consumers. This publication includes statutes and relevant case and other information helpful in trial preparation and requesting accommodations and was sent to District Attorneys throughout the State.

Beginning in 2002, the DDS instituted a comprehensive community-based risk mitigation and management system that is supported by an investment of approximately $12 million annually. The system is comprised of three key components: (1) revised and expanded special incident reporting regulations, (2) a statewide electronic regional center special incident reporting (SIR) system, and (3) engagement of a contractor (Columbus) to perform independent risk mitigation and management services. The system operates on both a statewide and local regional center level. The SIRs the regional centers report to DDS through the State's electronic reporting system are the foundation of the system. This data is analyzed on a statewide basis by Columbus, and on a local basis by the regional center, to identify trends and strategies to prevent and/or mitigate consumer risk. Each regional center is now required to establish a Risk Mitigation and Management Committee and develop a Risk Mitigation Plan pursuant to applicable Title 17 regulations. Through Columbus, a quarterly newsletter addressing prevention and risk mitigation activities is published and distributed, and an information website (www.ddssafety.net) for consumers, families, service providers, clinicians, and regional center staff is updated monthly. Annual training sessions for regional center staff, literature reviews, and routine SIR trend analyses

are also provided by Columbus. This comprehensive system provides the DDS information and data reportedly from which to plan new initiatives and address issues of public policy in its efforts to protect consumers' health and safety and to their quality of life.

Pursuant to AB 1499 and AB 1690, each long-term health care facility[17], community care facility[18], and residential care facility for the elderly[19] is required to provide training in recognizing and reporting elder and dependent adult abuse. Welf. & Inst. Code § 15655. According to DSS, training materials include the DOJ video tape and accompanying printed material. Staff are required to sign a statement acknowledging that they are mandated reporters of abuse. CCL is responsible for verifying training is completed. (Department of Social Services, electronic mail, May 30, 2003).

The Crime Victims with Disabilities Initiative (CVDI) , funded beginning in 2000, addresses the issue of violent crimes against people with disabilities including: (1) assisting crime victims with disabilities; (2) providing training programs on personal safety and prevention, risk reduction strategies, and detection and reporting of crimes; (3) creating a public information campaign regarding violent crimes against people with disabilities; (4) funding six Crime Victims with Disabilities Specialist pilot programs throughout the State; and (5) under the direction of the California Health and Human Services Agency, approved plans developed by the departments of Aging, Rehabilitation, Developmental Services, Mental Health, Health, and Social Services for addressing crimes against their constituents with disabilities, including comprehensive manuals and training from the top down throughout each department. The Crime Victims with Disabilities Specialist pilot programs train and directly assist law enforcement and other agencies within the criminal justice system when a victim of a crime has a disability. These programs are expected to increase the reporting and investigation of crimes involving people with disabilities. They represent a concerted effort to enhance the criminal justice system's response to crimes against people with disabilities and the eventual increased prosecution of predators. This program was not included in the Governor's budget for FY '03-04 and all programs will cease.

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[17] Long-term health care facilities include skilled nursing facilities, intermediate care facilities, nursing facilities, and pediatric day health and respite care facilities. Health & Safety Code § 1418.

[18] Community care facilities include residential facilities, adult day programs, therapeutic day services facilities, foster family agencies and homes, small family homes, social rehabilitation facilities, community treatment facilities, and transitional shelter care and housing placement facilities. Health & Safety Code § 1502.

[19] Residential care facility for the elderly means a housing arrangement where varying levels and intensities of care and supervision, protective supervision, or personal care are provided. Health & Safety Code § 1569.2.

Individual regional centers statewide have criminal justice projects and programs which address some of the problems identified in this report. Some regional centers have established resources for victims of crime, including purchasing crime victim recovery services. There are five forensic projects, which focus primarily on offenders with developmental disabilities. While these programs are assisting regional center clients accused of crimes, many of the same barriers confronting offenders are faced by victims.

In 2001, an eight hour advanced officer training course, entitled "Police Response to People with Mental Illness or Developmental Disabilities," was developed by POST in consultation with community, local and state organizations and agencies with expertise in the area of mental illness and developmental disabilities, along with consumer and family advocacy groups.

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ARCH National Resource Center for Respite and Crisis Care Services

Factsheet Number 36

Abuse and Neglect of Children with Disabilities

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Background

JoAnne, a fourteen-year-old girl, lives in a skilled nursing facility. She has profound mental retardation and multiple disabilities, including seizure disorder and cerebral palsy. She requires assistance for all her daily living activities. When she was discovered to be eight months pregnant, facility staff reported suspected child abuse. The perpetrator was never identified. Of the remaining ninety-eight residents living in the same facility, over 80% tested positive for a variety of venereal diseases.

Child abuse and neglect was identified as a "national epidemic" in the 1991 report of the U.S. Advisory Board on Child Abuse and Neglect. In 1993, the National Committee to Prevent Child Abuse (NCPCA) determined that approximately 2.9 million children were identified and/or reported as victims of child abuse and neglect throughout the United States. Until recently, however, the number of children with disabilities who have been abused and neglect has not been well documented.

In November, 1993, the National Center on Child Abuse and Neglect (NCCAN) released a study regarding the abuse of children with disabilities. This first national effort to determine the incidence of abuse among this population found that children with disabilities are abused at approximately twice the rate of children without disabilities (WESTAT, 1993). Other studies document an increased risk of abuse for children with disabilities between four to ten times that of the generic population (Baladerian, 1990).

All forms of abuse, including multiple types of abuse with the same child, multiple perpetrators of abuse, and multiple victims within a grouping of children, are found within the population of children with disabilities. The vast majority of the perpetrators are well known to the abuse victim. Perpetrators may include family members and service providers such as teachers, doctors, administrators, direct care providers, therapists, and transportation providers.

Abuse Can Cause Disabilities

Sammy, now thirteen years old, had mild mental retardation and cerebral palsy. In counseling he revealed that he was thinking about his future, including marriage and parenthood. Afraid that his children would be retarded like me, "he was asked the cause of his disability. "I was born normal. My Dad used to come home drunk and get real mad. I remember he would throw me against the wall. My head hurt a lot. This happened all the time, when I was little. Now I'm retarded." Although Sammy understood the origin of his disability, he did not understand genetics or heredity. When told that his children would probably be born just like he had been, he was happy. He said, "I would never hurt my kids like my Dad [did] (sic)."

In addition to the fact that children with disabilities are at increased risk of abuse is the fact that child abuse can cause disabilities. The exact number of abuse-caused disabilities is unknown, but it is estimated to represent 25% of all developmental disabilities (Baladerian, 1992). In addition, more than 50% of the child victims of severe neglect sustain permanent disabilities, including mental retardation and other forms of learning and cognitive disabilities.

According to a 1990 study, 53% of child abuse related fatalities were children under one year of age, and 90% of the children were under five years of age (April 1994 Carnegie Report). Head trauma is the leading cause of death for children who die from child abuse (Michael Durfee, 1994). It is unknown how many more children suffer "near misses" and retain serious permanent disabilities due to head and neck trauma. Specific causes of brain and other central nervous system injuries may result from the "shaken baby syndrome," blows to the head (e.g., slapping, hitting, child tossing), as well as asphyxiation (due to suffocation or strangling).

Identification

The signs of abuse characteristic of children in the general population are pertinent to children with disabilities. These signs include the following:

- physical injuries including unexplained bruises, welts, broken bones, burns
- frequent unexplained injuries
- aggressive or withdrawn behavior
- unusual fears
- craving for attention
- wary of physical contact
- afraid to go home
- destructive to self and others
- poor social relations
- fatigue
- lack of concentration
- unusual knowledge of sex

Unfortunately, for children with severe disabilities, discovery of their abuse is usually dependent upon the emergence of incontrovertible physical signs (e.g., death, pregnancy, venereal disease, physical injury) and/or obvious behavioral signs (e.g., sudden changes in behavior that re-enact the abuse). Less obvious behavioral signs do not necessarily alert the untrained caregivers to possible abuse. Even more problematic is that professionals providing services to children with disabilities have too often attributed clear signs of abuse to a disability. This oversight has left children in abusive situations, in some cases for several years.

In addition, many people have difficulty believing that children with disabilities can be victims of abuse and neglect. This misperception creates an exaggerated level of vulnerability, as children with disabilities, and their families, are not prepared psychologically, intellectually, or physically to resist or respond to abuse. One woman, who has a severe disability, recently stated that, "until as an adult I was sexually abused, I never thought that persons with disabilities were rape victims. I'd never heard of it. Of course I know about sexual abuse, but it never occurred to me that people with disabilities were abused. I was so naive."

Prevention

Parents of children with disabilities often receive a lot of information about disabilities, child care, child development, and community resources, but are rarely prepared or trained on the subject of physical or sexual abuse or neglect. While abuse prevention programs exist in various forms throughout the country, these are rarely offered to children with disabilities and their families. When programs are offered, they are not always age appropriate, as when programs designed for younger children are presented to older children with disabilities.

Programs that are designed with the "No-Go-Tell" concept as their base are not, in general, useful for the child with a disability. These programs teach children to tell the potentially abusive adult, "No!," then to go to someone they trust, and tell them about the other adult's behavior. Telling an adult, "no," is difficult for any child; children with disabilities, however, may have even greater difficulty as they are usually taught to strongly respect the authority of almost any adult or person who is "in charge." In addition, most persons who abuse children with disabilities are in positions of trust, authority, and relationship with the children (e.g., parents, professionals, paraprofessionals, or other family friends). Thus the ability to socially resist an abuse is diminished.

So, what does work? First, the parents and family members of children with disabilities should be informed that their children, like other children, are at risk. Frequently parents, and the children themselves, believe that due to the disability they cannot become abuse victims. Second, parents should talk directly to their children about abuse awareness, and develop a communication cue that will alert the parent that something has happened. Parents need to be empowered to take firm action to apprehend the identified perpetrator.

Many children with disabilities can benefit from self defense programs with individually tailored defense and response techniques, depending on the child's disability. Programs are in effect all across the country, and in Europe, teaching self defense techniques to children with intellectual, communication, mobility, and sensory disabilities. Practicing communication cues and self defense techniques is important. Equally important is teaching and implementing assertion and personal empowerment skills. If a child is only encouraged to be assertive when and if an assault is in progress, success is unlikely. Only when the child is assertive in all areas of life can it be expected to be successful in the face of assault.

Unfortunately, in many cases a child cannot stop or avoid the abuse. In these cases, the child and parents must be encouraged to "do everything possible," which may include identifying the event as abuse and reporting it immediately. Such a response can be empowering for both the child and the family, ameliorating the effects of the abuse itself.

Challenges to Effective Intervention

Recently the fields of child abuse protection and disabilities have begun to recognize their common interest in working to prevent abuse of children with disabilities. Both fields have much to learn to become competent to deal with the specific issues of abuse for this population. This collaboration is thought by many to be the key to successful intervention and amelioration of maltreatment of children with disabilities.

In reducing the risk of abuse for children with disabilities, and in providing effective and sensitive intervention services, professionals will need to develop working relationships in a structure that allows for cross referral, cross training, consultation across a variety of agency lines, and increased accessibility and understanding for the disabled community. This will require changes for both abuse protection and disability service agencies.

Increasingly child abuse response professionals, program administrators, and the law enforcement community are seeking skills to help in the identification, reporting, interviewing, and adjudication of suspected child abuse for children with disabilities. With this interest and a matching commitment on the part of funding sources, the specialized training they seek can be provided. Additionally, disability specialists and service providers are seeking the expertise of those in the child abuse community to learn how to recognize and respond effectively and appropriately to the epidemic of child abuse.

Intervention includes a myriad of services, ranging from the initial observation and report taking to assessment and interviewing, placement, court, treatment, and monitoring. As therapists skilled in providing treatment for severely disabled abuse victims become more available, CPS workers will more easily make referrals for the children they serve.

These changes will take time, but with increasing interest in this population, and the availability of good training programs as well as models for inter-agency collaboration, it is likely that these changes can be in place in the near future.

Recommendations

States may want to follow the leadership of Florida, Washington, and California, where some legislation and activities are in place to address the issue of abuse of children with disabilities. For example, in California the state chapter of the National Committee to Prevent Child Abuse (NCPCA) has attempted to develop liaisons at the local, state, and national levels by writing to all NCPCA chapters alerting them to the problems of child abuse and neglect for children with developmental disabilities. They have encouraged the chapters to contact their State Councils on Developmental Disabilities to establish working relationships. A similar letter was sent to each of the State Councils.

In the past five years, awareness of the problem of abuse and neglect of children with disabilities has begun to increase. It is important to foster greater awareness of this issue. This can be done through comprehensive public awareness campaigns by adding a few critical facts to the generic child abuse awareness campaigns.

- Child abuse happens to children with disabilities.
- Child abuse and neglect can *cause* disabilities.
- Children with disabilities can resist abuse attempts when given information and skills development training.
- Parents of children with disabilities can learn to distinguish signs of abuse and disability related problems.
- Children with disabilities are competent to communicate their abuse experience.
- Children with disabilities can be acknowledged as credible witnesses to their own experience.

Summary

The problem of abuse of children with disabilities is a serious issue, but is still not largely recognized by service agencies. Prevention and abuse awareness programs need to include information about the heightened risk of abuse of children with disabilities, and the onset of a permanent disability as a consequence of abuse. The utilization of training programs for children, parents, families, and child abuse response and disability services providers, will play a unique and critical part in the reduction of risk for children with disabilities.

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Resources

Disability, Abuse and Personal Rights Project, SPECTRUM Institute, P.O. Box 65756,

Los Angeles, CA 90065, (310) 391-2420, Ext. 333. Produces annual national conference on abuse and persons with disability; conducts research and produces reports on abuse and disability; provides training and produces training materials for both abuse response service providers and disability related service providers. Provides advocacy services for persons with disabilities related to civil rights and abuse related issues.

National Center for Child Abuse and Neglect (NCCAN)

The incidence study on maltreatment of children with disabilities is available from: Clearinghouse on Child Abuse and Neglect Information, P.O. Box 1182, Washington, DC 20013, 1-800-394-3366.

National Coalition on Abuse and Disability, P.O. Box "T," Culver City, CA 90230-0090, (310) 391-2420, FAX (310) 390-6994. This provides a quarterly newsletter and has approximately 250 members whose work includes or specializes in abuse and neglect of children with disabilities. There is no charge for membership. Annual meetings are held in conjunction with the NCPCA Conference.

About the Author

Nora J. Baladerian, Ph.D., *is a licensed psychologist who has dedicated her professional interests over the past twenty years to the issues of children and adults with disabilities. She has authored over fifty articles and*

handbooks, and has presented hundreds of seminars and workshops, training those in both the disabilities and abuse response communities in the effective intervention, amelioration and risk reduction of abuse of children with disabilities.

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Overview Results Steering Committee Bios

Goals of the Building Partnerships Initiative

- To provide protection, treatment and continuity of care for persons with disabilities;
- To increase awareness of crimes being committed against persons with disabilities;
- To increase communication and cooperation between law enforcement and agencies providing services to persons with disabilities, and
- To ensure that crimes committed against persons with disabilities are promptly reported and investigated by trained law enforcement personnel and prosecuted by experienced assistant district attorneys.

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Primary Partners

- District Attorneys
- Massachusetts State Police
- Disabled Persons Protection Commission (DPPC)
- Department of Mental Retardation (DMR)
- Department of Mental Health (DMH)
- Massachusetts Rehabilitation Commission (MRC)
- Massachusetts District Attorneys Association (MDAA)
- Massachusetts Office for Victim Assistance (MOVA)

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Prevalence of Violence

In 1998, the United States Department of Justice reported that there were 54 million Americans living with disabilities. According to one study, in 2000, approximately five (5) million crimes are committed against persons with developmental disabilities each year in comparison to 1.4 million child abuse cases and one (1) million elder abuse cases.[1] Persons with disabilities are some of our most vulnerable citizens. The vulnerability of a person with a disability is heightened when he or she is dependent upon a caregiver. The close personal contact involved with assisting persons with disabilities with daily living activities such as bathing, dressing and personal hygiene fosters dependence upon the caregiver. Persons with disabilities may also have an impaired ability to utilize self-defense and avoidance of

violence mechanisms. It is a common misperception that persons with disabilities are asexual, incapable of relationships and not able to engage in sexual acts. Consequently, when a person discloses that she or he is a victim of sexual abuse, they are frequently not believed. These situations are complex and place persons with disabilities at greater risk of sexual assault and abuse.

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Statistics

Crimes committed against persons with disabilities are a *frequently unrecognized and underreported problem* that has reached epidemic proportions in the United States as reflected in the following statistics:

- More than ninety percent (90%) of people (both male and female) with developmental disabilities will experience sexual abuse at some point in their lives. Forty-nine percent (49%) will experience ten or more abuse incidents.
- Only three percent (3%) of sexual abuse cases involving people with developmental disabilities will ever be reported. [2]
- Adults with developmental disabilities are at risk of being physically or sexually assaulted at rates four to ten times greater than other adults.[3]
- A study of psychiatric inpatients found that 81 percent had been physically or sexually assaulted. [4]
- 62% of women with physical disabilities reported experiencing emotional, physical or sexual abuse.[5]

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'House of Horrors' - the Case that Changed the System in Massachusetts

In 1997, an incident of abuse and neglect of two men with disabilities made headline news in print and broadcast media. The story began in 1989 when Tim, a 19 year old man with mild mental retardation, was placed alone on a bus in Louisiana by his mother. The young man's destination was Massachusetts. This young man, who professionals in both Louisiana and Massachusetts described as eager to please, compliant, shy and lacking self-esteem, was departing a life composed of years of sexual and physical abuse and deprivation. He was about to enter a world of torture, torment and slavery.

After arriving in Massachusetts, Tim lived with two brothers, and Almus, another man with mild mental retardation. Over the next seven and one-half years, the two men with mild retardation were financially exploited, and physically and sexually abused by the two brothers. In particular, Almus was beaten with thorn sticks and a hammer, burned with boiling water, sexually assaulted, tied to a hot radiator, made to sleep in a doghouse and hit with a motor chain, causing blindness in one eye. Several reports of the abuse were made to various authorities, yet no substantial action was taken. When action was finally taken, the perpetrators were arrested, prosecuted, convicted and sent to prison.

How did the abuse continue for so long? The answer is simple - it was the result of the failure of a system supposed to protect persons with disabilities. This case changed the system in Massachusetts. As

soon as the story broke in 1997, the living situation of the two men was immediately resolved. As a result of this and other high profile cases, the Massachusetts House Post Audit Committee and Oversight Bureau released a scathing report identifying serious problems with investigations involving persons with disabilities. To say that the report was scathing would be an understatement. It stated that the Department of Mental Retardation (DMR) had lost sight of its mission - focusing on the health and safety of its clients.

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Why the Initiative Was Formed

In June 1997, in response to the legislature's report, Gerald J. Morrissey, Jr., the then newly hired Commissioner of DMR, appointed an Investigations Advisory Panel to determine how DMR could improve its investigative capacity and systems for protecting the safety and well being of the people it serves. The panel, chaired by Northwestern District Attorney Elizabeth D. Scheibel, was composed of nine individuals representing the Massachusetts State Police, judiciary, academia and families of consumers from across the state.

The panel concluded that most of the problems hampering the effectiveness of the Investigations Unit were systemic in nature and included such issues as poor relations between agencies, the lack of a layered system prioritizing the most serious cases and the insufficient, untimely and, in some cases, lack of referrals to the appropriate law enforcement and criminal justice authorities. There was an absence of formal procedures and cooperative agreements with law enforcement agencies for the management and investigation of complaints of criminal conduct. Reasons for underreporting and inadequate investigations included lack of awareness, lack of effective coordination between law enforcement and human service agencies, and reluctance by police, prosecutors and judges to rely on the testimony of a person with a disability. When crimes committed against persons with disabilities were reported to the authorities, they were often reported days or even weeks after the incident occurred. Crime scenes and physical evidence were destroyed. Testimonies were damaged by repeatedly interviewing the victim and perpetrator.

These problems contributed to underreporting and low arrest and prosecution rates for persons who committed crimes against persons with disabilities. In Massachusetts, in 1997, the Disabled Persons Protection Commission (DPPC) referred 32 cases statewide to law enforcement for criminal investigation, none of which were prosecuted. Consequently, crime victims with disabilities did not have equal access to the criminal justice system. As a result of the vulnerability of persons with disabilities, the national studies, the Massachusetts statistics, the House Post Audit Report, the House of Horrors case, the lack of abuse reporting, lack of criminal prosecutions, the feedback from the public hearings and the DMR's Investigations Panel's report identifying serious problems with recognizing, reporting, investigating and prosecuting crimes committed against persons with disabilities, this project was selected and the Building Partnerships for the Protection of Persons with Disabilities initiative was created.

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Solutions

To address the lack of awareness of crimes being committed against victims with disabilities, the lack of reporting and the lack of and ineffective criminal investigations and prosecutions, a comprehensive, multi-agency response was required.

May of 1999 marked the first time that representatives from the Attorney General's office, the district attorney's offices, Massachusetts State Police, adult protective services, and human service agencies came to the table with the primary objective being the establishment of a formal written protocol that would ensure the swift and effective reporting and investigation of crimes committed against persons with disabilities. This partnership has become known as the Building Partnerships for the Protection of Persons with Disabilities initiative (BPI). The Building Partnerships initiative has been institutionalized through formal Memorandums of Understanding (MOU). This agreement brings together the eleven district attorneys, Massachusetts State Police, the Disabled Persons Protection Commission and human service victim advocate agencies, using a multidisciplinary approach to address crimes committed against persons with disabilities. The MOU's are the cornerstone of the Building Partnerships for the Protection of Persons with Disabilities initiative, describing each agency role and responsibility to ensure all situations are addressed and to prevent duplication.

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Accomplishments

The single most important achievement of the Building Partnerships initiative is the enhanced safety and protection of crime victims with disabilities. Thousands of reports of abuse against persons with disabilities are received through a single point of entry at the DPPC and screened by experienced state police detectives assigned to the agency. Reports alleging criminal activity are now investigated by trained law enforcement officers and prosecuted by specially trained assistant district attorneys. Through the Building Partnerships goals and objectives, identified in yearly grant applications, training curricula were developed for local and state police officers, APS investigators, assistant district attorneys, victim witness advocates and service providers.

Over the past seven years, accomplishments have been numerous and include, but are not limited to, the following:

- **State Police Detective Unit (SPDU):** Legislation statutorily mandated that a SPDU be established and located within the adult protective services (APS) office of DPPC. The SPDU reviews all abuse reports received through DPPC's 24 hour hotline, and identifies and forwards complaints of criminal activity to the appropriate district attorney's jurisdiction for assignment of the criminal investigation.

- **Memoranda of Understandng (MOUs):** An MOU was established between law enforcement, APS and human service agencies. The MOU outlines a multidisciplinary approach to addressing violence committed against persons with disabilities and identifies the specific role of the parties involved. The multidisciplinary team is comprised of, but not limited to, the district attorney, state police, DPPC, DMR, DMH and MRC. Each of the eleven district attorneys has a MOU specific to their district and a ll district attorneys have formally signed on to the agreement.

- **APS Training:** A forty hour basic investigation training and a 40 hour sexual assault training was developed and is provided to APS investigators. The training is conducted by the state police and held at the state police academy.

- **New Recruit Training:** Municipal recruits all over Massachusetts are educated through a full day training on responding to crime victims with disabilities. The curriculum, *Adults with Disabilities and Law Enforcement,* developed by BPI formally replaced the Municipal Police Training Committee's existing curriculum on Special Needs.

- **Veteran Police Distance Learning:** *Reporting and Investigating Crimes Committed Against Persons with Disabilities* was created by BPI and is accessible to all Massachusetts veteran municipal and state police officers through the Massachusetts State Police on-line training academy.

- **Practical Guide for Court Personnel:** BPI, in conjunction with Massachusetts Continuing Legal Education (MCLE), developed a practical guide to the reporting, investigation and prosecution of crimes committed against persons with disabilities. The book was distributed to all the courts in Massachusetts.

- **Provider Training:** A video was created to educate professionals that provide services to persons with disabilities on recognizing, reporting and responding to violence committed against persons with disabilities. The video, *Protect, Report, Preserve: Abuse Against Persons with Disabilities* and accompanying manual is distributed to agencies throughout the state that provide services to persons with disabilities.

- **Legislation:** Senate Bill 1083, drafted by BPI, with input from the Attorney General's Office, provided for enhanced penalties for those who commit crimes against persons with disabilities. It was passed in the fall of 2005. BPI has other bills pending.

- **Public Awareness Campaign:** An extensive public awareness plan has been developed to increase awareness of crimes being committed against persons with disabilities within the commonwealth. BPI has a website that includes general information on the program and links to the participating agencies. Laminated reporting cards, educational brochures and posters have been developed and distributed throughout the Commonwealth. Other public awareness materials include laminated cards for police officers, magnets with reporting information for service providing agencies, water bottles with reporting information distributed at trainings, key chains with reporting information for persons with disabilities and various educational brochures tailored to specific disciplines.

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Recognition

Efforts of the Building Partnerships Recognized...

2002 Northwestern District Attorney and State Police Lieutenant receives DMR's Public Service Award

Northwestern District Attorney Elizabeth D. Scheibel and Massachusetts State Police Detective Lieutenant Susan M. Cronin received the Partners in Public Service Award from the Department of Mental Retardation for their outstanding and ongoing contribution in addressing crimes committed against persons with disabilities.

2003 DMR Commissioner and DPPC Executive Director receives MOVA's Innovations Award
In 2003 Gerald J. Morrissey, Jr., Commissioner of the Department of Mental Retardation (DMR) and Nancy A. Alterio received the Innovations award from the Massachusetts Office for Victim Assistance (MOVA) for their leadership in the Building Partnerships for the Protection of Persons with Disabilities initiative. The award is given to professionals whose work has raised public and professional awareness and made contributions to victim services through innovative collaborations. For details on all of MOVA's Awards, contact MOVA at 617-727-5200 or visit the MOVA website at www.mass.gov/mova

2004 Massachusetts State Police Receives Top Law Enforcement Award
IACP/Motorola Webber Seavey Award Recognizes Trailblazing Approach to Protecting Persons with Disabilities. For its innovative approach to addressing crimes against persons with disabilities, the Massachusetts State Police received the International Association of Chiefs of Police (IACP)/Motorola Webber Seavey Award for Quality in Law Enforcement during special ceremonies held in conjunction with the IACP annual meeting in Los Angeles on November 15, 2006. The IACP/Motorola Webber Seavey Award is presented annually to agencies and departments worldwide in recognition for promoting a standard of excellence that epitomizes law enforcement's contribution and dedication to the quality of life in local communities. Among a field of more than 179 nominees – almost 20 percent coming from countries other than the U.S. – three departments were selected to receive law enforcement's most distinguished honor. A key component of the Building Partnerships initiative is a State Police Detective Unit (SPDU) assigned and housed at the Disabled Persons Protection Commission (DPPC), an adult protective service agency. The troopers of the SPDU review all abuse reports received through the agency's 24-hour hotline and track each utilizing a statewide database. The new infrastructure allows for the timely and efficient processing of all cases and has significantly enhanced the safety and protection of crime victims. For details on all of the 2004 IACP/Motorola Webber Seavey Award winning programs, contact the IACP at 800-843-4227 or visit the IACP website at www.theiacp.org.

2005 Leaders in Massachusetts Recognized for Collaborative Efforts
The National Organization for Victim Assistance (NOVA) annually presents awards to recognize extraordinary accomplishments of individuals and programs in the victims' movement. In 2005 leaders in Massachusetts received the Tadini Bacigalupi Program of Distinction Award from NOVA for their innovation in service, longevity of program and quality of services for crime victims with disabilities. In May of 2005 in Atlanta, Georgia, NOVA paid tribute to Elizabeth D. Scheibel, Northwestern District Attorney, Gerald J. Morrissey, Jr., Commissioner of the Department of Mental Retardation, Nancy A. Alterio, Executive Director of the Disabled Persons Protection Commission and Mary Ann Brennen, Project Director of the Building Partnerships for the Protection of Persons with Disabilities initiative for their role in addressing abuse and crimes committed against victims with disabilities. For more information on all NOVA's awards contact:

Mary Young, P.O. Box 203, Lebanon, MO 65536;
fax: 417-532-8252;
email: yramy@webound.com
telephone 1-800-698-9196 or:
visit NOVA's website at www.trynova.org

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NATIONAL
DISABILITY RIGHTS
NETWORK
Protection & Advocacy for Individuals with Disabilities

December 2009

Re: A Decade of Little Progress Implementing Olmstead

In 1999 the U.S. Supreme Court, in *Olmstead v. Lois Curtis and Elaine Wilson*, stated loud and clear that it is a violation of the civil rights of Americans with disabilities to require a person to be institutionalized in order to receive necessary disability supports and services, if these services are more appropriately provided in the community. It is simply unacceptable, that 10 years later, there has been almost no progress reducing the numbers of Americans with disabilities, nationwide, who live in institutions. This report, "*A Decade of Little Progress Implementing Olmstead: Evaluating Federal Agency Impact After 10 Years*," evaluates the efforts of key federal agencies to enforce the *Olmstead* decision over the past decade. We found next to no federal oversight of enforcement efforts and no repercussions for states who fail to make reasonable efforts to end unnecessary institutionalization. This approach is an affront to the people with disabilities. NDRN calls for more urgent federal enforcement of the *Olmstead* mandate.

With every year that passed in the last Administration, it appeared that federal efforts to spur *Olmstead* enforcement waned. This report highlights problematic trends like this and recommends a more effective, aggressive federal approach to bring about community integration. The research for the report was largely completed in September 2009. Since that time new leadership has been appointed to the U.S. Department of Justice (DOJ) and we've seen a renewed focus on *Olmstead* enforcement. Some welcome signs include:

- DOJ has been more proactive to reach out to members of the disability community to identify potential *Olmstead* cases where their participation might advance the law and help to clarify questions that remain unsettled after the Supreme Court's decision. Questions which, if resolved, may remove barriers to individuals transitioning to the community.

- Recent DOJ investigations and filings under the Civil Rights of Institutionalized Persons Act (CRIPA) have made clear that *Olmstead* issues are deeply intertwined with problems of inadequate conditions, and solving these problems must look at whether the people in the facility belong there and whether the institution is complying with laws governing discharge planning and transition.

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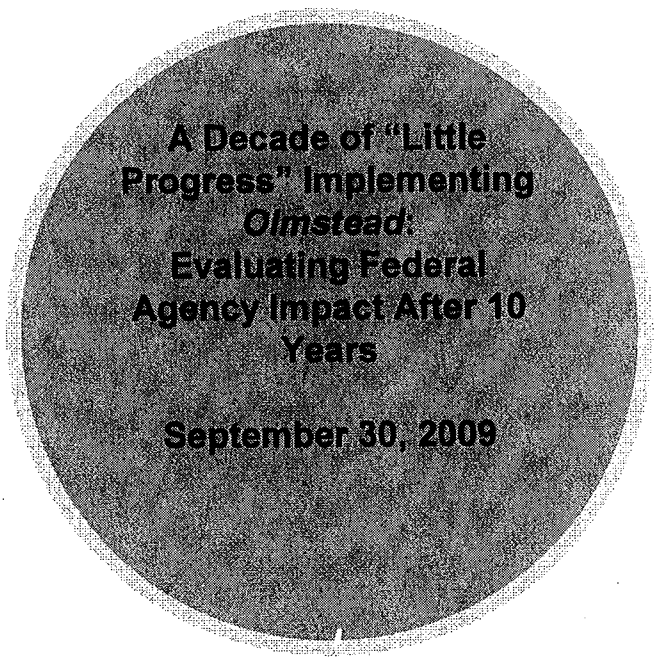
Hopefully, we will see a similar sense of urgency at the new HHS, Office of Civil Rights; and this aggressive commitment to enforcement of the Olmstead mandate will continue throughout the full Obama Administration and beyond. The ebbs and flows of budgets may pressure DOJ and the U.S. Department of Health and Human Services (HHS) to slow their commitment. However, America can't afford to slow down community integration. We have a generation of baby boomers facing disabilities as a result of aging, and thousands of recently wounded Iraq and Afghanistan veterans who deserve a future outside of institutions.

Sincerely,

Curtis L. Decker
Executive Director

NATIONAL
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NETWORK

Protection & Advocacy for Individuals with Disabilities



NDRN is the nonprofit membership organization for the federally mandated Protection and Advocacy (P&A) Systems and Client Assistance Programs (CAP) for individuals with disabilities. Collectively, the P&A/CAP network is the largest provider of legally based advocacy services to people with disabilities in the United States. NDRN provides legally based assistance to P&As and works at the national and state levels to create a society in which people with disabilities are afforded equality of opportunity.

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NDRN calls for more urgent federal action to compel compliance with the civil right to live in, work and enjoy the community.

EXECUTIVE SUMMARY

A decade ago, the U.S. Supreme Court ordered States to stop unnecessarily segregating individuals with disabilities in institutions in order to receive long term services.1 Yet, ten years later, there has been little national progress moving people with disabilities out of nursing facilities and public institutions and into communities with supports.2 People who want to live with their families and neighbors are still needlessly confined in large public and private institutions. NDRN calls for more urgent federal action to compel compliance with this civil right.

The National Disability Rights Network (NDRN) reviewed the efforts of the U.S. Department of Justice (DOJ) and the U.S. Department of Health and Human Services (HHS) -- two agencies charged with enforcing the Supreme Court's mandate. At HHS, we found a reliance on short-term voluntary financial incentives to encourage state compliance, coupled with a lack of monitoring and data collection about the effectiveness of these efforts. At DOJ, we found a lack of attention to enforcement of the ADA's integration mandate and many missed opportunities. Particularly when compared to DOJ's heavy focus on the need to fix up those crumbling old institutions that have a history of failing to keep its residents safe from abuse and neglect, this approach is an affront to people waiting – often for decades -- in inappropriate institutions for the opportunity to return to the home communities.

The Obama Administration has announced that 2009 will be the "Year of Community Living."3 This is a hopeful sign of a renewed federal commitment to ending unnecessary institutionalization. There is no more time to waste. Our society is aging and more people are in need of community supports to remain employed and at home. Neither must we fail the hundreds of recent veterans who may return home to face institutionalization because of an inadequate community supports.

This report offers stories of individuals who are unnecessarily institutionalized and recommends practical strategies for HHS and DOJ to do more to spur compliance with

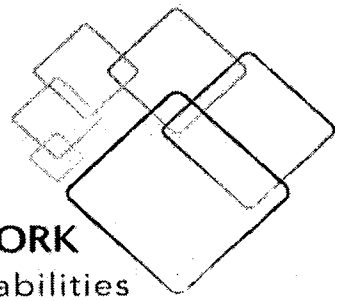
1 *See Olmstead v. L.C. ex rel Zimring*, 527 U.S. 581(1999) holding that it is a violation of the Americans with Disabilities Act (ADA) to unnecessarily segregate an individual in an institution to receive care when these supports could be provided in the community.
2 *See* Braddock *et al.*, State of the States in Developmental Disabilities, University of Colorado 2008 at 101-305. (Some states have made significant progress moving individuals into appropriate community settings. However, a handful of states have actually increased their institutional populations.)
3 http://www.ich.gov/readmore/THE_YEAR_OF_COMMUNITY_LIVING.htm

Americans' civil right to remain living and working in the community. Americans waiting to leave institutions include both adults and children. For example:

Dan Smith (not his real name) is in his thirties and has Down Syndrome resulting in a mild intellectual disability. He successfully lived with his family in the community until 15 years ago when both his parents passed away, then he was moved into a 96-bed institution. He is capable of taking care of his needs, and can read, knows how to balance a checkbook, and held a job at a video store until the store closed. He is known as friendly with an engaging sense of humor. Mr. Smith would very much like to move to a small community-based group home in a setting closer to one of his siblings. He is frustrated after living so many years in an institution with very little privacy and severe limits on his choices, including those as basic as when to get up in the morning or when to turn out his reading light at night. His doctors at the institution have determined that the community would be more appropriate for Mr. Smith, but he remains needlessly confined in the institution.

David (not his real name) is 8 years old and has intensive mental health needs. He is eligible for Medicaid and his mother has asked for the therapeutic home-based mental health services that his doctor has prescribed. Medicaid has denied these medically necessary home based services and as a result, on numerous occasions, David has been forced to leave his family and go to the state hospital in order to obtain limited, episodic mental health treatment. At his young age removal from his family adds to the trauma he already experiences from his psychiatric impairment. David is at a critical period of development in his life. Denial of the services he needs like case management, crisis intervention, and in-home supports is causing long-term damage that can affect his later ability to live successfully in the community.

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A Decade of "Little Progress" Implementing *Olmstead*: Evaluating Federal Agency Impact

The *Olmstead* Decision: A Mandate for Community Integration

A decade ago, In *Olmstead* v. *Lois Curtis and Elaine Wilson* the U.S. Supreme Court ruled that unjustified institutional isolation of people with disabilities is a form of discrimination under the Americans with Disabilities Act.[4] To remedy or avoid such discrimination, States are required to provide community-based services for persons with disabilities, who are otherwise entitled to institutional services, when:
1) the State's treatment professionals reasonably determine that community placement is appropriate;
2) the person does not oppose such placement; and,
3) the placement can reasonably be accommodated, taking into account resources available to the State and the needs of others receiving state-supported disability services.[5]

The ADA's reasonable accommodation regulation does not require states to make "fundamental alterations" in its services or programs.[6] However, just what constitutes a fundamental alteration has been the subject of much litigation over the past decade.[7] Significantly, however, the Court said that States can show that they are reasonably accommodating persons with disabilities if they develop a comprehensive, effectively working plan for placing qualified individuals in less restrictive settings, and a waiting list that moves at a reasonable pace not controlled by a State's efforts to keep its

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4 *Olmstead*, 527 U.S. at 597.
5 *Id.* at 607
6 *Id.* at 595
7 *See e.g.: Radeszewski v. Maram*, 383 F.3d 599, 613-14 (7th Cir. 2004); *Fisher v. Oklahoma Health Care Auth.*, 335 F.3d 1175, 1182-83 (10th Cir. 2003); *Townsend v. Quasim*, 328 F.3d 511, 520 (9th Cir. 2003);*Pennsylvania Protection and Advocacy, Inc. v. Pennsylvania Dept of Public Welfare*, 402 F.3d 374 (3d Cir. 2005); *Frederick L. v. Dept of Public Welfare*, 364 F.3d 487 (3d Cir. 2004), and *Sanchez v Johnson*, 2005 WL 1804195.

institutions fully populated.[8]

Data Shows Little National Progress Providing Disability Supports in the Most Integrated Settings Appropriate to the Individual

The data over the past 10 years shows only a modest 11% reduction, nationwide, in the numbers of persons with intellectual disabilities living in public or private institutions (with 7 or more beds). In 1998, the number was 182,490 and in 2006, the number was 159,909.[9] The data for individuals with mental illness living in state hospitals is similarly disappointing. Twenty years of national state hospital census data (1984-2003) were used to assess trends in the rate of declines from pre- to post-*Olmstead* periods. The data shows a steady decline in census over 20 years, but the decline has slowed significantly during the post-*Olmstead* period.[10]

On a state level, the level of progress varies greatly. Some States have made dramatic progress reducing the number of individuals with intellectual disabilities (the data is not available for individuals residing in state hospitals) residing in institutions, while a few states have made no progress.[11] As of 2006, the states with the fewest amount of individuals with intellectual disabilities living in their own homes or small group homes (homes with 6 or fewer persons) are: Alabama, Arizona, Georgia, Illinois, Kentucky, Mississippi, South Carolina, Texas, Utah, and Virginia.[12] Another way of measuring progress is to look at the percentages in which States have lowered their spending on institutions. Unfortunately, seven States failed to lower their level of spending on institutions for individuals with intellectual disabilities[13] in the decade between 1996 and 2006, including: Connecticut, Iowa, Kentucky, Louisiana, Mississippi, Nebraska, and New Jersey.[14]

Statistics also show that, nationwide, America continues to spend a greater percentage of its Medicaid long-term-care dollars in institutions rather than on community supports and services. According to a report by Thompson/Reuters, in FY 2007, nationally, only 42% of all Medicaid long term care costs where spent on community-based services, including, home and community-based (HCBS) waivers, the personal care option, and the home health services option. During the same period, 58% if all Medicaid long term care dollars were spent on institutional care, including nursing facilities and intermediate care facilities (ICF) for individuals with intellectual disabilities.[15]

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8 *Olmstead,* 527 U.S. at 605-606.
9 State of the States in Developmental Disabilities, at 308.
10PSYCHIATRIC SERVICES ♦ ps.psychiatryonline.org ♦ October 2006 Vol. 57 No. 10, p. 1. *State Psychiatric Hospital Census After the 1999 Olmstead Decision: Evidence of Decelerating Deinstitutionalization* , Mark S. Salzer, Ph.D., Katy Kaplan, M.Ed. and Joanne Atay, M.A.
11 Braddock,at 101-305 (state profiles)
12 *Id.* at 19.
13 The author could not find information on level of spending for state hospitals for individuals with mental illness by state.
14 *Id.* at 9. .
15 Medicaid Long-Term Care Expenditures in FY 2007, September 26, 2008, By Brian Burwell, Kate Sredl, and Steve Eiken, Healthcare Thomson Reuters, 1 (http://www.ancor.org/issues/Data-Statistics/Data-Statistics.html).

The data can be broken out differently to reveal that the shift to community-based care is particularly slow for elderly persons and persons with disabilities other than intellectual disabilities. Specifically, if funding for ICFs is removed, 69% of Medicaid long term care services were spent in state hospitals and nursing facilities and only 31% on community-based services.[16]

The slow shift of funding towards community services for the elderly and persons with mental or physical disabilities is in sharp contrast to an AARP survey showing that "89% of people 50 years and older intend to remain in their own homes rather than go to nursing facilities."[17] The failure to shift dollars to the community also makes no fiscal sense, as demonstrated by a recent AARP study which showed that "[O]n average, Medicaid dollars can support nearly three older people and adults with physical disabilities in Home and Community-Based Services (HCBS) for every person in a nursing home."[18]

So why have some States made significant progress complying with the ADA's integration mandate and others made none? Generally, it is due to a lack of leadership, a lack of responsiveness to the requests or demands of persons with disabilities, and a lack of compliance with federal law. Sometimes, there is opposition to downsizing or closure of an institution among some family members of those in institutions or by unions whose members work in institutions. In addition, legislators representing districts where institutions are situated can be protective of the economic and other benefits they derive from the institutions. The Illinois P&A, known as Equip for Equality, studied this phenomenon in their State and learned

> that it is possible to address the concerns of parents of institutional residents, unions, and political representatives without reneging on the state's responsibilities to people with disabilities and their right to live in the least restrictive setting. Common strategies for overcoming opposition to community living included having parents and guardians of family members in the institutions meet with parents whose children have successfully transitioned into the community. Additionally, parents and guardians were sometimes apprised of the many longitudinal studies that show that, despite initial opposition to deinstitutionalization, parents of individuals in institutions had come to view the experiences of their family members in the community as positive, affording a better quality of life than the institution. In the case of unions, their concerns have often been addressed by finding jobs for their members in state-operated community residences or elsewhere in state government.[19]

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16 *Id.* at Table I Medicaid expenditures for long-term care services FY 2007.
17 Across the States Profiles of Long Term Care and Independent Living" (http://assets.aarp.org/rgcenter/il/d19105_2008_ats.pdf), 3
18 *Id.*
19 SEGREGATION OR COMMUNITY INTEGRATION: ENSURING THE CIVIL RIGHTS OF PEOPLE WITH DEVELOPMENTAL DISABILITIES IN ILLINOIS (2004) 4 HTTP://WWW.EQUIPFOREQUALITY.ORG/PUBLICATIONS/CIPPREPORT.PHP

The Federal Government Has A Key Role In Ending Unnecessary Institutionalization

In 2001, recognizing the leadership role that federal agencies can have to facilitate *Olmstead* implementation, then President Bush signed Executive Order 13217, which required all federal agencies to evaluate their regulations, policies, and programs to determine whether any should be revised or modified to improve the availability of community-based services for individuals with disabilities.[20] The two federal agencies we are reviewing in this report, the U.S. Department of Health and Human Services; and the U.S. Department of Justice completed this evaluation and identified numerous steps they could take to facilitate community integration.[21]

A. U.S. Department of Health and Human Services

The Department of Health and Human Services (HHS) Office of Civil Rights (OCR) is primarily responsible for ensuring that HHS policy promotes access to home and community-based services for individuals with disabilities. As part of that effort, the HHS Centers for Medicare and Medicaid Services (CMS) also has a role to ensure that Medicaid policy is administered in a manner that does not lead to unnecessary institutionalization. Both of these agencies have focused on enforcement but could be much more aggressive and transparent in their efforts.

Office for Civil Rights, U.S. Department of Health and Human Services

OCR is the agency primarily responsible for ensuring that state HHS agencies comply with Olmstead. In this role they immediately began educating states about *Olmstead*'s requirements and the possible implications for HHS programs. In particular, OCR advised states concerning development of a comprehensive effectively working plan for moving unnecessarily institutionalized persons into the community.[22] On January 14, 2000, OCR and CMS issued a joint letter to state Medicaid Directors indicating that state plan development would be an initial focus of OCR's enforcement efforts. It reads:

> Our intent in this enclosure is to identify some of the key principles, including the involvement of people with disabilities throughout the planning and implementation process. These principles also will be used by the Office for Civil Rights as it investigates complaints and conducts compliance reviews involving "most integrated setting" issues. We strongly recommend that States factor in these principles and practices as they develop plans tailored to their needs.

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20 See: http://www.presidency.ucsb.edu/ws/index.php?pid=61498

21 For the DOJ and HHS responses to EO 13217 *see* http://www.namiscc.org/newsletters/December01/hhs-report.htm

22 *Olmstead* at 605-606 (The Supreme Court had ruled that such a plan would provide states with a fundamental alteration defense to a judicial finding that the state is in violation of the ADA integration mandate).

This letter also signaled to states that OCR would be investigating complaints and conducting compliance reviews. This program guidance from HHS was a standard against which states and advocates could monitor and assess *Olmstead* compliance. The other component of OCR's enforcement efforts was to encourage disability advocates to file complaints with their office on behalf of individuals who were unnecessarily institutionalized. Unfortunately, neither OCR's intent to hold states accountable to Olmstead plans, nor its outreach to citizens to file *Olmstead* complaints, was implemented effectively.

For example, OCR's push for disability advocates to file *Olmstead* complaints, was followed up by an investigation process that frequently excluded the individuals who filed complaints. While not universal, many OCR regional offices failed to acknowledge receipt of complaints or follow-up regarding the outcome of the investigation. The "closed" investigation process also meant that, with a few exceptions, OCR has not consulted with protection and advocacy agencies (P&As) or other advocates when investigating a complaint. P&As could provide OCR investigators with information to help them determine whether the violation is restricted to one resident or is evidence of a systemic failure within the institution.

OCR's non-transparent approach to its investigations persists at the national level as well. The Office has released only raw data and minimal details about investigations and compliance reviews conducted. In the future, we urge OCR to release more information about the process used and specific outcomes of its *Olmstead* complaint investigations. Better data would help states and advocates to assess state compliance efforts, and tell us if OCR is resolving complaints on a systems level. For example, releasing data on the particular settings that are the subject of *Olmstead* complaints, would allow P&As to identify which facilities are frequent settings of Olmstead complaints. With this information P&As and advocates would know to reach out to these facilities with training and information on best practices for conducting community needs assessments and discharge planning.

OCR efforts to monitor state *Olmstead* plan development and implementation has also been less aggressive and transparent than what is needed to ensure *Olmstead* compliance. HHS's January 2000 guidelines for state plans seemed promising, but there is no evidence that, after 2002, states plans were reviewed to ascertain compliance with these guidelines.[23]

At a minimum, OCR needs to begin, on an annual basis, tracking whether states are making progress reducing their institutional census or decreasing institutional spending. States that are not making noticeable progress ending inappropriate institutionalization should be feeling public pressure from OCR to make changes or face a DOJ lawsuit. OCR could also track which states have applied for the federal grants made available

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23 In 2002 the US DOJ did issue a letter of corrections that cited Olmstead and referred to the guidelines for "state Olmstead plans" that were set out in the January 2000 letter, *See* http://www.usdoj.gov/crt/split/documents/laguna_honda_hosp.pdf

over the past decade to incentive state spending on home and community-based services. Those states that did not apply for any of these programs could be prioritized for OCR technical assistance and assessment of Olmstead compliance. OCR should also put the U.S. Department of Justice on notice that these states may be violating the *Olmstead* mandate.

Data shows that seven states have failed to decrease their spending on institution services, [24] Yet, OCR does not appear to have questioned these states *Olmstead* compliance efforts. If OCR has done so secretly, it is time to break the silence. Reprimanding a state secretly is not nearly as effective an enforcement tool as if the state is publically warned to increase its compliance efforts.

On a funding level, OCR's ability to enforce *Olmstead* aggressively over the past 10 years has been hamstringed. In the year of *Olmstead*'s passage, a Commission report stated that:

> OCR operates under severe budgetary constraints . . . OCR's responsibilities and workload have increased over the past several years, yet its funding and staffing have decreased. OCR's budget has fluctuated around $20 million since 1981, and has not kept up with inflation.[25]

Three years later the Annual budget for OCR was not significantly increased[26] and yet OCR enforcement responsibilities had greatly expanded to include not only oversight of Olmstead, but also of the Health Insurance Portability and Accountability Act. Happily, this funding trend is beginning to change. The 2008 -2009 budget contained a six million dollar increase, and the 2009-2010 budget has a slight one million dollar increase. A tight budget however, does not excuse a failure to approach Olmstead enforcement more systemically and to reach out to P&As and disability advocates as a component of its enforcement reviews. Neither should it mean so few compliance reviews are conducted, nor effect whether details of these reviews are made known to the public.

Centers for Medicare and Medicaid Services (CMS), Department of Health and Human Services

CMS can provide the regulatory framework for States to rebalance Medicaid long-term care funding to facilitate community integration. Unfortunately, over the past 10 years, CMS has not appeared aggressive in its efforts to look for policy changes that would promote community integration. First let's switch from what CMS could have done to what the U.S. could have done to promote compliance with the Olmstead mandate. The U.S. Congress has not been as helpful as it could be to advance movement from institutions to the community. Specifically, Congress has passed mainly short term

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24 Braddock at 9.

25 U.S. Commission on Civil Rights - Funding Federal Civil Rights Enforcement: 2000–2003, published April 2002 available at: http://www.usccr.gov/pubs/crfund02/report.htm

26 Budget of the United States Government, Fiscal Year 2003, at 466.

financial incentive programs that states can voluntarily apply for in order to receive funding to promote movement from institutions to the community. Some of the major financial incentives Congress has passed over the past decade include:

- Congress in 2000 created the Real Choice Systems Change grant program. Between June 2001 and June 2008, over 8 funding cycles, 342 Real Choice Systems Change grants have been issued awarding approximately $270 million to the 50 states, the District of Columbia and two U.S. territories27.

- Section 6071 of the 2005 Deficit Reduction Act, created the Money Follows the Person Rebalancing Demonstration, which makes it easier for states to apply for home and community based waivers. The program authorized $1.7 billion in grants to states and lasts from 2007-2011.

- Another section of the Deficit Reduction Act established a demonstration program so people with disabilities will receive a single comprehensive assessment on the date of discharge from a hospital. The purpose of the "comprehensive assessment" is to "determine the appropriate placement of such patient in a post-acute care site. The "assessment instrument" establishes a presumption for community-services, and a hospital protocol that focuses on home and community-based services.

- the Health Insurance Flexibility and Accountability Initiative, one aspect of which is to make it simpler and easier for states to submit waiver requests and to have those requests promptly considered.

These programs have been vital to some states that have moved individuals out of inappropriate institutions and into the community with supports28. However other states applied and did not receive funding or never even applied for funding. Another big problem with Congressional reliance on short-term grants to re-balance Medicaid is the constant threat that as the *Olmstead* decision becomes a distant memory Congress will shift their funding to newer priorities and *Olmstead* grants will dry up.

It would be much quicker if Congress facilitated Olmstead compliance by changing the Medicaid statute. Current Medicaid law makes it mandatory for all states that participate in the Medicaid program to provide institution based care for those who need it. On the

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27 http://www.cms.hhs.gov/RealChoice/

28 The largest of these grants is the Real Choice Systems Change grants, which include: the Money Follows the Person Initiative; the Independence Plus Initiative; a national state-to-state technical assistance program for community living at Rutgers University; family-to-family health care information and education centers; community-based treatment alternatives for children; respite care for children; and technical assistance for consumer task forces; respite care for adults; and 2 demonstration projects, including, one to assess a new definition of homebound for purposes of Medicaid coverage; and the second, to attract and retain home health workers.

other hand, there is no requirement for states to provide home and community based services for those who need it, provision of these services is optional. This is known as Medicaid's institutional bias and it is a statutory requirement that hinders compliance with the Olmstead mandate. For nearly a decade, some members of Congress have introduced bills attempting to correct the institutional bias in Medicaid law. 29 Unfortunately, these bills have not passed.

Switching from what Congress to do, back to what CMS can do to enforce Olmstead, there are many ways CMS can promote *Olmstead* enforcement without needing Congressional action. Over the past decade CMS has done some work in this area, but with national data still showing that more funding goes to institutions than to the community, it is clear more needs to be done. Some examples of CMS *Olmstead* related efforts in the past decade include:

- clarifying that Medicaid waiver funds can be used to cover one-time transition costs associated with moving and to purchase medical equipment for nursing facility residents in the process of transitioning to the community;

- providing guidance on how to use existing CMS Medicaid data (known as minimum data set) to identify individuals who are in nursing facilities and have indicated an interest in moving to the community with supports. The guidance also discussed the reasonable accommodation requirements of Title II of the ADA.

- working with HUD to coordinate Medicaid HCBS transition programs with HUD housing. Collaboration is vital because Medicaid does not pay for room and board. Some examples of CMS coordination with HUD over the past decade, include: the Access Housing initiative which targeted 2000 vouchers over 5 years for persons transitioning out of nursing facilities; awarding funds to housing authorities to improve accessibility in public housing; and removing policy barriers that made it difficult for people with disabilities to utilize housing vouchers.

CMS policy has not always supported community integration, however. For example, on December 4, 2007, CMS issued an interim final rule on case management services. The rule restricted payment for transitional case management, a vital support for individuals with disabilities. Advocates and providers submitted comments to CMS arguing that the rule would make it more difficult for community providers to offer individuals with mental illness coordinated mental health, substance abuse, and primary care.30 Despite knowledge of its negative impact, CMS went forward with the rule.

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29 Examples of allowing individuals eligible for skilled nursing facility care to receive community based attendant services, include: The Medicaid Community Attendant Services and Supports Act (S. 971); the Community Choice Act (CCA) (S683/HR1670) and the Community First Choice Act included in a 2009 Senate health reform proposal.

30 http://www.ncd.gov/newsroom/publications/2009/pdf/ProgressReport.pdf at 33.

CMS has also failed to accept advocates recommendations on low-cost, simple ways to remove administrative barriers to community integration. For example: broadening state authority to cover "nurse delegated" services (nursing services that a nurse can legally delegate under state law to a lower level qualified provider – thus reducing the cost and increasing the possibility that an individual can find a community-based provider of the needed service); and prohibiting states from requiring that beneficiaries be homebound before they can receive home health services. This reluctance to remove known regulatory barriers to community integration – perpetuates the feeling that *Olmstead* compliance is not taken as seriously as a civil right.

The good news is that the current Administration was willing to partially rescind the harmful rule on Medicaid coverage of targeted case management, May 6, 2009. Also that summer, the Administration broadened state authority to cover "nurse delegated services" and loosened Medicare's homebound requirements. Another positive step forward is the recent draft regulations which would eliminate the diagnosis based criteria for Medicaid waivers, and replace it with the more encompassing "needs based" criteria. Hopefully, these long awaited regulatory fixes will continue.

One area ripe for HHS program guidance relates to the connection between Pre-Admission Screening and Resident Review (PASRR) and *Olmstead* enforcement. PASRR is a provision of federal Medicaid law.[31] It requires states to screen individuals with intellectual disabilities or mental illness prior to placing them in a nursing facility, to determine whether the individual requires nursing facility level services or whether their needs can be met in the community. PASRR is designed to prevent inappropriate placement of people with intellectual disabilities or mental illness in a Medicaid certified nursing facility when community living is appropriate. PASRR also requires states to provide people with these disabilities living in nursing facilities with the therapy and health care that would assist them to be able to move to the community.

In 2006 The HHS, Substance Abuse and Mental Health Services Administration, issued a report on PASRR implementation in nursing facilities and found that 34 states have "some consideration of PASRR within the broader context of their Olmstead planning"[32]. HHS went on to recommend that CMS "Increase guidance to States, clarify/modify certain regulations."[33]

CMS should fulfill this recommendation and issue guidance clarifying that: 1) a PASRR determination that a nursing facility is needed should only be made by a staff member adequately trained in meeting mental illness needs; and 2) If an individual is found to require specialized services to treat their mental illness, the State Medicaid agency ultimately is responsible for providing or arranging for provision of those specialized

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31 Nursing Home Reform Act under the Omnibus Reconciliation Act (OBRA) of 1987, as amended by OBRA 1990, 42 USC 1396r (e) (7), later revised by the Balanced Budget Act of 1996.
32 "PASRR Screening for Mental Illness in Nursing Facility Applicants and Residents" at: http://nasmd.aphsa.org/medicaid_mental/docs/PASRR_Screening_for_Mental_Illness_in_Nursing_Facilities.pdf page 35.
33 *Id.* at 37.

services.. The guidance would also encourage states to: 1) have a policy linking people found eligible for "skilled nursing facility level of care" to appropriate community based services to support these needs; 2) request permission from CMS to obtain and use Medicaid data to identify people in nursing facilities who have indicated they wish to leave; and 3) expand PASRR reviews to include individuals with brain and spinal cord injuries.

B. The U.S. Department of Justice (DOJ)

Civil Rights Division, U.S. Department of Justice

The DOJ Civil Rights Division (CRD) has enforcement authority for the ADA Title II, and the "integration mandate" regulation. Yet, a CRD October 2008 report to Congress on DOJ enforcement of the Americans with Disabilities Act "*Access for All: Five Years of Progress Enforcing the ADA"* includes no mention of the *Olmstead* decision or any Division efforts to enforce the integration mandate of Title II. This is not to say that the DOJ has not enforced *Olmstead*, it has done so, but it has never brought a suit primarily to ensure *Olmstead* compliance.

As of the time this research was completed, in September 2008, DOJ *Olmstead* enforcement has been a secondary outcome of DOJ's main focus which is squarely on enforcement of the Civil Rights of Institutionalized Persons Act (CRIPA). CRIPA allows the DOJ to investigate conditions in public residential facilities and to take appropriate action if they see a pattern or practice of unlawful conditions, such as abuse or neglect that deprives persons confined in the facilities of their constitutional or federal statutory rights. DOJ indicates in its 2008 *Report of Activities to Enforce CRIPA* that one aspect of CRIPA enforcement is to "ensure that public officials operating healthcare facilities are taking adequate steps to provide services to residents in the most integrated setting appropriate to their needs"[34]

From January 20, 2001 through September 30, 2008, the Division opened 94 CRIPA investigations, issued 71 findings letters, filed 32 cases, and obtained 69 substantial agreements.[35] As is the case with U.S. HHS, data available concerning DOJ enforcement of ADA integration mandate is available but is not comprehensive. This National Council on Disability spoke of this problem in a 2005 report stating that:

> In short, DOJ's annual reports make it impossible for Congress or other interested parties to monitor DOJ's work. More important, the absence of strong annual reports undermines DOJ's ability to leverage its work through voluntary compliance and serves to discourage people in institutions from reporting illegal conditions in institutions to DOJ. .. [NCD] *Recommendation:* DOJ should improve its CRIPA enforcement reports to Congress by including the full range of data required under the statute.

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34 Department of Justice Activities Under the Civil Rights of Institutionalized Persons Act Fiscal Year 2008 http://www.usdoj.gov/crt/split/documents/split_cripa08.pdf , 19).
35 *Id.* at 2

> Doing so will increase accountability and enable the public to better understand the Federal Government's enforcement of the rights of people who reside in institutions.[36]

The data we have shows that over the past 10 years CRIPA activities have not focused on integration mandate compliance with the same commitment as it does whether the state plans to fix up institutions that have failed to keep residents safe from abuse and neglect.

A particular frustration documented by NDRN is the DOJ's willingness to sign settlements affecting individuals living in institutions without ensuring that residents will receive services in the most integrated settings appropriate and a failure to collaborate with the P&A systems when completing CRIPA investigations. These frustrations were also expressed by NCD in 2005 in a report to Congress that recommended:

> [CRIPA] Department staff should err on the side of being more, rather than less, prescriptive in case settlements. Department staff should insist on specific outcomes rather than more general policies and procedures to remedy violations and guard against regression when monitoring ends [and] DOJ should make better use of local protection and advocacy agencies charged with investigating abuse and neglect in institutions, and other nonprofit advocacy organizations with well-established records of protecting the rights of people in institutions."[37]

DOJ CRIPA settlements can be an important vehicle for ensuring state *Olmstead* compliance. Yet, an NDRN review of several proposed and approved CRIPA settlement agreements reached by the DOJ between 2005 - 2009 with states and municipalities, revealed that the focus of these settlements was heavily tilted toward improving conditions at facilities and little on ensuring residents will be receiving services in the most integrated settings appropriate to their needs.[38]

In considering the essential provisions for a DOJ CRIPA settlement, minimum requirements for any agreement should include adoption of the principal of providing services in the most integrated setting and the recognition and acceptance that all individuals can be served in the community. A settlement should ensure: individual involvement; informed decision-making and choice; person-centered planning; transition planning; implementation of plans; developing and expanding community capacity; monitoring of community placements; and quality assurance. Until future DOJ settlements focus on community integration, instead of just improving services in already failing institutions, the Department is virtually guaranteeing that institutions remain the *status quo* for individuals with disabilities.

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36 The Civil Rights of Institutionalized Persons Act: Has It Fulfilled Its Promise??, by the National Council on Disability August 8, 2005http://www.ncd.gov/newsroom/publications/2005/personsact.htm#appendixiii

37 *Id.* at "Executive Summary."

38 This report and press release, "National Disability Rights Network Applauds "Year of Community Living", Continues to Question Department of Justice Pouring Millions into Preservation of Failed Institutions," is available at http://www.ndrn.org/media/default.htm

In addition, DOJ should clarify some oft litigated ADA integration mandate questions. One method of clarification is to issue "DOJ findings letters." Excerpted below is an April 2003 DOJ "letter of findings" regarding an agreement entered with San Francisco in July 2001 under its CRIPA authority. The DOJ and HHS, OCR conducted a joint review of the California Laguna Honda Hospital and Rehabilitation Center (LHH) and issued these findings related to the City's compliance with Title II of the ADA. It is one of very few good examples of DOJ clarification of *Olmstead* requirements:

> [DOJ and OCR] have identified several areas of deficiencies that contribute to the unnecessary isolation of qualified residents at LHH. These areas include inadequate assessments, inadequate discharge planning, and inadequate capacity in the community to meet the needs of LHH residents for whom community placement is appropriate[39].

The letter goes on to list specific actions that "at a minimum" LHH and San Francisco must take to remedy including:

> Allocate adequate funding for, or otherwise provide home and community-based services to ensure that LHH residents are not unnecessarily isolated at LHH; and 2) Develop and implement a system-wide assessment of various subcontracted community programs to identify network gaps as well as areas of highest demand, and to provide a basis for comprehensive planning, administration, and resource targeting in San Francisco.[40]

Another mechanism for clarifying integration mandate requirements is by filing or intervening in cases that raise questions about the scope of the legal mandate. As the National Council on Disability (NCD) noted in its 2000 report "Promises to Keep: A Decade of Federal Enforcement of The Americans with Disabilities Act":

> The Department of Justice's ability to enforce ADA is not restricted to waiting for individuals with disabilities to file complaints of violations. Compliance monitoring refers to proactive measures to assess and ensure conformance with the requirements of a law in advance of the report of a violation.[41]

The NCD report further explains that:

> Title II of the ADA ... is subject to the same remedies, procedures, and rights set forth in Section 505 of the Rehabilitation Act of 1973. [which]... is subject to the same remedies, procedures, and rights

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39 *See*,http://www.usdoj.gov/crt/split/documents/laguna_honda_hosp.pdf Page 3.
40 *Id.* at 25.
41 " at: http://www.ncd.gov/newsroom/publications/2000/promises_2.htm
[*See* section 2.4 Compliance monitoring]

> set forth in title VI of the Civil Rights Act of 1964. Under the Department of Justice's regulations implementing Title VI, the Department shall conduct periodic compliance reviews of recipients to determine whether they are complying with Title VI. (28 C.F.R. § 42.107(a).) Thus, through this chain of references, the Department has authority to conduct compliance reviews under [ADA] Title II.42

The Obama Administration has indicated that it intends to move in this direction. Hopefully, future reports will show examples of DOJ cases brought to enforce the Olmstead mandate; DOJ intervention to support plaintiffs in Olmstead cases brought by private attorneys; strong community integration requirements in all relevant CRIPA settlements; and a focus on the importance of person-centered transition planning; and Olmstead compliance in all relevant CRIPA investigations.

Other methods of DOJ *Olmstead* guidance need to continue. For example, it is vital that DOJ clarify the meaning of the language in *Olmstead* which states that, "Nothing in the ADA or its implementing regulations condones termination of institutional settings for persons unable to handle or benefit from community settings."43 A few courts have held that states must maintain institutions just so that individuals living in an institution can remain in their current institution.44 The majority of courts, however, have held that there is nothing in *Olmstead* that suggests that a state has to provide institutionalized care at the facility of the resident's choosing. The integration mandate is simply the right to be transferred to a community placement, if medically appropriate and if the State can reasonably accommodate the placement.45

Just as vital is the need for DOJ advice on what constitutes a fundamental alteration in the context of the *Olmstead* decisions. This could include guidance on the interplay between Medicaid waiver cost caps and the integration mandate and re-iteration of the necessary components for a comprehensive effectively working state plan for moving individuals into the most integrated settings.

INDIVIDUALS WAIT NEEDLESSLY IN INAPPROPRIATE SETTINGS

P&As hear from dozens of people each year seeking assistance to avoid or move out of nursing facilities, intermediate care facilities and state hospitals, and return to their own homes, neighborhoods and communities with supports. The stories of just some of these individuals follow.

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42 *Id.*

43 *Olmstead v L.C. and E.W.* at 601-602.

44 These arguments have been presented most powerfully and consistently by the Voice of the Retarded

45 *See, Richard C. ex. Rel. Kathy B. v. Houstoun,* 196 F.R.D. 288, 292 (W.D. 1999) aff. *sub. nom, Richard C. v. Snider,* 229 F. 3d 1139 (Table) (3d Cir. 2000). By its specific terms, the integration mandate requires movement from more to less restrictive settings, not the reverse. *See, Richard C. v. Houston,* 196 F.R.D. 288, 291-92 (W.D. Pa. 1999).

A 55 year old client with mild intellectual disability and anxiety disorder had been living in a state-operated residential facility since 1969. Because of her anxiety, the client was afraid of the extensive dental work she needed. In 2008, a PADD advocate of the Office of Protection and Advocacy for Persons with Disabilities (the Connecticut P&A) helped the client try an anti-anxiety medication and begin a desensitization process of regular dentist visits. As a result, the client had several successful dental appointments, has made positive strides, and is making a plan for community placement.

A 16 year old girl lived at a state hospital for approximately 8 months due to self-inflicting, harmful behaviors. The client lived in one particular foster home in her home county where she wished to return upon discharge. The hospital agreed she was no longer a suicide risk, but had made no plans for her release. The client's former foster parent called Disability Rights Wisconsin (the Wisconsin P&A) to get her out of the hospital. P&A staff attended discharge planning meetings and helped to prepare an appropriate plan of services. She now lives with the foster family of her choice and is doing well in the community.

Indiana Protection and Advocacy Services (the Indiana P&A) helped a 23-year-old man with quadriplegia from a spinal cord injury who wished to remain in his temporary home, given to him through community placement. The client was happy with the fully-accessible home in which he had a spacious room, roll-in shower, and private deck. However, his insurance company and case manager informed him that the placement was only temporary. The client's provider determined he could stay if he received more hours of personal care assistant (PCA) supports. At the client's request, PAIR staff helped him complete and submit a PCA appeal to the Department of Human Services (DHS), which determined he needed a higher number of PCA hours for proper care. The increased PCA hours enabled the client to remain in his chosen home where he is currently enjoying freedom to date his girlfriend, investigate post-secondary school options, and maintain his health.

A 41 year old female with traumatic brain injury, intellectual disabilities and substance abuse, contacted DisAbility Rights Idaho (the Idaho P&A) while residing at a state facility. The client requested assistance to enter into a community outpatient addiction recovery rehabilitation program she was told was necessary prior to a discharge from the facility. PAIMI staff ensured that her discharge was planned and helped facilitate transportation in the community. As a result of PAIMI intervention, the client completed appropriate programming, was discharged, and is living independently in the community with community supports.

Ohio Legal Rights Service (the Ohio P&A) helped a client who lived in a nursing facility for more than a year and wanted to live in a home or apartment. PAIMI staff attended team meetings and negotiated with staff and the client's guardian to permit discharge to a home of the client's choice. However, the manager denied her application based on presumptions about her ability to succeed in independent housing because of her mental illness. PAIMI staff represented the client at an informal hearing to challenge the denial of her application. The management reversed its decision and accepted the

client's application for residency. PAIMI successfully protected the client from discrimination based on disability, as well as her fair housing rights and right to accommodations.

South Dakota Advocacy Services (the South Dakota P&A) assisted a 67 year old male with severe depression and diabetes. The client's treating physician considered placing him at the state inpatient psychiatric hospital because he feared the client lacked the ability to take care of his medical needs at home. PAIMI staff contacted the state's adult services department regarding funding and home health care service options. PAIMI staff also contacted several of the client's support systems in the community. A civil commitment hearing was scheduled, and PAIMI staff met with the client's court appointed attorney and the qualified mental health professional conducting an evaluation to determine whether to recommend long-term psychiatric care. Because of PAIMI involvement, the petition for commitment was dismissed and the client was discharged with more services and supports in place to continue living independently in the community.

Disability Rights Oregon assisted a 12 year old with autism and bi-polar avoid institutionalization and obtain appropriate community supports. The child's mother called requesting assistance accessing services for son. The school had told her that the child was not welcome to return to any of the schools in the rural district. The district told the mother that in order to get needed services she should sign over her parental rights and make her son a ward of the state. The district said that if client hurts his sister then the state would take both of the son and daughter away from their mother. The client has episodes where he is emotionally distraught, kicks, throws himself, shakes his head, etc and he can sometimes hurt others in the process. These episodes are part of his disabilities. The district refused the mother's requests for an aide. The P&A helped the mother fight institutional placement. Instead appropriate services were found in a day treatment program. The child is receiving services and still able to return home with his family in the evenings.

RECOMMENDATIONS FOR THE OBAMA ADMINISTRATION

In fulfillment of this Administration's commitment to "The Year of Community Living" HHS and DOJ must move beyond use of voluntary incentives, and spur on stubborn states with mandates. States have had 10 years to beef up their community integration infrastructure. For a handful of states the voluntary approach has been effective – populations and funds are shifting. For the other states the time for voluntary action has expired. In these states people are not moving off of community support waiting lists at a reasonable pace; Olmstead plans have not been implemented and institution censuses have barely declined. This is the Year for Community Living – the time in which civil rights are taken seriously. NDRN urges the following recommendations:

A. **Department of Justice**:

- File and intervene in cases to support full enforcement of the ADA Integration mandate.

- Strengthen the community integration aspects of all future CRIPA settlements.

- Clarify some questions regarding the integration mandate on which federal courts are split

B. Health and Human Services, Office of Civil Rights:

- Prepare an annual report of state institutional census. This would include tracking whether states are making progress reducing their institutional census. States that are not make noticeable progress ending inappropriate institutionalization should be under public pressure from OCR to make changes or face a DOJ lawsuit.

- Work collaboratively with P&As and disability advocates to supplement *Olmstead* compliance reviews.

- Conduct annual reviews in selected states which have failed to implement plans that met the basic components identified in the January 14, 2000 HHS letter to state Medicaid Directors.

- Communicate with DOJ regarding state efforts, or lack thereof, to ensure that individuals receive services in the most integrated settings appropriate to their needs. Issues to report on could include: States which have reduced home and community based programs; States that have not reduced populations in either state hospitals, ICF's, or nursing facility populations; and states that have not applied for Medicaid community integration incentive programs.

C. Health and Human Services, Center for Medicare and Medicaid Services:

- Continue to collaborate with HUD, including announcing an expectation that State Medicaid Agencies will coordinate funding and programs with state housing finance departments, and state community development agencies;

- Issue guidance to clarify PASRR requirements focusing on its role in promoting community integration and preventing unnecessary placement in a

nursing facility. Coordinate with DOJ to facilitate better enforcement of PASRR requirements.

- Issue guidance clarifying that EPSDT can cover teenagers from 18 to 21 and explaining promising practices in transition services.

- Issue guidance offering best practices in short-term mental health crisis services. States that increase their crisis service capacity can minimize costly and disruptive hospitalization.

CONCLUSION

This report has highlighted problematic trends in the federal approach to enforce the *Olmstead* decision over the past decade. It is simply unacceptable, that after ten years there has been little progress in reducing the numbers of Americans with disabilities, nationwide, who live in institutions. The National Disability Rights Network offers this report and recommendations with the hope that federal enforcement of the Olmstead mandate by the U.S. Department of Justice and the U.S. Department of Health and Human Services -- the two agencies charged with enforcement – will turn the promise of the *Olmstead* decision into a reality for all individuals languishing needlessly in institutions.

NATIONAL DISABILITY RIGHTS NETWORK

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National Disability Rights Network Applauds "Year of Community Living", Continues to Question Department of Justice Pouring Millions into Preservation of Failed Institutions

[Print]

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Washington (July 22, 2009) - The National Disability Rights Network (NDRN) applauds President Obama's proclamation of the "Year of Community Living," but decries the Department of Justice's continued support of segregation of persons with disabilities. The recent proclamation of the "Year of Community Living" from President Obama and the follow-up of specific programs from the Department of Health and Human Services are important steps to the full integration of people with disabilities

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into the community. However, across the Washington Mall at the Department of Justice (DOJ), actions by the Special Litigation Section of the Civil Rights Division continue to force states to funnel millions of precious state dollars into maintaining outmoded, discriminatory, and dangerous facilities that will warehouse people with disabilities for generations to come.

On June 22, 1999, the U.S. Supreme Court, in *Tommy Olmstead v Lois Curtis and Elaine Wilson,* ruled that unnecessarily segregating an individual into an institution when community supports exist is a violation of the American with Disabilities Act (ADA) Title II. Specifically, the regulations covering Title II of the ADA , 42 U.S.C. § 12131, *et seq.*, and its implementing regulations at 28 C.F.R. § 35.130(d) contain what is commonly called "the integration mandate," requiring states to provide community-based services for persons with disabilities who are otherwise entitled to institutional services, when certain factors are met.

Despite the ruling in *Olmstead*, the Department of Justice continues to carry out the Bush Administration practice of forcing states to "fix up" facilities that many states have abandoned as unworkable and unsafe settings for people with disabilities to live. A review by NDRN of proposed and approved settlement agreements negotiated by DOJ under the Civil Rights of Institutionalized Persons Act (CRIPA) clearly shows the failure of the DOJ to creatively work to move people into the community in a planned and safe manner, in opposition to the will of a vast majority of disability advocates. DOJ's settlements stand in stark contrast to

the litigation brought by Protection and Advocacy agencies and others that have used the dreadful conditions in these facilities to move to a more humane community based system.

If the Administration is serious about its commitment to community integration, it is critical that DOJ CRIPA settlement agreements, including those pending in Texas, Georgia, and other states, be directed toward improving community integration. By wasting hundreds of millions of dollars in taxpayer money on segregated institutions, DOJ is virtually guaranteeing that these failed institutions remain the *status quo* for individuals with developmental disabilities in Texas and elsewhere.

###

The National Disability Rights Network (NDRN) is the nonprofit membership organization for the federally mandated Protection and Advocacy (P&A) Systems and the Client Assistance Programs (CAP) for individuals with disabilities. Collectively, the Network is the largest provider of legally based advocacy services to people with disabilities in the United States.

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Page last updated: 9/15/08

Assumptions

Current Assumptions regarding Seclusion and Restraint Use, prepared by the National Association of State Mental Health Program Directors (NASMHPD), for 2006 TASC Skills Building Conference (Powerpoint Presentation) (References)

Autism

Michigan Autism Society v. Fuller – Complaint filed by Michigan Protection and Advocacy, Inc. on behalf of Michigan Autism Society (May 2, 2005) (declaratory and injunctive relief to prevent inappropriate restraint and seclusion in Michigan school district)

Brochures and Training Tools for P&As

Website Accessibility

Roadmap to Seclusion and restraint Free Mental Health Services, publised by the U.S. Department of health and Human Services, Substance Abuse and Mental Health Services Administration, Center for Mental Health Services (2006). Training Manual to increase the knowledge of mental health service direct care staff, administrators, and consumers on alternatives to the use seclusion and restraint. http://www.mentalhealth.samhsa.gov /publications/allpubs/sma06-4055/

Sample Rights Brochures on Seclusion and Restraint (Dec 2005)

Comfort Rooms:

Comfort Rooms: Reducing the Need for Seclusion and Restraint, by Gayle Bluebird Residential Group Home Quarterly Vol 5 No 4, P5 (Spring 2005)

Deaf/Hard of Hearing

Reducing the Use of Seclusion and Restraint (Part III): Lessons from the Deaf and Hard of Hearing Communities, prepared by the National Association of State Mental Health Program Directors

Debriefing

Restraint and Seclusion Patient Debriefing Form (Iowa Mental Health Institute, Independence Iowa) (Feb 2005)

Developmental disabilities, individuals with

Reducing the Use of Seclusion and Restraint Part II: Findings, Principles and Recommendations for Special Needs Populations, prepared by the National Association of State Mental Health Program Directors **(March 2001)**

Evidence Based Practices

Evidenced-Based Practices Goran Jovanovic and Matthew Johnsen, Restraint and Seclusion: can they become obsolete Practices, Center for

mental Health Services Research, vol 3, issue 2 **(Feb. 2006)** (discuss research about what strategies effectively reduce restraint and seclusion)

Government Accounting Office (GAO) Reports

Improper Restraint and Seclusion Use Places People at risk – The GAO's October 1, 1999 report confirms that there is no adequate system of restraint and seclusion (R/S) reporting at the state level, making it impossible to determine the true level of deaths and injuries that result from R/S abuses and preventing independent agency investigations. GAO calls on CMS to issue regulations which: (1) establish strict standards on the use of R/S in all facilities which receive Medicaid and Medicare, and (2) require reporting to P&As regarding all deaths and serious injuries among those with mental illness or mental retardation indicating whether R/S was used -- for investigation by P&As. (10/5/99) PDF

Hartford Current articles

A Five-Part Series published in The Hartford Courant, beginning on October 11, 1998. Go to: http://www.charlydmiller.com/LIB05/1998hartfordcourant11.html

Leadership

Leadership towards Organizational Change, prepared by the National Association of State Mental Health Program Directors (NASMHPD), for 2006 TASC Skills Building Conference (references)

Medical Risks

Restraint and Seclusion: A Risk Management Guide, by Stephen Haimowitz, J.D., Jenifer Urff, J.D. and Kevin Ann Huckshorn R.N. M.S.N. CAP, ICADC **(Sept 2006)**

The Lethal Hazard of Prone Restraint: Positional Asphyxiation, prepared by Protection and Advocacy, Inc (CA P&A)(April 2002)

In the matter of Neil Larkin: A case study on

restraint, Traumatic Asphyxia and Investigations
by New York Commission on Quality Care and Advocacy for Persons with Disabilities (NY P&A)
(good discussion of dangers of prone restraint)

Organizations working on reduction of seclusion and restraint

A.P.R.A.I.S. The Alliance to Prevent Restraint, Aversive Interventions, and Seclusion, www.tash.org/aprais

The Alliance to Prevent Restraint, Aversive Interventions, and Seclusion was founded in April 2004 by members of the nation's leading education, research and advocacy organizations to protect children from abuse in their schools, treatment programs, and residential facilities. APRAIS is responding passionately to the increasing toll of deaths, injuries, and trauma resulting from the use of inhumane practices in programs serving children and youth with disabilities.

Center for Public Representation, www.centerforpublicrep.org

The Center for Public Representation is organized as a self-sufficient public interest law firm to promote change in the quality of lives of individuals with disabilities in Massachusetts and to pursue the systemic enforcement of legal rights on a statewide and national basis. The Center's primary purpose is to serve people who have or are considered to have disabilities. The Center also may assist, to a limited extent, other people who are institutionalized, discriminated against, or otherwise denied fundamental human rights.

Child Welfare League of America, www.cwla.org

The Child Welfare League of America is the nation's oldest and largest membership-based child welfare organization. It is committed to engaging people everywhere in promoting the well-being of children, youth and their families and protecting every child from harm.

Judge David L. Bazelon Center for Mental Health Law, www.bazelon.org

For three decades, the Judge David L. Bazelon Center for Mental Health Law has been the nation's leading legal advocate for people with mental disabilities. Our precedent-setting litigation has outlawed institutional abuse and won protections against arbitrary confinement. In the courts and in Congress, our advocacy has opened up public schools, workplaces, housing and other opportunities for people with mental disabilities to participate in community life.

NAMI, www.nami.org

NAMI (the National Alliance on Mental Illness) is the nation's largest grassroots mental health organization dedicated to improving the lives of persons living with serious mental illness and their families. Founded in 1979, NAMI has become the nation's voice on mental illness, a national organization including NAMI organizations in every state and in over 1100 local communities across the country who join together to meet the NAMI mission through advocacy, research, support, and education.

National Association of State Mental Health Program Directors (NASHMPD), www.nasmhpd.org

Founded in 1959 and based in Alexandria, VA, the National Association of State Mental Health Program Directors (NASMHPD)

represents the $23 billion public mental health service delivery system serving 6.1 million people annually in all 50 states, 4 territories, and the District of Columbia. NASMHPD (pronounced "NASH-bid") operates under a cooperative agreement with the National Governors Association and is the only national association to represent state mental health commissioners/directors and their agencies.

TASH, www.tash.org

TASH is an international association of people with disabilities, their family members, other advocates, and professionals fighting for a society in which inclusion of all people in all aspects of society is the norm.

Neurobiological and Psychological Effects

The Neurobiogical and Psychological Effects of Trauma, prepared by the National Association of State Mental Health Program Directors (NASMHPD), for 2006 TASC Skills Building Conference (Powerpoint Presentation) (References)

P&A Priorities

Sample Seclusion and Restraint Reduction Priorities of P&As (Dec 2005)

Model Seclusion and Restraint Reduction Priority (Dec. 2005)

Prevention Tools

Seclusion and Restraint Prevention Tools, prepared by the National Association of State Mental Health Program Directors (NASMHPD), for 2006 TASC Skills Building Conference (Powerpoint Presentation) (References)

Prone Restraints

The Lethal Hazard of Prone Restraint: Positional Asphyxiation, prepared by Protection and Advocacy, Inc (CA P&A)(April 2002)

In the matter of Neil Larkin: A case study on restraint, Traumatic Asphyxia and Investigations by New York Commission on Quality Care and Advocacy for Persons with Disabilities (NY P&A) (good discussion of dangers of prone restraint)

Schools

Abuse and Neglect of Children with Disabilities in NY Non-Residential Schools, published by Disabled Abuse Coalition (April 2009)

Reduce Your Risk: Evidence-based Practices to Prevent Harmful Student Restraint and Seclusion, LRP Publications Audio Conference (April 7, 2009)

Use of Seclusion, Restraints on Students at Issue (Education Week)(April 2009)

Use of Restraint and Seclusion in Public Schools – Guiding Principles (NDRN)

Colorado Public Report of an Investigation into the Improper Use of Restraint and Seclusion of Students with Disabilities at Will Rogers Elementary School, prepared by (March 9, 2007)

Connecticut – An Act Concerning Restraints and Seclusion in Public Schools (eff. 10/1/07)

Massachusetts Department of Education Regulations on the Use of

Restraint in Public Schools – provides a detailed approach to limiting use of restraints

Restraint and Seclusion in California Schools – A Failing Grade, produced by Protection and Advocacy, Inc. (California P&A) (June 2007)

(Wisconsin) Guidelines for the Appropriate Use of Seclusion and Restraint in pecial Education Programs, prepared by Wisconsin Department of Public Instruction (Sept. 2005)

Standing

Autism Society of Michigan and Michigan Protection and Advocacy Services, Inc. v. Fuller, No 5:05-CV-73 (W.D. Mich. May 26, 2006) (plaintiffs sought declaratory and injunctive relief for purpose of getting school officials to establish seclusion and restraint policies and to train staff - dismissed for lack of standing)

State Incentive Grants

SAMSHA Notice of Funding Availability **(June 1, 2004)**

Inventory of Seclusion and Restraint Reduction Interventions

State Statutes and Policies - Models

Selected State R&S laws (July 2006)

Iowa Mental Health Institute – Independence, IA.

Restraint and Seclusion Policy **(Feb 2005)**

(Patient) Information to Help Avoid Restraint/Seclusion: Risks, Triggers, Signs and Coping Aids

Restraint or Seclusion Prescription

Restraint and Seclusion (monitoring) Checklist and Narrative

Restraint and Seclusion Patient Debriefing Form

Restraint and Seclusion – Same Day Staff Analysis

Restraint and Seclusion Debriefing Form – Next Working Day Team Analysis

Trauma Informed Care

Trauma Informed Care, prepared by the National Association of State Mental Health Program Directors (NASMHPD), for 2006 TASC Skills Building Conference (powerpoint)(references)

Traumatic Brain Injuries

Reducing the use of Restraint of Individuals Traumatic Brain Injury, by the Health Resources and Services Administration Federal TBI Program Webcast (July 27, 2006)

Transport

Vermont Passes Law Prohibiting Transport of Children in Shackles (June 2006) - The new law (H.306)--which covers the transport of pregnant woman in correctional settings, individuals residing in inpatient settings, and children within the jurisdiction of the state department of children and families -- generally establishes a policy disfavoring the use of restraint during transport and requires state officials to ensure that transport is done in a manner which prevents physical and psychological trauma, respects the privacy of the individual, and represents the least restrictive means necessary for the safety of the individual. The law also requires significant documentation and data collection about restraint use during transport.

NCTSN The National Child Traumatic Stress Network

Facts on Traumatic Stress and Children with Developmental Disabilities

National Child Traumatic Stress Network
Adapted Trauma Treatment Standards Work Group

This project was funded in part by the Substance Abuse and Mental Health Services Administration, U.S. Department of Health and Human Services

Facts on Traumatic Stress and Children with Developmental Disabilities

From the

National Child Traumatic Stress Network
Adapted Trauma Treatment Standards Work Group
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National Child Traumatic Stress Network
www.NCTSNnet.org

2004

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NCTSN The National Child Traumatic Stress Network

Facts on Trauma and Children with Developmental Disabilities

Federal Definition of Developmental Disability

General

The term *developmental disability* means a severe, chronic disability of an individual that

1. is attributable to a mental or physical impairment or combination of mental and physical impairments;

2. is manifested before the individual attains age 22;

3. is likely to continue indefinitely;

4. results in substantial functional limitations in three or more of the following areas of major life activity:

    a. self-care,
    b. receptive and expressive language,
    c. learning,
    d. mobility,
    e. self-direction,
    f. capacity for independent living,
    g. economic self-sufficiency; and

5. reflects the individual's need for a combination and sequence of special, interdisciplinary, or generic services, individualized supports, or other forms of assistance that are of lifelong or extended duration and are individually planned and coordinated.

Infants and Young Children

An individual from birth to age nine, inclusive, who has a substantial developmental delay or specific congenital or acquired condition, may be considered to have a developmental disability without meeting three or more of the criteria described in clauses (a) through (g) of subparagraph (4) if the individual, without services and supports, has a high probability of meeting those criteria later in life.

Reference: *Developmental Disabilities Assistance and Bill of Rights Act of 2000*, Public Law 106-402.

Incidence of Disability in the General Population

- The national prevalence rate for developmental disabilities in the U.S. is 1.8 percent, based on an estimate conducted by Golay & Associates and used by the Federal Administration on Developmental Disabilities to extrapolate state level prevalence rates.

- About 3 percent of the population has an IQ of less than 70. The standard Wechsler IQ tests are based on a normal curve, so that 13 percent of the population has an IQ between 70 and 85, 68 percent between 85 and 115, 13 percent between 115 and 130, and 3 percent above 130.

- The exact prevelance of autism is not known, but estimates range from 1-in-250 to 1-in-1,000 in the United States (National Institutes of Mental Health, 2003).

Statistical Information Regarding the Incidence of Trauma for this Population

The following statistics should be interpreted with caution. Most reports regarding the incidence of trauma for people with developmental disabilities indicate it is likely the statistics reported under-represent the prevalence of trauma. A variety of factors interfere with the ability to report, such as difficulty communicating that abuse has occurred, difficulty in being believed, and problems related to communication in general.

- Individuals with developmental disabilities are at increased risk for abuse as compared to the general population (Gil, 1970; Mahoney & Camilo, 1998; Ryan, 1994).

- Goldson, 2002 reports maltreatment among children with disabilities:

Incidents per 1,000

	Children without Disabilities	Children with Disabilities
Physical Abuse	4.5	9.4
Sexual Abuse	2.0	3.5
Emotional Abuse	2.9	3.5

- Individuals with disabilities are over four times as likely to be victims of crime as the non-disabled population (Sobsey, 1996).

- Sixty-four percent of the children who were maltreated had a disability. The most common disabilities were behavior disorders, speech/language, learning disability, and mental retardation. The most common type of maltreatment was neglect. Children with mental retardation were the most severely abused. Children with communication disorders were more likely to be physically and sexually abused (Sullivan & Knutson, 1998).

- Five million crimes are committed against individuals with disabilities each year in the United States (Petersillia, 1998).

- Individuals with disabilities are 2-to-10 times more likely to be sexually abused than those without disabilities (Westat Ind., 1993).

- Maltreatment of children with disabilities is 1.5-to-10 times higher than of children without disabilities (Baladerian, 1991; Sobsey & Doe 1991; Sobsey & Vamhagen, 1989; Sullivan & Knutson, 2000; Westat, 1991).

- One of 30 cases of sexual abuse or assault of persons with developmental disabilities is reported as opposed to one of five in the nondisabled population (James, 1988).

- Even when the abuse is reported, the charges are rarely investigated when the victim is disabled (Senn, 1988).

- Victims typically have difficulty accessing appropriate services (Sobsey & Doe, 1991).

- Risk of abuse increases by 78 percent due to exposure to the "disabilities service system" alone (Sobsey & Doe, 1991).

- Immediate family members perpetrate the majority of neglect, physical abuse, and emotional abuse. Extrafamilial perpetrators account for the majority of sexual abuse (Sullivan & Knutson, 2000).

- Sexual abuse incidents are almost four times as common in institutional settings as in the community (Blatt & Brown, 1986).

- Ninety-nine percent of those who commit abuse are well known to, and trusted by, both the child and the child's care providers (Baladerian, 1991).

Special Characteristics of the Population that May Influence the Incidence of Trauma

Abuse and neglect have profound influences on brain development. The more prolonged the abuse or neglect, the more likely it is that permanent brain damage will occur. Not only are people with developmental disabilities more likely to be exposed to trauma, but exposure to trauma makes developmental delays more likely.

- "The developing brain is exquisitely sensitive to stress." Persistent states of fear in children impair their capacity to benefit from cognitive, social, and emotional experiences (Perry, 2001).

- Exposure to trauma can modify the child's ability to access different levels of brain functioning, resulting in changes in their perception of time, cognitive style, affective tone, ability to develop solutions to problems, and ability to respond to and understand rules, regulations, and laws (Perry, 2001).

- Severe neglect can result in reduced brain size, density of neurons, and head circumference (Perry and Pollard, 1997).

People with developmental disabilities are

- trained to be compliant to authority figures;
- dependent on caregivers for a longer period of time for more types of assistance than a nondisabled child, and they are dependent on a larger number of caretakers;
- often unable to meet parental expectations;
- isolated from resources to whom a report of abuse could be made;
- sometimes impaired in their ability to communicate;
- sometimes impaired in their mobility;
- more likely than other children to be placed in residential care facilities;
- sometimes more credulous and less prone to critical thinking than others, which may result in it being easier for others to manipulate them;
- often not provided with general sex education, and caregivers may feel that people with developmental disabilities are asexual, although
    - for people with mild to moderate mental retardation sexual development and sexual interest occur at approximately the same age as the normal population (Tharinger, 1990), and
    - precocious puberty is 20 times more likely to occur in persons with developmental disabilities than in the normal population (Siddigi, 1999); and
- viewed negatively by society, which may label them as "bad" because they are different or may view them as less than human.

People with developmental disabilities may also experience

- cognitive and processing delays that interfere with understanding of what is happening in abusive situations, and
- feelings of isolation and withdrawal due to their differences, which may make them more vulnerable to manipulation because of their increased responsiveness to attention and affection.

In addition, the effect of trauma is increased for people with developmental disabilities due to

- a predisposition toward emotional problems and impaired resiliency before the abuse occurs (Burrows & Kochurka, 1995);

- reduced protective factors that could lessen the effects of sexual abuse (Mansell et al., 1998);

- a long-standing belief that people with developmental disabilities cannot benefit from traditional verbally oriented therapies (Mansell, et al., 1998); and

- a lack of trained professionals who are comfortable in working with people who have developmental disabilities to help them in processing traumatic incidents.

Possible Reasons for a Higher Incidence of Mental Illness for Clients with Developmental Disabilities Than the General Population
(Avrin, Charlton, Tallant, 1998)

- It is more difficult to cope with normal life stressors given the limited resources the client has available.

- There is increased vulnerability to abuse in the home, since these children are often very difficult to raise and place a high level of strain on the family.

- These children are more vulnerable to abuse in the community because of their poor judgment and lack of self-protective skills.

- An additional stressor for the higher functioning clients is awareness of their intellectual deficits. They have many grief and loss issues associated with their functioning problems.

- People with developmental disabilities experience greater difficulty in getting help for mental illness due to communication and processing problems.

Suggestions for Modifying Evaluation and Therapy to Meet the Needs of this Population

- Because of the high likelihood that the ability to communicate will be severely impaired, it is extremely important that a wide range of caregivers be involved in both the assessment and treatment process. These should include parents/guardians and school and daycare personnel.

- Since reporting of trauma by this population is unlikely, it is important that caregivers receive training on the type of behavioral changes that may be associated with trauma exposure so they may assist in reporting and obtaining services.

- All children with developmental disabilities tend to behave like much younger children, so when working with very young children with developmental disabilities, it is extremely important to slow down speech, use simple language, present one concept at a time, supplement therapy with drawing and play materials, and make related adaptations.

Special Diagnostic Considerations with Clients
Who Have Developmental Disabilities
(Avrin, Charlton, Tallant, 1998)

1. Their thought process are usually very concrete. Responses to common mental status questions may sound very bizarre because of the client's concrete interpretations.

2. Their concrete thought processes make the use of projective assessment techniques such as the Rorschach and TAT ineffective in identifying pathology.

3. If the client has sufficiently high verbal skills, sometimes the MMPI-2 or A can be helpful, if interpreted conservatively. Use of audio tapes is recommended, even if the reading level seems sufficient, as the multisensory input often improves comprehension of the questions.

4. People with developmental disabilities often share the following thought processes:

    a. difficulty with fluidity and flexibility of thinking,
    b. a dislike of ambiguity (black and white thinkers),
    c. a tendency to concentrate on one aspect of a situation while neglecting other aspects,
    d. difficulty prioritizing and breaking down tasks into manageable projects,
    e. a tendency to have highly focused areas of expertise and interests, e.g., beets, weather, sports, statistics, phone numbers, dates, and so on,
    f. a tendency for poor generalization skills—a person belongs in one and only one environment—and utilization of a skill in one situation but not others.

5. People with developmental disabilities often share the following communication problems and social issues:

    a. idiosyncratic speech,
    b. inability to perceive social cues,
    c. difficulty utilizing or understanding nonverbal communication well,
    d. frequent miscommunications and misunderstandings,
    e. a tendency toward one-sided conversations,
    f. a tendency to ask many questions, especially when uncomfortable with a conversation,
    g. a tendency to return to familiar, rote questions, or subjects of personal interest when anxious,
    h. intrusive behavior,
    i. an ability to pretend to be normal,
    j. a poor understanding of the impact of behavior on others, and
    k. difficulty making and keeping friends.

6. People with developmental disabilities may also have the following miscellaneous issues:

    a. special talents, including memory for facts, artistic talents, and unique insights (Albert Einstein, Temple Grandin);
    b. difficulty with change, especially unexpected changes, including
        i. anticipatory anxiety and
        ii. continued use of a familiar plan even if it doesn't work;

c. significant anxiety in many situations, which may present as agitation, acting out, worry, perseveration, or obsessive-compulsive behaviors, often with the following characteristics:
    i. responses when anxious tend to be highly predictable,
    ii. even though the pattern is predictable, it may be hard to see when the anxiety is high, and
    iii. the acting out may be chaotic;
d. difficulty with Impulse control, particularly when frustration, anxiety, or tension builds until behavioral acting out occurs.

Be aware that all types of psychiatric treatment are useful if properly selected and executed (Szymanski et al., 1994). Behavioral and cognitive behavioral strategies are particularly effective and easy to adapt for this population.

Suggestions for Therapy
(Avrin, Charlton, Tallant, 1998)

1. Slow down your speech.

2. Use visuals whenever possible to reinforce your verbal messages:
    a. draw pictures, and
    b. write down suggestions for change in brief, outline form.

3. Present information one item at a time.

4. Ask for feedback after each item to ensure clear comprehension.

5. Be specific in making suggestions for change.

6. Practice different ways of handling tough situations the client is likely to encounter.

7. Format your therapy session so that several repeats of key information occur. For example

    a. review information covered in the previous meeting,
    b. discuss how week has gone,
    c. work on specific ways of handling various troublesome events that occurred,
    d. review the key things you want the client to work on during the week, and
    e. write the homework assignment out and review it with the client to be sure it is clear.

8. Work on building coping skills rather than insight.

9. Remember that with these clients change will occur more slowly than with others. Be content to measure change with a micrometer rather than a yardstick.

10. Remmber that effective treatment for people with developmental disabilities must also include a variety of support and education services for families and caregivers.

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Retardation & Abuse

Back Up

Sexual abuse can happen with our trusting WS children. The following article found in the ARC home page offers some advice.

People with Mental Retardation & Sexual Abuse

by Leigh Ann Reynolds, M.S.S.W., M.P.A.
Health Promotion & Disability Prevention Specialist

What is sexual abuse?

Sexual abuse includes a wide range of sexual activities that are forced upon someone. People with mental retardation are often unable to choose to stop abuse due to a lack of understanding of what is happening during abuse, the extreme pressure to acquiesce out of fear, a need of acceptance from the abuser or having a dependent relationship with the abuser. Sexual abuse consists of sexually inappropriate and non-consensual actions, such as exposure to sexual materials (such as pornography), the use of inappropriate sexual remarks/language, not respecting the privacy (physical boundaries) of a child or individual (e.g., walking in on someone while dressing or in the bathroom), fondling, exhibitionism, oral sex and forced sexual intercourse (rape).

How often are people with mental retardation sexually abused?

According to research, most people with disabilities will experience some form of sexual assault or abuse (Sobsey & Varnhagen, 1989). The rate of sexual victimization in the general population is alarming, yet largely goes unnoticed. At least 20 percent of females and 5 to 10 percent of males are sexually abused every year in the U.S. Although these figures are disturbingly high, people with mental retardation and other developmental disabilities are at an even greater risk of sexual victimization. Victims who have some level of intellectual

impairment are at the highest risk of abuse (Sobsey & Doe, 1991).

More than 90 percent of people with developmental disabilities will experience sexual abuse at some point in their lives. Forty-nine percent will experience 10 or more abusive incidents (Valenti-Hein & Schwartz, 1995). Other studies suggest that 39 to 68 percent of girls and 16 to 30 percent of boys will be sexually abused before their eighteenth birthday. The likelihood of rape is staggering: 15,000 to 19,000 of people with developmental disabilities are raped each year in the United States (Sobsey, 1994).

Why is sexual abuse so common among people with mental retardation?

People with mental retardation may not realize that sexual abuse is abusive, unusual or illegal. Consequently, they may never tell anyone about sexually abusive situations. People with and without disabilities are often fearful to openly talk about such painful experiences due to the risk of not being believed or taken seriously. They typically learn not to question caregivers or others in authority. Sadly, these authority figures are often the ones committing the abuse. Many special education programs have encouraged students to be compliant in a wide range of life activities, ultimately increasing the child's vulnerability to abuse (Turnbull, et.al., 1994). They often think they have no right to refuse sexually abusive treatment and are not taught risk reduction skills. Risk factors associated with sexual abuse include social powerlessness, communication skill deficits, impaired judgment, family isolation/stress and living arrangements that increase vulnerability.

WHAT TO LOOK FOR*

Physical Signs

- Bruises in genital areas
- Genital discomfort
- Sexually transmitted disease
- Signs of physical abuse
- Torn or missing clothing
- Unexplained pregnancy

Behavioral Signs

- Depression
- Substance abuse
- Withdrawal
- Atypical attachment
- Avoids specific setting
- Seizures
- Avoids specific adults
- Excessive crying spell

- Regression
- Sleep disturbances
- Disclosure
- Poor self-esteem
- Noncompliance
- Eating disorders
- Resists exam
- Self-destructive behavior
- Headaches
- Learning difficulty
- Sexually inappropriate behavior

Circumstantial Signs

- Alcohol or drug abuse by caregiver
- Devaluing attitudes
- Excessive or inappropriate eroticism
- Isolation of social unit
- Other forms of abuse
- Previous history of abuse
- Seeks isolated contact with children
- Strong preference for children
- Surrogate caregivers
- Unresolved history of abuse
- Pornography usage

*Adapted from *Violence and Abuse in the Lives of People with Disabilities* (1994), D. Sobsey.

What are the effects of sexual abuse?

Sexual abuse causes harmful psychological, physical and behavioral effects (see above chart). Individuals who experience long-term (chronic) abuse by a known, trusted adult at an early age suffer more severe damage compared to those whose abuse is perpetrated by someone not well known to the victim, begins later in life, and is less frequent and nonviolent (Tower, 1989). Regardless of the circumstances surrounding sexual abuse (e.g., length of time it occurred, who the abuser is and the victim's age), all forms of sexual abuse are serious and have the potential to be very damaging to the individual if left unaddressed and unspoken.

Who is most likely to abuse?

As is the case for people without disabilities who experience sexual abuse, those most likely to abuse are those who are known by the victim, such as family members, acquaintances, residential care staff, transportation providers and personal care attendants. Research suggests that 97 to 99 percent of abusers are known and trusted by the victim who has developmental disabilities (Baladerian, 1991).

While in 32 percent of cases, abusers were family members or acquaintances, 44 percent had a relationship with the victim specifically related to the person's disability (such as residential care staff, transportation providers and personal care attendants). Therefore, the delivery system created to meet specialized care needs of those with mental retardation contributes to the risk of sexual abuse.

What type of treatment or therapy is available for victims of sexual abuse?

People with developmental disabilities who have been sexually abused typically are not provided a way to "work through" or talk about their traumatic experiences in a treatment or therapeutic setting. Generally, the more severe the disability, the greater the difficulty in accessing services. This may be due to prejudices some people still have about people with disabilities. For example, the benefit of psychotherapy for people with mental retardation is questioned, as well as the impact of the abuse (whether or not abuse impacts people with mental retardation as strongly as others without disabilities).

Yet, all people who experience sexual abuse are affected and can benefit from therapeutic counseling, even if they are non-verbal. Children and adults who suffer abuse need to learn how to tell someone and who to tell. A variety of training techniques that teach self-defense, body integrity, prevention and reporting should be used. Human service workers must understand that people with developmental disabilities can and do benefit from therapy.

Locating a qualified therapist may be difficult since the person should be trained in both child/adult sexual abuse, as well as disabilities and sexuality. Payment for the therapy can be obtained through victim witness programs, community mental health centers or developmental disability centers.

How can the incidence of sexual abuse of people with mental retardation be reduced?

Society has been slow to admit that sexual abuse of people with mental retardation is not only possible, but actually happening (Baladerian, 1992).

The first step in reducing the occurrence of sexual abuse is recognizing the magnitude of the problem and confronting the ugly truth that people with mental retardation and other developmental disabilities are more vulnerable to sexual victimization than those without disabilities.

Abusers typically abuse as many as 70 people before ever getting caught. Without reporting, there can be no prosecution of offenders or treatment for victims. Underreporting of sexual abusive incidents involving people with disabilities has in the past, and continues to be, a major obstacle in preventing sexual abuse. Only three percent of sexual abuse cases involving people with developmental disabilities will ever be reported (Valenti-Hein & Schwartz, 1995). Few people ever disclose sexual abuse for a variety of understandable reasons. However, such non-disclosure promotes an environment ripe for continued victimization.

Reporting can be increased through educating individuals with disabilities and service providers, improving investigation and prosecution, creating a safe environment that allows victims to disclose and, finally, employment policies must change to increase safety. For

example, background checks on new employees should be conducted on a routine basis; and those with criminal records should be reported to the police, rather than firing the suspected abuser. Otherwise the individual will more than likely continue abusing others while working for future employers.

What should I do if I suspect sexual abuse?

All states have laws requiring professionals, such as institutional care providers, police officers and teachers to report abuse. All states allow the general public to report abuse as well. If you suspect a child is being sexually abused, contact your local child protective agency. If the person is an adult, contact adult protective services. These are also referred to as "Social Services," "Human Services" or "Children and Family Services" in the phone book. *You do not need proof to file a report.* If you believe the person is in immediate danger, call the police. After a report is made, the incident is referred for investigation to the state social service agency (who handles civil investigations) or to the local law enforcement agency (who handles criminal investigations). For more information on sexual abuse of people with disabilities, contact:

The National Task Force on Abuse and Disabilities
P.O. Box "T" Culver City, CA 90230
1-310-391-2420
e-mail: abuses@soca.com

The National Committee to Prevent Child Abuse
332 S. Michigan Ave., Ste. 1600, Chicago, IL 60604
1-800-555-3748

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The Arc

Q&A

People with Intellectual Disabilities and Sexual Violence

By Leigh Ann Davis, M.S.S.W., M.P.A.
Assistant Director of Professional & Family Services

What is sexual assault/sexual abuse?

Sexual assault is a crime of violence, anger, power and control where sex is used as a weapon against the victim. It includes any unwanted sexual contact or attention achieved by force, threats, bribes, manipulation, pressure, tricks, or violence. It may be physical or non-physical and includes rape, attempted rape, incest and child molestation, and sexual harassment. It can also include fondling, exhibitionism, oral sex, exposure to sexual materials (pornography), and the use of inappropriate sexual remarks or language.

Sexual abuse is similar to sexual assault, but is a *pattern* of sexually violent behavior that can range from inappropriate touching to rape. The difference between the two is that sexual assault constitutes a single episode whereas sexual abuse is ongoing.

Sexual violence occurs in the home (sexual abuse of children, sexual assault by partners or relative), outside the home (in group homes or institutions), on the job, on transportation systems (while riding the bus or a taxi) and virtually anywhere.

How often do adults and children experience sexual violence?

Studies consistently demonstrate that people with intellectual disabilities are sexually victimized more often than others who do not have a disability (Furey, 1994). For example, one study reported that 25 percent of girls and women with intellectual disabilities who were referred for birth control had a history of sexual violence (Sobsey, 1994). Other studies suggest that 49 percent of people with intellectual disabilities will experience 10 or more sexually abusive incidents (Sobsey & Doe, 1991).

Any type of disability appears to contribute to higher risk of victimization but ***intellectual disabilities, communication disorders, and behavioral disorders appear to contribute to very high levels of risk, and having multiple disabilities (e.g., intellectual disabilities and behavior disorders) result in even higher risk levels*** (Sullivan & Knutson, 2000).

Children with intellectual disabilities are also at risk of being sexually abused. A study of approximately 55,000 children in Nebraska found that children with intellectual disabilities were 4.0 times as likely as children without disabilities to be sexually abused. (Sullivan & Knutson, 2000).

Women are sexually assaulted more often when compared to men whether they have a disability or not, so men with disabilities are often overlooked. Researchers have found that men with disabilities are twice as likely to become a victim of sexual violence compared to men without disabilities (The Roeher Institute, 1995).

WHAT TO LOOK FOR

Physical Signs

Bruises in genital areas	Pain in genital areas
Sexually transmitted disease	Signs of physical abuse
Tearing of vaginal or anal area	Headaches/stomachaches

Behavioral/Psychological Signs

Depression	Substance abuse	Withdrawal
Avoids specific setting	Seizures	Phobias
Avoids specific adults	Crying spells	Regression
Sleep disturbances	Irritability	Guilt/shame feelings
Change in appetite	Resists physical exam	Change in prior mood
Self-destructive behavior	Feelings of panic	Change in habits
Learning difficulty	Sexually inappropriate behavior	Severe anxiety & worry

Possible Signs To Look For In An Abuser

Alcohol or drug abuse	Devaluing attitudes
Excessive or inappropriate eroticism	Socially isolated
Uses other forms of abuse	Previous history of abuse
Seeks isolated contact with children	Strong preference for children
Surrogate caregivers (particularly males)	Unresolved history of abuse
Pornography usage	

Adapted from *Violence and Abuse in the Lives of People with Disabilities* (1994), D. Sobsey.

Why is sexual violence so common among people with intellectual disabilities?

People with severe intellectual disabilities may not understand what is happening or have a way to communicate the assault to a trusted person. Others with a less severe disability may realize they are being assaulted, but don't know that it's illegal and that they have a right to say no. Due to threats to their well-being or that of their loved ones by the abuser, they may never tell anyone about the abuse, especially if committed by an authority figure whom they learn not to question. In addition, they are rarely educated about sexuality issues or provided assertiveness training. Even when a report is attempted, they face barriers when making statements to police because they may not be viewed as credible due to having a disability (Keilty & Connelly, 2001).

What risk factors contribute to the occurrence of sexual violence?

Some risk factors may include a feeling of powerlessness, communication skill deficits and inability to protect oneself due to lack of instruction and/or resources. Individuals may live in over-controlled and authoritarian environments, contributing to the feeling of powerlessness over their situation. In addition, they are not given enough experiential opportunities to learn how to develop and use their own intuition (those who are taught can often detect between safe versus unsafe situations.)

Other factors include the caretaker's failure to 1) request information on the background of all those involved in the person's life, such as professionals, paraprofessionals, ancillary and volunteer staff, 2) become familiar with the abuse-reporting attitudes and practices of the agency, and 3) assure there is a plan in place for responding to reports of abuse when they occur. Also, offenders are typically not caught and/or held accountable for these crimes, which allows abuse to continue.

Who is most likely to sexually assault?

As is the case for people without disabilities who experience sexual violence, perpetrators are often those who are known by the victim, such as family members, acquaintances, residential care staff, transportation providers and personal care attendants. Research suggests that 97 to 99 percent of abusers are known and trusted by the victim who has intellectual disabilities. While in 32 percent of cases, abusers consisted of family members or acquaintances, 44 percent had a relationship with the victim specifically related to the person's disability (such as residential care staff, transportation providers and personal care attendants). Therefore, the delivery system created to meet specialized care needs of those with intellectual disabilities contributes to the risk of sexual violence (Baladerian, 1991).

What are the effects of sexual violence on someone with intellectual disabilities?

Sexual violence causes harmful psychological, physical and behavioral effects (see chart on front page). The individual may become pregnant, acquire sexually transmitted diseases, bruises, lacerations and other physical injuries. Psychosomatic symptoms often occur, such as stomachaches, headaches, seizures and problems with sleeping. Common psychological consequences include depression, anxiety, panic attacks, low self-esteem, shame and guilt, irrational fear, and loss of trust. Behavioral difficulties include withdrawal, aggressiveness, self-injurious and sexually inappropriate behavior (Sobsey, 1994).

What type of treatment or therapy is available for victims of sexual violence?

In the past the benefit of psychotherapy for people with intellectual disabilities was questioned, as well as the impact of sexual violence (whether or not it impacts people with intellectual disabilities as strongly as others without disabilities). Today, however, it is widely acknowledged that all people who experience sexual violence are affected and do require therapuetic counseling, even if they are non-verbal.

Locating a qualified therapist may be difficult since the person should be trained in child/adult sexual abuse and sexual assault treatment as well as intellectual disabilities. The therapist should also be trained in non-verbal mind-body healing modalities that do not require an intellectual processing component of the therapy. Payment for the therapy can be obtained through victim witness programs, community mental health centers or developmental disability centers.

How can sexual violence of people with intellectual disabilities be prevented?

The first step is recognizing the magnitude of the problem and facing the reality that people with intellectual disabilities are more likely to be assaulted sexually than those without disabilities. Also, societal attitudes must change to view victims with disabilities as having equal value as victims without disabilities, and giving them equal advocacy. Every sexual assault, regardless of who the victim is, must be taken seriously.

Secondly, sexual violence must be reported in order for repeat victimization to stop. While few people ever disclose sexual violence for a variety of understandable reasons, such non-disclosure promotes an environment ripe for continued victimization. Reporting can be increased by educating individuals with disabilities and service providers about sexual violence, improving the investigation and prosecution of this crime, and creating safe environments that allow victims to disclose.

In addition, employment policies must change to increase safety. For example, background checks on new employees should be conducted on a routine basis and those with criminal records should not be hired. Routine checks should consistently be conducted for current employees as well.

Sex education must be provided on a regular, on-going basis, and self-determination and relationship-building skills taught so individuals with intellectual disabilities can learn how to develop safe relationships. Classes on sexual violence should be provided to teach individuals how to respond and protect themselves when they become sexual assault victims.

What should I do if I suspect sexual abuse/assault of someone I know?

All states have laws requiring professionals, such as case managers, direct care workers, police officers and teachers to report abuse. Some states require the general public to report abuse as well. If you suspect a child is being sexually abused, contact your local child protective agency. If the person is an adult, contact adult protective services. These are also referred to as "Social Services", "Human Services" or "Children and Family Services" in the phone book. ***You do not need proof to file a report.*** If you believe the person is in immediate danger, call the police. After a report is made, depending on how serious the abuse is, the incident is referred for investigation to the state social services agency (who handles civil investigations) or to the local law enforcement agency (who handles criminal investigations).

For more information on how you can help prevent sexual assault/abuse, contact Prevent Child Abuse America at 1-800-555-3748 (200 S. Michigan Ave., 17th floor, Chicago, IL 60604) or visit their web site at www.preventchildabuse.org and The Arc Riverside's CAN DO! Project at www.disability-abuse.com

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APPENDIX G

MODIFIED ALTERNATIVE C: ALTERNATE OFFICE PARK TRAFFIC CIRCULATION OPTION

MODIFIED ALTERNATIVE C

ALTERNATE OFFICE PARK TRAFFIC CIRCULATION OPTION

An on and off-site traffic circulation option has been created under Modified Alternative C which would prohibit project operational or construction-related traffic on Cypress Avenue, which is largely residential in nature. Under this option, both project traffic and construction traffic would be prohibited from accessing the site from Airport Street north of the project site. Therefore, for project traffic, the site would be accessed using North or South Capistrano Road to and from Cabrillo Highway. Construction trucks would access the site using North Capistrano Road to and from Cabrillo Highway. The revised traffic route includes only non-residential streets. The alternate route is shown in Figure D of the FEIR.

The site plan would include onsite signs prohibiting traffic from making a right turn when entering the site and a left turn when exiting the site, as well as modifications within the public right-of-way to prevent such turns. The Figure F of the DEIR shows the proposed improvements to Airport Street to route all project traffic to the south to avoid impacts to the residential communities to the north.

BENEFITS OF ALTERNATE TRAFFIC CIRCULATION

The traffic circulation option would direct project traffic, as estimated by Hexagon Transportation Consultants, Inc., in a report dated June 24, 2009 (Hexagon Traffic Report) prepared for the Big Wave Wellness Center and Office Park Draft EIR, to streets in Princeton that largely serve industrial and commercial uses. The alternate route is intended to maintain the residential character of Cypress Avenue, as well as the residential character of side streets along Airport Street north of the project site, such as La Granada Avenue (access to the Pillar Ridge Mobile Home Park) and Los Banos Ave.

Implementation of this option would also significantly reduce or eliminate project-generated traffic to the above intersections. As sated in the Draft EIR, under worst-case project conditions, the northbound left-turn movement on Cypress Avenue at Cabrillo Highway (Study Intersection 6) would operate at LOS F with a delay of 59.8 seconds. Under this option, project traffic would not utilize Cypress Avenue or Airport Street north of the project site. The alternate route transfers project traffic volume (86 AM trips and 77 PM trips as shown in Figure 12 of the Hexagon Traffic Report) from Study Intersection 6 to Study Intersection 8 (Cabrillo Highway at North Capistrano Road).

Based on the foregoing, intersection LOS for the following intersections would not be impacted or only minimally impacted by the project and would remain at existing or "background" levels[1], as presented in the DEIR:

[1] *Background conditions include existing traffic plus additional traffic generated by approved developments in the area.*

- Cypress Avenue at Cabrillo Highway (Study Intersection 6)
- Airport Road at Los Banos Avenue (Study Intersection 5)
- Airport Road at La Granada Avenue (Study Intersection 4)

POTENTIAL IMPACTS OF ALTERNATE TRAFFIC CIRCULATION

The traffic circulation option transfers project traffic (86 AM trips and 77 PM trips) from the Cypress Avenue at Cabrillo Highway at Cabrillo Highway (Study Intersection 6) to Cabrillo Highway at North Capistrano Road (Study Intersection 8). Intersection LOS for the following Princeton intersections may be further impacted than the level discussed in the DEIR:

- Cabrillo Highway at North Capistrano Road (Study Intersection 8)
- Prospect Way at Capistrano Road (Study Intersection 1)
- Prospect Way at Broadway/Cornell Avenue (Study Intersection 2)
- Airport Road at Stanford Avenue/Cornell Avenue (Study Intersection 3)

Additional trips through these intersections under this alternate traffic route are shown in Tables 1 through 8, below. However, as described below, project impacts to intersection LOS would not be considered significant with implementation of the recommended mitigation measures. The following is an analysis of the anticipated impact of this option to intersection LOS levels:

A. CABRILLO HIGHWAY AT NORTH CAPISTRANO ROAD (STUDY INTERSECTION 8)

At the Cabrillo Highway at North Capistrano Road (Study Intersection 8) intersection, under original project conditions[2], Figure 13 of the Hexagon Traffic Report estimates 31 AM westbound trips (from Cabrillo Highway to North Capistrano Road) and 25 PM northbound trips (from North Capistrano Road to Cabrillo Highway), where intersection LOS is "C" in both the AM and PM during peak hours with 15.1 seconds of delay in the AM and 18.5 seconds of delay in the PM. The revised route would add 86 AM westbound trips and 77 PM northbound trips. This intersection is configured with left and right turn pockets and a left turn and right turn merge lanes. The intersection has sight visibility for cars being detained at the signalized intersection of Capistrano South.

[2] *Project traffic volumes for "project conditions" are the sum of Background trips plus Project trips, based on the assignment in the June 2009 traffic report by Hexagon Transportation Consultants, Inc.*

Table 1
Cabrillo Highway at North Capistrano Road (Study Intersection 8) – Original & Optional Traffic AM & PM Volumes

Cabrillo Highway at North Capistrano Road	*Original Project Traffic Volumes*			Additional Revised Project Trips	Revised Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Cabrillo Highway to North Capistrano Road – westbound (AM)	31	*C*	*15.1*	86	117
2. North Capistrano Road to Cabrillo Highway – northbound (PM)	25	*C*	*18.5*	77	102
Total	56			163	219

As AM and PM LOS levels are at level "C" under original project conditions, the additional trips from the alternate traffic route may impact AM & PM intersection LOS such that both exceed level "C" (over 25 seconds of delay for unsignalized intersections). Implementation of mitigation measures in the Final EIR, as summarized below, would reduce the impact related to project peak-hour traffic volumes and intersection LOS to a less-than-significant level.

- Mitigation Measure TRANS-1 requires the property owner to submit a traffic report to the County, at full occupancy of every 60,000 sq. ft. of office space up until full project occupancy and bi-annually after full project occupancy. The report should be study level of service at the following intersections: Cypress Avenue and SR 1 (Study Intersection 6), Airport Street & Stanford/Cornell (Study Intersection 3), Broadway & Prospect Way (Study Intersection 2), Prospect Way & Capistrano (Study Intersection 1) and State Route 1 & Capistrano (Study Intersection 8) to evaluate if they maintain a LOS level "C" or better. If traffic reports reveal that the LOS of any of these intersections exceeds level "C", the applicant will be required to implement recommendations, such that LOS levels are maintained at level "C" or better, within 1 year of the date of that report.

In addition, as stated in the FEIR, the applicant proposes to implement Traffic Demand Management (TDM) measures, including an off-site parking agreement and shuttle services to the Office Park (to accommodate a minimum of 50 cars and their drivers) for the purpose of reducing project traffic along the Cabrillo Highway to North Capistrano Road to Prospect Way to Broadway to Cornell Avenue/California Avenue or Harvard Avenue/Yale Avenue to Airport Street

route. Therefore, the project as currently proposed and mitigated, would result in impacts related to project peak-hour traffic volumes and intersection LOS that are considered less than significant.

B. PROSPECT WAY AT CAPISTRANO ROAD (STUDY INTERSECTION 1)

Figure 13 of the Hexagon Traffic Report estimates original project traffic volume[3] between Prospect Way and South Capistrano Road at 251 AM westbound trips and 274 PM southbound trips. Between Prospect Way and North Capistrano Road, Figure 13 of the Hexagon Traffic Report estimates original project traffic volume at 29 AM westbound trips and 29 PM northbound trips. Intersection LOS under original project conditions is at level "A" in the AM and level "B" in the PM. The revised route would add 86 AM westbound trips and 77 PM northbound project trips to project conditions.

While AM intersection LOS is at a level "A" and is not likely to exceed level LOS "C", the alternate traffic route may impact PM intersection LOS, currently at LOS B. The additional PM trips from this option added onto total project traffic volumes along Prospect Way (north and southbound) could cause intersection LOS to exceed level "C" (or 25 seconds of delay) in the PM. As illustrated in the table below, the additional 77 PM northbound trips would be added to the estimated 303 PM trips under project conditions for a total of 380 PM trips.

[3] *Project traffic volumes are the sum of Background trips plus Project trips, based on the assignment in the June 2009 traffic report by Hexagon Transportation Consultants, Inc.*

Table 2
Prospect & Capistrano Intersection (Study Intersection 1) – Original & Optional Project Traffic AM & PM Volumes

Prospect & Capistrano Intersection	*Original Project Traffic Volumes*			Additional Revised Project Trips	Revised Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. North Capistrano Road to Prospect Way – Westbound (AM)	29	*A*	*9.4*	86	115
2. South Capistrano Road to Prospect Way – Westbound (AM)	251	*A*	*9.4*	--	251
AM Total	280			86	366
3. Prospect Way to North Capistrano Road – Northbound (PM)	29	*B*	*11*	77	106
4. Prospect Way to South Capistrano Road – Southbound (PM)	274	*B*	*11*	--	274
PM Total	303			77	380
Total	583			163	746

To reduce the potential impact to PM intersection LOS, the applicant porposes to construct a designated left turn lane from Prospect Way onto North Capistrano Road, such that traffic turning left onto North Capistrano does not delay traffic turning right to proceed onto South Capistrano Road. Implementation of Mitigation Measures TRANS-1 (requires traffic reports and implementation of recommendations such that LOS levels are maintained at "C" or better) and shuttle and designated turn lane proposals would reduce the impact related to project peak-hour traffic volumes and intersection LOS to a less-than-significant level.

C. PROSPECT WAY AT BROADWAY/CORNELL AVENUE (STUDY INTERSECTION 2)

As illustrated in the table below, the alternate traffic route would result in an additional 86 AM trips onto the estimated 114 AM trips (LOS "B" with 11.8

seconds of delay) estimated under original project conditions in Figure 13 of the Hexagon Traffic Report, for a total of 200 trips. The alternate traffic route would result in an additional 77 PM trips onto the estimated 167 trips (LOS "B" with 13.8 seconds of delay) estimated under original project conditions in Figure 13 of the Hexagon Traffic Report, for a total of 244 PM trips.

Table 3
Prospect Way at Broadway/Cornell Avenue (Study Intersection 2)– Original & Optional Project Traffic AM & PM Volumes

Prospect Way at Broadway/Cornell Avenue	*Original Project Traffic Volumes*			Additional Revised Project Trips	Revised Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Prospect Way to Broadway/Cornell Avenue – westbound (AM)	114	*B*	*11.8*	86	200
2. Broadway/Cornell Avenue to Prospect Way – eastbound (PM)	167	*B*	*13.8*	77	244
Total	281			163	444

While the additional 86 AM trips is unlikely to increase the delay from 11.8 under LOS B to over 25 seconds such that intersection LOS exceeds level "C" in the AM, there is a small potential for intersection LOS to exceed level "C" in the PM (increase from 13.8 seconds of delay under LOS B to over 25 seconds of delay). This potential is reduced as traffic is more likely to disperse between Cornell Avenue and Harvard Avenue (drivers will shift their route to maintain the shortest delay), rather than concentrate on Cornell Avenue as originally analyzed in the DEIR. This is illustrated in Figure D of the Final EIR. In addition, implementation of Mitigation Measures TRANS-1 (requires traffic reports and implementation of recommendations such that LOS levels are maintained at "C" or better) and the proposed shuttle would further reduce the impact related to project peak-hour traffic volumes and intersection LOS to a less-than-significant level.

D. Airport Road at Stanford Avenue/Cornell Avenue (Study Intersection 3)
The alternate traffic route could potentially add 86 AM northbound trips and 77 PM eastbound trips onto the 131 AM northbound project trips and 109 PM eastbound project trips, estimated under original project conditions in Figure 13 of the Hexagon Traffic Report.

Table 4
Airport Road at Stanford Avenue/Cornell Avenue (Study Intersection 3)
Original & Optional Project Traffic AM & PM Volumes

Airport Road at Stanford Avenue/Cornell Avenue	*Original Project Traffic Volumes*			Additional Revised Project Trips	Optional Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Stanford Avenue/Cornell Avenue to Airport Road – northbound (AM)	131	*B*	*10.7*	86	217
2. Airport Road at Stanford Avenue/Cornell Avenue - eastbound (PM)	109	*B*	*11.9*	77	186
Total	240			163	403

While the additional AM and PM trips are unlikely to increase the delays under LOS B shown in Table 4 to over 25 seconds[4] such that intersection LOS exceeds level "C", there is a small potential for this to occur. This potential is reduced as traffic is more likely to disperse between Cornell Avenue and Harvard Avenue (drivers will shift their route to maintain the shortest delay), rather than concentrate on Cornell Avenue as originally analyzed in the DEIR. This is shown in Figure D of the Final EIR. In addition, implementation of Mitigation Measures TRANS-1 (requires traffic reports and implementation of recommendations such that LOS levels are maintained at "C" or better) and the proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers, would further reduce the impact related to project peak-hour traffic volumes and intersection LOS to a less-than-significant level.

POTENTIAL CUMULATIVE IMPACT OF ALTERNATE TRAFFIC CIRCULATION

In the Hexagon Traffic Report, cumulative (20-year horizon) conditions were evaluated with and without the project. Traffic volumes under cumulative conditions were estimated by applying a growth factor to existing volumes and adding trips from approved developments. Project trips were then added in the "cumulative with project" scenario.

CUMULATIVE BENEFITS OF REVISED TRAFFIC CIRCULATION

[4] *LOS C includes delays of 15.1 to 25 seconds for unsignalized intersections.*

The alternate traffic circulation would prohibit access to or from the Office Park from Airport Street north of the project site and Cypress Avenue. Therefore, under ”cumulative with project” conditions, intersection LOS for the following intersections would not be impacted or only minimally impacted by the project and would remain at “cumulative without project” levels, as shown in Table IV.M-11 of the DEIR:

- Cypress Avenue at Cabrillo Highway (Study Intersection 6)
- Airport Road at Los Banos Avenue (Study Intersection 5)
- Airport Road at La Granada Avenue (Study Intersection 4)

POTENTIAL CUMULATIVE IMPACTS OF ALTERNATE TRAFFIC CIRCULATION

The following is an analysis of the anticipated impact of the alternate traffic circulation to “cumulative with project” intersection LOS levels as presented in the Hexagon Traffic Report:

E. CABRILLO HIGHWAY AT NORTH CAPISTRANO ROAD (STUDY INTERSECTION 8)

The alternate route would add 86 AM westbound trips from Cabrillo Highway to North Capistrano Road and 77 PM eastbound trips from North Capistrano Road to Cabrillo Highway, where Figure 15 of the Hexagon Traffic Report estimates 36 AM westbound trips and 28 PM eastbound trips under original “cumulative with project” conditions.

Table 5
Cabrillo Highway at North Capistrano Road (Study Intersection 8) – Cumulative Traffic AM & PM Volumes With Alternate Traffic Route

Cabrillo Highway at North Capistrano Road	*Cumulative With Original Project*			Additional Revised Project Trips	Cumulative with Optional Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Cabrillo Highway to North Capistrano Road – westbound (AM)	36	*C*	*17.3*	86	122
2. North Capistrano Road to Cabrillo Highway – eastbound (PM)	28	*C*	*23.2*	77	105
Total	64			163	227

Under the alternate traffic route, there is a potential for both AM and PM intersection LOS to exceed level "C" under cumulative with project conditions. However, this potential is reduced due to the existing configuration of the intersection (left and right turn pockets, left turn and right turn merge lanes, and sight visibility for cars being detained at the signalized intersection of Capistrano South). Therefore, the alternate traffic route would not result in a potentially significant impact to intersection LOS. The implementation of Mitigation Measures TRANS-1 and proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers would further reduce the project impact to cumulative intersection LOS to a less-than-significant level.

F. PROSPECT WAY AT CAPISTRANO ROAD (STUDY INTERSECTION 1)

Under original "cumulative with project" conditions, Figure 15 of the Hexagon Traffic Report estimates traffic between Prospect Way and South Capistrano Road at 279 AM westbound trips and 309 PM southbound trips. Between Prospect Way and North Capistrano Road, Figure 15 of the Hexagon Traffic Report estimates "cumulative with project" conditions at 35 AM westbound trips and 35 PM northbound trips. Intersection LOS under original "cumulative with project" conditions is at level "A" in the AM and level "B" in the PM. The revised route would add 86 AM westbound trips and 77 PM northbound project trips to project traffic conditions.

While AM intersection LOS is not likely to exceed level LOS "C" (as intersection LOS under original "cumulative with project" is estimated at level "A"), the revised traffic circulation may impact PM intersection LOS, currently at LOS

"B". The additional PM trips from the alternate traffic route onto total cumulative project traffic volumes along Prospect Way (north and southbound) could cause intersection LOS to exceed level "C" (or 25 seconds of delay) in the PM. As illustrated in the table below, the additional 77 PM northbound trips would be added to the estimated 344 PM trips under project conditions for a total of 421 PM trips.

Table 6
Prospect & Capistrano Intersection (Study Intersection 1) – Cumulative Project Traffic AM & PM Volumes with Alternate/Optional Traffic Route

Prospect & Capistrano Intersection	*Cumulative With Original Project*			Additional Revised Project Trips	Cumulativ with Optional Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. North Capistrano Road to Prospect Way – Westbound (AM)	35	*A*	*9.6*	86	121
2. South Capistrano Road to Prospect Way – Westbound (AM)	279	*A*	*9.6*	--	279
AM Total	314			86	400
3. Prospect Way to North Capistrano Road – Northbound (PM)	35	*B*	*11.9*	77	112
4. Prospect Way to South Capistrano Road – Southbound (PM)	309	*B*	*11.9*	--	309
PM Total	344			77	421
Total	658			163	821

Implementation of Mitigation Measures TRANS-1 and proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers would reduce project impact to cumulative PM intersection LOS to a less-than-significant level.

G. PROSPECT WAY AT BROADWAY/CORNELL AVENUE (STUDY INTERSECTION 2)

As illustrated in the table below, the addition of 86 AM trips to the 136 trips (LOS "B" with 12.8 seconds of delay) estimated under original "cumulative with project" conditions shown in Figure 15 of the Hexagon Traffic Report would result in a total of 222 AM trips. The alternate traffic route would result in the addition of 77 PM trips to the 200 trips (LOS "C" with 16 seconds of delay) estimated under original "cumulative with project" conditions, for a total of 277 PM trips.

Table 7
Prospect Way at Broadway/Cornell Avenue (Study Intersection 2) – Cumulative Project Traffic AM & PM Volumes

Prospect Way at Broadway/Cornell Avenue	*Cumulative With Original Project*			Additional Revised Project Trips	Cumulative with Optional Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Prospect Way to Broadway/Cornell Avenue – westbound (AM)	136	*B*	*12.8*	86	222
2. Broadway/Cornell Avenue to Prospect Way – eastbound (PM)	200	*C*	*16*	77	277
Total	336			163	499

While the additional 86 AM trips is unlikely to increase the delay from 12.8 to over 25 seconds[5] (an increase in of 12.3 seconds), there is the potential for intersection LOS to exceed level "C" in the PM at Broadway/Cornell Avenue. This potential is reduced, as traffic is more likely to disperse between Cornell Avenue and Harvard Avenue (drivers will shift their route to maintain the shortest delay), rather than concentrate on Cornell Avenue as originally analyzed in the DEIR. This is shown in Figure D of the Final EIR. In addition, implementation of Mitigation Measures TRANS-1 proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers, would reduce project impact to cumulative peak-hour traffic volumes and intersection LOS to a less-than-significant level.

[5] *LOS C includes delays of 15.1 to 25 seconds for unsignalized intersections.*

H. AIRPORT ROAD AT STANFORD AVENUE/CORNELL AVENUE (STUDY INTERSECTION 3)

As illustrated in the table below, the alternate traffic route would result in an additional 86 AM trips onto the estimated 135 AM trips (LOS "B" with 11 seconds of delay) estimated under original "cumulative with project" conditions as shown in Figure 15 of the Hexagon Traffic Report, for a total of 221 AM trips. The alternate traffic route would result in an additional 77 PM trips onto the estimated 111 PM trips (LOS "B" with 11.9 seconds of delay) estimated under original "cumulative with project" conditions, for a total of 188 PM trips.

Table 8
Airport Road at Stanford Avenue/Cornell Avenue (Study Intersection 3) – Cumulative Project Traffic AM & PM Volumes

Airport Road at Stanford Avenue/Cornell Avenue	*Cumulative With Original Project*			Additional Revised Project Trips	Cumulative with Optional Project Traffic Volume
	Trips	Worst Case LOS	Delay (in seconds)		
1. Stanford Avenue/Cornell Avenue to Airport Road – northbound (AM)	135	*B*	*11*	86	221
2. Airport Road at Stanford Avenue/Cornell Avenue - eastbound (PM)	111	*B*	*11.9*	77	188
Total	246			163	409

While the additional AM and PM trips are unlikely to increase the delay to over 25 seconds, there is a small potential for AM and PM intersection LOS to exceed level "C". This potential is reduced, as traffic is more likely to disperse between Cornell Avenue and Harvard Avenue (drivers will shift their route to maintain the shortest delay), rather than concentrate on Cornell Avenue as originally analyzed in the DEIR. In addition, implementation of Mitigation Measure TRANS-1 proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers, would reduce project impact to cumulative peak-hour traffic volumes and intersection LOS to a less-than-significant level.

CONCLUSION

In summary, the alternate traffic route would result in reduced project impacts to local intersections which are largely residential, these being Cypress Avenue at Cabrillo Highway (Study Intersection 6), Airport Road at Los Banos Avenue (Study Intersection 5), and Airport Road at La Granada Avenue (Study Intersection 4), but may increase potential project impacts (under cumulative and non-cumulative scenarios) to non-residential intersections. Non-residential intersections potentially impacted by the revised traffic circulation are Cabrillo Highway at North Capistrano Road (Study Intersection 8), Prospect Way at Capistrano Road (Study Intersection 1), Prospect Way at Broadway/Cornell Avenue (Study Intersection 2), and Airport Road at Stanford Avenue/Cornell Avenue (Study Intersection 3). However, with implementation of Mitigation Measures TRANS-1, proposed off-site parking agreement and shuttle to accommodate a minimum of 50 cars and their drivers, and proposed improvements to Airport Street to prohibit project traffic north of the project site on Airport Street, intersection LOS for the above intersections would be maintained at a level of "C" or better under project and cumulative scenarios. Therefore, potential traffic impact of the alternate traffic route would be less-than-significant.

APPENDIX H

ADDITIONAL INFORMATION REGARDING CONSTRUCTION PHASING AND SCHEDULE PROVIDED BY THE APPLICANT

Additional Applicant-Provided Information Regarding Construction Phasing and Schedule:

In addition to the information provided in the DEIR and under Topical Response 12, Construction Phasing for the Office Park, the following additional description of project construction and phasing is provided by the applicant, as follows:

> *Phase 1:* Construct rough grading (for whole site), install main utilities (for whole site), construct the visual and sound barriers (native trees and irrigation system for the whole site. If required the additional flexible sound barrier will be installed during each Office Park building permit. Conventional farming will start the transition to organic farming. Construct Phase I of the Wellness Center (Eight one story breezeway units). Construct the sewer connection to GSD for the initial 8 units. Construct the water recycling and water systems for the wellness center, construct the parking lot and initiate phased wetlands restoration for the Wellness Center. Construct the site access and encroachments (including sidewalk) for the Wellness Center.
>
> *Phase 2*: Construct the remainder of the Wellness Center under a separate building permit.
>
> *Phase 3*: Construct the commercial buildings and the Communications Building on the Wellness Center Parcel under a separate building permit.
>
> *Phase 4*: Construct the site access and encroachments (including sidewalk) to Airport Street and other offsite street improvements required by the County TMD's for the Office Park. Construct the first building for the Office Park when the local economy can support the project. Office park construction on the northern parcel will be done with separate building permits for each building (or building groups) that includes the necessary parking, water and wastewater, storm drainage systems and complies with all the CCRs and CCC permit conditions for each permit. Since all of the buried utilities and the rough grading will be done in Phase 1, the construction of each building will take only 12 months. The size of the crew will be proportionally smaller that the crew size for building all of the buildings simultaneously. The mitigated project requires drilled instead of driven piers. Drilling the piers for one building will take a proportional smaller amount of time relative to the square footage of the buildings. The pier concrete will placed with the grade beam concrete.
>
> *Phase 5*: Construct the improvements to Cypress Street, Capistrano or other intersection if required by the traffic study required for the first 60,000 square feet of commercial space permitted to maintain all intersection at LOS level C or better. .
>
> *Phase 6*: Repeat same process for the remainder of the Commercial Building on the northern parcel.

Impacts of Additional Information to Phasing and Schedule:

- The project phases are essentially the same as those that are listed in the DEIR the only differences is that the construction effort is less concentrated and spread over a longer time.

- The majority of the impacts will be accomplished the initial phased including the site grading and the impacts to Airport Street

- The vegetative sound and visual barrier will be mature while the office buildings are constructed. This will shield the site construction from view and construction noise.

- The size of the construction crew will be smaller at any particular time and the delivery of construction material will be a fraction of the total at any particular time. This will have a lower impact on traffic and the smaller crews and operation will have a lower maximum noise impact.

- The use of water for the development will increase gradually over time and the impacts can be monitored and additional requirements can be incorporated by the County in the building permit process.

- The vegetative sound and visual barrier is the primary use for recycled water. This strip will be mature by the time the individual recycling systems) will come on line.

- There will be adequate time and data to demonstrate the effectiveness of the water recycling on a smaller scale before the full project is developed.

- There is considerable lower risk to the environment with the gradual development of the project. The wetlands restoration will be phased along with the development and the design can be modified if appropriate for each permit to maximize its effectiveness.

- The current farming practice will be modified from conventional to organic during phase 1, this will immediately reduce the impacts of farming on the marsh.

- The phasing allows for the phased construction of the wetlands restoration. Each phase of the construction will include a phase of the wetlands restoration. The wetlands will not be restored if the project is not built. If the project is not built the site will continue to be farmed.

- If the first phase includes the underground work, the rough site grading and the planting of the visual screening and sound barrier, the impacts of the site work will be the same. If each subsequent phase involves the construction of a fraction of the buildings, the building construction impacts will be related to the fractional amount constructed. If the first phase for the office park constructs the northerly building and plants the associated wetlands and visual and noise shielding, the adjoining residential section will be shielded from the construction noise and impacts associated with the following phases. Phasing the project over a 20 year period does not increase the project impacts and as long as the same mitigations apply to the phased project, the impacts of construction over a 20 year phased period of time are

APPENDIX I

LETTER FROM THE FEDERAL AVIATION ADMINISTRATION (FAA),
DATED JULY 8, 2010.

U.S. Department
of Transportation
**Federal Aviation
Administration**

Western-Pacific Region
Airports Division

P. O. Box 92007
Los Angeles, CA 90009-2007

San Mateo County Airports

JUL 12 2010

RECEIVED

July 8, 2010

Mark Larson
Airport Manager
Half Moon Bay Airport
620 Airport Drive
San Carlos, CA 94070

Dear Mr. Larson:

Half Moon Bay Airport
Planned Wellness Center

We are providing comments regarding the proposal to construct a Big Wave Wellness Center (Center) next to Half Moon Bay Airport (HAF). Based on the information available to us, the Center will be built approximately 500 feet west of runway 30. The presence of a center for the developmentally disabled that is so close to the runway represents a use that is not compatible with normal airport operations. Therefore, it is our determination that the selected site is not appropriate. An alternative site outside HAF's influence area should be used for the Center.

San Mateo County is reminded of the requirements of Assurance 21, *Compatible Land Use.* Airport sponsors are required to take appropriate action to restrict the use of land adjacent to the airport to activities that are compatible with normal airport operations. Clearly, a clinical residential center serving disabled patients would not be considered a compatible use so close to the airport and its runway.

Even if the center is not inside the noise contours of HAF, aircraft operations will have some disturbing impact on the Center. Its occupants will surely be aware of normal airport operations because aircraft over-flight noise will occur. The duration and intensity of the noise, even if it is intermittent, will likely be deemed to be an undesirable nuisance by occupants and residents of the center.

From a practical perspective, the consequences of incompatible land uses should not be taken lightly. The airport's neighbors will surely complain about airport noise. Incompatible land uses such as the Center will eventually provoke persistent criticism related to noise, safety, and emissions.

Once incompatible land uses are established, it is the airport that is expected to undertake remedial action to mitigate the offending irritants. For example, the San Mateo County General Plan was formulated to "promote and protect the public health, safety, peace, morals, comfort, convenience and general welfare." Additionally, the "Airport Land Use Plan includes policies, standards, and criteria to address each of these issues to assist local agencies to achieve land use compatibility with existing and future airport development and operations."

Yet, because of incompatible land uses in the vicinity of HAF, "the County has implemented noise abatement procedures at HAF to further reduce aircraft noise impacts in the surrounding noise sensitive areas."

The above example discloses the land-use incompatibility shortcoming related to the proposed location of the Wellness Center. The planning and environmental documents proffer that there will not be any negative environmental impacts related to the proximity of the Center to the airport. However, experience actually reveals that the opposite is true. Inevitably, the Center's users will complain about the airport. The unfortunate public policy reaction to the complaints will inevitably be proposals to impose additional restrictions on normal airport operations. Historically, case after case shows that incompatible land use becomes a quality of life issue for the airport's neighbors and, thereafter, a losing proposition for the airport.

For these reasons, we must express our objection to the proposed site of the Wellness Center. If you have any questions, please call me at 310-725-3634.

Sincerely,

Tony García

Tony García
Airports Compliance Program Manager/
Safety-Certification Inspector

APPENDIX J

ATTACHMENTS TO COMMENT LETTER 230 FROM MID-COAST COMMUNITY COUNCIL, NEIL MERRILEES, DATED DECEMBER 23, 2009.

Item No. #6

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San Mateo County
Planning Division

DRAFT

Action Minutes for the April 30, 2009 C/CAG Airport Land Use Committee (ALUC) Special Meeting

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1. *Call to Order, Roll Call*

Richard Newman, Aviation Representative and Committee Chairperson, called the Special Meeting of the C/CAG Airport Land Use Committee (ALUC) to order, at approximately 4:05 p.m. in the City Council Chambers, at Burlingame City Hall, 501 Primrose Road, Burlingame, California. David F. Carbone, C/CAG Airport Land Use Committee (ALUC) staff, called the roll. A quorum (at least 7 Regular Members) was present, as follows:

Regular Members Present

Ann Keighran, City of Burlingame
David Canepa, City of Daly City
Marina Fraser, City of Half Moon Bay (Alternate)
Paul Seto, City of Millbrae
Ken Ibarra, City of San Bruno
Omar Ahmad, City of San Carlos
Richard Garbarino, City of South San Francisco (Alternate)
Mark Church, County of San Mateo/Aviation Representative
Richard Newman, Aviation Representative
George Auld, Half Moon Bay Airport Pilots Association

Regular Members Absent

City of Brisbane
City of Foster City
City of Redwood City

Airport Land Use Committee Staff

David F. Carbone, C/CAG Airport Land Use Committee (ALUC) Staff

Others Present

There was no audience attendance list for this meeting.

2. Election of ALUC Officers for Calendar Year 2009

a. Election of ALUC Chairperson

Action: ALUC Vice-Chairperson Mark Church NOMINATED Richard Newman, current ALUC Chairperson, to serve as ALUC Chairperson for calendar year 2009. Ann Keighran SECONDED the motion. Vice-Chairperson Church MOVED to close the nominations. Omar Ahmad SECONDED the motion. The MOTION CARRIED, unanimously. Richard Newman was unanimously ELECTED ALUC Chairperson for calendar year 2009.

b. Election of ALUC Vice-Chairperson

Action: ALUC Chairperson Richard Newman NOMINATED Mark Church, current ALUC Vice-Chairperson, to serve as the ALUC Vice-Chairperson for calendar year 2009. Omar Ahmad SECONDED the motion. Omar Ahmad MOVED to close the nominations. Ann Keighran SECONDED the motion. The MOTION CARRIED, unanimously. Mark Church was unanimously ELECTED ALUC Vice-Chairperson for calendar year 2009.

3. Public Comment on Items Not on the Agenda

None.

4. Consideration/Adoption of ALUC Resolution No. 01- 09 to Specify the Day, Time, and Place for Holding Regular Meetings of the C/CAG Airport Land Use Committee (ALUC) for Calendar Year 2009 to Comply With the Relevant Provisions in the Ralph M. Brown Act

Action: ALUC Vice-Chairperson Mark Church MOVED approval of ALUC Resolution No. 01-09, as shown on p. 7 of the Agenda Packet for April 30, 2009. Ann Keighran SECONDED the motion. The MOTION CARRIED, unanimously.

5. Consideration a Referral From the City of South San Francisco, re: Airport/Land Use Compatibility Plan (CLUP) Consistency Review of the *South El Camino Real General Plan Amendment*

David F. Carbone, ALUC Staff, presented the ALUC Staff Report on this item. He noted that, prior to this meeting, he discussed the proposed ALUC Staff recommended conditions with South San Francisco Planning Staff. Based on that discussion, he explained ALUC Staff is recommending a revised set of CLUP consistency conditions, as follows:

Agenda Item No. 5 - continued

Revise Condition No.1 to read as follows:

"At the time that C/CAG formally adopts the Airport Influence Area (AIA) boundary for the environs of San Francisco International Airport, the City shall coordinate with C/CAG to ensure that all future planning activities in the City adhere to the then applicable AIA boundary configuration and the related airport/land use commission formal review process."

Condition No. 2 A. – Ok as written.

Revise Condition No. 2 B. to read as follows:

Incorporate text that indicates all future development in the South El Camino Real Corridor is subject to the FAR Part 77 airspace protection surfaces (height limits) for the environs of San Francisco International Airport and the related federal notification and review process for new construction.

Revise Condition No. 3A:

Delete the text in the bullet item at the top of page 9-3 in the general plan amendment.

Condition No. 3 B – Ok as written.

Condition No. 4 - Ok as written.

Condition No. 5 - Put the ALUC staff recommended text in the resolution that adopts the general plan amendment rather than in the text of the amendment.

Elizabeth Pucinelli, representing the former movie theater property at the corner of Huntington Ave. and Noor Ave. in South San Francisco (Syufy), expressed her concern about a potential change in land use and zoning that would affect the theater property. David Carbone, ALUC Staff, suggested that she discuss her concerns with the South San Francisco Planning Staff.

Action: Ken Ibarra MOVED approval of the revised CLUP consistency conditions, regarding the City of South San Francisco *South El Camino Real Corridor General Plan Amendment,* as recommended by ALUC Staff. ALUC Vice-Chairperson Mark Church SECONDED the motion. The MOTION CARRIED unanimously.

6. Consideration of a Referral From the Town of Hillsborough, Re: Airport/Land Use Compatibility Plan (CLUP) Review of the Hillsborough *General Plan Housing Element*

David F. Carbone, ALUC Staff, briefly reviewed his Staff Report and presented a revision to his proposed CLUP consistency condition. The revised condition would put the proposed text of his recommendation into the Town Council resolution to adopt the *Housing Element 207-2014*, rather than in the document itself.

Action: Richard Garbarino MOVED approval of the revised ALUC Staff CLUP consistency recommendation, regarding the Town of Hillsborough *General Plan Housing Element.* Vice-Chairperson Mark Church SECONDED the motion. The MOTION CARRIED unanimously.

7. Informational Presentation: Presentation by the Project Sponsor for the Big Wave Office Park and Wellness Center, a Mixed-Use Development on Airport Street in the Unincorporated Princeton Area Adjacent to the Southwest Corner of Half Moon Bay Airport

Note: *This was an informal presentation. No action was taken by the ALUC on this item.*

Project Background

The proposed project is a proposed mixed-use development on two adjacent properties across the street from Half Moon Bay Airport, near the threshold of Runway 30. The proposed land uses include: (1) a Wellness Center that will include residential units for developmentally disabled children and adults (50 ultra-low income units and 20 low income units for on-site staff) and support activities; all units will be resident owned, and (2) 156,000 square-feet of high tech office space, related parking, and a two-story storage building.

The 5.2-acre Wellness Center site is zoned W/AO/DR (Waterfront, Airport Overlay, and Design Review). None of the dwelling units are located within the AO zone portion of the property. The 14.6-acre office park site is zoned M-1/DR (Light Industrial/Design Review). All of the proposed land uses are allowed in the existing zoning districts with approval of a conditional use permit. The project does not require a general plan amendment or a rezoning and therefore is not subject to formal ALUC/CCAG review/action.

The project sponsor, Big Wave Group, Inc. is a non-profit 501 (c) 3 organization. Its goal is "to provide affordable housing, food services, employment, recreation, and educational services for developmentally disabled children and adults." The project will be operated as a Cooperative, with the residents owning shares of the residential units and the office park.

Agenda Item No. 7 - continued

Big Wave Project Required Permits:

Office Park (14.2 acres); 156,000 sq. ft.
- Coastal development permit
- Major subdivision in to 5 parcels
- *Grading permit for* 38,000 *cubic yards*
- Off-street parking exception

Wellness Center (5.2 acres; 70 dwellings)
- Coastal development permit
- Minor subdivision in to 2 parcels
- Conditional Use Permit
- Design Review
- Grading permit for 12, 000 cubic yards

Comments from the Project Sponsor and ALUC Representatives

Nicole DeMartini, Big Wave Project spokesperson, presented a powerpoint overview of the proposed project. She noted that the Big Wave Company sees Half Moon Bay Airport as an asset for marketing the project. She further explained the project goal is to develop a high-tech office park development supported by a special needs community (developmentally disabled). She further explained that the office park is the economic engine for the proposed Wellness Center. She also noted the about half of the property will be devoted to environmental protection.

Ms. DeMartini mentioned several airport considerations:

Airport neighbors
The DEIR will address aircraft noise impacts and mitigation actions
The project will include double/triple pane windows
The occupant will grant and avigation easement/noise release to San Mateo Co.

She emphasized the Big Wave project is a "unique opportunity of a lifetime."

ALUC Chairperson Richard Newman noted several airport-related concerns regarding the proposed project:

Aircraft noise impacts
Safety impacts'
Wind impacts

Agenda Item No. 7 - continued

He expressed his concern about the placement of the proposed buildings opposite the approach area to Runway 12/30 at Half Moon Bay Airport, in reference to wind impacts. He described a similar existing situation at San Carlos Airport where wind blows between two buildings that are located opposite of the approach area to the runway and the increased wind velocity created by the proximity of the buildings makes for an unsafe condition for a light aircraft at slow speed for landing.

Ms. Martini explained Pillar Point Ridge is located directly behind the property and the proposed buildings will be located below the ridgeline. She indicated the Big Wave staff would research the wind issue related to aircraft operations.

George Auld, Half Moon Bay Airport Pilots Association Representative, noted the biggest concern is aircraft noise impacts and the frequency of aircraft operations. Camille Leung, County Project Planner, noted the potential airport impacts would be addressed in the DEIR.

8. Information Item: Review of Correspondence/Information Items

ALUC Staff noted the October 3, 2009 letter in the Agenda packet to the City of San Carlos, from Richard Newman ALUC Chairperson, re: ALUC comments regarding a proposed general plan amendment and a zoning ordinance text amendment to facilitate development of a mixed-use commercial/residential project at 767 Industrial Road near San Carlos Airport, w/o attachments.

9. Member Communications/Announcements

Ann Keighran noted she cannot attend the May 28, 2009 ALUC meeting.

10. Adjourn

The meeting was adjourned at approximately 5:10 p.m.

Attachment: Additional information for Agenda Item No. 7, re: the Big Wave Office Park and Wellness Center, a Mixed-Use Development on Airport Street in the Unincorporated Princeton Area Adjacent to the Southwest Corner of Half Moon Bay Airport

ADDITIONAL INFORMATION FOR AGENDA ITEM NO. 7

C/CAG SPECIAL AIRPORT/LAND USE COMMITTEE (ALUC) MEETING

APRIL 30, 2009

DIVISION OF AERONAUTICS – M.S.#40
1120 N STREET
P. O. BOX 942873
SACRAMENTO, CA 94273-0001
PHONE (916) 654-4959
FAX (916) 653-9531
TTY 711

Flex your power!
Be energy efficient!

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Ms. Camille Leung
San Mateo County
455 County Center, 2nd Floor
Redwood City, CA 94063

November 17, 2008

Dear Ms. Leung:

San Mateo County's Notice of Preparation of a Draft Environmental Impact Report for the Big Wave Wellness Center and Office Park; SCH# 2008102109

The California Department of Transportation (Caltrans), Division of Aeronautics (Division), reviewed the above-referenced document with respect to airport-related noise and safety impacts and regional aviation land use planning issues pursuant to the California Environmental Quality Act (CEQA). The Division has technical expertise in the areas of airport operations safety, noise and airport land use compatibility. We are a funding agency for airport projects and we have permit authority for public-use and special-use airports and heliports. We offer the following comments for your consideration.

The proposal will include "housing and employment opportunities for low-income developmentally disabled (DD) children and adults." The two primary components include a "Wellness Center" and "Office Park." The project site is located immediately adjacent to southwest boundary of the Half Moon Bay Airport.

Half Moon Bay Airport provides a variety of emergency service and response functions including: Air-Ambulance and Medivac flights; law enforcement and homeland security patrols; Coast Guard sea-rescue operations; and use as a disaster relief staging site for the airlifting of emergency supplies in the event that roads are closed during a disaster or emergency. Half Moon Bay is an active airport, with approximately 80 based aircraft, over 60,000 annual operations and several aviation related businesses.

A portion of the project site appears to be within the Approach Protection Zone (APZ) for Half Moon Bay Airport as designated in the San Mateo County Comprehensive Airport Land Use Plan (CALUP). The CALUP recommends against residential uses and business uses within the APZ. Protecting people and property on the ground from the potential consequences of near-airport aircraft accidents is a fundamental land use compatibility-planning objective. While the chance of an aircraft injuring someone on the ground is historically quite low, an aircraft accident is a high consequence event. To protect people and property on the ground from the risks of near-airport aircraft accidents, some form of restrictions on land use are essential. The two principal methods for reducing the risk of injury and property damage on the ground are to limit the number of persons in an area and to limit the area covered by occupied structures. This should be addressed in the Draft Environmental Impact Report (DEIR).

The northern third of the project site also appears to be within an area identified as "extremely noise sensitive areas" on the Half Moon Bay Airport-Noise Abatement Procedures. It is likely that some future residents and tenants will be annoyed by aircraft noise in this area. A thorough airport-related noise analysis should be included in the DEIR.

The proposal should also be submitted to the San Mateo County Airport Land Use Commission (ALUC) for a consistency determination. The proposal must also be coordinated with Half Moon Bay Airport staff to ensure that the proposal will be compatible with future as well as existing airport operations.

State Public Utilities Code Section 21659 prohibits structural hazards near airports. In accordance with Federal Aviation Regulation, Part 77 "Objects Affecting Navigable Airspace" a Notice of Proposed Construction or Alteration (Form 7460-1) may be required by the Federal Aviation Administration (FAA). Form 7460-1 is available on-line at https://oeaaa.faa.gov/oeaaa/external/portal.jsp and should be submitted electronically to the FAA.

Business and Professions Code Section 11010 and Civil Code Sections 1102.6, 1103.4, and 1353 address buyer notification requirements for lands around airports and are available on-line at http://www.leginfo.ca.gov/calaw.html. Any person who intends to offer subdivided lands, common interest developments and residential properties for sale or lease within an airport influence area is required to disclose that fact to the person buying the property.

The protection of airports from incompatible land use encroachment is vital to California's economic future. Half Moon Bay Airport is an economic asset that should be protected through effective airport land use compatibility planning and awareness. Although the need for compatible and safe land uses near airports is both a local and State issue, airport staff, airport land use commissions and airport land use compatibility plans are key to protecting an airport and the people residing and working in the vicinity of an airport. Consideration given to the issue of compatible land uses in the vicinity of an airport should help to relieve future conflicts between airports and their neighbors.

These comments reflect the areas of concern to the Division with respect to airport-related noise and safety impacts and regional airport land use planning issues. We advise you to contact our Caltrans District 4 office concerning surface transportation issues.

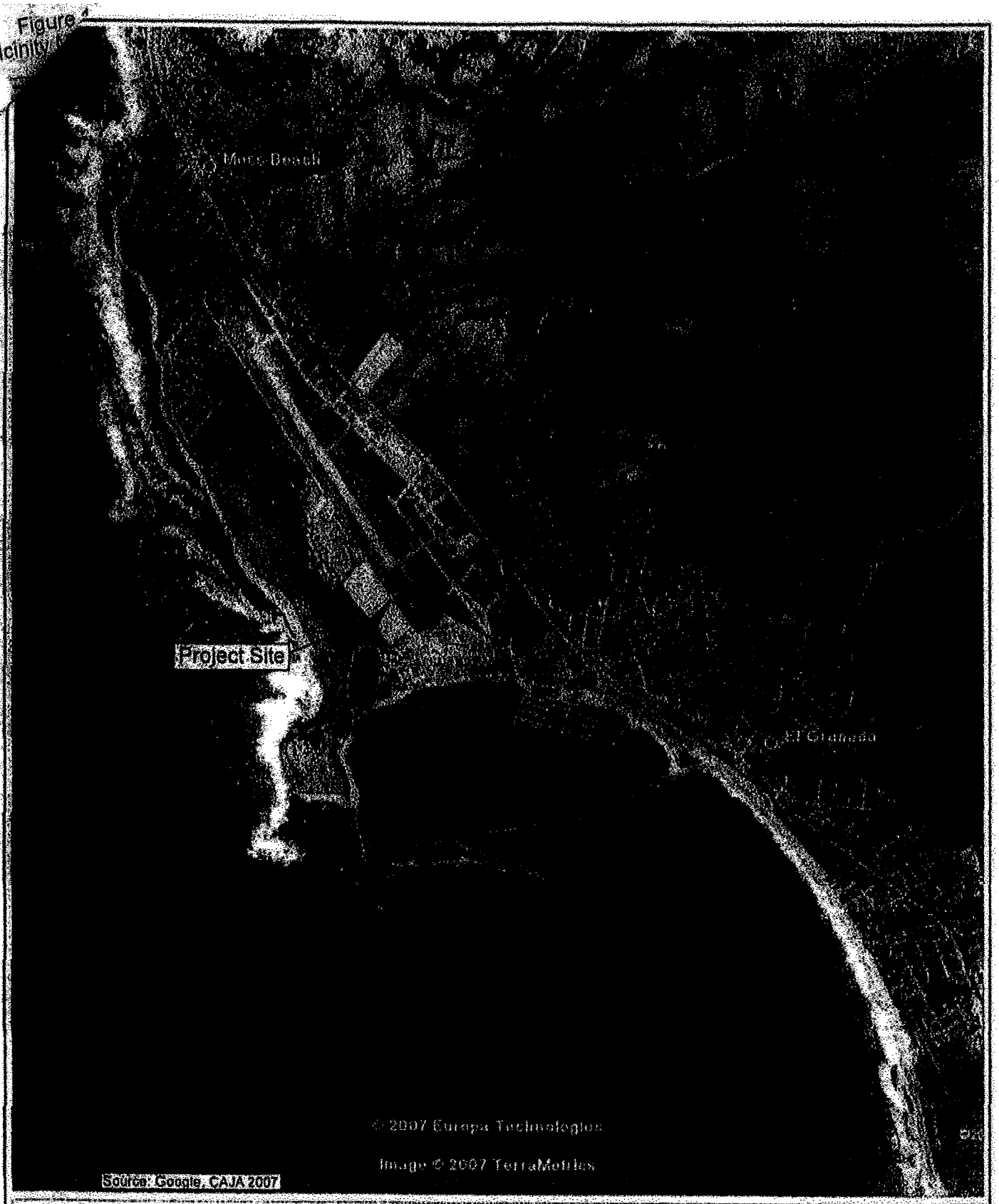
Thank you for the opportunity to review and comment on this proposal. If you have any questions, please call me at (916) 654-5314.

Sincerely,

Original Signed by

SANDY HESNARD
Aviation Environmental Specialist

c: State Clearinghouse, Half Moon Bay Airport, San Mateo County ALUC



CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

Figure 2
Aerial Photograph of Site

421 Aviation Way
Frederick, Maryland 21701

T. 301-695-2000
F. 301-695-2375

www.aopa.org

December 4, 2008

County of San Mateo, Planning and Building Department
Attn: Camille Leung, Planner
455 County Center, 2nd Floor
Redwood City, CA 94063

Re: Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the Big Wave Wellness Center and Office Park

Dear Ms. Leung:

The Aircraft Owners and Pilots Association (AOPA) represents the general aviation interests of 415,000 members, more than two-thirds of the nation's pilots – including 49,809 of our members in the state of California. On behalf of our membership, AOPA is committed to ensuring the future viability and development of general aviation airports and their facilities as part of a national transportation system. In that regard, we appreciate the opportunity to comment on the Notice of Preparation of an Environmental Impact Report for the Big Wave Wellness Center and Office Park, proposed for a site adjacent to the Half Moon Bay Airport (HAF).

AOPA is opposed to this development because such a project would be an incompatible land use adjacent to an airport. The EIR must look at the impact of this project on the airport's current and future operations and mitigation should not penalize the airport. Rather, a more compatible use should be sought for the property. As the airport sponsor, the County has the obligation to ensure compatible land uses around the airport under both the quit claim deed from the Federal government and the receipt of Federal Aviation Administration (FAA) airport improvement funds.

The proposed site location is located within several airport safety zones for runway 30 that should preclude residential development. The first safety zone that impacts the project area is comprised of the FAA mandated runway protection zone which is a trapezoid shape extending from 200 feet east of the displaced threshold on Runway 30 out 1000 feet with a base width of 500 feet widening to a width of 1000 feet. The 2002 *California Airport Land Use Planning Handbook* prohibits any dwelling units within that zone.

In addition, the Approach Protection Zone overlies a portion of the property, and the state of California recommends limiting development to one dwelling unit per 10 to 20 acres. This precludes placing any of the proposed 45 residential units in this area.

The majority of the property is within the traffic pattern zone, which allows residential uses but discourages schools, day care centers and nursing homes. Despite the allowance for residential use within this zone, AOPA contends residential uses adjacent to the airport are incompatible and should not be permitted. The County should identify a more compatible land use for this property.

Again, we appreciate the opportunity to share comments and look forward to reviewing the EIR in the future.

Sincerely,

John L. Collins
Manager
Airport Policy

Department of Public Works

MARK CHURCH
RICHARD S. GORDON
JERRY HILL
ROSE JACOBS GIBSON
ADRIENNE TISSIER

JAMES C. PORTER
DIRECTOR

COUNTY OF SAN MATEO

555 COUNTY CENTER, 5TH FLOOR • REDWOOD CITY • CALIFORNIA 94063-1665 • PHONE (650) 363-4100 • FAX (650) 361-8220

December 5, 2008

Ms. Camille Leung
Planning and Building Department
455 County Center, 2nd Floor
Redwood City, CA 94063

Dear Camille:

RE: Notice of Preparation of an Environmental Impact Report for the Big Wave Wellness Center and Office Park.

Thank you for the opportunity to comment on the Notice of Preparation of an Environmental Impact Report for the proposed Big Wave Wellness Center and Office Park (Project) located on Airport Street adjacent the Half Moon Bay Airport.

The proposed Project is located approximately 300-feet from the Half Moon Bay Airport (Airport) runway. The Airport is open year-round 24-hours a day and has approximately 40,000 to 60,000 aircraft take-offs and landings per year. The proposed Project area is subject to single-event aircraft noise impacts from aircraft take-offs, departures, overflights, arrivals and pre-flight run-ups at the Airport.

The Project is located directly across from the beginning of Runway 30. Prevailing wind conditions at the Airport dictate that Runway 30 be used for take-offs and landings approximately 80 percent of the time. Due to its proximity to the beginning of the runway, the project area is also subject to extended single-event propeller, jet and engine noise impacts as aircraft apply full take-off power and begin to accelerate for take-off.

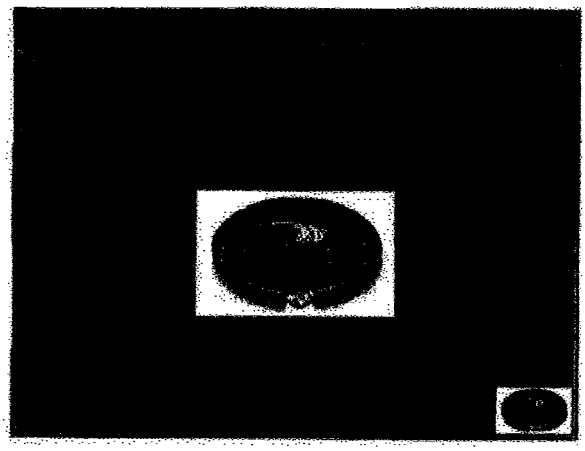
The requirements, guidelines and recommendations in the California Airport Land Use Planning Handbook from the State Department of Transportation should also be considered as they relate to specific land uses in the vicinity of airports as well as aircraft noise impacts and the safety of aircraft occupants and people and property on the ground.

Please give me a call at (650) 573-3700 if you have any questions or I can provide any additional information.

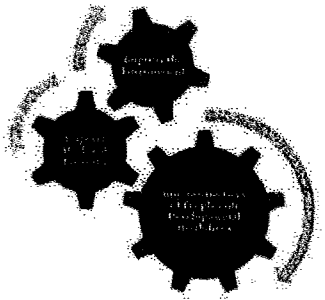
Very truly yours,

Mark Larson
Airports Manager

Cc: Jim Porter, Director of Public Works
Dave Carbone, County Airport Environs Planner



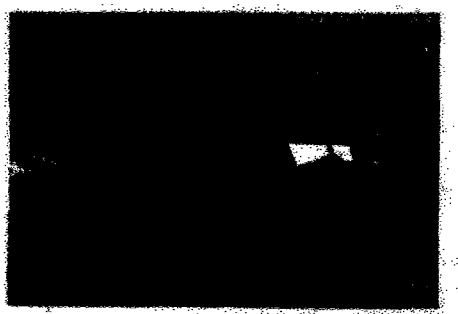
Big Wave Model: Creates a Sustainable Alliance of Human, Business and Environmental Imperatives



The Big Wave Model provides sustainability for all stakeholders adding value to:

- The Coastside's developmentally disabled community
- The local economy
- The coastal environment
- The strength of the local community

Big Wave's Two Adjacent Building Sites



Big Wave Wellness Center: Independent, Sustainable Living for the Developmentally Disabled



Big Wave Office Park: The Financial Engine

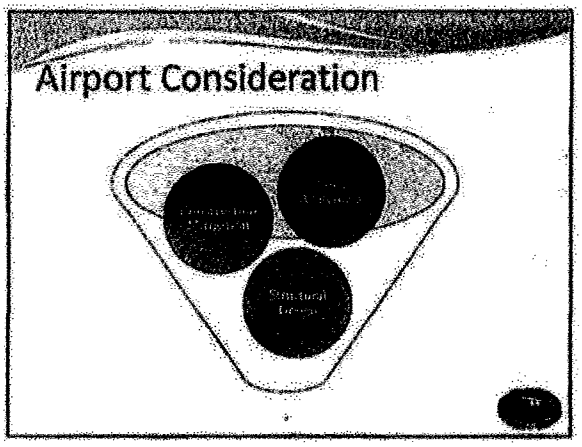


Big Wave Leads the Way in Sustainable Environmental and Energy Design

Improve the Environment:

All facilities will be Platinum Leadership in Energy Environmental Design (LEED) Certified Construction.

- All water will be recycled.
- All power will be renewable.
- Nearly 50% of the site will be restored from current farmland into high functioning coastal wetlands.


Airport Consideration



Midcoast Community Council

An elected Municipal Advisory Council to the San Mateo County Board of Supervisors
Serving 12,000 coastal residents
Post Office Box 248, Moss Beach, CA 94038-0064
Office Fax: (650) 728-2129 ***http://mcc.sanmateo.org***

February 27, 2009
Camille Leung, Planner III
455 County Center, 2nd Floor
Planning & Building Department
Redwood City, CA 94063

RECEIVED

DEC 24 2009

San Mateo County Planning Division

Re: Big Wave Facilities Plan Draft 2

Ms Leung,

Thank you for forwarding a copy of the Big Wave Facilities Plan Draft 2.

The following comments are based on review of the Facilities Plan and community input resulting from the Big Wave project presentation at our February 11th, 2009 MCC meeting.

Developing a Coastside assisted living community for people with disabilities is an appealing concept however there are many issues in the Big Wave Facilities Plan that we recommend addressing early in the planning process.

Project Description: environmental issues chapter 1.0 page 1

The Facilities Plan states; "Over 50% of the site will be restored into high functioning coastal wetlands." Upon measuring the undeveloped space in Figure 1.1.1: in the Wellness Center Site Plan the developed space (using the fire-trail as the divider) is clearly much larger than the wetlands space. Similarly, Figure 1.3.1: in the Office Park Site Plan clearly shows the undeveloped space to be much less than the developed space. Either the estimates of coverage (Table 1.1.2.1) are incorrect, or the site maps are drawn incorrectly. The numbers given for Figure 1.1.1 and Figure 1.3.1 are inconsistent and it is unclear witch is correct.

The wetland determination and requirements, using all three of the Coastal Act standards, should be done immediately.

Wellness Center Site

The Wellness Center as proposed is an assisted living facility housing 20 staff and 50 developmentally disabled adults for a total of 70 residents. The Wellness Center is sited in a light-industrial (zoning W/DR) area. Table 7.1.2 indicates that many of the residents would not drive, which could leave them separated from general interaction with the community. The site is separated from schools, grocery stores, library, cafes, community parks, shopping and other residential support services by a warehouse district. Pedestrians would be forced to negotiate loading trucks, forklifts and other industrial hazards in an area that does not have sidewalks or paths. This site could feasibly be developed as light industrial. While this might not preclude the placement of the Wellness Center in the industrial area, it is a serious issue and is not adequately addressed in the Facilities Plan. Issues overlooked in the planning process could negatively impact the quality of life for Wellness Center residents and other local residents. We hope all the site-specific concerns will be addressed in detail.

Office Park Site

The size and scale of the proposed Office Park is out of character with its surroundings. Buildings of this size and mass are unprecedented on the Midcoast. Zoning Regulations Section 6565.7 requires the design of the structure be in harmony with the shape, size and scale of adjacent building in the community. On one side it abuts the W/DR light industrial Princeton area, where buildings are all less than 36 ft tall. On the other side the proposed project abuts a one-story residential manufactured home park. The proposed 3-story 51-6" buildings would dwarf not only its neighbors, but all other buildings on the Midcoast. We feel it would seriously affect the view of the ocean from Hwy 1. There are many 3-story buildings in the Princeton light industrial area that are only 36' tall, and work quite well. We suggest story poles at an early stage in the application process to assist the community in accurately evaluating the effects of the unprecedented height.

Traffic

The Summary of Project Features clearly states the Big Wave development would, "Reduce traffic on Hwy 1". This statement contradicts Table 7.1.2, which estimates the development would add 3787 car trips per day. Hwy 1 traffic would be negatively impacted by 3787 additional car trips per day and the narrow access roads would become congested.

In the Bay Area, residents from as far away as the Central Valley commute to office parks. The suggestion that a large office park in a fairly remote location would alleviate traffic is unrealistic. The addition of 225,000 sq. ft. of office space to the Coastside would draw commuters from other parts of the Bay Area. A project of this size would have significant negative effects on traffic through Devils Slide (tunnels) and the already congested Hwy 92. Large business parks located in remote locations do not reduce traffic. Business parks located near transit hubs (BART) or existing commute routes can reduce traffic. A new office park might have something to offer our community, however we should think realistically about the traffic issues.

Parking

In the Facilities Plan, the applicant asks for a parking exception (1 space per 250 sq ft, instead of the zoning-required 1 space per 200 sq ft) based on being located next to public transit. The plan cites other cities in San Mateo County with public transit that allow lower numbers. Cities in San Mateo County are typically densely urban as compared with the unincorporated Midcoast. Those cities offer a higher level of public transportation compared to the semi-rural Midcoast. Many cities in San Mateo County provide a range of public transportation (BART, Caltrain, park & ride) and public parking facilities. These transit and parking options are not available on the Midcoast. The Office Park site also lacks overflow parking. If the on-site parking is full there are no lots nearby. By looking at the site map (Figure 1.3.1) it is clear that on-site parking cannot be expanded in the future. Even in that semi-rural location there is already an existing parking problem on Airport Blvd due to consistent overflow from Pillar Ridge. We suggest that the existing (1 space per 200 sq. ft.) parking requirement is reasonable and appropriate.

Table 7.2.2 suggests a mix of uses (40% office, 25% research, 15% storage, 20% manufacturing), which require different parking components. The proposed buildings however, are all office buildings and while they could be used for lower intensity uses, they could also be used in the highest capacity, which is for General Office. Once built, it would be difficult for the County to enforce the proposed mixed use. If there were more demand for general office space, then the required parking spaces would be insufficient.

Storage buildings (of which there are many existing in Princeton) are less expensive to build, usually lack windows, are usually not heated & cooled. Manufacturing buildings usually have limited heating, large roll-up doors and are 1-2 stories tall (there is limited demand for 2nd & 3rd story manufacturing). Since the 51' tall buildings in Figure 1.3.5 appear to be office buildings, and could all be used as Office buildings, they should be subject to the parking requirements and traffic impacts for general office space.

Financial Feasibility

The economic data contained in the Plan is dated 2007. The economy has shifted radically during the last two years. Based on our current economic situation the data is optimistic and outdated.

Many counties require a feasibility study as part of the EIR. We strongly recommend that independent analysis be required.

This proposed project will double the office space on the San Mateo County Coastside. The commercial space in the nearby Harbor Village is currently vacant.

The residential units are designated for low income and ultra-low income people. What agency will oversee compliance with this requirement? We recommend that this information be included in an independent analysis.

Emergency Evacuation

The proposed project site is in the Tsunami evacuation zone. The evacuation route is north on Airport Blvd, to Cypress Ave, to Hwy 1. The existing roads and intersection with Hwy 1 are completely inadequate to handle the number of evacuees from the site. It is also questionable as to whether Hwy 1 could handle the additional number of cars evacuating the Big Wave site.

Airport Overlay

The site of the proposed development is in close proximity to the Half Moon Bay Airport runway. We recommend the County take the latest FAA safety standards into consideration when reviewing the project.

Subdivisions

The Planning applications mention a request for subdivision however no further information is included.

Additional Natural Resources Questions

- No permitting agency wetland determination is included in this document and should be completed as soon as possible.
- What are the regulations concerning private, commercial water recycling programs? Are there any located in the Bay Area? What effect will recycled water have on runoff to wetlands?
- Is the solar generation capability dependent on grant funds? What if these funds are not obtained? Is fuel cell technology speculative?
- What will be done to protect the groundwater, the Pillar Ridge water supply and marsh from saltwater intrusion? Where will the monitoring wells be?
- Does this area contain archaeological sites?
- Should a project of this scale be built next to the Fitzgerald Marine Reserve an Area of Special Biological Significance (ASBS) and part of the federally protected Monterey Bay National Marine Sanctuary?
- Where will the livestock be housed? What long-term effect will increased agricultural land use have on creeks?
- Allied Waste is not the garbage collection company serving this area as stated in the Plan.
- Where will the water recycling plant be located?

The "green" and agricultural aspects of the proposed project are under-defined in the Facilities Plan. We hope a comprehensive EIR will address these issues in detail and that the County will require concrete answers prior to going forward.

General

In summary, after viewing the Facilities Plan Draft 2, holding a public meeting, and receiving feedback from the public, we have the following overall comments:

- While there is a feeling that the Wellness Center could be a good addition for the Midcoast, there are concerns regarding the location in a warehouse district. Many residents feel that development consistent with the zoning in this area is critical. Variances create inconsistent land usage and are not good planning.
- The Density, Height and Scale of the proposed Office Park are out of scale with the character of the site on the semi-rural Midcoast. A more moderate proposal with smaller scale buildings would be more appropriate for the area, and could still generate profit for the developer.
- There is concern that the traffic generated would overwhelm the semi-rural and residential roads that provide access to the proposed site.
- While the project includes many "green" proposals, the concept of locating large-scale concentration of office space at the fringe of the urban area away from major traffic corridors and transit hubs would result in large scale commuting, which is not good planning.
- Pedestrian and bicycle safety on the effected access roads is already a major problem.

Thank you,

Deborah Lardie
Chairperson
Midcoast Community Council

Cc: R. Gordon