5.7 Geology and Soils

5.7.1 Introduction

This section describes the existing geology and soils setting of the project area, and evaluates whether the development of the proposed desalination plant and related facilities would result in adverse effects to geologic resources. Specifically, the evaluation focuses on whether the proposed project would result in or be subject to adverse effects related to earthquakes, seismic ground shaking, ground failure, landslides, liquefaction, soil erosion, or loss of topsoil. The evaluation also includes a determination on whether the project would be located on a geologic unit or soil that is unstable, or located on expansive or corrosive soils.

The description of the existing setting and evaluation of impacts is based on review of published geologic maps, soil maps, U.S. Geological Survey maps, other relevant data published by the California Geological Survey, and field observations of the project area. Other key resources include: **Appendix F, scwd² Seawater Desalination Program Offshore Geophysical Study**; **Appendix I, Seawater Intake Facility Conceptual Design Report scwd² Regional Seawater Desalination Project (**Seawater Intake Facility Conceptual Design Report); *Preliminary Review of Geologic and Geotechnical Hazards and Mitigation – Proposed City of Santa Cruz Desalination Facility* (contained in **Appendix L, scwd² Seawater Desalination Plant – Phase 1 Preliminary Design: Volume 1 – Report & Volume 2 - Drawings** [Preliminary Design Report]); and *Geologic and Seismic Discussion – City of Santa Cruz General Plan Update* (Nolan, 2009). Additional information in this section related to environmental setting, regulatory framework, and the analysis of impacts and mitigation measures is derived from Section 5.7, Geology, Soils and Seismicity, of the *Integrated Water Plan Program Environmental Impact Report* (IWP Program EIR) (City, 2005a), as well as from other references cited throughout this section[1].

Public and agency comments related to geology and soils were received during the public scoping period in response to the Notice of Preparation, and are summarized below:

- Assess potential for sinkholes at pump station location at Mitchell's Cove.
- Discuss seismic impacts on infrastructure.
- Discuss impacts to geology and geohydrology, including impacts due to pumping seawater, and drilling on the ocean floor.

[1] Referenced documents in this EIR are available for review at the City of Santa Cruz Water Department offices at 212 Locust Street, Suite D, Santa Cruz, California 95060, Monday through Thursday 8:00 a.m. to Noon and 1:00 p.m. to 5:00 p.m., except holidays. Likewise, these documents are available for review at the Soquel Creek Water District offices at 5180 Soquel Drive, Soquel, CA 95073, Monday through Friday 8:00 a.m. to Noon and 1:00 p.m. to 5:00 p.m., except holidays.

- Assess coastal erosion rates and potential effects of coastal erosion on proposed facilities.

To the extent that issues identified in public comments involve potentially significant effects on the environment according to the California Environmental Quality Act (CEQA), and/or are raised by responsible and trustee agencies, they are identified and addressed in this EIR. For a complete list of public comments received during the public scoping period, refer to **Appendix A, Scoping Report City of Santa Cruz and Soquel Creek Water District (scwd²) Regional Seawater Desalination Project.**

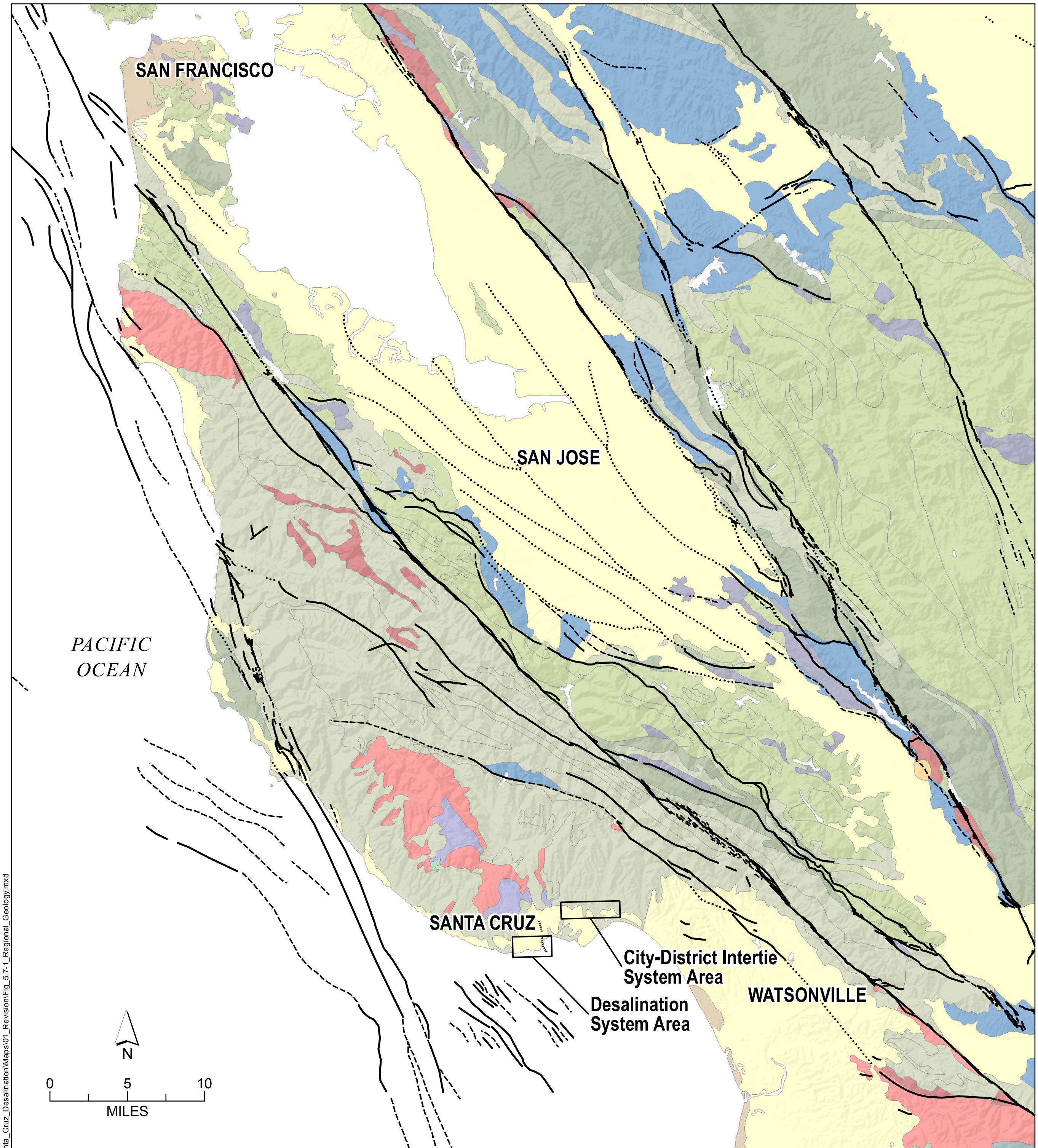
5.7.2 Environmental Setting

Regional Setting

Geology

The geology of the region is shown in **Figure 5.7-1, Regional Geology**. The project area is situated on the southwestern slope of the central Santa Cruz Mountains, which is part of the Coast Ranges geomorphic province of California. The structural grain of the Coast Ranges is controlled by a complex of active faults within the San Andreas fault system, which trends northwest-southeast. The Coast Ranges, including the Santa Cruz Mountains, are underlain by a large, northwest-trending, elongated prism of granitic and metamorphic basement rocks that are Cretaceous in age, or older. The granitic and metamorphic basement is overlain by a sequence of marine sedimentary rocks of Paleocene to Pliocene age, and non-marine sediments of Pleistocene and Holocene age. The older sedimentary rocks are moderately to strongly deformed, with steep-limbed folds and several generations of faults associated with uplift of the Santa Cruz Mountains (Nolan, 2009).

The younger sedimentary rocks (Tertiary and Quaternary age) are draped over the older granitic and metamorphic bedrock. The Tertiary rock units include the Santa Margarita Sandstone, the Santa Cruz Mudstone, and sandstones of the Purisima Formation (see **Figures 5.7-2a and 5.7-2b, Local Geology**). Surficial Quaternary deposits locally overly the Tertiary units. These units include marine terrace deposits, stream or river alluvium, and landslide deposits. The marine terrace deposits directly underlie much of the City of Santa Cruz, and generally range from a few feet thick, to at most a few tens of feet thick. They consist of marine sands, including ancient beach sands, deposited while the marine terrace was being carved by the ocean, and colluvium deposited over the marine sands after the terrace was exposed by falling sea levels. Soil derived from weathering of all the older geologic units is present in thicknesses up to a few feet throughout the area (Nolan, 2009).



System Area

Faults

- Certain
- Approximately located
- Concealed
- Postulated

Geologic Units

- Alluvium; Quaternary marine and non-marine
- Selected large landslide deposits
- Extensive sand dune deposits
- Pre-Tertiary volcanic
- Pre-Tertiary marine
- Tertiary marine sedimentary rocks
- Tertiary volcanic
- Tertiary non-marine sedimentary rocks
- Franciscan Complex
- Schist of various types and ages, metased. or metavol.
- Pre-Cenozoic granitic and metamorphic rocks, undiv.
- Limestone of probable Paleozoic or Mesozoic age
- Ultramafic rocks, chiefly Mesozoic
- Undivided pre-Cenozoic metased. and metavol. rocks

Data sources:
Faults - Bryant, W.A. (compiler), 2005, Digital Database of Quaternary and Younger Faults from the Fault Activity Map of California, version 2.0: California Geological Survey.

Geology - Jennings, C.W., with modifications by Gutierrez, C., Bryant, W., Saucedo, G., and Wills, C., 2010, Geologic Map of California: California Geological Survey, Geologic Data Map No. 2, scale 1:750,000.

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Figure 5.7-1
Regional Geology

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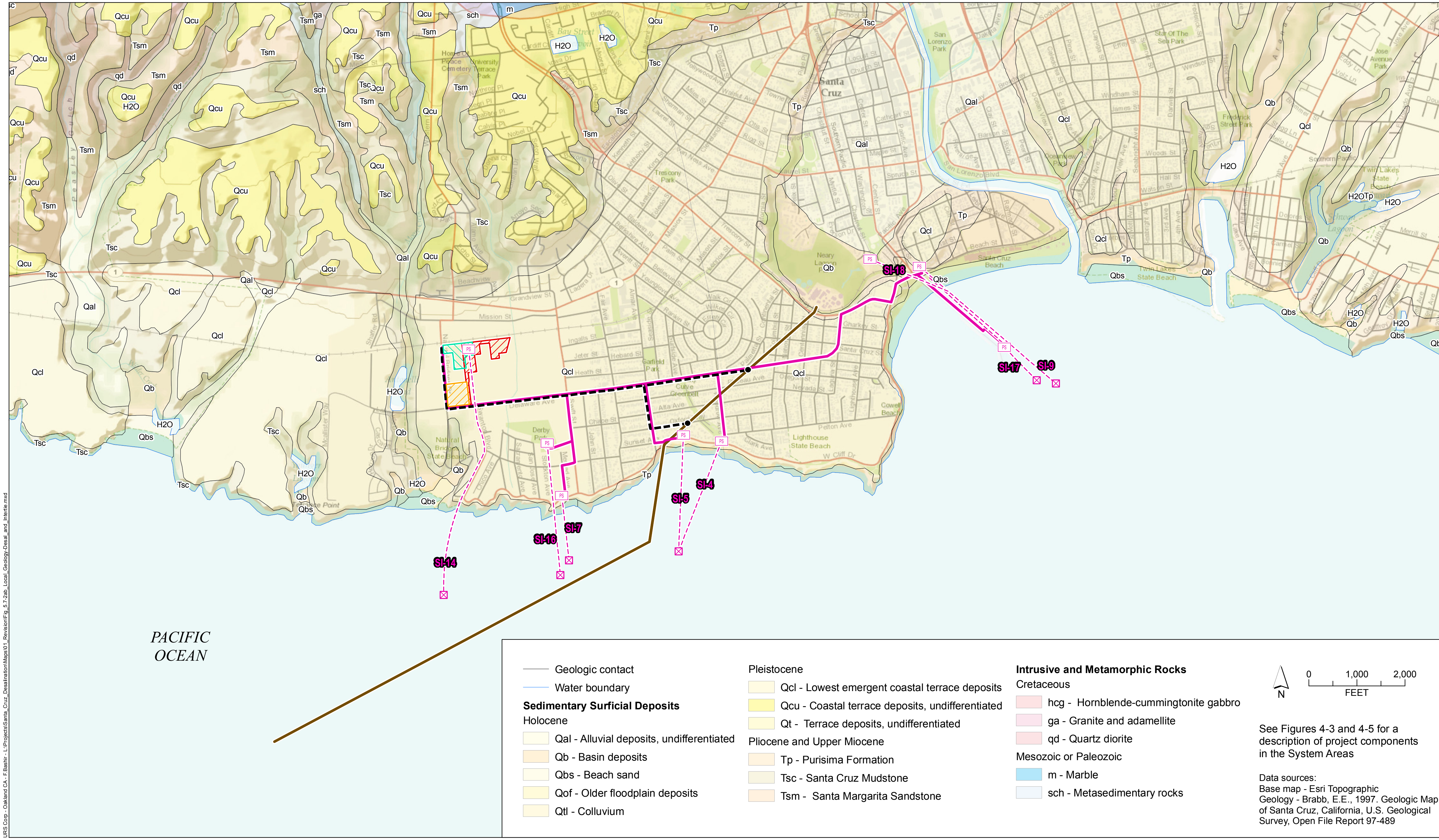

URS City of Santa Cruz and Soquel Creek Water District
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Figure 5.7-2a
Local Geology - Desalination System Area

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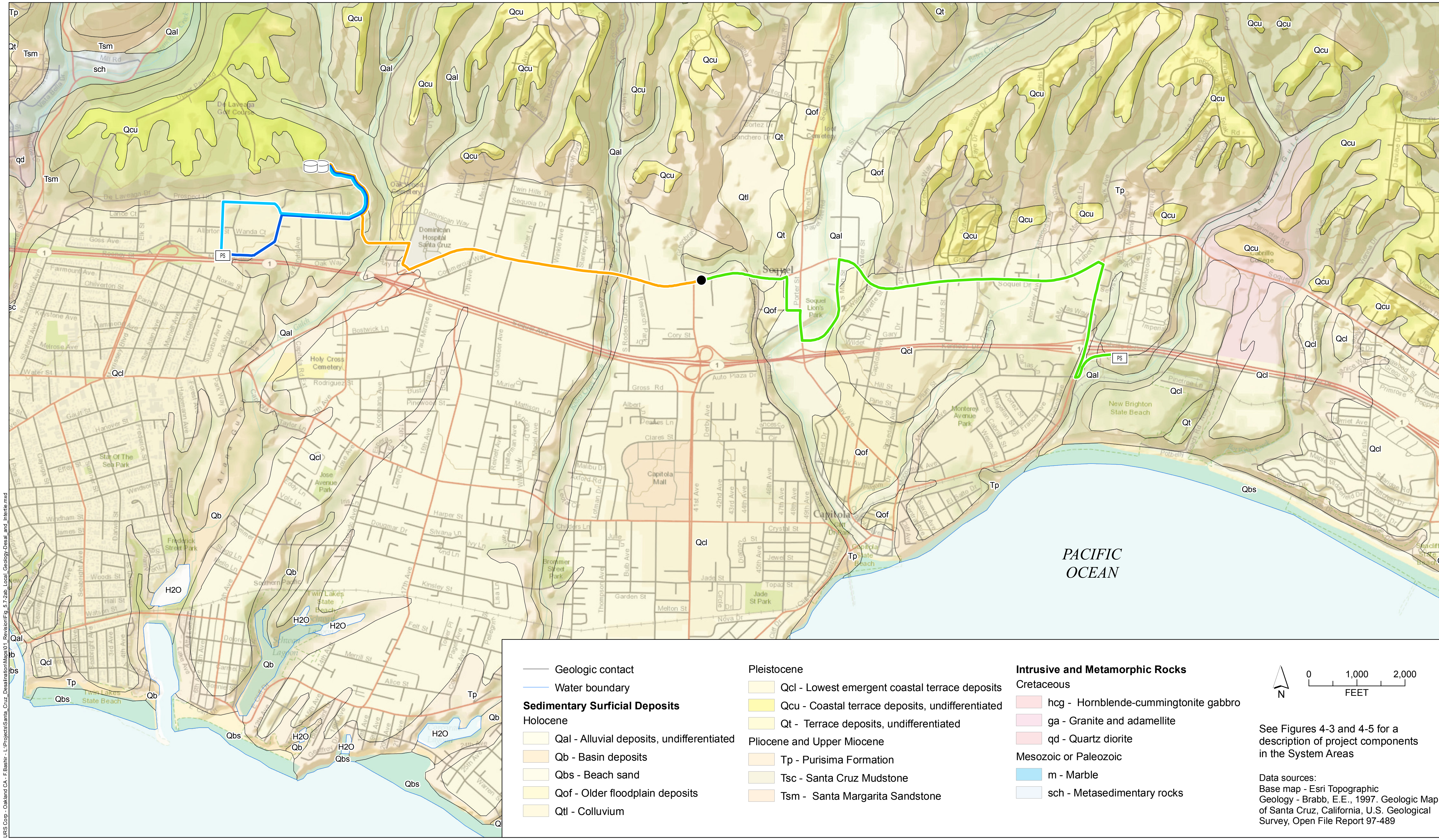

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Figure 5.7-2b
Local Geology - City-District Intertie System Area

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Seismicity and Faulting

California's broad system of strike-slip faulting has a long and complex history. There are active and potentially active faults in the region that have the potential to affect conditions in the project area. Locally, the San Andreas, Zayante-Vergeles, and San Gregorio faults, and the Monterey Bay-Tularcitos fault zone (see **Figure 5.7-3, Regional Seismicity**) are considered to be active. For purposes of this discussion, an "active" fault is one that has moved during Holocene time (approximately 11,000 years), where a "potentially active" fault has demonstrated movement within Quaternary time (approximately 1.6 million years). This is consistent with recent interpretations of the California Geological Survey (Jennings and Bryant, 2010). The term "historically active" refers to faults that have moved during historical time (approximately 200 years), which are a subset of "active" faults.

The Alquist-Priolo Earthquake Fault Zoning Act discussed in **Section 5.7-3, Regulatory Framework,** was passed by the State of California in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. No Alquist-Priolo Earthquake Fault Zones are in the project area.

The only fault thought to be in the actual project area is the Ben Lomond fault, which projects toward Mitchell's Cove. This fault trends southward from its intersection with the Zayante fault down the San Lorenzo Valley towards Santa Cruz. The fault has only been confidently mapped as far south as Felton, several miles north of Santa Cruz (Greene, 1977). Because of indirect geophysical evidence, it has been postulated that the Ben Lomond fault extends southward through the City into Monterey Bay (Nolan, 2009). Vertical movement on the fault, west side up, is thought to be responsible for uplift and tilting the granitic rock mass that forms Ben Lomond Mountain. Most of the movement occurred on this fault prior to about 6 million years ago, and the fault is not considered to be active (Nolan, 2009).

The most severe historical earthquakes to affect the project area have been attributed to the nearby San Andreas Fault: the 1906 San Francisco earthquake, and the 1989 Loma Prieta earthquake. The 1906 San Francisco earthquake resulted in approximately 290 miles of surface fault rupture. Horizontal displacement along the fault approached 17 feet near the epicenter. It had a Richter magnitude of 8.3 and a Moment Magnitude (Mw, the measure of total energy released by an earthquake) of 7.9. The more-recent 1989 Loma Prieta earthquake, which had a Richter magnitude of 7.1 (Mw of 6.9), resulted in widespread damage throughout the Bay Area.

Other nearby faults have been the source of a number of historic earthquakes. Zayante-Vergeles is thought to be responsible for a 4.0-magnitude earthquake in 1998. Monterey Bay-Tularcitos may be responsible for two earthquakes in 1926, both estimated at 6.2 on the Richter scale. However, possible inaccuracies in locating the epicenters of these earthquakes have led some to believe that these 1926 earthquakes actually occurred on the nearby San Gregorio fault (Green, 1977). Major faults and historic seismicity are presented on **Figure 5.7-3**. Active and potentially active faults are further described below.

San Andreas Fault

The main trace of the San Andreas fault trends northwest-southeast and extends over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault passes offshore and merges with the Cascadia fault zone. Surface rupture during historical earthquakes, fault creep, and historical seismicity confirm that the San Andreas fault and its branches, the Hayward, Calaveras, and San Gregorio faults, are all active today.

Geologists have recognized that the San Andreas fault system can be divided into segments, with "characteristic" earthquakes of different magnitudes and recurrence intervals. Two overlapping segments of the San Andreas fault system are responsible for historic earthquakes in the project area. The first segment is defined by the rupture that occurred from Mendocino to San Juan Bautista along the San Andreas fault during the great San Francisco earthquake of 1906; it has been suggested that this "1906 rupture" segment experiences earthquakes with comparable magnitudes (Mw 7.9) about every 200 years (WGNCEP, 1996). The second segment is defined approximately by the rupture zone of the Mw 6.9 Loma Prieta earthquake; it has been suggested that earthquakes of Mw 7.0 on this segment of the fault have a recurrence interval of 138 years (WGNCEP, 1996).

Zayante-Vergeles Fault

The Zayante fault lies southwest of the San Andreas fault and trends about 50 miles northwest from the Watsonville lowlands into the Santa Cruz Mountains (see **Figure 5.7-3**). The assumed southern extension of the Zayante fault, known as the Vergeles fault, merges with the San Andreas fault south of San Juan Bautista. Stratigraphic and geomorphic evidence indicates that the Zayante-Vergeles fault has undergone late Pleistocene and Holocene movement (Nolan, 2009).

Some historical seismicity may be related to the Zayante-Vergeles fault (Griggs, 1973). A magnitude 4.0 earthquake in 1998 in the Santa Cruz Mountains occurred on the Zayante fault (Gallardo et al., 2004). The Zayante-Vergeles fault is considered active and is capable of generating an Mw 6.8 earthquake with a recurrence interval of almost 9,000 years (Petersen et al., 1996; Cao et al., 2003).

San Gregorio Fault Zone

The San Gregorio fault zone is primarily offshore, with various strands that cut the ocean floor seaward of Monterey Bay and skirt the Santa Cruz County coastline before coming on land at Point Año Nuevo. North of Año Nuevo, it passes offshore, intersecting the coast again at Half Moon Bay (see **Figure 5.7-3**). North of Half Moon Bay, the San Gregorio fault zone lies offshore until it connects with the San Andreas fault near Bolinas. Southward from Monterey Bay, the San Gregorio fault intersects the coast at Point Sur, and eventually connects with the Hosgri fault in southern-central California.

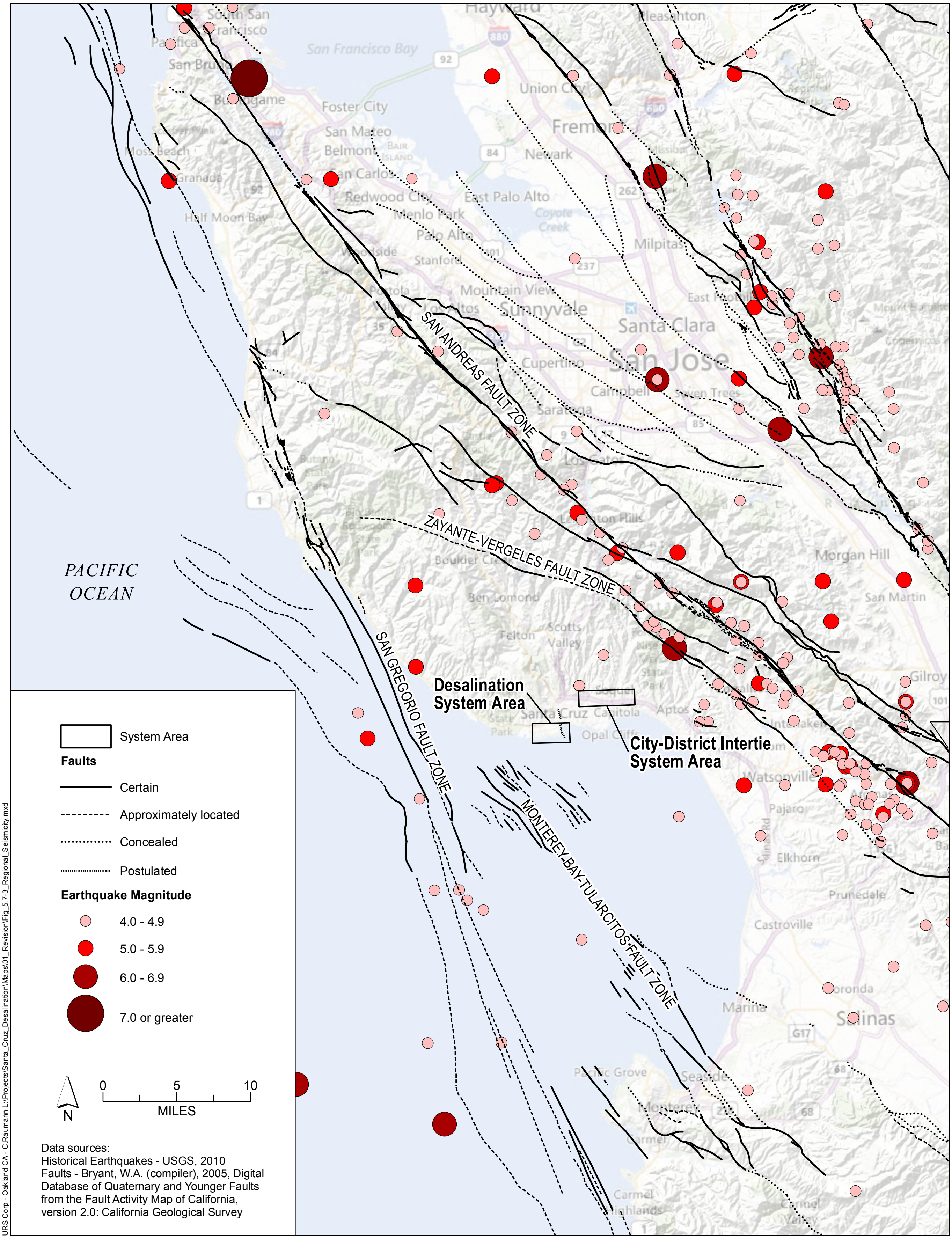

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Figure 5.7-3
Regional Seismicity

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The onshore segments of the San Gregorio fault at Point Año Nuevo and at Half Moon Bay show evidence of late Pleistocene and Holocene displacement (Simpson et al., 1997). In addition to stratigraphic evidence for Holocene activity, the historical seismicity in the region is partially attributed to the San Gregorio fault. Due to inaccuracies of epicenter locations, the magnitude 6+ earthquakes of 1926, tentatively assigned to the Monterey Bay fault zone, may have actually occurred on the San Gregorio fault (Greene, 1977). The San Gregorio fault zone in the Santa Cruz County area has a recurrence interval of 400 years, with the potential to generate an Mw 7.3 earthquake (Petersen et al., 1996; Cao et al., 2003).

Monterey Bay-Tularcitos Fault Zone

The Monterey Bay-Tularcitos fault zone is based on an assumed connection between the Tularcitos fault, located on land near the Monterey Peninsula, and the offshore Monterey Bay fault zone (see **Figure 5.7-3**). The Monterey Bay fault zone is 6 to 9 miles wide and about 25 miles long. Both offshore and onshore fault traces in this zone have displaced Quaternary age rock layers, and therefore are considered potentially active. One offshore trace has displaced Holocene beds, and is therefore considered active.

Seismically, the Monterey Bay-Tularcitos fault zone may be historically active. The largest historical earthquakes tentatively located in the Monterey Bay-Tularcitos fault zone were two events in October 1926, estimated at 6.2 on the Richter scale. Because of potential inaccuracies in locating the epicenters of these earthquakes, it is possible that these earthquakes actually occurred on the nearby San Gregorio fault (Greene, 1977). An earthquake of Mw 7.1-7.3 may be expected on the Monterey Bay-Tularcitos fault zone, with an effective recurrence interval of 2,600 to 2,800 years, based on Holocene offsets noted on an offshore strand of the fault (WGNCEP, 1996).

Project Area Setting

Topography and Santa Cruz Geology

Local geology in the project area is presented on **Figure 5.7-2a** and **Figure 5.7-2b,** and is discussed further in the geologic, geotechnical, and seismic review undertaken as part of **Appendix I**.

The project area consists largely of a series of five Quaternary marine terraces that were formed by a combination of tectonic uplift and sea-level fluctuation. During periods when the Earth's climate was relatively warm and the sea level was relatively high (glacial minima), coastal erosion carved out flat, wave-cut platforms and deposited shallow marine sediments. During periods when the Earth's climate cooled down and more of the Earth's water was stored on land in glaciers (glacial maxima), the sea level fell, leaving these platforms exposed. When the sea level began to rise during the next glacial recession, the previously formed wave-cut platforms were preserved, because they had been tectonically uplifted above the zone of sea-level fluctuation.

During the glacial maxima, the San Lorenzo River and other small streams dissected these marine terraces, cutting channels through the underlying bedrock and depositing fluvial sediments. At the end of the glaciation, as the sea level rose, these bedrock valleys were filled with alluvial deposits, basin deposits, and then shallow marine deposits.

The bedrock units in the project area are generally made up of the Purisima Formation overlying the older Santa Cruz Mudstone. As a result, the Purisima Formation represents the bulk of the exposed bedrock, with Santa Cruz Mudstone occurring predominantly west of Swift Street.

Santa Cruz Mudstone is generally described as medium- to thick-bedded and faintly laminated, blocky weathering, pale-yellowish-brown siliceous organic mudstone. The Purisima Formation is described as very thick-bedded yellowish-gray tuffaceous and diatomaceous siltstone. The marine terrace typically is blanketed by Pleistocene coastal terrace deposits (Qcl), with bedrock only exposed along the actively eroding coastal cliffs, and where creeks and river drainages are dissecting the terrace surface. These terrace deposits are described as semi-consolidated, generally well-sorted sands with a few thin, relatively continuous layers of gravel deposited in nearshore marine environments.

The San Lorenzo River has deeply dissected the coastal terrace along the eastern edge of the project area, forming an alluvial valley approximately 3,500 feet wide at the coast, bordered by bedrock cliffs. This valley is filled with a range of Holocene (10,000 years and younger) sediments, including basin deposits (Qb), alluvial deposits (Qal), and at the coast, beach sands (Qbs).

Site-Specific Geology

This section describes site-specific geologic conditions that exist in the project area, and refers to the various project components described in **Section 4, Project Description**. That section should be referred to for a full description of the proposed project. The various components of the project are shown on figures provided in this section, as appropriate.

Seawater Intake and Conveyance System

The geology of the eight alternative seawater intake sites is described below, based on information presented in the Seawater Intake Facility Conceptual Design Report (**Appendix I)**:

- SI-4, SI-5, and SI-7 are in areas where the pump station would be positioned near the edge of the youngest emergent coastal terrace, and the intake structure offshore would be on the modern, wave-cut bedrock platform. A review of existing maps and literature indicates that SI-7 would be founded on Santa Cruz Mudstone. SI-4 and SI-5 would likely encounter Purisima Formation at the surface, but may encounter Santa Cruz Mudstone during tunneling and pump-station excavation. All units are relatively flat-lying.

- SI-9 is in an area where the pump station would be on the youngest coastal terrace, and the intake structure on fluvial and shallow marine sediments. At this site, it is anticipated that Purisima Formation bedrock would be encountered during construction of onshore facilities.

- SI-14 and SI-16 are in areas where the pump station would be on relatively flat, open ground on the first of the marine terraces. SI-14 would be co-located with the desalination plant; SI-16 is approximately ¼ mile to the southeast. Artificial fill may overlay Purisima Formation bedrock in portions of these sites.

- SI-17 and SI-18 are in areas where both the pump station and intake structure would be underlain by highly variable fluvial, basin, and shallow marine sediments associated with the San Lorenzo River System and Santa Cruz Main Beach.

Seawater Desalination Plant

The geology of the alternative seawater desalination plant sites is described below, based on the Preliminary Design Report **(Appendix L)**.

Plant Site A-1. Plant Site A-1 is on Natural Bridges Drive, just south of the railroad tracks. It is a T-shaped site situated at the top of a gently sloping coastal plain, elevated between 62 and 72 feet above mean sea level (msl). A large mound of fill related to industrial operations on the site is present at the western edge of the site along Natural Bridges Drive. The site is mostly an open field, with the exception of the aforementioned industrial operations. The ground surface appears to have been disturbed in various locations around the property, presumably by historic grading operations.

It is likely that this site is underlain by a blanket of marine terrace deposits composed of very stiff clay capping loose to dense sands, all of which is underlain by a fossil wave-cut platform that has been beveled into the Santa Cruz Mudstone at about 50 feet above msl. Groundwater is likely shallow at the site, and probably rises and drops seasonally due to rainfall, percolations, and the general lack of transmissivity of the Santa Cruz Mudstone.

It is possible that the site contains pockets or mounds of non-engineered fill, as evidenced by the disturbed ground surface. The large mound of materials at the western edge of the site is most certainly fill.

Plant Site A-2. Plant Site A-2 is on the corner of Delaware Avenue and Natural Bridges Drive. The site spans a gently sloping coastal plain that descends abruptly into an unnamed drainage on the western side of the site, which drains into Natural Bridges Creek to the south of Delaware Avenue. Elevations range from about 46 to 66 feet above msl. The ground surface is highly variable, with the eastern half of the site gently sloping with some scattered mounds, which were likely created by historic grading of the site. The western half of the site descends steeply into the unnamed drainage, the topography of which is very irregular, possibly from historic excavation and filling.

The site is underlain by uplifted marine terrace deposits. These terrace deposits are primarily comprised of medium-dense to dense, semi-consolidated silty and clayey sands. These sands unconformably overlay Santa Cruz Mudstone bedrock. A layer of expansive clay may have formed within the upper 5 feet of the marine deposits as a result of weathering over tens of thousands of years.

It is likely that this site is underlain by a blanket of marine terrace deposits 10 to 15 feet thick, composed of very stiff clay capping loose to dense sands, all of which is underlain by a fossil wave-cut platform that has been beveled into the Santa Cruz Mudstone. The marine terrace deposits are likely to be overlain by non-engineered fill of variable thickness. The incision of the drainage has probably exposed the terrace deposits, and possibly the Santa Cruz Mudstone. Groundwater is likely shallow at the site, and probably rises and drops seasonally due to rainfall, percolations, and the general lack of transmissivity of the Santa Cruz Mudstone.

Plant Site A-3. Plant Site A-3 is just south of the railroad tracks between Swift Street and Natural Bridges Drive. This area spans a modified coastal plain, cut slopes, and an excavated building pad flanked by an existing large industrial building to the west and south. Elevations range from approximately 60 to 70 feet above msl. The ground surface is broken up into two distinct, gently sloping areas separated by a cut slope that is up to 12 feet high. The portions of the site adjacent to the existing building are on a nearly flat, graded pad that terminates at the toe of a 12-foot-high steep cut slope that steps up to the north toward the railroad. The same cut slope wraps to the east and then to the south, gradually stepping down, decreasing in height and merging into the southeastern corner of the building pad.

Prior geotechnical investigations on parcels east of the site along Swift Street encountered a blanket of artificial fill and marine terrace deposits with an aggregate thickness of up to 19.5 feet. This blanket was primarily composed of loose to very-dense sands containing varying amounts of gravel, silt, and clay; and sometimes a layer of gravelly clay. These surficial sediments blanketed the Santa Cruz Mudstone that was encountered at an elevation of approximately 50 feet above msl. These prior studies also estimated that groundwater levels across the eastern edge of the site ranged between about 58 and 56 feet above msl. This means that groundwater may be encountered at approximately 10 feet below the ground surface on the upper coastal plain portion of the site, and very near the ground surface.

Brine Disposal and Conveyance System

The brine disposal and conveyance system corridors occur on the relatively flat ground of the first marine terrace. This area is underlain by marine terrace deposits, which primarily comprise medium-dense to dense, semi-consolidated silty and clayey sands (Brabb, 1997). The terrace deposits unconformably overlay Santa Cruz Mudstone bedrock; and east of Fair Avenue, they are likely to overlay Purisima Formation bedrock (Brabb, 1997).

Potable Water Distribution System Improvements

Potable water distribution system improvements to provide for an intertie system between the City and District service areas would span from the corner of Trevethan Avenue and Morrissey Boulevard in the City of Santa Cruz, to McGregor Drive in the City of Capitola. The majority of the pipelines and the pump station improvements would be on flat ground on the first marine terrace. The grades along the pipeline corridor generally do not exceed 30 percent.Steeper slopes occur on the rise up from the first marine terrace to the DeLaveaga tanks, on the second marine terrace (Brabb, 1997). **Figure 5.7-4, Areas with Slope Greater than 15 Percent**, shows the slopes in this portion of the project area. Steeper slopes also exist where the alignment crosses smaller steams, including: Arana Creek, Rodeo Gulch, Soquel Creek, and Nobel Gulch.

The Morrissey pump station and the majority of the intertie system pipeline alignment are underlain by marine terrace deposits (Brabb, 1997). However, the pipelines up to and down from the DeLaveaga tanks are on the second marine terrace, and are underlain by Purisima Formation bedrock (Brabb, 1997). The alignment is underlain by narrow fingers of alluvial deposits where it crosses Arana Creek, Rodeo Gulch, Soquel Creek, and Noble Gulch (Brabb, 1997). The valleys carved by the aforementioned creeks expose the underlying Purisima Formation bedrock in areas adjacent to the stream beds (Brabb, 1997).

Soils

Figures 5.7-5a/b, Soils, and **Table 5.7-1, Dominant Soil Types in Project Area,** present the relevant soil types (based on an agricultural nomenclature developed by the Soil Conservation Service, now the Natural Resources Conservation Service) crossed by the different project components. The engineering characteristics of the dominant soils to be crossed by elements of the proposed project are shown in **Table 5.7-2, Characteristics of Dominant Soil Types**. Most project components are situated on some variety of Watsonville loam soils, which tend to have very slow permeability characteristics, but high shrink-swell potential, and a high risk of corrosion to uncoated steel pipe and concrete.

Geologic Hazards

In the project area, geologic hazards that are statically induced (not seismically induced) include landslides, slope instability, and coastal cliff retreat, each of which is discussed below.

Landslides

Landslides are the rapid downward or outward movement of rock, earth, or artificial fill on a slope. Factors causing landslides include rock strength, the orientation of rock structure such as layering or fractures in the slope, erosion, weathering, high rainfall, steepness of slopes, and human activities such as the removal of vegetation and inappropriate grading (Nolan, 2009).

Landslides in Santa Cruz tend to be most common in areas with steep slopes. Consequently, landslide hazards are confined to a few particular locations: (1) along the modern sea cliff hugging West Cliff Drive (see Coastal Bluff Retreat below); (2) along the steeper banks of the San Lorenzo River valley, and along the banks of smaller stream drainages; and (3) along the steep risers separating successively older marine terraces, such as in the vicinity of the DeLaveaga tanks.

Table 5.7-1. Dominant Soil Types in Project Area

Project Component[1]	Dominant Soil Types Crossed[2]
Seawater Intake and Conveyance System	109, 116, 132, 133, 135, 170, 176, 178, 179
Seawater Desalination Plant	116, 132, 176, 178
Brine Disposal and Conveyance System	116, 176, 178, 179
Potable Water Distribution System Improvements	
Morrissey Pump Station to DeLaveaga Tanks – Morrissey Alignment Option	116, 158, 177, 178, 179
Morrissey Pump Station to DeLaveaga Tanks – Trevethan Alignment Option	116, 158, 177, 178, 179
DeLaveaga Tanks to City-District Intertie	116, 133, 143, 158, 171, 177, 178, 179
City-District Intertie to McGregor Drive Pump Station	125, 129, 130, 133, 135, 136, 148, 170, 171, 174, 177, 178, 179

Notes:
1. Refer to Figure 4-3 and Figure 4-5 for location of project components.
2. Refer to text and Table 5.7-2 for discussion of soil types. Refer to Figures 5.7-5a and 5.7-5b for maps of soil types in relation to the project components.

In general, landsliding can be considered a potentially significant hazard where slopes exceed a gradient of about 50 percent. Slope instability can sometimes occur on less-steep slopes, but the risk is typically much lower (Nolan, 2009). **Figure 5.7-4** indicates that there are some isolated areas where steep slopes exist in the vicinity of the pipeline corridors leading up to and down from the DeLaveaga tanks. However, it should be noted that there are few landslide deposits that have been mapped to date in this area (Nolan, 2009).

Coastal Bluff Retreat

The term "bluff retreat" is commonly used to describe the horizontal (landward) erosion of the shoreline along the coastline. Coastal erosion includes both cliff (or bluff) erosion and beach erosion, and is a result of winter wave attack and long shore currents, as well as slowly rising sea level. Winter storm waves are larger, steeper, and contain more energy, and typically move significant amounts of sand from the beaches to offshore bars, creating steep, narrow beaches. In the summer, lower, less-energetic waves allow the sand to return, making for wider beaches. During the winter months—when beaches are narrow, or absent altogether—storm waves attack the cliffs and bluffs more frequently (Nolan, 2009).

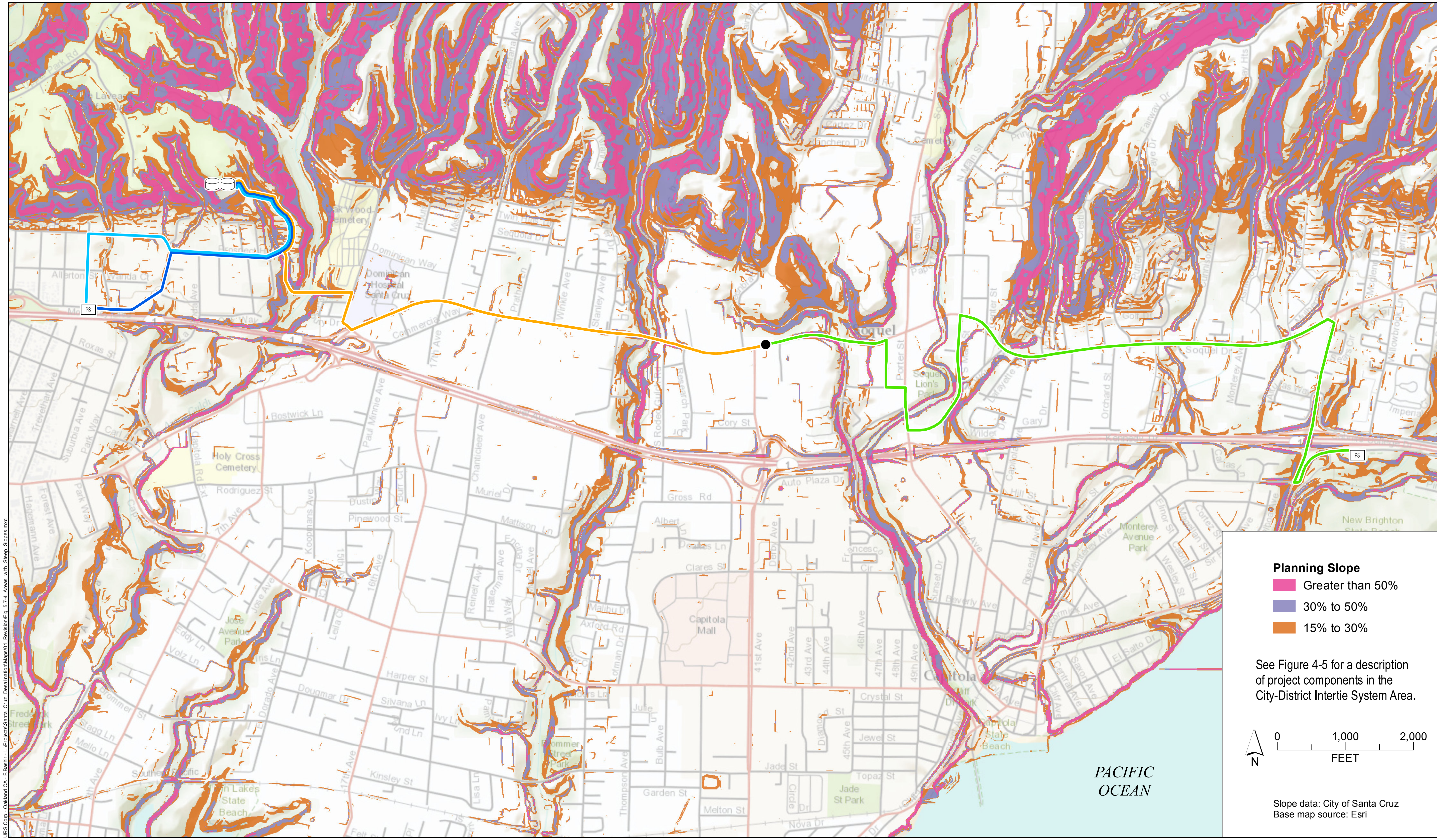

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Figure 5.7-4
Areas with Slope Greater Than 15%

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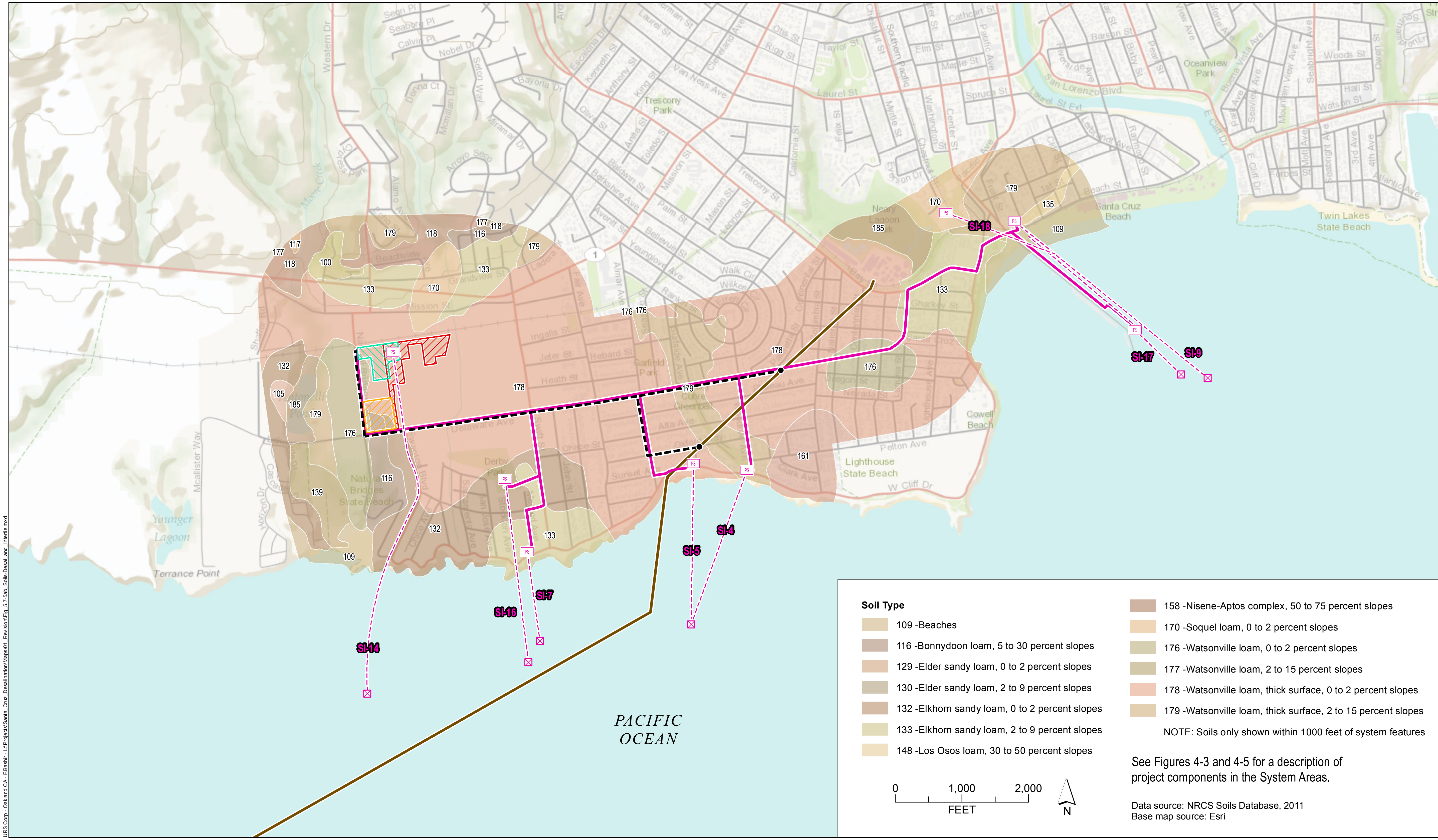

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Figure 5.7-5a
Soils - Desalination System Area

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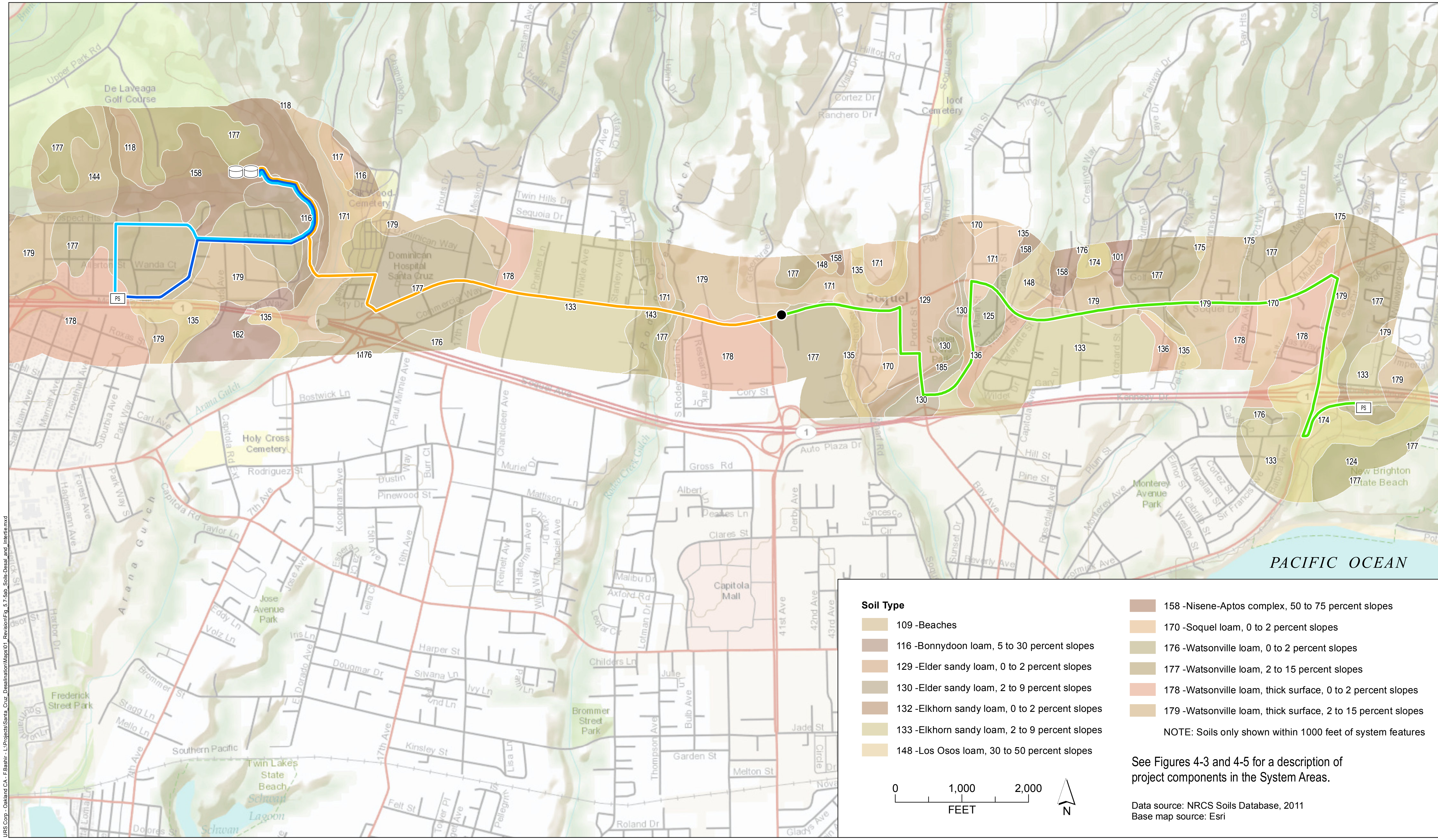

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Figure 5.7-5b
Soils - City-District Intertie System Area

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Table 5.7-2. Characteristics of Dominant Soil Types[1,2]

No.[3]	Name	Parent Material	Permeability	Runoff	Erosion Hazard	USCS[4]	Liquid Limit[5]	Plasticity Index[6]	Shrink-Swell Potential	Risk of Corrosion	
										Uncoated Steel	Concrete
109	Beaches	Varies	High	Varies	Very High	N/A	N/A	N/A	N/A	N/A	N/A
116	Bonnydoon Loam 5-30% Slopes	Mudstone and/or Sandstone/Shale	Moderate	Medium-Rapid	Moderate-High	CL-ML	25-35	5-15	Moderate	Moderate	Low
125	Danville Loam 2-9% Slopes	Alluvium	Slow	Slow-Medium	Slight-Moderate	CL/CL-ML/SC/SC-SM/CH	25-60	5-30	High	High	Moderate
129	Elder Sandy Loam 0-2% Slopes	Mixed Alluvium	Moderate	Slow	None-Slight	SM	10-20	NP-5	Low	Moderate	Moderate
130	Elder Sandy Loam 2-9% Slopes	Mixed Alluvium	Moderate	Slow	Slight-Moderate	SM	10-20	NP-5	Low	Moderate	Moderate
132	Elkhorn Sandy Loam 0-2% Slopes	Marine Deposits	Moderate-Slow	Slow	Slight	SM/SC/CL	10-40	NP-15	Low/ Moderate	Moderate	Low
133	Elkhorn Sandy Loam 2-9% Slopes	Marine Deposits	Moderate-Slow	Slow-Medium	Slight-Moderate	SM/SC/CL	10-40	NP-15	Low/ Moderate	Moderate	Low
135	Elkhorn Sandy Loam 15-30% Slopes	Marine Deposits	Moderate-Slow	Rapid	High	SM/SC/CL	10-40	NP-15	Low/ Moderate	Moderate	Low
136	Elkhorn-Pfeiffer complex 30-50% Slopes	Marine Deposits	Moderate-Rapid	Rapid	High	SM/SC/CL	10-40	NP-15	Low/ Moderate	Moderate	Low
143	Lompico-Felton complex 50-75% Slopes	Mudstone and/or Siltstone and/or Sandstone/Shale	Moderate	Rapid	High	CL-ML/CL/SC/SM/SC-SM/ML	22-54	6-25	Low/ Moderate	High	High
148	Los Osos Loam 30-50% Slopes	Sandstone/ Shale	Slow	Rapid	High	CL/CH/ML	20-60	5-30	Moderate/ High	High	Moderate
158	Nisene-Aptos Complex 50-75% Slopes	Sandstone/ Shale	Moderate	Very Rapid	Very High	SM/SC/CL	20-40	NP-20	Low/ Moderate	Moderate	Moderate
170	Soquel Loam 0-2% Slopes	Alluvium	Moderate-Slow	Slow	None-Slight	CL–ML	20-45	5-20	Moderate	Moderate	Moderate

Table 5.7-2. Characteristics of Dominant Soil Types[1,2]

No.[3]	Name	Parent Material	Permeability	Runoff	Erosion Hazard	USCS[4]	Liquid Limit[5]	Plasticity Index[6]	Shrink-Swell Potential	Risk of Corrosion	
										Uncoated Steel	Concrete
171	Soquel Loam 2-9% Slopes	Alluvium	Moderate-Slow	Slow-Medium	Slight-Moderate	CL/CL-ML	20-45	5-20	Moderate	Moderate	Moderate
174	Tierra-Watsonville complex 15-30% Slopes	Alluvium	Very Slow	Rapid	High	SM/SC-SM/CH/CL/ML/SC	15-60	NP-35	Low/High	High	Moderate
176	Watsonville Loam 0-2% Slopes	Alluvium	Very Slow	Slow	Slight	SC/ML/CL/CH	20-60	NP-35	Low/High	High	High
177	Watsonville Loam 2-15% Slopes	Alluvium	Very Slow	Slow-Medium	Slight-Moderate	SC/ML/CL/CH	20-60	NP-35	Low/High	High	High
178	Watsonville Loam, Thick Surface 0-2% Slopes	Alluvium	Very Slow	Slow	Slight	SC/ML/CL/CH	20-60	NP-35	Low/High	High	High
179	Watsonville Loam, Thick Surface, 2-15% Slopes	Alluvium	Very Slow	Slow-Medium	Slight-Moderate	SC/ML/CL/CH	20-60	NP-35	Low/High	High	High

Source: USDA-NRCS, 2013. Web Soil Survey of Santa Cruz County, California.
Notes:
1. Soil types with only minimal contact with project components are not listed.
2. Range in values reflects different stratigraphic layers and indicates entire range.
3. Refer to Table 5.7-1 and Figures 5.7-5a and 5.7-5b for location of dominant soil types relative to major components of the proposed project.
4. Unified Soil Classification System (USCS):
   CL = clay;
   CH = clay of high plasticity;
   ML = silt;
   SC = clayey sand;
   SM = silty sand.
5. Liquid Limit is the percentage moisture content at which the soil passes from a plastic to a liquid state.
6. Plasticity Index is the range of moisture content within which the soil remains plastic.
   NP = non-plastic

Bluff retreat is usually expressed in terms of a uniform rate, such as feet per year or cubic yards of eroded sediment per linear foot of shoreline per year. However, bluff retreat is mostly the result of specific events associated with major coastal storms, earthquakes, or landslides; many years' worth of retreat at a particular point may occur during the course of one particularly intense winter storm, or may be due to a single landslide event. Therefore, although average retreat rates calculated over many decades may be accurate, actual retreat events may be much larger than average retreat rates would predict, although infrequent (Nolan, 2009).

Bluff retreat rates are calculated by comparing older survey information along the coast that shows where the bluff was in the past with modern survey data, as well as by reviewing aerial photos. Human activities, such as construction of shore protection structures and dredging, may also impact retreat rates. Another factor that is having an impact on the rate of bluff retreat is gradual sea-level rise due to global warming. The precise impact of observed sea-level rise on bluff-retreat rates is not known, and uncertainty in the rate of future sea-level rise compounds the difficulty in predicting its impacts. Retreat rates are influenced by the orientation of the cliff relative to the prevailing storm wave direction, coastline geometry, rock type, and beach width and persistence.

A number of studies have been completed on coastal retreat rates in the Santa Cruz area, including area-wide studies and site-specific studies for individual coastal development projects. A comprehensive study of coastal bluff retreat for Santa Cruz and San Diego counties measured average retreat rates at 2.75 to 5.9 inches per year along the portion of coast studied within the City of Santa Cruz (Moore et al., 1999). However, that study started at the mouth of the San Lorenzo River and proceeded to the south, and thus did not specifically evaluate the sea cliffs in the project area. More localized studies (Griggs and Johnson, 1979) indicate that areas underlain by the Santa Cruz mudstone are more resistant to erosion than areas underlain by the Purisima formation (see **Figure 5.7-2a**).

A coastal bluff retreat study was conducted for the entire California coast in 2007 (Hapke and Reid, 2007). Average retreat rates for the Monterey region (between Davenport and the Monterey Peninsula) were approximately 16 inches per year, with cliffs in the area between Davenport and Capitola generally retreating at a lesser rate than the average (mostly between 0 and 20 inches per year). The highest rates of retreat (up to 70 inches per year) were found in southern Monterey Bay, where bluffs are formed in unlithified Quaternary sand dunes, particularly in places with a long history of sand mining. It is unclear if any transects from this study were in the specific project area.

Gradual sea-level rise due to global warming may have an effect on the rate of bluff retreat in certain areas. The Sea-Level Rise Task Force of the Coastal and Ocean Working Group of the California Climate Action Team has developed interim guidelines for sea-level rise (CO-CAT, 2010). According to the guidelines, 16 inches in sea-level rise (above year 2000 levels) should be planned for by the year 2050, and up to 55 inches by the year 2100. This approach is consistent with the California Ocean Protection Council's resolution on sea-level rise (COPC, 2011).

Seismic Hazards

Potential seismic hazards include fault rupture, strong seismic shaking, soil liquefaction and related types of seismically induced ground failure, and tsunami. Except for tsunami hazards, these hazards are discussed individually below. See **Section 5.1, Hydrology and Water Quality**, for a discussion of tsunami hazards.

Ground-Surface Rupture Due To Faulting

Earthquakes are caused by slippage along faults, or cracks, in the Earth's crust. Where the fault intersects the ground surface, this slippage causes offset of the ground surface that can damage or destroy structures placed over the fault. The only suspected fault trace crossing through the project area is the Ben Lomond fault, but it is not considered to be active; therefore, any risk of ground surface rupture across the fault trace must be considered low. Ground-surface rupture due to faulting is therefore not considered a significant risk in the project area.

Seismic Shaking Hazard

For the purpose of evaluating seismic shaking potential in the project area, this discussion focuses on the San Andreas, Zayante-Vergeles, San Gregorio, and Monterey Bay-Tularcitos fault systems (see **Figure 5.7-3**). These faults are considered active seismic sources by the State of California. Although other faults in this region may be active, their potential contribution to seismic hazards is overshadowed by these four larger or closer faults. The distances between these faults and both the eastern and western ends of the project area, are listed in **Table 5.7-3, Distances to Local Faults**, as is the maximum expected earthquake size and the approximate time interval between major earthquakes on each fault. All of these faults are considered capable of Mw 6.5 or larger earthquakes.

Table 5.7-3. Distances to Local Faults[1]

Fault	Approximate Distance from Plant Vicinity (miles)	Approximate Distance from Intertie Vicinity (miles)	Maximum Expected Earthquake Magnitude (Moment Magnitude)	Approximate Time Between Major Earthquakes (years)[2]
San Gregorio	8.8 – 10.8	10.8 – 15.2	7.2	400
Zayante-Vergeles	4.8 – 8	4 – 7.6	7.9	8,820
Monterey Bay-Tularcitos	4.8 – 6.4	6.8 – 10.4	6.5	2,840
San Andreas	10.8 – 12.4	7.6 – 10.4	7.9	210

Source: Nolan, 2009. Geologic and Seismologic Discussion – City of Santa Cruz General Plan Update.
Notes:
1. The project components in the vicinity of the plant span an area that is about 2.5 miles long, and the intertie component spans an area that is about 5 miles long, both oriented essentially east-west. Because the fault systems are all oriented approximately northwest-southeast, a range of distances is provided from the closest approach of a given fault to the eastern and western ends of the potential project components.
2. Numbers were rounded to the nearest 10.

A qualitative measure of earthquake-shaking intensity is provided by the Modified Mercalli Intensity Scale (**Table 5.7-4, The Modified Mercalli Intensity Scale**). The Mercalli Scale (and other, similar qualitative scales) provides a way to gauge earthquake-shaking intensity based on verbal or published descriptions of earthquake damage. It was the principal means of measuring earthquake size before the advent of seismograph arrays in the early 20th century. Modified Mercalli Intensities of VIII to IX were measured in the City of Santa Cruz for the 1989 Loma Prieta and 1906 San Francisco earthquakes, respectively. Similar shaking intensities are expected in future earthquakes.

Table 5.7-4. The Modified Mercalli Intensity Scale

The modified Mercalli scale measures the intensity of ground shaking as determined from observations of an earthquake's effect on people, structures, and the Earth's surface. This scale assigns each event a Roman numeral from I to XII as follows:	
I	Not felt by people, except rarely under especially favorable circumstances.
II	Felt indoors only by persons at rest, especially on upper floors. Some hanging objects may swing.
III	Felt indoors by several. Hanging objects may swing slightly. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	Felt indoors by many, outdoors by few. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle. Wooden walls and frame may creak.
V	Felt indoors and outdoors by nearly everyone; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset; some dishes and glassware broken. Doors swing; shutters, pictures move. Pendulum clocks stop, start, change rate. Swaying of tall trees and poles sometimes noticed.
VI	Felt by all. Damage slight. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware break. Items fall off shelves; pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked.
VII	Difficult to stand. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in badly designed or poorly built buildings. Noticed by drivers of automobiles. Hanging objects quiver. Furniture broken. Weak chimneys broken. Damage to masonry; fall of plaster, loose bricks, stones, tiles, and unbraced parapets. Small slides and caving in along sand or gravel banks. Large bells ring.
VIII	People frightened. Damage slight in specially designed structures; considerable in ordinary substantial buildings, partial collapse; great in poorly built structures. Steering of automobiles affected. Damage or partial collapse to some masonry and stucco. Failure of some chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed pilings broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	General panic. Damage considerable in specially designed structures; great in substantial buildings, with some collapse. General damage to foundations; frame structures, if not bolted, shifted off foundations and thrown out of plumb. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Landslides on river banks and steep slopes considerable. Water splashed onto banks of rivers, lakes. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground; earth slumps and landslides widespread. Underground pipelines completely out of service. Rails bent greatly.
XII	Damage nearly total. Waves seen on ground surfaces. Large rock masses displaced. Lines of sight and level distorted. Objects thrown upward into the air.

The principal factors that affect the severity of seismic shaking in a given area are the magnitude of the earthquake, and the distance from the earthquake source to the location of interest. All of the listed faults, because of their size and proximity to the project area, are significant potential sources of strong seismic shaking. Another factor that affects the intensity of shaking is the type of geologic materials underlying the site. Certain types of earth materials can amplify or dampen shaking.The expected ground motion values listed in **Table 5.7-5, Predicted Seismic Ground Motions in Soft Rock,** are based on average (soft rock) site conditions.

Table 5.7-5. Predicted Seismic Ground Motions in Soft Rock

Probability	Mean Peak Horizontal Ground Acceleration (g)	
	Plant Vicinity	Intertie Vicinity
10% probability of Exceedance in 50 years	0.37	0.40
2% probability of Exceedance in 50 years	0.63	0.70

Source: USGS, 2008. National Seismic Hazards Mapping Project 2008 Probabilistic Seismic Hazard Analysis.
Acronyms:
g = the acceleration due to Earth's gravity, equivalent to g-force

Actual ground motions during an earthquake may vary due to differences in the way portions of the Earth's crust transmit seismic energy or because of unique site conditions, such as soil type, bedrock type, and topography. Sites underlain by very hard bedrock tend to produce the least-damaging effects on buildings—other factors being equal, while relatively soft alluvial deposits can increase the amplitude of ground shaking that affects buildings. **Table 5.7-6, Seismic Ground Motions Measured during the Loma Prieta Earthquake,** shows ground accelerations in different soils types as measured during the Loma Prieta Earthquake. Some parts of the project area are situated on young alluvial deposits (see **Figure 5.7-2a** and **Figure 5.7-2b**). This type of earth material amplifies the effects of seismic shaking on buildings. Other portions of the project area are primarily underlain by sandstone and shale that can be categorized as soft rock. The impact of seismic shaking in these areas would be less than on alluvial deposits.

Table 5.7-6. Seismic Ground Motions Measured during the Loma Prieta Earthquake

Measurement Site	Peak Ground Acceleration (g)	Earth Material at Measurement Site
Corralitos	0.64	Landslide deposits
Capitola	0.54	Alluvium
University of California, Santa Cruz	0.47	Marble

Source: Nolan, 2009. Geologic and Seismologic Discussion – City of Santa Cruz General Plan Update.
Acronyms:
g = the acceleration due to Earth's gravity, equivalent to g-force

Liquefaction/Subsidence Potential

Liquefaction, a common cause of ground failure, is the process by which water-saturated sediment temporarily loses strength and acts as a fluid. It is most commonly caused by ground shaking due to earthquakes. The project alignment crosses several high-liquefaction-potential areas, predominantly in the low areas in the Beach Area and in the alluvial floodplains of Arana Creek, Rodeo Gulch, and Soquel Creek (Dupre, 1975).

Lateral Spread

Lateral spread is the movement of near-surface soil, generally along a near-surface liquefiable layer. It can occur on flat to gently sloping ground, and is particularly common near the free surface of gullies or channels, or where groundwater is shallow. The lower ground surface in a channel provides a point of release for the increased pressure of liquefaction, causing the surface layer to move laterally toward the channel. Documentation of local lateral spread is not available, but is assumed to overlap with areas where liquefaction is common. Sediments in the downtown district experienced some lateral spread during the 1989 Loma-Prieta earthquake (Holzer, 1998).

Off-Fault Ground Cracking

During the 1989 Loma-Prieta earthquake, numerous ground cracks opened up along the crests and flanks of ridges. The ground cracks ranged from fractions of an inch to many feet wide, and up to ¼ mile long. Where the ground cracks crossed under buildings, the buildings were often severely damaged. These ground cracks are considered to be co-seismic ground-surface rupture; that is, they occur in response to severe ground shaking, but are not caused directly by offset of a fault. Ground cracking can also occur due to liquefaction, but such cracks are generally grouped with lurch cracking, and are not included in this category. The co-seismic ground cracks may occur for a variety of reasons, but they are generally associated with steep topography, particularly ridge crests. With the exception of the crest of coastal bluffs, the topography in the project area is generally not conducive to formation of co-seismic ground cracks, and this hazard is therefore considered to be low. Ground cracking is expected to occur in zones up to 50 feet wide landward from the crest of coastal bluffs, or anywhere there is a high, vertical or near-vertical cliff face (Nolan, 2009).

5.7.3 Regulatory Framework

The proposed project would be subject to applicable regulations pertaining to geological and seismic hazards, building code requirements, and grading/excavation. Regulations pertaining to geology and soils in the project area that are relevant to the analysis of project impacts are detailed below. See also **Section 5.4, Land Use, Planning, and Recreation** for evaluation of potential conflicts with relevant land use plans, policies, and regulations of agencies that have jurisdiction over the proposed project.

Geological and Seismic Hazards

Federal Disaster Mitigation Act

The Federal Disaster Mitigation Act of 2000 (Public Law 106-390), which was adopted by Congress in October 2000, requires state and local governments to develop hazard mitigation plans in order to apply for federal grant assistance. The *City of Santa Cruz Local Hazard Mitigation Plan 2007-2012* (Local Hazard Mitigation Plan) was adopted in September 2007 (City, 2007c). This detailed 5-year plan identifies potential natural and man-made hazards, assesses their potential risks, and includes mitigation methods to reduce risks. The potential hazards identified in the plan include earthquakes and liquefaction, wildfires, floods and associated coastal storms, coastal erosion, drought, tsunami, dam failure, and landslides. Similarly, mitigation measures include hazard event planning, emergency preparedness coordination, as well as education, facility upgrades, and monitoring actions. The City is currently in the process of updating this plan.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed by the State of California in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The purpose of the Act is to prevent the construction of buildings used for human occupancy over the surface trace of active faults. The Act requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones) around the surface traces of active faults, and to issue appropriate maps. Local agencies must regulate most development projects within the zones. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault, and must be set back from the fault (generally 50 feet), although local agencies can be more restrictive than state law requires. There are no state-delineated Alquist-Priolo fault zones in the project area.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act (SHMA) was passed by the State of California to address non-surface fault rupture earthquake hazards—including strong ground shaking, liquefaction, and seismically induced landslides—in order to mitigate seismic hazards, thereby protecting public health and safety. In accordance with the SHMA, the State Department of Conservation provides local governments with seismic hazard zone maps that identify areas susceptible to various seismic hazards; for example, amplified shaking, liquefaction, and earthquake-induced landslides or other ground failures. Site-specific geotechnical hazard investigations are required by SHMA when construction projects fall within these areas. No part of the project area is in a currently designated State Seismic Hazard Mapping Program zone (California Geological Survey, 2007).

California Coastal Act

Section 30253 of the Coastal Act requires new development to:

a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard; and

b) Assure stability and structural integrity, and neither create or contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

As such, new development must be located that it will not be subject to erosion or stability hazards over the course of its design life, and such that no seawall, groin or other shoreline protective structure would be needed to protect the development over the course of its design life.

Building Codes

Uniform Building Code

The International Conference of Building Officials, published by the Uniform Building Code (UBC), forms the basis of about half of the state building codes in the United States, including California's. The UBC has been adopted by the California Legislature, together with modifications to address the specific building conditions and structural requirements of California.

The UBC defines various regions of the United States and rates them according to their seismic hazard potential. The four regions include Seismic Zones 1 through 4, with Zone 1 representing the least seismic potential, and Zone 4 representing the highest seismic potential. The UBC also provides guidance on foundation design and structural engineering for various soil types.

California Building Code

Title 24 of the California Code of Regulations, formerly known as the Uniform Building Code and now known as the California Building Code (CBC), sets forth minimum requirements for building design and construction in public buildings and a large percentage of private buildings. In the context of earthquake hazards, the CBC design standards have a primary objective of ensuring public safety; and a secondary goal of minimizing property damage and maintaining function during and following a seismic event. The CBC prescribes seismic design criteria for different types of structures, and provides methods to obtain ground-motion inputs. The CBC does not, however, specifically address every component or site condition anticipated on the proposed project. Therefore, during the design phase, site-specific design criteria would need to be developed for the major project components. The CBC also requires analysis of liquefaction potential, slope instability, differential settlement, and surface displacement due to faulting or lateral spreading for various categories of construction. Recognizing that the risk of severe seismic ground motion varies from place to place, the CBC seismic code provisions vary depending on location (Seismic Zones 0, 1, 2, 3, and 4—with 0 the least stringent and 4 the most stringent). The City of Santa Cruz is in Seismic Zone 4.

Earthworks and Grading

City of Santa Cruz

The City's Municipal Code Chapter 24.14 (Environmental Resource Management) includes "Conservation Regulations." Section 24.14.030 provides "Slope Regulations" to minimize risks associated with development in areas characterized by combustible vegetation, and steep and/or unstable slopes. Generally, areas with 30+ percent slopes cannot be included in the density determination for a project, and the regulations prohibit development in areas of 30+ percent slopes. The regulations also include setback requirements for buildings near 30 to 50+ percent slopes. Section 24.14.070 requires a site-specific geotechnical investigation for all development, except projects with less than four units, in areas identified in the City's General Plan as having a high liquefaction potential. Section 24.16.060 requires an erosion control plan for projects in high erosion hazard areas as designated in the General Plan, or for development on slopes greater than 10 percent.

The Grading Ordinance is a subset of Title 18, Buildings and Construction, of the City's Municipal Code, and is included in Chapter 18.45 (Excavation and Grading Regulations). It provides technical regulations of grading and excavation, in conjunction with the Environmental Resource Management provisions in Chapter 24.14, in order to safeguard life, health, safety, and the public welfare; protect fish and wildlife, riparian corridors and habitats, water supplies, and private and public property; and to protect the environment from the effects of flooding, accelerated erosion, and/or deposition of silt. The ordinance accomplishes this by providing guidelines, regulations, and minimum standards for clearing, excavation, cuts, fills, earth-moving, grading operations (including cumulative grading), water runoff, and sediment control. In addition, the ordinance includes provisions regarding administrative procedures for issuance of permits and approval of plans and inspections during construction, and subsequent maintenance. The City revised the Grading Ordinance in April 2004 in order to strengthen the ordinance regarding implementation of best management practices, including those for erosion and sediment control.

Santa Cruz County

Chapter 16.10 of the Santa Cruz County Code sets forth regulations and review procedures for development and construction activities, including grading, septic systems installation, development permits, changes of use, building permits, minor land divisions, and subdivisions throughout the County, and particularly in mapped geologic hazards areas and areas of special flood hazard. These regulations and procedures are administered through a system of geologic hazard assessment, technical review, development, and building permits.

Chapter 16.20 of the Santa Cruz County Code presents rules and regulations to control all grading, including excavations, earthwork, road construction, dredging, diking, fills, and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspections.

The City of Capitola

Chapter 15.28 of the Capitola Municipal Code presents guidelines, rules, regulations, and minimum standards to control excavation, grading, clearing, erosion control, and maintenance, including cut-and-fill embankments; requires control of all existing and potential conditions of accelerated erosion; establishes administrative procedures for issuance of permits; and provides for approval of plans and inspections during construction and maintenance.

5.7.4 Impacts and Mitigation Measures

This section contains the evaluation of potential environmental impacts associated with the proposed project related to geology and soils. The section identifies the standards of significance used in evaluating the impacts, the methods used in conducting the analysis, and a detailed evaluation of impacts for the proposed project and any potential future expansion.

Standards of Significance

Based on CEQA Guidelines, Section 15065; Appendix G of the CEQA Guidelines; applicable agency plans, policies, and/or guidelines; and agency and professional standards; the proposed project would cause a significant impact related to geology and soils if it would:

7a. Expose people or structures to potential substantial adverse effects, including substantial risk of loss, injury, or death resulting from the rupture of a known earthquake fault, seismic ground shaking, landslides, or seismic-related ground failure, including liquefaction;

7b. Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the project, and potentially result in an onsite or offsite landslide or slope failure/instability, including that related to coastal bluff retreat, creating substantial risks to life or property;

7c. Result in substantial soil erosion or loss of topsoil and subsequent sedimentation into local drainage facilities and water bodies (see **Section 5.1**);

7d. Be located on expansive soil, as defined by the Uniform Building Code or subject to other soil constraints that might result in deformation of foundations or damage to structures, creating substantial risks to life or property; and

7e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for disposal of wastewater.

Analysis Methodology

The above standards of significance are assessed in this section as the basis for determining the significance of impacts related to geology and soils. If necessary, mitigation measures are proposed to reduce significant impacts to less than significant. Impacts are analyzed for all project components and related component alternatives, where relevant, and where impacts would differ between alternatives.

Impacts and Mitigation

This section provides a detailed evaluation of geology and soils impacts associated with the proposed project. The analyses address impacts related to seismic hazards (standard 7a), coastal bluff retreat (standard 7b), other slope instability hazards (standard 7b), and expansive soils (standard 7d).

As indicated in Section 5.7 of the IWP Program EIR, and in the Initial Study (see **Appendix A**), the proposed project would not propose the use of septic systems or alternative wastewater systems (standard 7e). Therefore, this topic is not further evaluated in this EIR. The potential for soil erosion and subsequent sedimentation in local waterways (standard 7c) is discussed in **Section 5.1**.

The impacts related to geology and soils are summarized in **Table 5.7-7, Summary of Potential Geology and Soils Impacts**, and are categorized as either “not applicable” or “no impact,” “less than significant impact,” “less than significant impact with mitigation,” or “significant and unavoidable impact.” The impacts are presented for each individual project component, where relevant. The detailed analysis of geology and soils impacts and mitigation measures follows this table.

Table 5.7-7. Summary of Potential Geology and Soils Impacts

Impacts	LEVEL OF SIGNIFICANCE													
	Seawater Intake Site Alternatives								Plant Site Alternatives			Other Components	Project Overall	Possible Future Expansion
	SI-4	SI-5	SI-7	SI-9	SI-14	SI-16	SI-17	SI-18	A-1	A-2	A-3			
5.7-1: Seismic Hazards	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM
5.7-2: Coastal Bluff Retreat	LTS	LTS	LTS	LTS	NI	NI	NI	LTS	NI	NI	NI	NI	LTS/NI*	LTS
5.7-3: Slope Stability	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM
5.7-4: Expansive and Corrosive Soils	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM	LTSM

Acronyms:
SU = Significant and Unavoidable Impact
LTSM = Less Than Significant Impact With Mitigation
LTS = Less Than Significant Impact
NI = No Impact
-- = Not applicable
* Impact significance of project overall will depend on the site alternative selected

SEISMIC HAZARDS IMPACTS

Impact 5.7-1:	If not properly designed, the proposed project could expose people or structures to potential substantial adverse effects involving substantial risk from: (i) seismic ground shaking; (ii) landslides; or (iii) seismic-related ground failure, including liquefaction.
Significance before Mitigation:	Potentially significant
Mitigation Measures:	See Mitigation Measures 5.7-1a and 5.7-1b
Significance after Mitigation:	Less than significant

Proposed Project

As indicated previously, the potential for ground-surface rupture during a seismic event is low, because no active or potentially active faults are in the project area, and there are no state-delineated Alquist-Priolo fault zones. Therefore, none of the project components would likely be subject to significant risk due to ground surface rupture.

The project area, however, is subject to intense ground shaking from nearby faults. This unavoidable hazard poses significant risk to structures in the project area, including roads, bridges, buildings, water storage facilities, utilities, and buried and surface pipelines. A variety of hazards related to earthquake events exists, including ground shaking, liquefaction, lateral spread, and landsliding. Physical injury to persons working at the desalination plant and at related facilities during construction and operation could potentially occur during a seismic event. In addition, facilities could also be damaged due to seismic-related hazards. The hazards posed to any particular project component would depend on the geology and location of the site, as well as the construction specifications and characteristics of the particular project component, which are further describe below for each component.

Seawater Intake and Conveyance System

Eight seawater intake location alternatives are being reviewed for the proposed project, as described in **Section 4.** All of the intake facilities associated with the seawater intake and conveyance system at these eight sites could be subjected to intense ground shaking during seismic events. Additionally, intake structures and pump stations at SI-9, SI-17, and SI-18 would be underlain by highly variable fluvial, basin, and shallow marine deposits. The intake structures for SI-9, SI-17, and SI-18 would be positioned on top of these marine and fluvial deposits. These areas are more prone to liquefaction and lateral spreading due to the sandy nature of these deposits.

The Seawater Intake Facility Conceptual Design Report recommends a universal intake structure design approach—consisting of a screen assembly on a pre-cast concrete slab—for all of the intake locations. To address the liquefaction potential at SI-9, SI-17, and SI-18, the conceptual design approach is to set the screen assembly on the sandy ocean floor unanchored; it would be attached to the intake pipelines with flexible pipe couplings. During a seismic event, this would allow the intake screen assembly to detach from the intake pipeline, and settle or move with the surrounding sandy soils. After a seismic event, the entire screen assembly could be inspected, and if necessary, resituated. For SI-4, SI-5, SI-7, SI-14, and SI-16, the conceptual design approach is to anchor the screen assembly to the underlying bedrock. These conceptual foundation approaches for the seawater intake will be reviewed and refined during final design, as described below.

Proper design of the open-ocean intake structure, and other components of the intake system, in accordance with the recommendations of a design-level geotechnical investigation (Mitigation Measure 5.7-1a), would minimize any potential seismic hazards that could damage the intake system, or cause other types of hazards. This investigation will provide further recommendations related to the intake foundation and/or placement of the intake structure, and other recommendations to reduce seismic hazards. With the implementation of this mitigation measure, the proposed seawater intake and conveyance system would not result in substantial risks to life or property related to seismic hazards, and the impact would be less than significant.

Seawater Desalination Plant

All three alternative plant sites are underlain by liquefiable sand or silt, expansive clay organic-rich soil, and non-engineered fill. Potential seismic hazards due to these geologic conditions include: liquefaction, lateral spreading, and earthquake-induced settlement (**Appendix L**). At Plant Site A-2, the slope that forms the side of the drainage may be subject to slope failure/landsliding in the future, particularly during a large-magnitude earthquake. Similarly, Plant Site A-3 has cut slopes that may also be subject to future slope failure/landsliding during an earthquake (**Appendix L**). Such slope failure could potentially damage facilities at the plant and/or result in safety hazards to those working at the facility. Proper design of buildings and other facilities in accordance with the recommendations of a design-level geotechnical investigation (Mitigation Measure 5.7-1a), and in accordance with the CBC (Mitigation Measure 5.7-1b), would minimize any potential seismic hazards that could damage buildings, structures, and infrastructure at the plant, or cause other types of safety hazards. The geotechnical investigation will provide recommendations related to proper foundation design, and other recommendations to reduce seismic hazards.

Preliminary geotechnical recommendations are provided in the Preliminary Design Report and include the use of a rigid structural mat or pile foundation system, ground modifications such as vibro-replacement or geo-piers, recompaction of existing fills, lime treatment of expansive clay soils, subsurface drainage for high groundwater issues, retaining or laying back of cut slopes, and the use of corrosion-resistant materials for new below-ground construction. These recommendations will be refined during final design, and in accordance with Mitigation Measures 5.7-1a and 5.7-1b. With the implementation of these mitigation measures, the proposed desalination plant would not result in substantial risks to life or property related to seismic hazards, and the impact would be less than significant.

Brine Disposal and Conveyance System

The brine pipeline would convey the brine from the desalination plant through City rights-of-way to the City's existing wastewater treatment facility effluent outfall pipeline, at one of two potential connection points (see **Figure 4-3, Desalination System Area**). The pipeline corridors associated with these connection points are on the first marine terrace, and would be installed in trenches within paved City rights-of-way. The brine conveyance system could be susceptible to intense seismic shaking, liquefaction, or lateral spread, which could result in damage or deformation to the pipeline. Proper pipeline design in accordance with the recommendations of a design-level geotechnical investigation (Mitigation Measure 5.7-1a) would minimize any potential seismic hazards that could damage the pipeline, or cause other types of safety hazards. A typical design solution would be to increase the thickness of the pipe wall to resist the compression and/or tension forces exerted from these seismic hazards. The necessary thickness and other pipe characteristics would be determined during the design phase. The geotechnical investigation will also provide recommendations related to proper trenching and backfilling to reduce seismic hazards. With the implementation of this mitigation measure, the proposed brine disposal and conveyance system would not result in substantial risks to life or property related to seismic hazards, and the impact would be less than significant.

Potable Water Distribution System Improvements

The District would receive potable water from the City's distribution system through a new intertie system between the two service areas. This system would consist of new and replacement pipelines, and pump station upgrades. All of these structures could be subject to intense seismic shaking, and possibly liquefaction in some areas, as further described below.

Pump Station Upgrades. The only pump station upgrade that would involve new building construction would occur at the Morrissey pump station, which is an existing underground pump station. A new, expanded pump station building would be constructed on the footprint of the existing pump station, and could be subjected to intense ground shaking during seismic events. Such ground shaking could damage the pump station. Proper design of the building and other facilities at the pump station in accordance with the recommendations of a design-level geotechnical investigation (Mitigation Measure 5.7-1a), and in accordance with the CBC (Mitigation Measure 5.7-1b), would minimize any potential seismic hazards that could damage buildings and infrastructure at the pump station, and cause other safety hazards. The geotechnical investigation will provide recommendations related to proper foundation design, and other recommendations to reduce seismic hazards. With the implementation of these mitigation measures, the proposed Morrissey pump station would not result in substantial risks to life or property related to seismic hazards, and the impact would be less than significant.

Conveyance Pipelines. Pipeline integrity would be at particular risk where the pipelines would be buried on steep, unstable slopes, or in unconsolidated sediments prone to liquefaction or intense shaking. This would be the case in the pipeline connections to and from the DeLaveaga tanks, because a portion of this piping would be on the slopes between the first and second marine terraces. See **Impact 5.7-3** for a discussion of slope-related impacts.

The intertie system pipeline alignment would be exposed to the risk of very intense seismic shaking where it crosses Arana Creek, Rodeo Gulch, Soquel Creek, and Nobel Gulch (Dupre, 1975). Even though the majority of the pipeline segments would be constructed in paved public rights-of-way, they could still be affected by conditions underlying these roadways and bridges, which could result in damage or deformation of these pipelines.

Proper pipeline design in accordance with the recommendations of a design-level geotechnical investigation (Mitigation Measure 5.7-1a) would minimize any potential seismic hazards that could damage the pipeline, or cause other types of safety hazards. As indicated above, the geotechnical investigation for this element of the project will provide recommendations related to pipe characteristics and proper trenching and backfilling to reduce seismic hazards. With the implementation of this mitigation measure the proposed potable water distribution system improvements would not result in substantial risks to life or property related to seismic hazards, and the impact would be less than significant.

Potential Energy Projects

The potential solar photovoltaic (PV) panels would be installed at the desalination plant, which is evaluated above. The micro-hydro system would be installed in the basement of the Graham Hill Water Treatment Plant (GHWTP) and would involve only interior improvements with no ground-disturbing activities. Therefore, this element of the proposed project would not result in seismic hazards and the impact would be less than significant.

Potential Future Expansion

If expansion of the proposed plant and related facilities was pursued in the future, the majority of the additional equipment would be installed inside existing structures at the plant and at the intake pump station. Further ground-disturbing activities would be involved in the construction of additional brine storage structure(s) and dissolved air flotation basin(s) at the plant, but would not occur elsewhere in the project area. Because site-specific investigations would already have been conducted for the proposed 2.5-mgd project under Mitigation Measure 5.7-1a, the findings from these studies can be used in design and construction of additional facilities at the plant site. Mitigation Measure 5.7-1b would be implemented during any future expansions to ensure that all structures associated with future expansions have been designed to withstand the “design-level” earthquake, as set forth in the CBC. Therefore, potential impacts related to seismic hazards that exist in the project area would be reduced to less than significant, because substantial risks to life or property would not occur.

Mitigation Measures

Mitigation Measure 5.7-1a

This mitigation measure applies to all proposed project components involving new facility construction. Once project component locations have been selected, a California-licensed geotechnical engineer, or engineers, shall complete design-level geotechnical investigations for all project components to inform final design and construction. These investigations shall address seismic and geologic hazards. Slope stability shall also be evaluated, where warranted. These investigations shall address, among other things, the best means for complying with all applicable state and local code requirements and other protective standards. The investigations shall include soil sampling and laboratory testing of materials in order to provide design criteria and recommendations applicable to foundation design, earthwork, backfill, site preparation, trenching, tunneling, materials, and other factors related to all project components.

All recommendations of the geotechnical investigations and of the geotechnical engineer(s) shall be incorporated into the final design and construction specifications for each project component, and shall be implemented by the construction contractors.

Mitigation Measure 5.7-1b

This mitigation measure applies to all project components involving new facility construction. All facility designs shall comply with the most recent edition of the CBC—or local building codes, if they are more stringent. In particular, a California-licensed geotechnical engineer shall ensure that all structures associated with the proposed project have been designed to withstand the "design-level" earthquake, as set forth in the CBC.

COASTAL BLUFF RETREAT IMPACTS	
Impact 5.7-2:	Coastal bluff retreat would not expose components of the seawater intake and conveyance system to damage or destruction.
Significance:	Less than significant
Mitigation Measures:	None required

Proposed Project

Coastal bluff retreat, as discussed previously, is a function of many factors, including proximity of the facility to the bluff, underlying geology, and existing shoreline protection devices. The seawater intake and conveyance system is the only project component that could be subject to the effects of coastal bluff retreat. The pump station locations for SI-14 and SI-16 are more than 1,000 feet from the coastal bluff edge, and SI-17 is adjacent to the Municipal Wharf. These pump station sites are therefore not considered to be subject to the hazard of coastal bluff retreat or beach erosion and would have no impact related to such hazards.

SI-9 and SI-18 are on the landward side of Beach Street, which is fronted by a sandy beach, not coastal bluffs. Therefore, coastal bluff erosion rates would not apply to SI-9 or SI-18. Beach erosion rates also would not apply to SI-9 or SI-18, given the presence of the seawall and beach commercial development along the south side of Beach Street and coastal erosion at these sites would be less than significant.

Intake pump stations at SI-4, SI-5, and SI-7, along West Cliff Drive, are the only locations where this hazard could potentially occur. Portions of the cliff along this section of West Cliff Drive have been stabilized by rip-rap consisting primarily of very large boulders, and a seawall is immediately south of the pump station location for SI-4. These pump station sites were reviewed and evaluated below, based on the Seawater Intake Facility Conceptual Design Report and the bluff-retreat rates presented in **Section 5.7.2, Environmental Setting**. Due to the depth of intake piping that would extend from these pump stations into the ocean, coastal bluff retreat would not impact this intake piping.

Average retreat rates along the coastline in the City of Santa Cruz have been measured at 2.75 to 5.9 inches per year (Moore et al., 1979; Nolan, 2009). Using the more-conservative average cliff retreat rate of about 6 inches per year, a time horizon of 75 years, and a buffer of 10 feet (Johnsson, 2005), a setback of at least 47.5 feet from the bluff-top edge would be required to provide protection from bluff retreat over that time frame. Erosion rates at these three locations could vary due to the underlying geology and other factors, but are still expected to be within the retreat rates noted above. SI-4 and SI-5, approximately 60 and 100 feet, respectively, from the bluff edge, could be expected to have average retreat rates at the higher end of this range, due to their location on bluffs underlain by the more easily erodible Purisima Formation (see **Figure 5.7-2a**). SI-7, approximately 150 feet from the bluff edge, could be expected to have average retreat rates at the lower end of this range, because it is underlain by the more resistant Santa Cruz Mudstone. The presence of rip-rap protection and/or sea walls at or near these intake locations may also influence the rate of coastal bluff retreat.

Gradual sea-level rise due to global warming may have an effect on the rate of bluff retreat in certain areas. As indicated in **Section 5.7-2**, interim guidelines for sea-level rise estimate that 16 inches in sea-level rise (above year 2000 levels) should be planned for by the year 2050, and up to 55 inches by the year 2100 (CO-CAT, 2010; COPC, 2011). Using this information, the calculated sea-level rise in a time horizon of 75 years from 2016, which is the earliest year of project operation, would be about 48 inches above 2000 levels, or about 4 feet. Given the height of the existing sea cliffs and the resistant nature of the underlying bedrock, an intake pump station at these locations would not be expected to be subject to bluff-retreat rates greater than those identified above, nor would the sites experience inundation due to sea-level rise. Inundation due to sea-level rise and other factors is evaluated in detail in **Section 5.1**.

Given the bluff-retreat rates described above, an intake pump station at SI-4, SI-5, or SI-7 would not result in damage to these facilities from coastal bluff retreat, and would not create substantial risks to life or property; the impact would be less than significant. Consequently, shoreline protection devices, coastal armoring, or other mitigation measures would not be required.

Potential Future Expansion

If expansion of the proposed plant and related facilities were pursued in the future, the necessary additional equipment (e.g., pumps) for the seawater intake and conveyance system would be installed inside the intake pump station building that would be constructed for the 2.5-mgd project. No expansion of the pump station building would be required; therefore, any potential future expansion of the project would not create substantial risks to life or property due to coastal bluff retreat. The impact is less than significant.

Mitigation Measures

None required.

OTHER SLOPE STABILITY IMPACTS	
Impact 5.7-3:	The proposed project could be on a geologic unit or soil that is unstable, or that could become unstable as a result of the project, and potentially result in an onsite or offsite landslide, slope failure, or collapse.
Significance before Mitigation:	Potentially significant
Mitigation Measures:	See Mitigation Measures 5.7-1a and 5.7-3
Significance after Mitigation:	Less than significant

Proposed Project

The project vicinity includes areas that have the potential for landslides, slope failure, and collapse. As described in the setting above, landslides in the project area are generally associated with steep slopes. Such slopes are along the coastal bluff on West Cliff Drive, between the marine terrace levels near the DeLaveaga tanks, and in canyons or depressions formed by creeks and rivers. Impact 5.7-2 describes the potential for coastal-bluff retreat near project components. Other types of slope failure or collapse are described below.

Seawater Intake and Conveyance System

One of the comments received during the public scoping period, as shown in **Section 5.7.1, Introduction**, dealt with the potential for sinkholes to develop at the intake pump station location at the Junction Structure at Mitchell's Cove, which was contemplated at the time the

Notice of Preparation was issued. As indicated in **Section 4**, this pump station location is no longer being pursued, because there would be construction and operational problems at this location, and there was not enough land area onshore to allow for the installation of the intake pipeline.

Sinkholes develop in a fractured, calcareous host rock, such as the marble on the University of California, Santa Cruz campus, where they have been historically observed. The intake pump station locations closest to Mitchell's Cove (SI-4 and SI-5) are underlain by up to about 15 feet of terrace deposits overlying sandy siltstone bedrock of the Purisima Formation (**Appendix I**), and would not be susceptible to the development of sinkholes and associated collapse. Therefore, impacts related to the potential for slope instability or failure and associated risks to life or property at these or the other intake pump station locations are considered to be less than significant.

Desalination Plant Site Alternatives

As indicated in the Preliminary Design Report, at Plant Site A-1, the cut slope along the eastern edge of the building area on this site could be subject to slope failure in the future. At Plant Site A-3, this same cut slope rings the western and northern edges of the building area on this site, which could also be subject to slope failure in the future. At Plant Site A-2, the slope that forms the side of the drainage on the western side of the site could be subject to slope failure/landsliding in the future. Slope failure in these locations could potentially damage buildings and other facilities on these sites, depending on their design and location. The implementation of Mitigation Measures 5.7-1a and 5.7-3, requiring geotechnical investigations and slope stability analyses, and implementing all recommendations, would reduce any potential hazards to plant facilities related to slope failure or collapse. The geotechnical investigation and slope stability analysis will provide recommendations related to foundation design, setbacks from slopes, retaining walls, and other measures to reduce hazards from slope failure and instability. With the implementation of these mitigation measures, the proposed desalination plant would not result in substantial risks to life or property related to slope failure or collapse, and the impact would be less than significant.

Brine Disposal and Conveyance System

The brine piping would be installed in paved public rights-of-way, and therefore would not be subject to slopes or unstable sediments that may occur along Arroyo Seco or other creeks along the brine pipeline alignment. Therefore, the brine piping would not result in substantial risks to life or property related to slope failure or collapse, and the impact would be less than significant.

Potable Water Distribution System

In general, potable water distribution piping associated with the intertie system would be installed in paved public rights-of-way along roadways and in bridges, and therefore would not be subject to slopes or unstable sediments that may occur along creeks in the project area. The exception to this is a segment between the DeLaveaga tanks and the City-District intertie connection point, which would need to cross Arana Creek at two locations. The potable water piping leading up to and down from the DeLaveaga tanks would be on the slopes between the first and second marine terraces. As indicated in **Section 5.7-2**, there are isolated areas in these locations that have steep slopes over 30 percent; and in certain locations, over 50 percent (see **Figure 5.7-4**). Areas with steep slopes are more susceptible to landsliding and slope failure. Damage or deformation to the intertie pipeline could occur in areas of steep slopes near DeLaveaga tanks and Arana Creek due to these conditions.

Implementation of Mitigation Measures 5.7-1a and 5.7-3, requiring geotechnical investigations and slope stability analyses, would reduce any potential hazards related to the installation of distribution piping that could result from landslides, slope failure, or collapse. The geotechnical investigation and slope stability analysis will provide recommendations related to depth of trenching, the use of shoring in trenches, and other measures to reduce hazards from slope failure and instability in areas with steep and/or unstable slopes near the DeLaveaga tanks and Arana Creek. With the implementation of these mitigation measures, the proposed intertie system would not result in substantial risks to life or property related to slope failure, and the impact would be less than significant.

Potential Energy Projects

The potential solar PV panels would be installed at the desalination plant, which is evaluated above. The micro-hydro system would be installed in the basement of the GHWTP and would involve only interior improvements with no ground-disturbing activities. Therefore, there would be no impact.

Potential Future Expansion

If expansion of the proposed plant and related facilities were pursued in the future, the majority of the additional equipment would be installed inside existing structures at the plant and at the intake pump station. Some additional ground-disturbing activities would be involved in the construction of additional brine storage structure(s) and dissolved air flotation basin(s) at the plant, but would not occur elsewhere in the project area. Given that site-specific investigations would have already been conducted for the proposed 2.5-mgd project under Mitigation Measures 5.7-1a and 5.7-3, the findings from these studies can be used in design and construction of additional facilities at the plant site. Therefore, potential hazards related to slope failure or collapse that exist in the project area would be reduced to less than significant, as substantial risks to life or property would not occur with the implementation of the mitigation measures noted above.

Mitigation Measures

Mitigation Measure 5.7-3

This mitigation measure applies to Plant Sites A-1, A-2, and A-3; and portions of the potable water distribution system in proximity to slopes or unstable soils at or near the DeLaveaga tanks and the Arana Creek crossings. As part of the geotechnical investigations performed under Mitigation Measure 5.7-1a, a survey of slope stability at selected sites shall be conducted by a geotechnical engineer. Recommendations based on the survey shall be incorporated into the design and construction specifications. Recommendations could include, but would not be limited to: (1) appropriate foundation design, setbacks from slopes, retaining walls for facilities to be constructed near slopes, and/or regrading of cut slopes to a stable configuration, such as at Plant Sites A-1, A-2, and A-3; (2) installing additional shoring in trenches where sediments are non-cohesive or saturated; and (3) burying pipelines at a greater depth to reduce risk from landslides or to key into more stable sediment. Recommendations shall be incorporated into the final design and construction specifications for applicable project components, and shall be implemented by the construction contractors.

EXPANSIVE AND CORROSIVE SOIL IMPACTS

Impact 5.7-4:	The majority of the proposed project components would be located on expansive and/or corrosive soils potentially creating substantial risks to life or property.
Significance before Mitigation:	Potentially significant
Mitigation Measures:	See Mitigation Measures 5.7-1a and 5.7-4
Significance after Mitigation:	Less than significant

Proposed Project

Expansive and corrosive soils have the potential to damage proposed project facilities involving the placement of new facilities and/or infrastructure in such soils. The effect of such soils on project facilities is described below.

Expansive soils shrink when dry and swell when wet. This movement can exert enough pressure to crack sidewalks, driveways, pipelines, and foundations. Of the soil types in the project area (**Tables 5.7-1 and 5.7-2**), the Danville Loam (2 to 9 percent slopes), Los Osos loam (30 to 50 percent slopes), Tierra-Watsonville complex (15 to 30 percent slopes), and the four types of Watsonville loam soils are potentially expansive. The Watsonville loam soils are encountered throughout the project area, whereas the Danville and Los Osos loams and Tierra-Watsonville complex are only encountered in small areas to the east of Soquel Creek.

The desalination plant sites are likely underlain by expansive clay and may also have shallow groundwater, as noted previously. If expansive soils are not properly accounted for during project design, they could lead to damage to foundations, driveways, and sidewalks, as well as damage to other subgrade facilities, such as pipelines and tanks.

Corrosive soils cause corrosion of underground ferrous and concrete components, including pipelines and foundations. Soil corrosion is a complex phenomenon, with a multitude of variables; corrosion generally occurs in soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts. The Lompico-Felton complex (50 to 75 percent slopes), encountered in the vicinity of Rodeo Gulch, has potential to be corrosive to uncoated steel and/or concrete, as do the seven expansive soils discussed in the preceding paragraph. If corrosive soils are not properly accounted for during project design, they could ultimately lead to damage to subgrade facilities.

Implementation of Mitigation Measure 5.7-1a and 5.7-4, requiring geotechnical investigations and site-specific soil surveys for new facility construction, would reduce any potential hazards related to expansive and corrosive soils that exist in the project area to less than significant, to the extent that substantial risks to life or property would not occur. The geotechnical investigations and soil surveys will provide recommendations related to appropriate foundation design, excavation and replacement or treatment of expansive soils, and other measures to reduce hazards from those portions of the project situated on expansive soils. This mitigation measure would not be required for the installation of new equipment inside existing buildings, such as would be required for the McGregor and Aptos pump station upgrades and the installation of a potential micro-hydro system at GHWTP.

Potential Future Expansion

If expansion of the proposed plant and related facilities were pursued in the future, the majority of the additional equipment would be installed inside existing structures at the plant and at the intake pump station. Some additional ground-disturbing activities would be involved in the construction of additional brine storage structure(s) and dissolved air flotation basin(s) at the plant, but would not occur elsewhere in the project area. Because site-specific investigations would already have been conducted for the proposed 2.5-mgd project under Mitigation Measures 5.7-1a and 5.7-4, the findings from these studies can be used in design and construction of additional facilities at the plant site. Therefore, potential hazards related to expansive and corrosive soils that exist in the project area would be reduced to less than significant, as substantial risks to life or property would not occur with the implementation of the mitigation measures noted above.

Mitigation Measures

Mitigation Measure 5.7-4

This mitigation measure applies to all project components requiring new facility construction. As part of the geotechnical investigations performed under Mitigation Measure 5.7-1a, site-specific soil surveys shall be conducted to identify areas of expansive and/or corrosive soils. For areas with expansive and/or corrosive soils, a geotechnical engineer shall make recommendations regarding alternative construction materials and methods. Recommendations may include appropriate foundation design; excavation and replacement of highly expansive or corrosive soils with appropriate fill material; treatment of expansive soils; subsurface drainage for high-groundwater issues; and use of corrosion-resistant materials for new below-ground construction. Recommendations shall be incorporated into the final design and construction specifications for each project component, and shall be implemented by the construction contractors.