County of San Mateo, Facilities Planning, Design and Construction

Cordilleras Mental Health Center Replacement

Preliminary Engineering Geology and Geotechnical Engineering Feasibility Report

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1 Introduction

Arup North America Ltd. (Arup) has been commissioned by the County of San Mateo, Facilities Planning, Design and Construction (Client) to undertake a preliminary engineering geology and geotechnical study to facilitate a feasibility level evaluation of engineering geological and geotechnical engineering conditions in the vicinity of the Cordilleras Mental Health Center Reconstruction project.

1.1 Project Description

From the draft Site Plan, dated May 23, 2014, and conversations with the design team representatives, Arup understands that the project will comprise the reconstruction of the existing Cordilleras Mental Health Center (Center) at 200 Edmonds Road in San Mateo County, California. The existing structure will be replaced and a total of six new structures will be built with associated utilities, retaining walls, pavements, landscaping, a creek culvert modification or relocation, and exterior flatwork improvements. Five of the new structures will each comprise one-story 10,500-square-foot structures of modular, wood frame construction.

The sixth structure will be the three-story Community Center building, with an approximate footprint of 15,000 square feet, and likely consist of a reinforced-concrete podium structure built into the hillside with a two-story, wood-frame structure above.

The existing Center is located partially within the footprint of the proposed buildings. The five single-story buildings are orientated west to east traversing the north valley floor and protected by a freestanding retaining structure cut into the valley slope. The main multi-story building is located immediately north of the central single-story building, and is cut into the north valley slopes. Cut slopes on the order of 55 feet high are proposed. Fill prisms on the order of 15 feet are proposed to contour the site the valley slope and reduce off-haul of spoils or import of fill.

Besides the building construction, the main feature of the proposed site reconstruction will be a curved retaining wall cut into the south wall of the valley. The overall length of wall will be on the order of 900 feet, with retained heights from less than 5 feet to over 50 feet.

1.2 Scope of Work

Arup (with the contribution of subconsultant Lettis Consultants International, Inc. [LCI]) has undertaken a preliminary engineering geologic study of the site, including geologic desktop study of existing information, site reconnaissance walkover survey, geotechnical evaluation, and development of preliminary recommendations.

The desk study and site reconnaissance walkover survey of the proposed site is to establish a general understanding of feasibility-level geological hazards and geotechnical conditions that could impact project costs. The site reconnaissance consisted of three geologists on site for one day surveying the site to map the local geological features and investigating the potential for geological hazards to affect the proposed construction.

For the feasibility level preliminary geotechnical engineering evaluation, Arup focused on geotechnical design approaches considering the geological hazards and conditions at the site, incorporating information from historical boring and soil report data from nearby sites. No new ground investigation was conducted as part of this feasibility study. Although key geotechnical recommendations are proposed for the new Center, these should be considered preliminary and not be considered for final design of foundations or other geotechnical aspects of the project.

1.3 Sources of Information

Arup reviewed a variety of sources of information during the compilation of this feasibility report, including but not exclusive to:

- United States Geological Survey (USGS)
- California Geological Survey (CSG)
- County of San Mateo

For a complete list of references refer to Section 8 of this report.

The client made the following geotechnical reports available to Arup:

- Jo Crosby & Associates. (2000). Geotechnical Investigation Report for the planned Water Storage Tank Site, off Edmonds Road, San Mateo County, California. Project 4200C-7, November.
- Jacobson Silverstein Winslow Architects. (1999) Feasibility Study for the Cordilleras Community Treatment Facility Youth Crisis House, off Edmonds Road, San Mateo County, California. January.
- Jo Crosby & Associates, (1998). Geotechnical Investigation Report for the planned CDF Cordilleras Fire Station, off Edmonds Road, San Mateo County, California. Project 4200-9. October.

2 Site Information

2.1 Site Location

The site is located at 200 Edmonds Road in San Mateo County, California, Latitude 37.4736 north, Longitude 122.2862 west. The site is located about a half mile from the western outskirts of Redwood City. Figure 1 shows the location of the site in relation to the local area.

2.2 Site Description

Figure 2 is a detailed site plan locating the proposed building in the context of the immediate surrounding area.

The site is located in the confluence of two valleys roughly orientated west to east that are associated with Cordilleras Creek. Two, steeply-sided valley features to the west merge to form one valley to the east, and the site is bounded to the north and the south by the valley slopes. To differentiate the locations of site features, the valleys are herein described as the north and south valleys, and are labeled in Figure 2. Edgewood Road follows the southerly valley wall and Edmonds Road is constructed on the valley floor to provide access to the site from the east.

The valley elevations rise steeply to the west and drop gently to the east. The topographic variation is shown to be up to 250 feet from the valley floor to high points in the surrounding ridges. The valley floor is heavily vegetated with mature trees and the high-relief valley sides are vegetated with mature trees and low level scrub.

Historical topographic information and site photographs indicate the historical course of Cordilleras Creek traversed the axis of the northern valley. Utility plans for the existing Center show the creek is diverted south of the existing Center. There are a number of incised cuts into the valley slopes where north-south orientated ephemeral streams are located, each a tributary of Cordilleras Creek.

Edgewood Road, located to the south and east of the site, connects Redwood City to Highway 280. This road is located on a raised embankment as it passes to the south of site. To the west and southeast of the site Edgewood Road is cut into bedrock comprising the steep hillsides. While no mesh or rock bolts were noted in these cut slopes, a boundary fence was located at the base of the cut slopes that could collect falling rocks.

Northwest of the site a bench is cut in the hillside. A water tank occupies the bench. The water tank provides service to the existing center. An access road leads up the northern valley slope to the water tank. Neighboring the Center to the southwest are the San Mateo County Fire Station and the Canyon Oaks Youth Center structures, about 100 and 200 feet from the existing Center, respectively.

2.3 Historical Map Review

Arup reviewed historical topographic maps and available historical photographs for the site. The earliest available historical map is circa 1902. The scale and the resolution of the maps vary and detailed interpretation is limited to identifying the presence of structures and highways. Table 1 presents the maps reviewed during this study and provides a summary on the development of the area.

Table 1 Summary of Reviewed Historical Maps and Aerial Photography

Date	Scale (ft)	Source	Description
1902	1:125,000	Santa Cruz, CA, Historical Map	Low resolution – No development on the site, Cordilleras Creek shown to cut through center of the site, close to the northern valley slope. The orientation of Cordilleras Creek changes from ESE trending as it runs down the valley to NE trending as it runs towards San Francisco Bay. Edgewood Road bounding the site to the south and east has been constructed.
1948	N/A	Google Earth Pro Historical Aerial Photography	Cordilleras Mental Health Center shown on the site, under construction, San Mateo County Hospital located to the south and west of the site has been constructed. Edmonds Road providing access to the Cordilleras Mental Health Center shown as a track. Hassler Health Home located north of the site on the hill has been constructed.
1953	1:24,000	Woodside, CA, Historical Map	Cordilleras Creek shown to have been diverted to the south of the Mental Health Center and the County Sanitorium, which has also been constructed. Edmonds Road is shown. In the wider area Pulgas Tunnel located approximately one mile north and east of the site has been constructed.
1956	1:250,000	San Francisco, CA, Historical Map	Reviewed – Low resolution, no discernible information for the site.
1957	1:250,000	San Francisco, CA, Historical Map	Reviewed – Low resolution, no discernible information for the site.
1960	1:250,000	San Francisco, CA, Historical Map	Reviewed – Low resolution, no discernible information for the site.
1961	1:24,000	Woodside, CA, Historical Map	Reviewed – high resolution. No change noted on the site or in the immediate surrounding area.
1964	1:250,000	San Francisco, CA, Historical Map	Reviewed – Low resolution, no discernible information for the site.
1982	1:100,000	Palo Alto, CA, Historical Map	Reviewed – Medium resolution, no discernible change noted on the site. Highway 280 noted on the map.
1991	N/A	Google Earth Pro Historical Aerial Photography	Hassler Health Center located north of the site has been demolished, believed to have been demolished in 1985. The remaining roadways form the trails for the Pulgas Ridge Open Space Reserve. No change noted on the site.
2002	N/A	Google Earth Pro Historical Aerial Photography	Reviewed – No change noted on the site or in the immediate surrounding area.

Date	Scale (ft)	Source	Description
2006	N/A	Google Earth Pro Historical Aerial Photography	Reviewed – No change noted on the site or in the immediate surrounding area.
2014	N/A	Google Earth Pro Historical Aerial Photography	Reviewed – No change noted on the site or in the immediate surrounding area.

Figure 3 presents the site with the historical features highlighted during the review of the historical land use.

2.4 Site Reconnaissance

On May 27, 2014, a site reconnaissance survey was performed by a team of three geologists, including a licensed Certified Engineering Geologist (CEG) and a licensed Professional Geologist (PG). A licensed Geotechnical Engineer (GE) was on site during the site safety briefing, which also included a representative from San Mateo County Facilities Planning, Design & Construction. Arup also collaborated with the Engineer of the Cordilleras Mental Health facility to obtain historical site-specific documents stored at the facility.

The purpose of the site reconnaissance was to identify local geological features (bedrock and Quaternary geology) and presence or absence of potential geological hazards (e.g., landslides, liquefiable deposits, faulting) relative to the proposed site development. Figure 4 is a site location plan showing the area reviewed during the field reconnaissance and key field observations (see Table 2 for notations). The field observation notes are summarized in Section 2.4.1 of this report, and select photographs from our site reconnaissance are included in Attachment A. Corresponding photographs of the observations are also listed in Table 2.

Table 2 Summary of Field Observations and Photographs

Figure 4 Key	Photograph Log Reference No (Attachment A)	Observation
1	1	Sandstone outcrop – highly weathered, highly fractured, fine to medium grained sandstone. Structure varies from blocky to disintegrated on a 6-foot scale. Three fracture sets present.
2	N/A	Highly weathered sandstone exposed along water tank access road – highly to completely weathered sandstone, friable and intermixed with slope colluvium.
3	N/A	Rock cut exposure directly south of water tower. Shows a concrete patch within the bedrock that is assumed to cap a water delivery pipe.
4	2	Cut slope beneath water tank consists of highly weathered, disintegrated to highly fractured sandstone that is commonly very friable and intensely fractured. Slope inclination of approximately 70° is relatively stable and reaches an approximate height of 8 feet.

Figure 4 Key	Photograph Log Reference No (Attachment A)	Observation
5	3 and 4	Rock cut located directly north of water tank is 10 to 20 feet high and exposes blocky to disintegrated graywacke sandstone; same material as observed at location 1 and generally contains similar fracture orientations.
6	5	Culvert within tributary to Cordilleras Creek – creek has incised approximately 6 to 8 feet into artificial fill, colluvium and alluvium. Base of culvert is rusted and compromised with water accessing fill. Fill to the south of the weir appears to have been placed in the former drainage and used for the water tank access road. It appears to form, in part, a 15 to 20 feet high slope at the rear of the existing building.
7	6	Cut slope near building loading area – outcrop of highly weathered sandstone intermixed with loose and friable colluvium.
8	7	Cordilleras Creek – dry during reconnaissance, contains fluvial banks comprised of silty, gravelly sand with cobbles (alluvium). The southern creek bank is topographically higher in places due to presence of artificial fill. The creek valley widens to the south near the mental health center where it enters a culvert and is re-directed.
9 and 10	8 and 9	South slope of northern valley containing Cordilleras Creek – three distinct, northeast-facing, steep colluvial hollows intersect this slope. The slopes are inclined approximately 40 to 45° and are mantled with shallow, loose soil and sandstone clasts. No rock outcrops were noted in the main slope, but slope colluvium consisted nearly entirely of sandstone, consistent with regional mapping.
11	N/A	Sandstone outcrop, base of valley slope adjacent to fire station – sandstone outcrop is same sandstone material seen elsewhere on site, highly weathered and fractured, with blocky and closely spaced fractures.
12	N/A	North slope of northern valley – cobbles of igneous intrusive dioritic/granitic rock noted, source of material not located. Quartz, biotite, small crystals – potentially a building material/dumped, few cobbles noted.
13	N/A	Sandstone outcrop on north slope of northern valley – disintegrated, structureless, fractures spacing of 2 to 5 inches.
14	N/A	Center recreation area boundary fence – engineered fill slope used for access road and burial of former tributary constructed from reworked alluvium and colluvium.
15	N/A	North slope of southern valley (behind fire station and youth center) – heavily vegetated slope, with no readily accessible rock outcrops due to access restrictions and dense vegetation.
16	10	Trail north of Edmonds Road – outcrop of Whiskey Formation, red fine to medium grained massive sandstone outcrop, fractured with apparent bedding.
17	N/A	Trail north of Edmonds Road – Franciscan Complex, same as the site sandstone, large block noted, not in-situ,. Boulder covered in lichen, not from recent movement – highlights the potential for rock fall.

Figure 4 Key	Photograph Log Reference No (Attachment A)	Observation
18	11	Junction between Edmonds road and Edgewood Road – cut slope of sheared sandstone and shale, material completely weathered comprising disintegrated sandstone and shale, unit KJfs (Brabb et al., 1998). Slope angle 65°, supported with temporary soil netting and straw wattles with stakes.
19	12	Road cut on Edgewood Road, east of site 1:1 rock cut slope within mélange unit KJfsr (Brabb et al., 1998) that consists of loose material; highly weathered and sheared rocks suggests a risk for raveling and slide debris during periods of heavy rainfall. Sandstone boulders, 4 feet in diameter at the base of the slope.
20	13	Road cut on Edgewood Road, south-east of site – sandstone, appears to be similar in composition to material found at the site. Rock mass structure is very blocky, more homogeneous than material from the site, appears to be fewer areas of disintegrated material. Slope cut to approximately 70°, little to no raveling of slope materials.
21	14	Road cut on Edgewood Road, south of the site – very competent, blocky sandstone. Steep slope angle with no apparent sign of raveling or instability.

2.4.1 Discussion of Observations

General Site Setting

The existing and proposed Center is located in the valley floor between two steep-sided valleys orientated west to east and southwest to northeast. The valley slopes are heavily vegetated with a mixture of juvenile and mature trees and low level shrubs. The following tree species were noted during the walkover: Oak, Bay, Laurel, and Maple. Poison oak was noted throughout all undeveloped areas of the site. Underfoot, the valley slopes were covered with loose material, comprising dry soil, leaves, and gravel- to cobble-sized weathered sandstone.

LiDAR Observations

We obtained LiDAR topographic imagery of the site from the USGS to assist in our desktop review. Shallow depressions on the southern slope of the north valley were noted in the LiDAR imagery, and confirmed to be colluvial hollows during the field reconnaissance survey. The hollows were vegetated with small trees and shrubs. No youthful headscarp was evident; however, any potential landslide-related features were masked by the organic debris, vegetation, and slope colluvium. These features are not believed to be historical based on appearance.

On the hillside, a northwest-southeast trending linear scar marks the location of a PG&E gas line located directly offsite. The northern valley wall was not traversed due to the thick covering of poison oak. Review of the LiDAR topographic imagery of the northern valley slope, west of the property line indicates the presence of geomorphic expressions similar in nature to the shallow depressions noted in the southern valley slope. The features indicate the potential for slope instability up the valley from the property on both the northern and southern valley slopes.

Hydrologic Setting

Cordilleras Creek, an ephemeral creek, incises the northern valley immediately adjacent to a man-made track cut into the northern valley slope. The topography in this area is variable, as the creek has incised through the valley and some fill has been placed immediately south of the creek in localized area. The topographic variation between the creek base and the valley floor is in excess of 15 feet in some locations. The thickness of the surficial deposits, were not constrained in this location, but were estimated to be up to 30 feet in some areas of the valley floor. Immediately west of the site Cordilleras Creek is culverted beneath the existing Center through a weir structure, and then passes to the south of the existing building where it connects to a pumping station located at the east/northeast boundary of the existing site. An unnamed ephemeral creek located immediately north/northeast of the site is also culverted into the pumping station, the steel culvert pipe had eroded and water will flow freely within the surficial material. The pumping station pumps water into the water tower located northwest of the site at a level of approximately 150 feet above the site.

A PG&E natural gas distribution pipeline traverses the steep slopes and Cordilleras Creek valley directly north of the site boundary. The pipeline traverses the creek on an elevated platform approximately 8 feet above the channel thalweg and in places has been undermined by channel bank incision. It does not appear to be at immediate risk of instability.

During the site reconnaissance survey, the facilities engineer for the Center indicated that the existing building basement floods seasonally in winter water occasionally enters the boiler room. The boiler room is a subgrade portion of the existing Center’s basement structure in the approximate location of the historical channel.

Surficial Deposits

Surficial deposits encountered at the site consist of artificial fill, colluvium and alluvium. Mapping of the surficial and bedrock geology was completed during field reconnaissance. The mapping results and interpretation of topographic and LiDAR were compiled to generate Figure 4. A brief description of the observed deposits is as follows:

- **Artificial Fill:** The artificial fill appears to have been predominantly derived from reworked alluvium, colluvium, and local bedrock. The fill occupies the previous creek valleys and thalwegs, is used for road base on various access roads, and also forms discrete mounds within the valley bottoms.
- **Colluvium and Alluvium:** Quaternary alluvium and colluvium are derived from Cordilleras Creek and hillslope processes. Where exposed, the colluvium appears to have been derived from the weathering of the shallow graywacke sandstone and consists of silty sand and angular gravel. Limited exposures of the alluvium

indicate the presence of poorly bedded to massive silty sand and gravel. The modern thalweg contains abundant subangular to subrounded cobble-sized clasts, suggesting winnowing of adjacent fluvial deposits coupled with periodic high flow conditions. The modern day creek channels are incised into older Quaternary deposits ranging from five to ten feet in depth. In the valley floor, within the footprint of the proposed mental health center, the alluvial material is considered to be in excess of 20 feet in certain locations.

For reference, a vicinity geologic map is included as Figure 5.

Bedrock Material

Rock outcrops were mapped in the valley margins surrounding the site and in road cuts alongside Edmonds and Edgewood Roads. The geological map by Brabb et al. (1998) indicates the site is underlain by sheared mélange of the Franciscan Complex (KJfsr) that is in fault contact with the Whiskey Hill Formation (Tw; a sandstone interbedded with shale) 300 feet east of the current Center structure. Brabb et al. (1998) describe the bedrock material as:

- **Franciscan Complex sheared rock (mélange) (KJfsr) –** "Predominantly graywacke, siltstone and shale, substantial portions of which have been sheared, but includes hard blocks of all other Franciscan rock types. Total thickness of unit is unknown, but is probably several tens of meters".
- **Whisky Hill Formation (middle and lower Eocene) (Tw) –** "Light gray to buff coarse-grained arkosic sandstone, with light-gray to buff silty claystone, glauconitic sandstone and tuffaceous siltstone. Sandstone beds constitute about 30 percent of map unit. Tuffaceous and silty claystone beds are expansive. Locally, sandstone beds are well cemented with calcite. In places within this map unit, sandstone and claystone beds are chaotically disturbed. The formation is as much as 900 meters thick".

The outcrops investigated on the site are recorded on Figure 4 and in Table 2. The observed bedrock outcrops at the site typically occurred at topographic protrusions at the base of the valley slopes. The northern valley had more rock exposures, noted along the access road to the water tank and in the cut behind the watertank.

The rock outcrops encountered during the field reconnaissance confirmed the presence of Franciscan Complex graywacke sandstone (KJfsr in Brabb et al., 1998). Where encountered, the graywake typically consisted of a massive brown to mottled grey and orange, fine-to-medium-grained, sandstone. Arup and LCI interpret that the sandstone encountered on the site is part of the sheared mélange of the Franciscan Complex. No bedding was observed, nor were distinct shear zones evident. The sandstone quality ranged from blocky (widely spaced fractures) to closely-spaced and disintegrated, friable sandstone. Several fracture sets were recorded within the few exposures observed during the reconnaissance, with three relatively common fracture orientations. The following structural information (strike in azimuthal direction and dip direction) were recorded in the northern valley slope rock outcrops and few observed southern valley outcrops near the fire station:

- 330°/85°E (Dominant)

- 050°/88°SE
- 020°/25°NE

Franciscan Complex mélange and sandstone of unit KJfsr were noted in road cuts from Edgewood Road to the east of the site. The following observations were made about both of the materials:

- Weathered fractured sandstone cut of approximately 70°. A boundary fence at the base of the slope was present. Limited raveling and debris were observed at the base of the slope. No netting or nailing was observed in the slope.
- The mélange in the road cut, was sloped to approximately 60°. At the base of the slope, loose debris and cobbles were noted, indicative of slope erosion and raveling.

The contact between the Franciscan Complex mélange and Whiskey Hill Formation as mapped by Brabb et al. (1998) was not identified during the reconnaissance; however, Whiskey Hill (Tw) graywacke sandstone was observed in the valley slopes northeast of the site along Edmonds Road and the sheared sandstone and shale (KJfs) was noted at the junction between Edgewood Road and Edmonds Road. The following observations were made regarding the above materials:

- The Whiskey Hill Formation is a massive, red, fine-to-medium-grained sandstone. Apparent bedding orientation of 030º (strike) and 23ºNW (dip) were noted. The contact between the Whiskey Hill Formation and the Franciscan Complex is shown as a fault contact located 300 feet east of the site.
- The sandstone and shale (KJfs) of the Franciscan Complex was evident in an engineered cut slope with an angle of approximately 55-60°. The exposed face was completely weathered and disintegrated. The slope was supported with temporary netting and straw wattles.

As mapped by Brabb et al. (1998), these formations do not intersect the site. Similar material was not observed in the limited exposures during the site walkover survey.

2.4.2 Summary of Site Reconnaissance

The following key observations were made during the site visit:

- As many as three swales or colluvial hollows are present along the southern hillside of the north valley directly above the proposed development. These features do not appear to have moved recently, however their geomorphic expression suggests shallow slope movement may have occurred in the past.
- Bedrock consists predominantly of Franciscan Complex graywacke sandstone. The bedrock is highly weathered, and ranges from large blocks to finely fractured, disintegrated and friable angular clasts. Low cut slopes of relatively limited lateral extent were observed at the water tank, access roads, and along Edgewood Road indicate that this sandstone is capable of maintaining relatively steep slopes without additional support.

- Surficial deposits of colluvium, alluvium and artificial fill occupy much of the site and may approach thicknesses greater than 25 feet. It is presumed that some or most these deposits are saturated within the valley floor.
- Cordilleras Creek flows within the north valley and enters a culvert at the northwestern margin of the existing development. A tributary to Cordilleras Creek located to the north of the existing site also enters a culvert. The historical Cordilleras Creek is mapped as intersecting the center of the present-day site and would have intersected the boiler room of the existing building.

3 Site Geology

The site reconnaissance survey confirmed the observations from the desktop review and added specific geologic and geotechnical observations relevant to the site.

3.1 Geological Setting

3.1.1 Regional Geologic Setting

The proposed site is located within the Coast Ranges geomorphic province (CGS Note 36, 2002) on the San Francisco Peninsula. The site is situated on the San Francisco Bay structural block located to the east of the San Andreas Fault (Nilsen and Brabb, 1979). The site is located within the Franciscan Complex basement, specifically shear mélange (Unit KJfsr). Pampayen et al. (1994) notes that in the San Francisco Bay block sheared rock is the most dominant unit. This unit also contains inclusions of greenstone, graywacke, glaucophane schist and chert. Younger Cenozoic coarse- to fine-grained sedimentary units overlay much of the San Francisco Peninsula.

3.1.2 Local Geologic Setting

Geological Map Review

Review of the USGS map publication *Geology of the onshore part of San Mateo County, California* (Brabb et al., 1998)' indicates that the site is underlain by 'Sheared rock (Franciscan Complex mélange) (KJfsr)'. The geological map includes the following note regarding this unit comprises "predominantly graywacke, siltstone, and shale, substantial portions of which have been sheared, but includes hard blocks of all other Franciscan rock types. Total thickness is unknown, but is probably at least several tens of meters" (1998).

The geological map indicates that surficial material is located within the valley, and is described as, "Alluvial fan and fluvial deposits (Pleistocene)" (Unit Qpaf) or out studies (QT). The geologic map includes the notation that this material comprises "brown dense gravely and clayey sand or clayey gravel that fines to sandy clay. All Qpaf [inferred as Pleistocene] deposits can be related to modern stream courses and display variable sorting" (Brabb et al., 1998).

An excerpt of the Brabb et al. (1998) geological map is shown in Figure 3 indicating the site location. The site is located approximately 1 mile east-northeast of the San Andreas Fault zone. The geologic map indicates that there are many faults within close proximity of the site although none directly intersect the site. The faulting in the area has led to complex bedrock structures and the juxtaposition of different units within close proximity of the site. The geologic map (Brabb et al., 1998) indicates the presence of the following units within 5 miles of the site:

- Tw – Whiskey Hill Formation (middle and lower Eocene) sandstone, siltstone and claystone beds,

- KJfs – Sandstone, coarse grained graywacke sandstone, with interbedded siltstone and shale,
- KJsp – Serpentine (cretaceous and/or Jurassic) sheared serpentine, enclosing variably abundant,
- KJfg – Greenstone, altered basaltic rocks.

Historical Ground Investigation Reports

Review of the historical ground investigation reports for sites within close proximity of the Center (listed in Section 1.3) provide very limited ground investigation data. In general, these data suggest variable alluvial materials overlying bedrock.

The surficial deposits (fill, alluvium and colluvium) are shown to range in thickness from 1 foot to greater than 21.5 feet and are expected to be thickest within the center of the valley. This is partly due to the presence of the historical location of Cordilleras Creek and where fill has been placed as part of the creek's diversion into a buried culvert. The placement and type of fill used for the culvert and creek diversion are not described in the historical investigation data available for this review. Quantitative determination of the depth of existing fill or alluvial material in the proposed building footprints was beyond the scope of this feasibility-level investigation.

The historical exploratory borehole logs from the site vicinity describe the surficial material as:

Artificial Fill: The artificial deposits are reported to a depth of 5.5 feet and typically consist of – 'moist gray brown loose to dense clayey to sandy GRAVEL (Base Rock)' scattered charcoal is occasionally reported in the borehole logs'. This material has a USCS classification of SC.

Alluvial Deposits: The alluvial deposits are reported to a depth in excess of 21.5 feet and are typically described as – 'clayey GRAVEL to sandy CLAY, moist, brown medium stiff/dense grading to stiff/dense with depth'. The proportion of the minor soil constituent varies between the fine-to coarse-grained soil classification from GC to CL. This description of the variation in the minor soil constituent is consistent with the depositional environment for recent narrow creeks and the USGS geological map (Jo Crosby & Associates, 1998).

Bedrock: The depth to bedrock increases in the center of the valley in the location of the existing Center. The bedrock material is reported as fractured shale and sandstone of the Franciscan Complex. The bedrock is also noted to have closely spaced fractures that are clay-lined. These findings are consistent with the USGS geologic map (Brabb et al., 1998).

Existing Building Plans

Arup reviewed the architectural and structural plans for the existing building, which included a plan with bedrock contours based on the Dames and Moore (1949) ground investigation. The bedrock contour plan indicates that bedrock is highly variable beneath the site to a depth of 245 feet elevation, with the current ground surface surveyed between 290 and 300 feet elevation. This indicates the potential for surficial deposits to be approximately 50 feet thick (Douglas Dacre Stone Architects, 1949).

3.2 Walkover Survey Information

The walkover survey, summarized in Section 2.4 of this report resulted in the following observations regarding the Quaternary and bedrock geology of the site:

- Quaternary Geology:
  - Surficial deposits of colluvium and alluvium are present in the valley floor and hillsides and appear to be in excess of 20 feet thick.
  - Man-made fill comprised of reworked colluvium and alluvium is present in the location of the existing building and water tank access road.
- Bedrock:
  - Limited exposures of bedrock indicate the presence predominantly of a brown, mottled grey to orange, fine-to medium-grained sandstone of the Franciscan Complex that ranges from competent to highly weathered and friable, blocky to disintegrated.
  - Limited structural information available indicate variable fracture orientations such as: 330°/85°E (dominant/low population of sampling data), with intersecting orientations of 050°/88°SE and 020°/25°NE. These generally developed a blocky structure to the bedrock.

3.3 Hydrogeological Setting

Arup has reviewed CDWR Bulletin 118 (2003), which indicates that the site is not located in a groundwater basin. The site and surrounding area is characterized by small ephemeral creeks occupying narrow steep-sided valleys. The depth to bedrock is often shallow, with bedrock recorded at surface in many of these locations.

Cordilleras Creek, dry during the site visit, is understood to contain flow following precipitation events. The site is understood to experience seasonal, localized flooding. The groundwater level is considered to fluctuate seasonally. As noted previously, the creek is culverted across much of the site. The depositional history of the valley may have resulted in interbedded granular and cohesive deposits, which could result in perched groundwater. It is understood that artesian conditions are possible during the wet season.

4 Site Geological Hazards

This desktop study, supplemented by field reconnaissance, has identified several potential geologic hazards at the site. Section 4 briefly summarizes the hazard and provides commentary on the associated risks and consequences. Qualitative magnitudes of the risk are provided in a risk register in Section 5.

4.1 Faulting and Seismicity

The site is located within the San Francisco Bay structural block, an area traversed by a series of northwest trending faults, including the San Andreas Fault, Pilarcitos Fault, San Gregorio Fault, and Seal Cove Fault (Pampeyan 1994). Figure 6 shows the known active and potentially active fault traces within a 50-mile radius of the site. The closet active fault to the site is the San Andreas Fault (Canada Fault splay) that is 1 mile west of the site.

Arup has reviewed USGS, CGS, and County of San Mateo information on active fault locations and prepared Table 3 summarizing information on the faults located within 50 miles of the site.

The following fault activity definition has been applied for the compilation of Table 3:

- CGS defines an active fault as displaying evidence of movement within the Holocene Epoch (past 11,000 years) and a potentially active fault as displaying evidence of movement within the Quaternary Period.

The following fault activity definition has applied for the compilation of Figure 6:

- USGS Quaternary active faults are defined as faults that have slipped within the Quaternary Period (past 1,800,000 years).

Table 3 **Fault Properties of Active Faults within 50 miles of the Site**

Fault Name/ Zone	Fault Type	Slip Rate (mm/yr)	Distance and Bearing to Cordilleras Site	*Maximum Predicted Earthquake		*Estin I
				Moment (M_w)	MMI Shaking	Maximu Event
Faults with ground rupture within recorded history – since 1776						
San Andreas Fault (including Canada Fault)	Right-Lateral Strike-Slip	>5	2 miles west	8.4	XI	1,000
Hayward Fault Zone	Right-Lateral Strike-Slip	>5	20 miles east	6.9	IX	200
Greenville Fault	Right Lateral Strike-Slip with Normal movement	1-5	45 miles east	6.9	IX	No Dat
Butano Fault	Right Lateral Strike-Slip	<0.2	40 miles south	No Data	No Data	No Dat
Faults with Holocene activity						
Seal Cove-San Gregorio	Right-Lateral Strike-Slip	0.75	15 miles north-west	No Data	No Data	No Dat
San Gregorio Fault	Right-Lateral Strike-Slip	0.75	12 miles west	7.1	IX	200
Calaveras Fault Zone	Right-Lateral Strike-Slip	1	25 miles east	6.9	IX	300
Greenville Fault	Right Lateral Strike-Slip with Normal movement	1-5	45 miles east	6.9	IX	No Dat
Green Valley Fault	Right-Lateral Strike-Slip	0.75	50 miles north-east	7.0	IX	200
Concord Fault	Right-Lateral Strike-Slip	0.75	50 miles north-east	7.0	IX	200
Rodgers Creek Fault	Right-Lateral Strike-Slip	>5	50 miles north-east	No Data	No Data	No Dat
Mount Diablo Thrust Fault	Thrust Fault	Unknown	42 miles north-east	No Data	No Data	No Dat
Sargent Fault	Normal with Right Slip movement	0.3	40 miles south east	6.4	VIII	No Dat

Fault Name/ Zone	Fault Type	Slip Rate (mm/yr)	Distance and Bearing to Cordilleras Site	*Maximum Predicted Earthquake		*Estin I
				Moment (M_w)	MMI Shaking	Maximu Event
Monte Vista Fault	Thrust Fault with Right Lateral movement	0.2-1	15 miles south-east	7.1	IX	No Dat
Pleasanton	Right-Lateral Strike-Slip	<0.2	40 miles north-east	5.5	VII	300
Verona Fault	Thrust	N/A	35 miles east	6.8	IX	No Dat
Los Politas Fault	Left Lateral Strike-Slip	Unknown	38 miles east	6.3	VIII	No Dat

Source: USGS, CGS 2010

*Maximum predicted earthquake and recurrence interval based upon cumulative damage potential from earthquake ground shaking memoir accompanying map I-1257

Seismicity refers to the frequency, distribution, and intensity of earthquakes in a specific geographic area. Historical seismicity has been is reviewed using the Modified Mercalli Intensity (MMI) scale of 1930. The USGS provides quantitative measurement of earthquake moment magnitude (Mw) and Peak Ground Accelerations (PGA) and relates the qualitiative MMI scale to PGA, as shown in Table 4.

Table 4 MMI v PGA Empirical Correlation (from USGS Website)

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

4.1.1 Surface Rupture

Surface rupture occurs when movement on a fault causes an offset in the Earth's surface and is addressed in the Alquist Priolo Act of 1972. The Alquist Priolo fault zone maps developed by the CGS (formerly the California Division of Mines and Geology [CDMG]) delineate the surface location of known active and potentially active fault traces using 7.5-minute quadrangle maps. The Cordilleras Mental Health Center is located within the Woodside quadrangle (CDMG, 1974). Review of this map indicates that there are no known active or potentially active faults crossing the site.

Review of the USGS Quaternary fault map (Sleeter et al 2004) and the USGS geological map of San Mateo quadrangle (Brabb et al., 1998) indicates that no known faults cross through the site. Figure 6 shows the known active and potentially active fault traces within close proximity to the site. The desk-based review did not indicate the presence of active fault traces intersecting the site. During the site reconnaissance and based on limited exposures, no fault-related geomorphic features were noted.

The majority of the site is steep and rugged and covered with dense vegetation, and culturally modified, all of which greatly reduce the likelihood of preserving evidence of recent surface-fault rupture. The site is located approximately 2 miles to the east of the active San Andreas fault zone, so there could be a remote possibility of potentially unmapped fault traces within the site vicinity. However, based on an overall review of available published and unpublished information, there is a low risk of fault rupture at the site.

4.1.2 Historical Ground Shaking

The USGS and CGS have published multiple maps and databases categorizing historical earthquakes (CGS, 2014 and USGS, 2014). These databases typically include information on epicenter location, earthquake magnitude, causative fault, rupture length and area. These widely available published maps and databases have been reviewed to evaluate the frequency, distribution and intensity of historical earthquakes in relation to the site. Table 5 is a selected list of significant earthquakes (>6.0 and MMI Zone Value >III) recorded in the region.

Table 5 Selected Historical Earthquakes near Cordilleras Mental Health Center

Date	Moment Magnitude (Mw)	MMI at the Site	Epicenter		Name or Location
			Latitude	Longitude	
1838 Jun	7.4	VIII	37.3	-122.15	San Francisco to San Juan Bautista
1858, Nov 26	6.2	VI	37.5	-121.8	San Jose region
1864, Feb 26	6.1	V	37.2	-121.6	Southeast of San Jose
1864, Mar 5	6	V	37.6	-121.855	East of San Francisco Bay
1865, Oct 8	6.5	VII	37.2	-121.9	Santa Cruz Mountains
1866, Jul 15	6	II-IV	37.7	-121.5	Western San Joaquin Valley
1868, Oct 21	7	VII	37.7	-122.1	Hayward Fault
1881, Apr 10	6.3	V	37.3	-121.3	Western San Joaquin Valley
1889, May 19	6	V	38.1	-121.8	Montezuma Hills
1892, Apr 19	6.6	V	38.4	-122	Vacaville
1892, Apr 21	6.4	II-IV	38.5	-121.9	Winters
1898, Mar 31	6.4	V	38.2	-122.5	Mare Island
1903, Jun 11	6.1	V	37.2	-121.8	San Jose
1903, Aug 03	6.2	VI	37.3	-121.8	San Jose
1906, Apr 18	7.8	VIII	37.7	-122.5	Great 1906 EQ
1911, Jul 01	6.4		37.25	-121.75	Southeast of San Jose
1984, Apr 24	6.2		37.3	-121.676	Morgan Hill
1989, Oct 18	6.9		37.0	-121.877	Loma Prieta
Source: CGS online, 2014					

Review of Table 5 indicates that the site has experienced severe shaking in historical time from a number of large earthquakes. The greatest recorded earthquake likely to have affected the site during historical time is the 1906 Great San Francisco earthquake (Mw 7.8).

The existing buildings also would have experienced severe shaking during the 1989 Loma Prieta earthquake. The USGS shakemap of the Loma Prieta earthquake shows that the site experienced an estimated PGA of 0.2g (2003). No information was provided to Arup on the performance of the building post Loma Prieta earthquake.

In 2007, The Working Group on California Earthquake Probabilities (with the USGS) revised its evaluation of the probabilities of significant earthquake occurrence in the San Francisco Bay Area. The 2007 report concludes there is a 93% probability that at least one magnitude 6.7 or higher earthquake will occur in the region in the following 30 years.

Review of the USGS and CGS databases of historical earthquakes which would have impacted the site, indicates that the site is located within a seismically active area impacted by more than 15 earthquakes Mw>6 with MMI rating >III within the historical record set. Given the frequency of earthquakes Mw>6 with MMI rating >III or higher, within the lifetime of the proposed structure it is anticipated that the site will experience significant seismic events.

4.1.3 Simplified Seismic Design Parameters

The proposed structures should be designed to resist the lateral forces generated by earthquake shaking in accordance with local design practice. This section presents seismic design criteria for use with the 2012 International Building Code (IBC, 2013) California Building Code (CBC).

The 2013 CBC refers to the design code by American Society of Civil Engineers (ASCE 7-10) for the development of site-specific response spectra. Values calculated by the USGS Design Maps website based on the 2013 CBC are tabulated below. Inputs of latitude, longitude, and soil profile type (determined in accordance with 2013 CBC §1613) are required. Site classes B and D have been selected for seismic design at this site for buildings founded on bedrock and soil, respectively, and the recommended design parameters are provided in Table 6 and Table 7 below. Final seismic design recommendations should be completed when a design-level geotechnical investigation has been completed and a foundation system has been selected. We have assumed the facility is a seismic risk category I/II/III. If the proposed structures are considered risk category IV, these recommendations should be revised during future design evaluations.

Table 6 USGS Hazard Calculator Seismic Parameters for Site Class B

Latitude: 37.4737º N **Longitude: 122.2859º W**	ASCE 7-10 Table/Figure	**Factor/Coefficient**	**Value**
Mapped Peak Ground Acceleration MCE_G	Figure 22-7	PGA	0.911g
Short-Period MCE_R at 0.2s	Figure 22-1	Ss	2.363g
1.0s Period MCE_R	Figure 22-2	S_1	1.134g
Soil Profile Type	Table 20.3-1	Site Class	B
PGA Site Coefficient	Table 11.8-1	F_{PGA}	1.0
Short Period Site Coefficient	Table 11.4-1	F_a	1.00
1.0s Period Site Coefficient	Table 11.4-2	F_v	1.00
Adjusted MC Spectral Response Parameters	Equation 11.8-1	PGA_M	0.911g
	Equation 11.4-1	S_{MS}	2.363g
	Equation 11.4-2	S_{M1}	1.134g
Spectral Acceleration Parameters	Equation 11.4-3	S_{DS}	1.575g
	Equation 11.4-4	S_{D1}	0.756g
Long-Period Transition Period	Figure 22-12	T_L	12s

Table 7 USGS Hazard Calculator Seismic Parameters for Site Class D

Latitude: 37.4737º N Longitude: 122.2859º W	ASCE 7-10 Table/Figure	Factor/Coefficient	Value
Mapped Peak Ground Acceleration MCE_G	Figure 22-7	PGA	0.911g
Short-Period MCE_R at 0.2s	Figure 22-1	Ss	2.363g
1.0s Period MCE_R	Figure 22-2	S_1	1.134g
Soil Profile Type	Table 20.3-1	Site Class	D
PGA Site Coefficient	Table 11.8-1	F_{PGA}	1.0
Short Period Site Coefficient	Table 11.4-1	F_a	1.0
1.0s Period Site Coefficient	Table 11.4-2	F_v	1.5
Adjusted MC Spectral Response Parameters	Equation 11.8-1	PGA_M	0.911g
	Equation 11.4-1	S_{MS}	2.363g
	Equation 11.4-2	S_{M1}	1.701g
Spectral Acceleration Parameters	Equation 11.4-3	S_{DS}	1.575g
	Equation 11.4-4	S_{D1}	1.134g
Long-Period Transition Period	Figure 22-12	T_L	12s

Based on the seismic design parameters calculated by the USGS Design Maps website, and per 2013 CBC § 1613.3.4 and § 1613.3.5, structures of Seismic Risk Category I, II, III, (defined in 2013 CBC Table 1604.5) should be designed according to Seismic Design Category "E" for both soil profiles B and D.

4.1.4 Liquefaction

The walkover survey identified surficial deposits in the footprint of the proposed Center. The surficial deposits were mapped as native alluvium and colluvium and artificial fill. The thickness of the deposits is poorly constrained but believed to be greater than 20 feet based on available historical borehole information and interpretation of the structural plans of the existing Center. There is sparse geotechnical information on the lithologic variability of these deposits; however available historical borehole logs from the Cordilleras Community Treatment Facility, located immediately south of the proposed site within the valley floor indicate that alluvial deposits exceed 21.5 feet in depth. The borehole logs identify the soil as 'sandy CLAY and clayey sandy GRAVEL'.

Review of the liquefaction susceptibility map of San Mateo County (Perkins and Youd, 1987) indicates there is a moderate to low (0.1 to 1.0%) risk of liquefiable soils being present on the site. More recent and detailed mapping by Witter et al. (2006) map the Cordilleras Creek valley floor as having moderate susceptibility to liquefaction.

With the code-based peak ground acceleration (PGA_M) value of 0.911 g, during the design seismic event, some cyclic softening of clay soils and liquefaction of sandy soils should be anticipated. Effects of liquefaction in the alluvial or fill materials include adverse lateral loads on deep foundation elements (piles) and differential settlement beneath foundations bearing in soil.

Considering the anticipated ground shaking, and the potential for cyclic strength loss during shaking, deep foundations deriving bearing capacity and lateral force resistance in the bedrock would be the optimum foundation design concept. Retaining walls with retained heights greater than 8 feet should also be supported by foundations deriving their bearing capacity bearing in the bedrock. The low-rise structures could be founded on structural mat slabs, provided that post-earthquake settlements on the order of a few inches could be tolerated and grading for building ingress/egress could be subsequently addressed as a post-earthquake repair measure. Underground utility connections to the buildings should be flexible to permit horizontal and vertical relative movement between the structures and the soil.

4.2 Slope Stability

No active landslides are mapped at the location of the site. Based on a review of the USGS map MF-2325-H (Locations of Damaging Landslides in San Mateo County, California, Resulting from 1997-98 El Niño Rainstorms, 1999), no damaging landslides occurred within five miles of the site. USGS map OFR 97-745C (Summary Distribution of Slides and Earth Flows in San Mateo County, California, 1997) indicates that the site is located in an area classified as having few landslides. USGS map I-1257D (Hillside Materials, San Mateo County, California, 1985) shows that slopes across the site vary from 0 to 15 percent near the base of the valley and increase up to 50 percent for the valley hillsides.

The site reconnaissance covered only a small portion of accessible topography at the site and did not identify any active slope instabilities, other than the presence of colluvial hollows and a possible landslide located northeast and outside of the site boundary. Evidence of historical slope movement and potential for recurrence of such movement was identified and is described below.

4.2.1 Static Landslides

Examination of available USGS LiDAR and topographic data indicates that much of the site shows evidence for the absence of landslide related geomorphology. Static slope creep is prevalent based on bowed trees and leaning boundary fences. Published geologic maps of the region also do not show any known active landslides within the site boundary.

4.2.2 Rainfall-Induced Landslides

Water in and on a slope is a common agent that can cause erosion and slope instability. For instance, during periods of intense rainfall, coupled with high infiltration rates, water causes pore pressures in slope soils to increase, which can lead to slope failure. Active water seepage was not noted during the site reconnaissance survey (the survey was performed during a severe drought in). The existing slope colluvium appears to be shallow, loose and relatively free draining. Surface water runoff can increase the rate of erosion and potentially initiate a debris flow of already loosened material.

4.2.3 Seismically-Induced Landslides

The potential for earthquake-induced land sliding increases when shear strength of slope materials decreases and hydrostatic pressure increases due to stresses developed from seismic shaking. The site reconnaissance revealed that the majority of the slopes are very rocky with a thin soil mantle. Slopes such as these pose a lower threat of seismically-induced slope failure than slopes composed of thicker soils, particularly liquefiable, granular soils.

4.2.4 Debris Flow

The review of the LiDAR data indicated three colluvial hollows (hillside depressions) on the north-facing slope of the ridge within the southwest portion of site. These features were confirmed to be soil-mantled hollows, and could be the source for future debris flows. Currently, these hollows have juvenile deciduous trees occupying the surface that provide a degree of slope stability; however, future development of this part of the site could destabilize these features.

4.2.5 Post Fire Slope Instability

Vegetation can protect slopes by reducing erosion, strengthening soil, and inhibiting shallow landslides. Water being intercepted and slowed by foliage reduces water available for infiltration and also reduces erosion from runoff. The roots reinforce the soil and increase its shear strength. After fire events, when vegetation has been removed, the exposed slopes are more susceptible to water-induced erosion and dry raveling. Since the site is highly vegetated, the risk for dry raveling and soil erosion would increase greatly after a fire that removes or significantly damages the slope vegetation. Principal debris flow source areas in San Mateo County are shown on USGS Open-File 97-745 E Sheet 7 of 11, however the site is not located in an area containing large flow source areas, as it primarily contains smaller, localized source areas.

4.2.6 Summary of Slope Stability Hazard

Earth movement is a potential hazard at the site. The slope material at the site is loose and free draining, so the hazard of rainfall-induced slope failure appears to be low to moderate. The hazard of localized debris flows being initiated by heavy rainfall coupled with site de-vegetation is moderate to high, but there is a low potential for widespread debris flows across the site. Due to the location of the site in a highly seismic region, the potential for seismically-induced slope failure at the site is moderate, especially for the slopes with thicker soil mantles in the northeastern portion of the site.

4.3 Rock Fall

Few outcrops were available for detailed inspection and the collection of structural information for a rock mass characterization. The limited bedrock exposures identified four sets of general fracture plane orientations that are suggestive of block and toppling failure. This data set is insufficient to develop design parameters for rock fall mitigation. However, during the site reconnaissance no large blocks or wedges were identified at the base of the current exposed cut slopes. If excavations are initiated with steeper gradients than present, and of larger lateral and vertical extent, and with variable slope intersecting orientations, there exists the potential for block, toppling and wedge failure.

Highly fractured material generally results in higher erosion rates and larger talus piles of small sized material at the toe of a slope. Massively bedded material has much lower erosion rates and thus usually a smaller volume of accumulated debris at the base of the slope. The slopes on site appear to be composed partially of talus with a thin soil mantle. Joint spacing of the sandstone encountered during the site reconnaissance varied from 2 feet to closely-spaced in exposures of up to 10 feet wide. A fence that transects the southwestern ridge at the site had a build-up of angular sandstone talus, which indicates that talus production and mobilization has occurred rather recently.

Review of the limited fracture data did not illuminate adverse fracture plane orientations. No fracture planes were identified as clearly day-lighting in slopes currently existing on site. Based on this analysis, wedge failure is a low to moderate risk on site with current slope configurations. However, with the introduction of cut slopes, the potential risk for wedge failure could increase.

4.4 Flooding

The proposed Center is located in the valley floor between two steep sided valleys. Cordilleras Creek runs through the west-east valley collecting water from the northern and southern valley slopes through a series of ephemeral tributaries, prior to being culverted and diverted to the south of the existing building. During the site reconnaissance survey an un-named creek was identified located in a valley immediately north of the proposed site. This creek is currently contained within a culvert to the north of the existing building.

4.4.1 Flash Flooding

Review of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), classifies the site as Zone X (unshaded) which is defined by the FEMA Flood Zones as ‘Minimal risk areas outside of the 1% and 0.2% annual chance floodplains’. No Base Flood Elevations (BFE) or base flood zones are shown within these zones. This statement is further caveated by the FEMA Flood Zone (2014) definition as:

> Areas of moderate or minimal hazard are studied based upon the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Local stormwater drainage systems are not normally considered in a community’s flood insurance study. The failure of a local drainage system can create areas of high flood risk within these zones. Flood insurance is available in participating

communities, but is not required by regulation in these zones. Nearly 25-percent of all flood claims filed are for structures located within these zones.

Review of National Oceanic and Atmospheric Administration (NOAA) precipitation intensity and depth predictions for the site indicates that the maximum anticipated 1:100 year 24-hour rain storm would result in 6.8 in of rainfall falling, with a peak intensity of (5-minute-duration rainfall event) of 5.3 inches/hour (NOAA, 2014). Based upon the possible conclusions from a review of the NOAA historical rainfall data for the site based upon the NOAA 2014 predictions, the site has experienced a 1:25-year, 24-hour rainstorm with 4.9 inches of precipitation falling during a 24-hour period in 1962 and a 1:10-year, 30-day rainstorm, with 12.4 inches of precipitation recorded in February 1998. The NOAA archives records date back to 1931.

Personal communication between the facilities engineer for the existing Center and Arup during the site reconnaissance indicated that the site is prone to seasonal flooding of the outdoor recreation area when high flows back up at the culvert entrance.

The proposed development involves significant earthworks in the valley floor, local de-vegetation and covering of natural soil with hard-standing all of which increases the surface runoff potential. There is therefore currently a flash flooding risk at the site, which without management could be exacerbated by the proposed development. Many of the risks posed by flooding can be mitigated during detailed design, and by planning major site earthworks to occur during dry seasons. During construction, best management practices and protection for culvert inlets would aid in flash flooding risk reduction.

4.4.2 Debris-Induced Flooding

The current drainage system diverts both Cordilleras Creek and the unnamed creek around the existing structure through buried culverts (Figure 4). Should debris or backed-up high flow dam the culvert, flooding could occur around the building. The site reconnaissance survey identified that the culvert was partially blocked by leaves and other detritus and in a poor state of repair.

De-vegetation of the valley floor or valley slopes would increase debris flow potential. There is a potential for debris flows to block the creek channel which could lead to localized flooding of the valley floor.

Review of the FEMA flood insurance risk maps and the NOAA historical data and prediction tools for the site indicates that the site is classed as Zone X (unshaded) minimal risk. Review of the historical NOAA rainfall data indicates that the site has experienced 1:25 year precipitation events. Evidence from the walkover survey indicates that the current site is prone to seasonal ponding of water, potentially related to the culvert system associated with the existing structure. This indicates that there is a potential risk associated with flooding at the site. Mitigations of this risk include re-grading the site to develop in zones further from the creek channel.

4.5 Development Hazards

Review of the proposed Center redevelopment, Option E1, dated April 2014, shows the proposed main structure and road to the overflow parking lot will cut into the northern and southern slopes of the northern valley, respectively. The western two single story buildings are located within the variable topography of the valley floor. The proposed redevelopment would require earthworks, slope cutting and potentially constructing retaining walls. This section examines the potential risks associated with this development in the context of the site.

4.5.1 Earthworks

The main earthworks identified in Section 4.5 are located in the base of the valley to the west of the existing Cordilleras Mental Health Center. The ground surface immediately south of Cordilleras Creek within the footprint of the proposed building shows a topographic rise of approximately 20 feet. We conclude from the walkover survey and historical documents that the existing topographic rise is comprised from colluvium and alluvium and some reworked fill material.

The proposed final grades require construction of a fill prism on the order of 15 feet thick. Differential constructed fill thicknesses greater than 5 feet will result in differential settlements at the surface as constructed fills consolidate over time. With no construction records of the existing site grades, it is unknown whether adequate site stripping was conducted prior to fill placement, so it is possible the existing fills in are underlain by a horizon of organics. To achieve stable constructed fills, the existing site soils and fill material will require rework for acceptable site fill performance. Keying and benching of constructed fills should be required.

Generally, removal of soil or rock from the toe of an existing slope removes the support for the slope. The proposed removal of significant volumes of fill and rock to construct the proposed retaining walls increases the potential for slope instability, both for shallow debris flow and surface raveling and deeper rotational or block slope movement. This risk can be mitigated by engineering evaluation during design, and lower risk scenarios can be coupled with an “observe and react” approach during construction.

4.5.2 Slope Cutting & Retaining Structures

As identified in Section 4.5 two slope cuts are proposed into the northern valley as part of the replacement of the Center. Slope Cut 1 into the northern valley is associated with the multi-story structure and Slope Cut 2 traverses the southern slope of the northern valley for approximately 600 feet.

The area of Slope Cut 1 was examined during the site reconnaissance survey. The proposed cut slope height appears to be less than 20 feet over a distance of approximately 100 feet. The location of the slope cut aligns with the steep valley trending north to south, in which the unnamed creek is located prior to being culverted north of the existing structure. The proposed cut passes through rock outcropping at the west of the proposed cut and then through native colluvium and alluvium and fill associated with the water tower access road. The rock at the western edge of the cut was identified as grey to brown, fine-grained sandstone, variable in fracture frequency structure, which varied from blocky to disintegrated. The outcrop was at a slope angle of approximately 75° with three fracture orientations noted, bedding was not apparent, although initial assessment based upon the fracture orientations does not appear conducive of wedge failure or sliding failure, but rock topple would be possible. Identification of the contact between the native material and non-native fill was not possible due to the boundary fence of the existing building. The engineered fill assumed to be constructed from the same material, was stable at angle of 45°.

Slope Cut 2 located within the southern valley slope was also examined during the site reconnaissance survey. The proposed cut is approximately 600 feet in length and the greatest cut height based on removal of material in the valley base is approximately 40 feet. A rock outcrop of weathered blocky sandstone with a three fracture sets spaced at approximately six inches to one foot. No other outcrops were noted along the length of the proposed cut. The existing slope surface comprised loose soil with leaf litter and cobbles of sandstone. Aside from small scale raveling there was no indication of recent slope movement. Above the level of the proposed cut three swallows indicative of historical slope movement were mapped during the walkover.

The presence of historical slope instability indicates the potential for slope instability on the southern valley slope, cutting of the slope may exacerbate this hazard.

As discussed in section 4.5 of this report, there are earthworks and slope cuttings associated with the proposed replacement Center. The principal hazards associated with the proposed development involve destabilizing the slope by remove toe support of the slope. The risks associated with this can be managed during the construction process. Additional ground investigation data would help to quantify the risk, especially in the location of the retaining structure cut into the southern valley slope, where no rock exposures were noted during the site reconnaissance and three swallows indicative of historical slope instability were noted.

4.6 Asbestos

4.6.1 Naturally Occurring Asbestos

Review of CGS Map Sheet 59 ‘Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Other Natural Occurrences of Asbestos in California’ (CGS & USGS, 2011) indicates that the site is not within a known location of asbestos occurrence. The literature indicates that two areas of ultramafic rocks or serpentine are located within San Mateo County. Review of the geologic map (Brabb et al., 1998) shows serpentine outcropping approximately 0.5 miles south of the site, with the contact between the Franciscan Complex and the serpentine in the topographic high south of Edgewood Road.

During the walkover survey no outcrops of serpentinite or other ultramafic rocks were noted on the site. To the north-east of the site along Edmonds Road, a small outcrop of in-situ serpentinite was noted.

The bedrock geology for the site is mapped as Franciscan Complex sheared rock mélange (KJfsr) (Brabb et al, 1998). A literature review of the Franciscan Complex mélange indicates that serpentine is often found within the mélange material.

During the walkover, not enough of the bedrock geology of the site was observed to rule out the presence of ultramafic or serpentine rocks to be present. From the desktop information available, Arup concludes that if there are ultramafic rocks on the site, the exposures should be isolated. Typical management practices on earthwork projects with natural deposits of asbestos include dust management schemes and careful disposal.

5 Risk Register

Table 8 summarizes risks posed by the geological hazards identified during the desk study and the site reconnaissance. The risk has been determined based upon an assessment of the likelihood of hazard occurrence and the consequence of the hazard occurring. The ease of management and mitigation of each hazard has also been considered and engineering judgment used to assign the final risk rating. The risk register gives final ratings for hazards of low, medium, or high.

A designation of a high risk hazard does not imply that the proposed site reconstruction is infeasible. The qualification of a risk as high is an indication that it will require more attention during detailed design. Based on the available data and site reconnaissance regarding the site geologic conditions and geological hazards, the proposed site reconstruction project is considered feasible.

Table 8 Risk Register Matrix

Hazard	Likelihood			Consequence			Risk	Management/Mitigation	C
	L	M	H	L	M	H			
Faulting Hazard – Surface Rupture	X					X	Low to Medium	Detailed mapping of the site, to investigate the potential for obscured fault traces.	Low risk assigne likelihood.
Seismic Hazard – Ground Shaking			X		X		Medium to High	Seismic shaking to be accounted for during the detailed design stage.	Medium to high frequency of ma possibility to mit
Seismic Hazard – Liquefaction			X			X	High	Deep foundations should support structures above one-story in height and retaining structures higher than 8 feet retained height.	With a PGAM o cyclic strength lo soils above the b the design (MCE CBC requires liq MCE level shaki be a contributor However, the eff mitigable by usi large structures (large retaining w one story structu
Slope instability – Static Landslip	X	X				X	Medium to High	Additional ground investigation data will lower the risk by confirming the presence/absence of any shear planes. Risk can be mitigated during detailed design.	Medium risk ass consequence and Greater determin can reduce risk.
Rainfall induced Slope Instability	X	X			X	X	Low to Medium	Careful monitoring of the slope during construction. Additional GI will identify potential volumes of material. Slope protection requirements can be assessed during detailed design phase.	Evidence of hist southern valley s walkover survey evident. Rainfall likelihood of ins

Hazard	Likelihood			Consequence			Risk	Management/Mitigation	C
	L	M	H	L	M	H			
Seismically Induced Slope Instability	X	X			X	X	Low to Medium	Careful monitoring of the slope during construction. Additional GI will identify potential volumes of material. Slope protection requirements can be assessed during detailed design phase.	Evidence of histo southern valley s walkover survey evident. No appa associated with r principally Loma
Debris Flow	X	X			X	X	Low to Medium	Careful monitoring of the slope during construction. Additional GI will identify potential volumes of material. Slope protection requirements can be assessed during detailed design phase.	Low to medium Assumed thin so walkover survey
Adverse bedding near proposed retaining structures	X				X		Low to Medium	Additional ground investigation will confirm the presence of adverse bedding near proposed structure.	Low to medium walkover survey area, assumed ad present. Consequ would result in la greater reinforce
Incidental Rockfall		X	X	X	X		Medium	Detailed mapping of all rock exposure in the valley above the slopes. Support of the rock face can assessed during the detailed design stage.	Highly fractured sided valley.
Post-fire debris flow	X					X	Medium to High	Should a fire occur in the upslope vegetation, immediate measures should be taken to stabilize the exposed de-vegetated soil before the next rainy season	This is a low-like requires two eve (not a geohazard (contributing to t consequences ca
Flash Flooding	X	X			X		Low	Modeling of flood potential – regarding of channel to accommodate flood waters.	Low risk due to mitigation/mana
Debris Flow Induced Flooding	X				X		Low	Mobilize equipment to clear any debris flow blockages. Design open channel replacement to reduce risk of debris blockage.	Low risk due to mitigation/mana

Hazard	Likelihood			Consequence			Risk	Management/Mitigation	C
	L	M	H	L	M	H			
Development Hazard – activating deep-seated landslide	X	X				X	Medium	Unknown likelihood – limited information. Ground investigation to investigate the likelihood.	Medium risk ass information – ris during the groun detailed design s
Development Hazard – Debris Flow/Slope Raveling		X	X	X	X		Medium	Loose material on slope, removing support at the toe could exacerbate slope instability. Monitoring and supporting of slope, phased construction could reduce the hazard.	Medium risk – h during constructi specification to c
NOA – Naturally Occurring Asbestos	X			X			Low	Presence of asbestos unlikely, if encountered during further works, can be easily managed/mitigated through the work plan.	Typical mitigatio monitoring and c measures.
Construction Asbestos	X	X		X			Low	Potential for asbestos from existing building spoil, if encountered during further works, can be easily managed/mitigated through the work plan. Risk can be managed during demolition of the existing structure.	
Post-construction differential settlement	X				X		Low	Full-time earthwork observation and frequent compaction testing during fill prism construction will be vital to achieving stable final grades.	Earthwork obser construction of t essential to achie for the single-sto expected perform events.

6 Geotechnical Conclusions and Recommendations

The following preliminary geotechnical conclusions have been prepared based on the review of the foundation plans of the existing structure, the geotechnical reports prepared for the nearby facilities, and our experience with similar types of construction.

The recommendations listed in this section are geared toward feasibility design supporting project design and construction cost estimation. The following paragraphs are not an exhaustive set of recommendations intended for final design, but include:

- Detailed recommendations for further geological and geotechnical site investigation, with an order-of-magnitude cost estimate
- Recommendations for the approach to geotechnical site demolition and clearing
- Conceptual recommendations for support of the proposed buildings
- Conceptual recommendations for support of freestanding retaining walls and retaining structures incorporated in-building structures

6.1 Key Geotechnical Considerations

The key geotechnical and engineering geological considerations for civil and structural engineering design include the following:

- A risk of unknown rock conditions at the site of the proposed high retaining structure
- Site seismicity and resulting potential for liquefaction
- Lateral loads on retaining structures in static and seismic cases
- Site grading and channel preservation to reduce flood risk for proposed facilities
- Collaboration of geotechnical and civil design to develop a site grading scheme that results in acceptable fill performance without differential fill thicknesses
- Unknown debris or obstacles in existing fill that could impede deep foundations construction
- Design of wall back drainage to prevent saturated conditions developing behind proposed subgrade building walls or exterior retaining structures
- Environmental clearances for geotechnical investigation for design and construction, if necessary
- Inclusion of rockfall netting in final design as needed to protect completed structures

The key geotechnical considerations for site clearing and grading include the following:

- Demolition of the existing development and backfill of the structures

- Puncturing and breaking the existing floor slabs so they do not impede groundwater migration
- Demolition of existing building subgrade retaining walls backfill of the resulting depressions to permit groundwater migration and provide uniform soil conditions up to the final grade
- Site clearing including removal of organics-laden soils for reuse only in the upper few feet of new landscape areas
- Excavation of existing fill and disturbed site soils to firm conditions, then construction of new fills to maintain site stability by keying new fills into existing soils
- Rock rippability will vary significantly across the site
- Careful excavation and grading of valley slopes for the Community Center podium and retaining wall construction under the observation of an engineering geologist or geotechnical engineer
- Repair and preservation of the existing Cordilleras Creek channel and culvert
- Processing of excavation and demolition spoils for reuse in site re-grading
- The existing structure could include asbestos-laden or lead-based construction materials that will be unsuitable for reuse in site fills
- Completion of site earthworks and retaining wall construction during dry season
- Flexible utility connections between site fill soils and one-story structures to permit relative static and seismic movements

The geotechnical considerations for foundation construction include the following:

- Site grading and compaction meeting specifications to provide uniform bearing for one-story structures on mat slab foundations
- Site fills and rework of existing soils containing sufficient fines and compacted to sufficient density to mitigate liquefaction potential, should saturated conditions develop
- Rock sockets construction for lateral and vertical support of the Community Center structure

6.2 Conceptual Geotechnical Design

Initial recommendations for the geotechnical design of the proposed buildings and retaining structures are included in this section. Detailed recommendations for pavement design, trenching, support of exterior flatwork, and miscellaneous site features are beyond the scope of this feasibility study.

6.2.1 Community Center

The podium structure for the Community Center will be a rigid structure relative to the wood frame construction of its upper stories. The podium will be set into the existing hillside and act as a retaining wall. Depending on the thickness of the existing overburden, much of the excavation for the footprint of the podium could expose the bedrock material. The final foundation design will be contingent on the depth to bedrock from the ground floor elevation. Shallow spread footings bearing in bedrock can be used to support vertical loads when bedrock is shallow. Where bedrock is deeper below the final ground floor elevation, vertical loads can be supported by drilled piers or longer footing elements bearing in bedrock. Lateral building loads can be resisted by a combination of friction (building weight) and passive resistance (footings or shear keys) constructed where the bedrock is shallow. Longer pier elements will have low capacity to resist lateral loads.

The retaining structure of the podium wall should be fully back-drained and waterproofed to prevent buildup of hydrostatic pressures and to reduce the potential for groundwater migration through the retaining walls to the interior. This will reduce the potential for unsightly interior efflorescence during the wet season. The walls will have to resist the static at-rest pressure of the rock and overburden soil, dynamic soil pressures during earthquake events, and surcharge loads from vehicular parking and the hill slope to the north, west, and east of the podium. Site grading should be planned so the wood-frame uppers floors do not act as a retaining structure.

Reinforced concrete cast-in-drilled-hole (CIDH) shafts should derive their axial and resistance by bearing at least 5 feet in bedrock, but they should not be relied upon for lateral capacity if they extend through significant thickness of soil overburden. Ultimate end-bearing resistance for properly-constructed CIDH elements, 18 inches in diameter, and embedded 5 feet into weak rock (assumed low shear strength of 5 ksf), would be on the order of 80 kips.

6.2.2 Single-Story Housing Units

We understand the single-story structures will be relatively light, wood-frame and potentially modular construction. For best performance on the relatively thick prism, these structures can be supported by a relatively stiff, continuous, perimeter shallow foundation bearing at least 24 inches below lowest adjacent soil grade. The shallow spread footings should be a minimum of 18 inches wide. Interior slabs-on-grade will require reinforcement for crack control but be generally non-structural. For adequate performance of these foundations, differential fill thickness for each pad should be limited to 5 feet. For the shallow spread footings, ultimate bearing pressures on the order of 6,000 psf can be achieved in properly compacted fill.

6.2.3 Retaining Structures

The retaining structures for the large cut into the southern valley slope can be either soldier pile and lagging structure for retained heights less than 10 feet, or tieback construction for retained heights above 10 feet. Several tieback wall options are possible depending on the final aesthetic desire. At the top of the wall, the slope will continue upward, which could leave the site below exposed to rockfall and scree from above. A rock netting system either free-standing at the top of the wall or incorporated into the wall structure will be required to reduce rockfall onto the development below.

7 Design-Level Geotechnical Investigation

7.1 Additional Ground Investigation Data

For the purpose of costing, additional ground investigation data are required. The proposed ground investigation information is based upon the preliminary building layout provided to Arup by the Client in Drawing titled “Cordilleras Mental Health Facility Feasibility Exhibit” dated May 22, 2014. The key features of the plan are: -

- 5 single-story buildings orientated west-east within the north valley.
- 1 multi-story building cut into the northern valley slope of the north valley.
- 1 retaining structure located in the northern valley slope of the north valley at the confluence of the north and south valleys.
- 1 retaining structure cut into the southern valley slope of the north valley.

The requirements of the additional ground investigation data will be subdivided based upon structures types and the specific requirements for each structure.

7.1.1 Community Center Building

The proposed location of the multistory Community Center building is in the northern valley slope of the north valley. Site reconnaissance information indicated that the cutting will truncate rock and surficial material. A creek tributary of Cordilleras Creek, orientated north-south, in the proposed building footprint. The key information for this structure is the depth to bedrock across the small creek valley.

Boreholes should be located in the four corners and the center of the structure to confirm the depth to bedrock. Between five and eight boreholes should terminate between 5 and 10 feet into the rock below the final floor elevation. Alternatively, one or two of the proposed borings in the Community Center footprint could be replaced by an excavated test pit. The objective of these explorations is to identify the depth and bearing capacity of the bedrock below final floor grade. The borings should also characterize the overburden to be removed (e.g. fill rubble or debris) for pricing the length and quantity of deep foundations elements.

The borings should be paired with geophysical methods to determine bedrock depth, velocity, and rippability.

7.1.2 Five Single-Story Buildings

These buildings are located within the valley floor and the flood plain of Cordilleras Creek, in the hillside cut area at the western end of the site. The key information for these buildings will be delineating the approximate depth to bedrock across the building footprints, extent of artificial fill, and characterizing the geotechnical properties of the valley alluvium. This investigation would include subsurface exploration through drilling, geophysical surveying, and shallow excavations. All borings drilled on the site should terminate a minimum of 5 feet into bedrock and geotechnical sampling of the surficial deposits is required.

Slope instability, in particular debris flow and raveling from the northern and southern valley slopes bordering the northern valley, poses a risk to these buildings. As such, shallow soil test pits excavated into the bedrock slopes to document the surficial deposits and bedrock properties is required. Lastly, multiple geophysical soil profiles within the valley floor and along the hillsides should be collected to assess the lateral and vertical extent of the surficial deposits and bedrock properties pertaining to rippability and site construction.

7.1.3 Retaining Structures

The retaining structure proposed to be cut into the southern valley slope will feature retained heights on the order of 50 feet. To support design, the key information to gather during the drilling campaign includes:

- Depth to bedrock
- Presence/absence of slip surfaces, fractures and their orientation, and bedding
- Characterize the surficial material for debris flow and rock fall potential

The valley slopes, in particular the southern slope of the north valley, are steep, heavily vegetated and mantled with surficial loose material that require special exploration consideration.

- Boreholes to be located in line with the proposed retaining structure on the southern slope, terminated at a level 15 feet below the planned retained level, with a minimum of 5 feet penetration into rock.
- The drill rig must be capable of extracting core at the in-situ orientation, so that bedding, fractures and any potential shear surfaces are known.
- Drill rig capable of operating on a steep hillside is required.
- Vegetation clearance for the hill slope.

At least two deep borings should be planned for the length of wall above 20 feet retained height. One boring at each of the lower ends of the wall with proposed retained heights less than 10 feet should also be completed to provide data supporting design parameters for soldier pile and lagging construction.

7.1.4 Ground Investigation Summary

Table 9 summarizes the proposed ground investigation and the termination information for cost estimation.

Table 9 Summary of Additional Ground Investigation

Structure	Boreholes		Trenches	
	Quantity	Depth (feet)	Quantity	Depth (feet)
Five Single Story Buildings	6	5 feet into rock	2	10 feet or to rock
Multi Story Building	5-8	10 feet into rock below the proposed final floor	0	N/A
South Valley Slope Retaining Structure	4	15 feet below retained level, minimum 5 feet into rock, whichever is deeper	2	10 feet or to rock

7.1.5 Approximate Costs for Detailed Ground Investigation

A standard, tire-mounted drilling rig can access much of the flat land at the site to complete the on-site drilling program. However, a limited access rig would be required to gain access to boring locations in the cut slope areas. These locations are more critical to assess structural designs of the proposed retaining structures.

A track-mounted light backhoe or excavator would be required to dig into the rock sufficiently to show the bedding in excavated the test pits. Having the excavator on-site concurrent with the limited access drilling rig would facilitate access, vegetation clearing, supply delivery, and construction of a key or bench of relatively level area for drilling. Based on the investigation requirements listed and considering the engineering analyses involved, a budget of $185,000 should be allocated, with a contingency of $25,000 if the encountered conditions warrant further investigation.

This estimate assumes that the project will not be subject to critical facility review by the California Office of Statewide Health Planning and Development and CGS. Geotechnical and engineering geological construction testing and observation are also excluded, but could be on the order of 0.4% to 0.7% of the overall construction cost.

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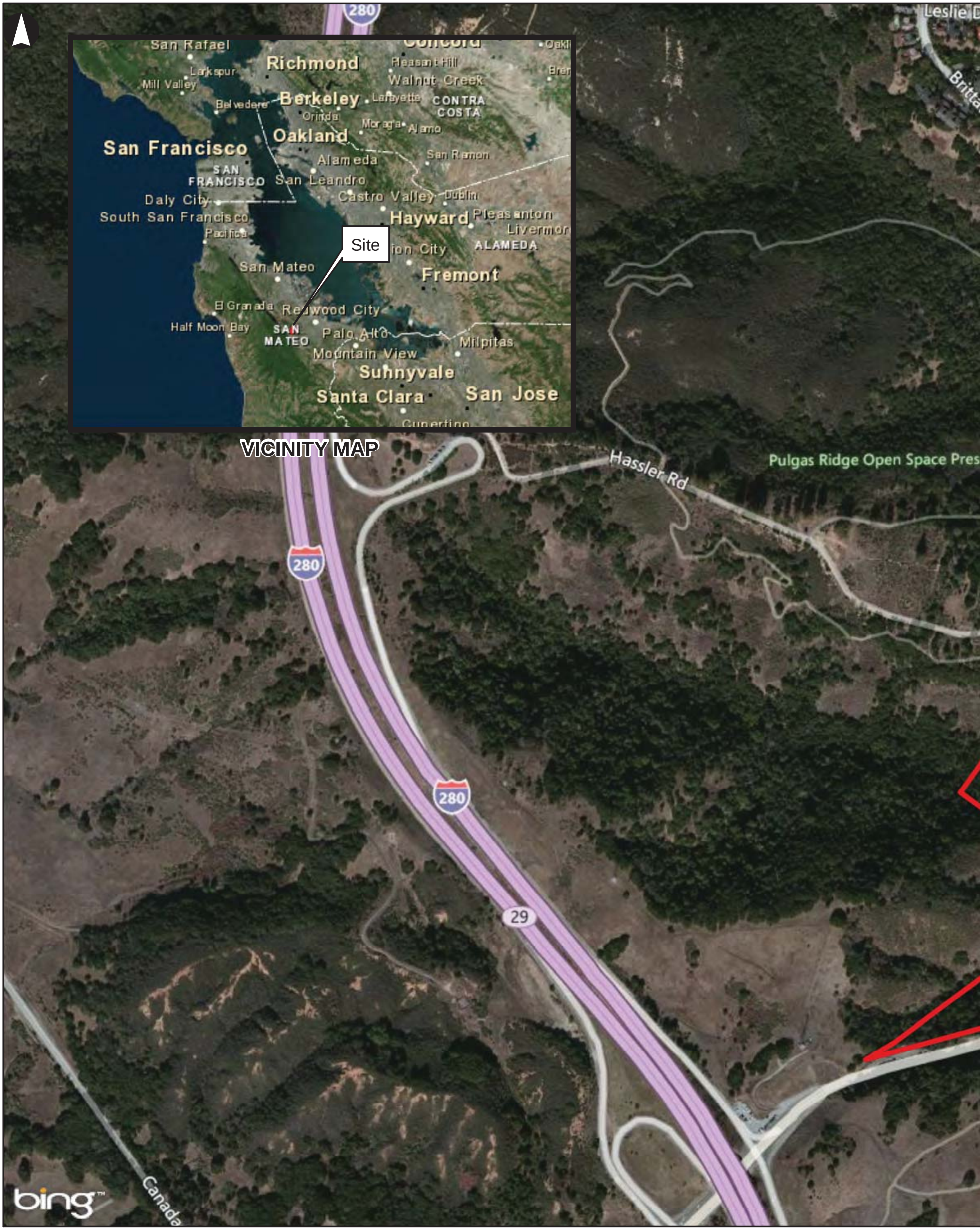
Figures



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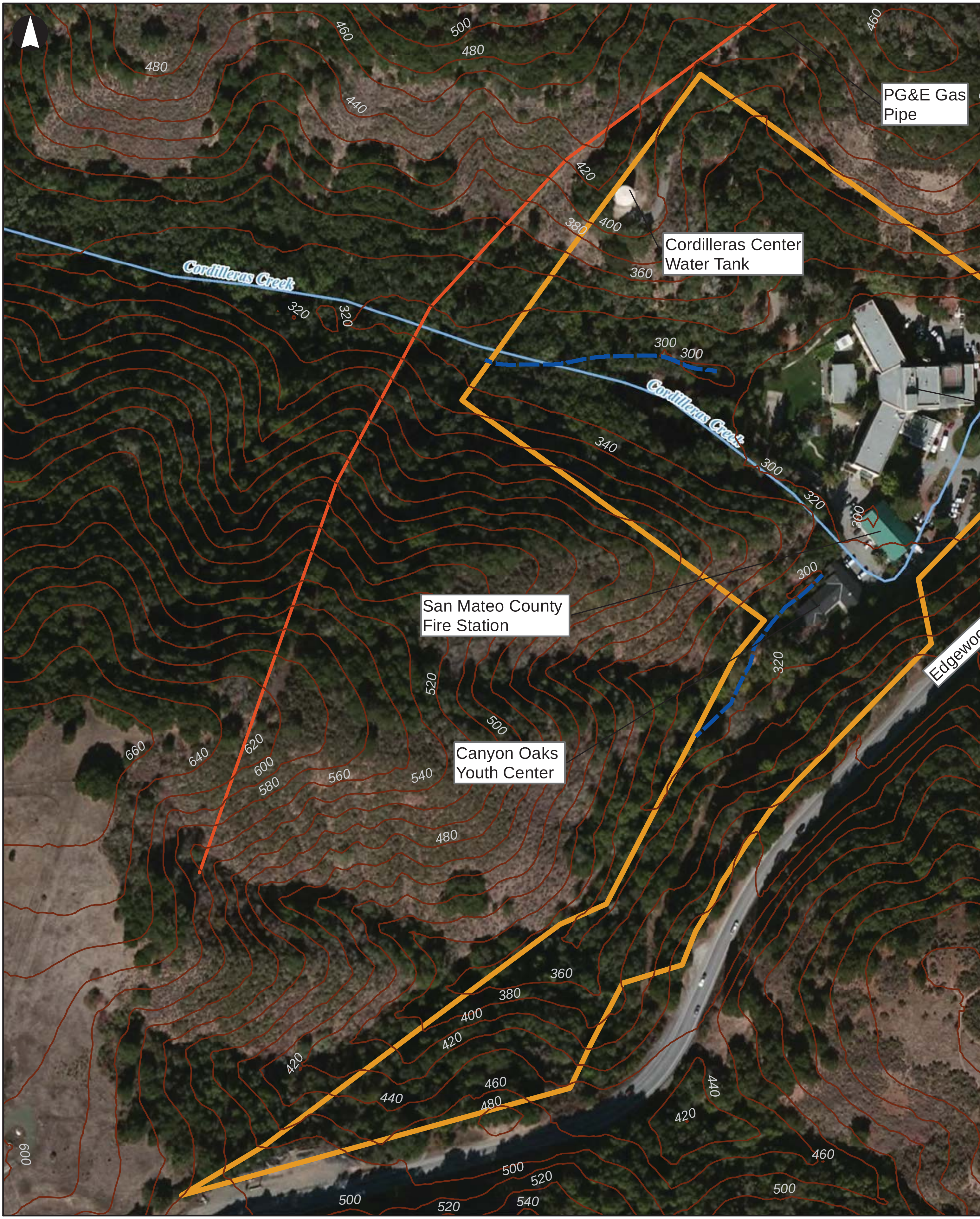

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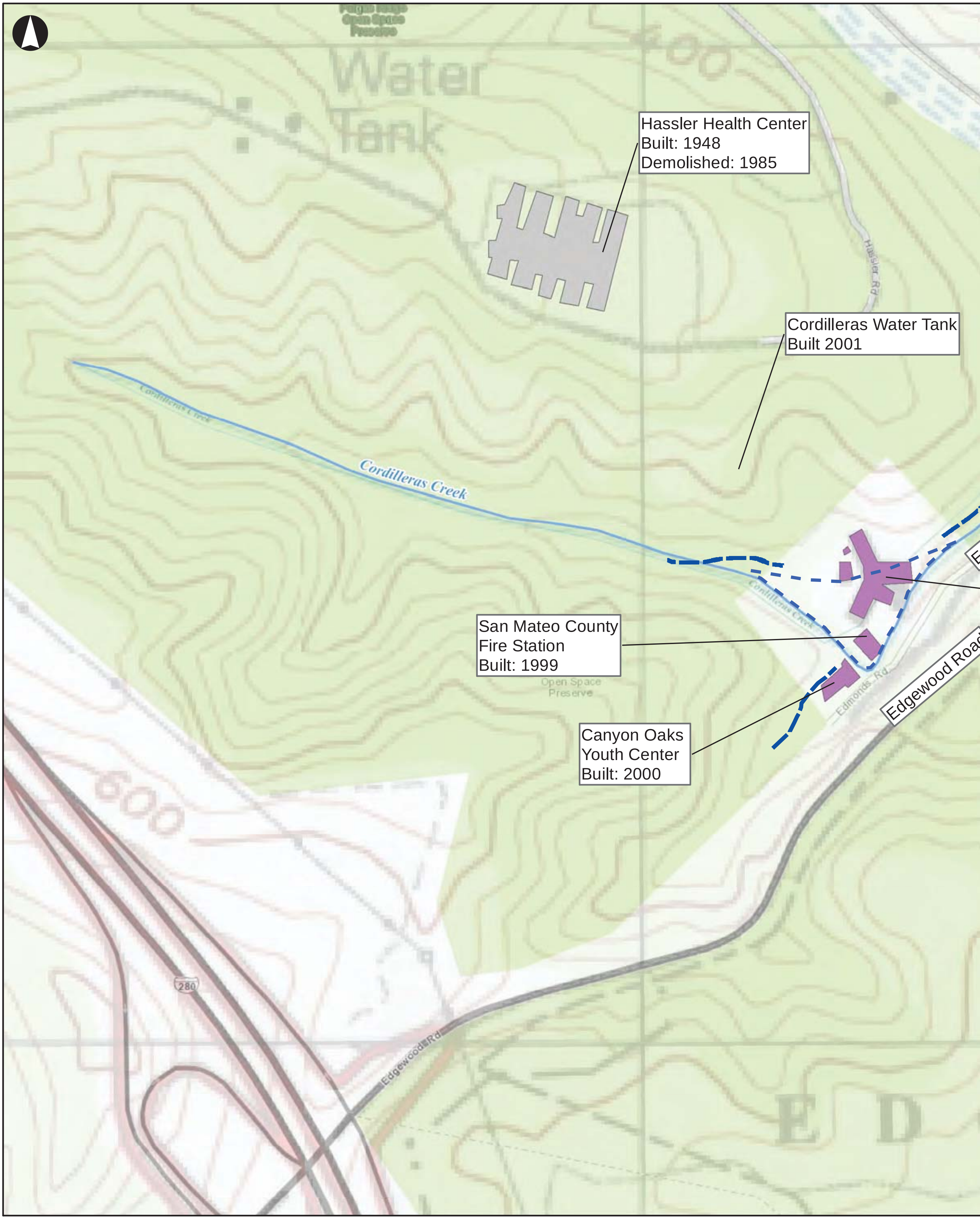

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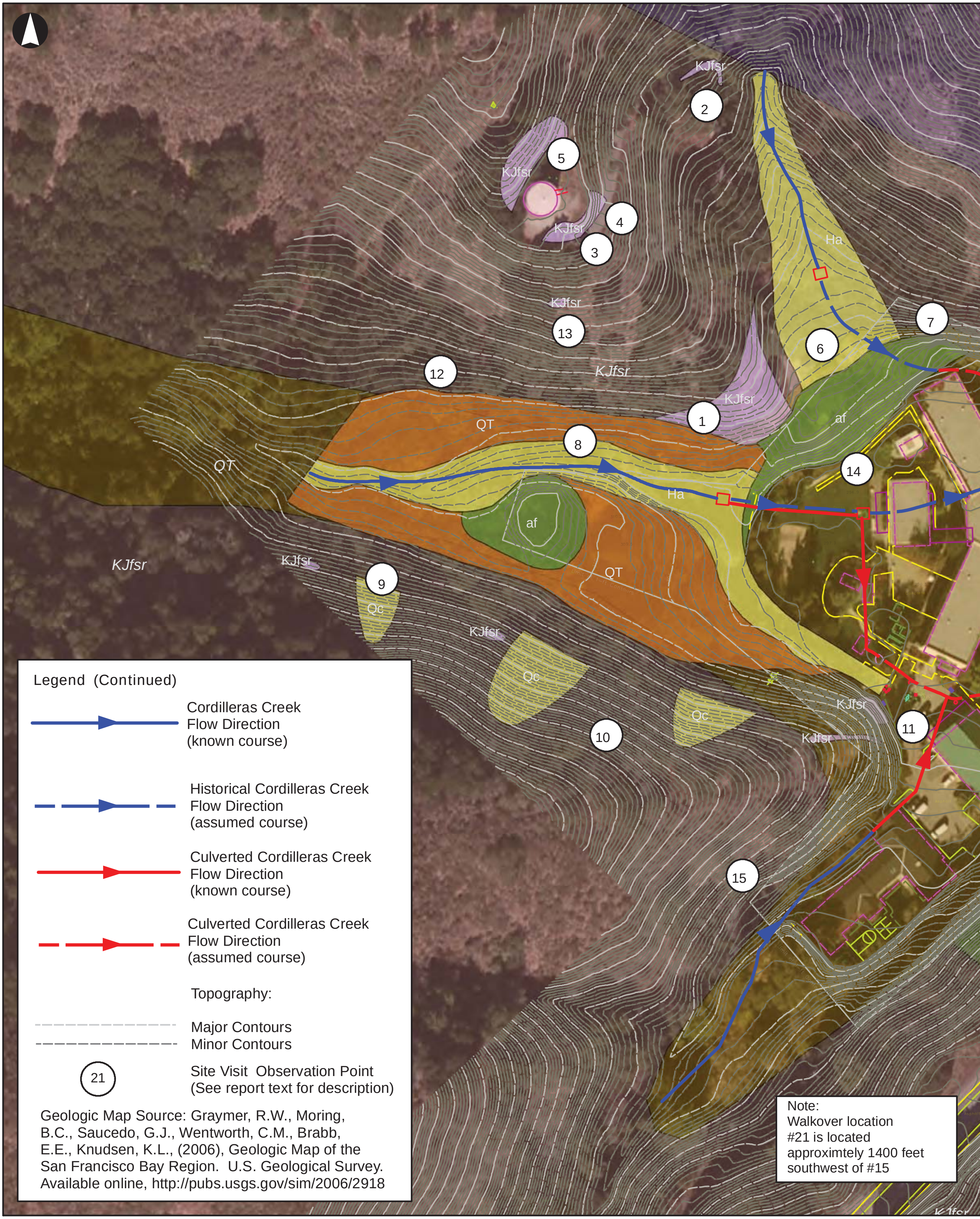

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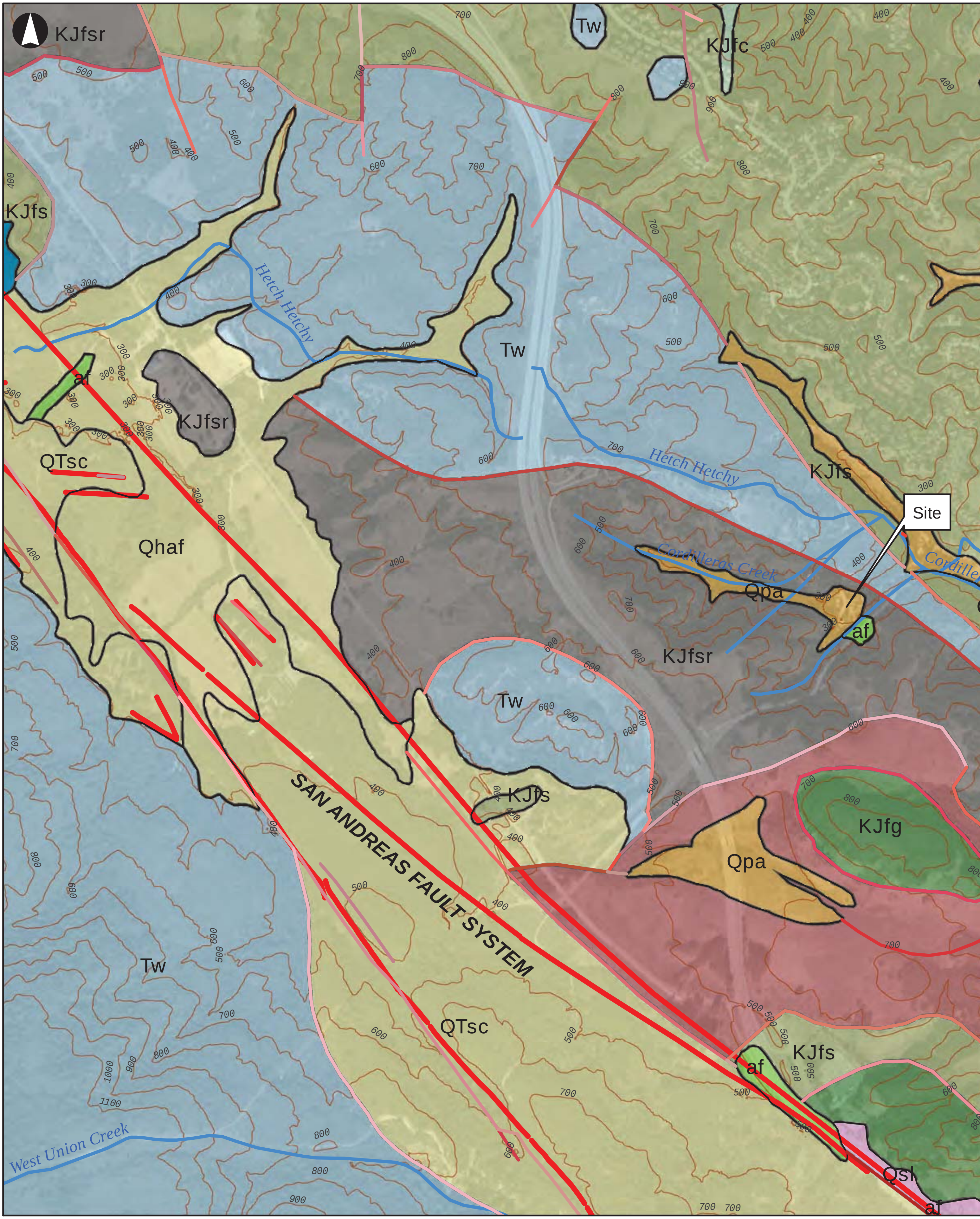

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SAN ANDREAS FAULT
SEAL COVE FAULT
HAYW
Site
bing

Attachment A

in road cut embankment

Photo 2: Cut slope beneath water tank

ater tank

Photo 4: Sandstone outcrop behind water tank

Survey Photos

ARUP

ary to Cordilleras Creek

Photo 6: Cut clope north of building loading dock

dry during site visit

Photo 8: South slope of north valley

Survey Photos

lebris accumulation against site boundary fence

Photo 10: Outcrop of Whiskey formation on trail off Edmonds Road

uction of Edmonds Road and Edgewood Road composed of
stone and shale

Photo 12: Road cut on Edgewood Road (east of site) composed of melange

Survey Photos

wood Road (southeast of site) composed of blocky sandstone

Photo 14: Road cut on Edgewood Road (south of site) composed of competent sandstone

Survey Photos