APPENDIX 11.4

Geology Report

GEOLOGIC, GEOTECHNICAL, AND SEISMIC TECHNICAL BACKGROUND REPORT (TBR) BAY BRIDGE PUMP STATION AND FORCE MAINS REHABILITATION STUDY, SP-178 ORANGE COUNTY SANITATION DISTRICT (OCSD) NEWPORT BEACH, ORANGE COUNTY, CALIFORNIA

Prepared for

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**SUBJECT: GEOLOGIC, GEOTECHNICAL, AND SEISMIC
TECHNICAL BACKGROUND REPORT (TBR)
BAY BRIDGE PUMP STATION AND
FORCE MAINS REHABILITATION STUDY – SP-178
ORANGE COUNTY SANITATION DISTRICT (OCSD)
NEWPORT BEACH, ORANGE COUNTY, CALIFORNIA
HAI Project No. RBF-15-001**

Dear Mr. Maher:

Hushmand Associates, Inc. (HAI) is pleased to submit the geologic, geotechnical, and seismic engineering technical background report (TBR) for the *Bay Bridge Pump Station and Force Mains Rehabilitation Study, SP-178* (project) located in Newport Beach, California, under the jurisdiction of Orange County Sanitation District (OCSD).

HAI appreciates the opportunity of being of service to RBF Consulting. Should you need additional information or any clarifications please call the undersigned.

Sincerely yours,

HUSHMAND ASSOCIATES, INC.

Kenneth Wilson, CEG, PG	Jorge Turbay, MS, PE	Ben Hushmand, PhD, PE
Associate Senior Geologist	Senior Project Engineer	President, Principal Engineer

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ORANGE COUNTY SANITATION DISTRICT (OCSD)
NEWPORT BEACH, ORANGE COUNTY, CALIFORNIA

HAI Project No. RBF-15-001

The Orange County Sanitation District (OCSD) owns, operates and maintains a large regional sewage system that consists of over 470 square miles of service area and includes 16 pump stations that convey wastewater flow to Plant No. 1 and Plant No. 2. Of this service area, three pump stations (Bay Bridge Pump Station, Rocky Point Pump Station, and Lido Pump Station, shown in Figure G-0) convey flow to the Newport Force Main, which feeds the Bitter Point Pump station. The Bay Bridge Pump Station and Newport Force Main are critical backbones of the collection service area conveying flows to the Bitter Point Pump Station that are ultimately delivered for treatment to OCSD Plant No 2. The largest and most critical of the three pump stations that feed into the Newport Force Main, is the Bay Bridge Pump Station; a pump station that conveys approximately 50% to 60% of the total flow through the Newport Force Main to Bitter Point Pump Station. Currently, OCSD is adding a large pump to the Bay Bridge Pump Station for added contingency during peak wet weather flow, while the Newport Force Main (a dual force main sized 30-inch to 36-inch located in Pacific Coast Highway) is rehabilitated as part of the OCSD 5-60 project. The current scope of the OCSD 5-60 project limits start at the western isolation vault at Bay Bridge, shown as a brown line in Figure G-0, to the connection at Bitter Point Pump Station. The OCSD Newport Force Main Rehabilitation project (OCSD 5-60) will be constructed over the next two years and is expected to be complete in year 2016.

RBF Consulting (RBF) is currently performing an alignment study to replace a portion of the Newport Force Main network constructed underneath Newport Bay Channel. In addition to the Pump Station and Force Main Study, RBF will provide OCSD with an Environmental Impact Report (EIR). The objective of HAI is to provide a geology, seismic, and soils technical background report (TBR) to assist RBF in the evaluation of the potential environmental impact of the project and possible mitigation measures. The work will be performed in adherence to California Environmental Quality Acts (CEQA). It is understood that a Mitigated Negative Declaration (MND) is to be prepared.

This document is a technical background report designed to support preparation of the Bay Bridge Pump Station and Force Main Rehabilitation Program (the Project) with the Newport Beach (City). As such the document relies on available information to support this desktop study of the geologic, geotechnical, and seismic conditions within and around the Project area. Existing building codes and land use planning requirements can address most of the hazards inherent in the geologic, geotechnical, and seismic setting of the Project area. Sources for this information include generalized regional reports and maps, and some site-specific information obtained from the Project area.

Our TBR follows the CEQA Guidelines (14 CCR 15000–15387), Appendix G to directly support preparation of the MND. In addition, we follow the California Geological Survey’s Guidelines for Geologic/Seismic Considerations in EIR's. Alignment Study data and other reference materials were consulted as appropriate, including, but not limited to: City’s General Plan (including the Seismic Safety Element); local and regional geologic mapping studies; Alquist-Priolo Earthquake Fault Zoning Act maps; Seismic Hazard Mapping Act maps; Mineral Resource Zone maps; and reference materials located in our in-house files.

1 OVERVIEW AND REGIONAL TECHNICAL ISSUES

1.1 General Geologic, Geotechnical, and Seismic Conditions

The City of Newport Beach (City) shares general geologic and seismic conditions with other cities that lie along the southern slope of the Santa Ana Mountains and foothills, e.g., from Orange on the northwest to San Juan Capistrano on the southeast. For millions of years tectonic movement and uplift along the Elsinore fault system northeast of the Santa Ana Mountains, and frontal faults along the southwest base of the mountains, has juxtaposed the old metasedimentary, volcanic, and crystalline basement rocks in the Santa Ana Mountains against the younger bedrock and alluvial deposits of the Santa Ana Valley sedimentary basin and coastal plain. Examples of active and potentially active faults that may contribute to the site seismicity are (a) faults in close proximity to the Project area (the Newport-Inglewood Fault Zone [NIFZ, onshore and offshore], Chino-Central Avenue, Elsinore, and Whittier faults), (b) faults that underlie the Project area (San Joaquin Hills blind thrust), and (c) faults that lie at some distance from the Project area (e.g., San Andreas, Coronado Bank, and Puente Hills faults). No designated Alquist-Priolo Earthquake Fault Zone (APEFZ) is located within or near the Project area.

Earthquake shaking has affected the Project area in the historic past, with a few large, distant earthquakes occurring within the recent memories of many residents. Events centered some distance from the Project area (e.g., 1992 Landers/Big Bear and 1994 Northridge) were unsettling but caused relatively minor local disruptions. However, the 1933 “Long Beach” earthquake (magnitude; Mw = 6.4) in the vicinity of the Project area could have caused some damage to elements of the current Project area infrastructure. The City is largely built upon the eroded young bedrock west of the San Joaquin Hills, the sloping older alluvial fan deposits emanating from the east, and younger to older near shore marine sediments along the coastline. Elevations in the Project area range from approximately 15 feet below mean sea level under and adjacent to the Bay Bridge, to approximately 15 to 20 feet above mean sea level (amsl) near proposed Pump Station Site 3 on the west. Uplifted older coastal marine deposits surround the project site in the higher elevations.

Very young coastal estuary deposits form the flatter areas and submarine areas more proximal to, and beneath, the Project site; under these marine deposits and forming the base of the bluffs on the northwest is siltstone bedrock. Based on the geology described above and the subsurface data that exist for other projects in the area, the specific geologic units that will impact the Project area are described in a subsequent section.

1.2 Geologic, Geotechnical, and Seismic Hazards

The following geologic, geotechnical, and seismic hazards are considered in accordance with the California Environmental Quality Act (CEQA) Guidelines:

“VI. GEOLOGY AND SOILS -- Would the project:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

ii) Strong seismic ground shaking?

iii) Seismic-related ground failure, including liquefaction?

iv) Landslides?

b) Result in substantial soil erosion or the loss of topsoil?

c) 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 on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?

d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property?

e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?"

Based on the nature of the proposed Project items b) and e) would not be relevant.

Viewed more specifically, the following hazards, conditions, and issues are components of the items a), c), and d).

- Primary seismic hazards
  - Ground shaking (strong earthquake ground motions)
  - Surface fault rupture
  - Co-seismic uplift, folding, and tilting
- Secondary seismic hazards
  - Earthquake-induced landslides including lateral spreading
  - Liquefaction, dynamic consolidation, and differential settlement
  - Ground lurching and cracking, fill mass deformation
  - Dam failure inundation/flooding
  - Flooding from tsunami and seiche
- Slope instability (landslides, mudslides, and debris flows)
- Poor geotechnical/soils engineering properties (expansive, collapsible, and corrosive)
- Shallow groundwater
- Flooding from tsunami, dam inundation, or precipitation
- Subsidence"

Primary and secondary seismic hazards, slope instability, poor geotechnical properties, shallow groundwater, and tsunami have the greatest potential to affect the Project area. For most geologic, seismic, and geotechnical conditions there are standard and special design measures available to minimize adverse effects on structures to a level less than significant.

1.3 Planning and Regulatory

Geologic and soils hazards (including geotechnical and seismic) include slope instability, severe erosion, and geotechnical constraints such as expansive, corrosive, organic-rich and collapsible-compressible soils, as well as seismic events (earthquakes). Seismic hazards result from the primary action of an earthquake (e.g., strong ground shaking and surface fault rupture) and the secondary effects caused by the earthquake shaking (e.g., liquefaction, induced settlement, landslides, ground fissures, dam failure inundation, tsunami, and seiche).

For CEQA planning purposes, geologic, soils, and seismic hazards play an important role in the selection of development locations, the process necessary to develop a safe project, and the studies necessary to design a project to avoid or withstand these natural hazards. The CEQA Environmental Impact Report (EIR) process provides information designed to describe conditions for a specific project that will allow environmental review and an understanding of the project technical issues and constraints.

Laws, regulations, and codes are established to ensure that proper precautions are taken in advance of development to prevent unreasonable levels of damage, injuries, or fatalities. The primary applicable regulatory measures for the subject project are:

- 1970 California Environmental Quality Act;
- 1972 Alquist-Priolo Special Studies Zones Act 1971;
- 1990 Seismic Hazards Mapping Act;
- Orange County/Newport Beach Sewage Pipeline Standards; and
- 2013 California Building Code.

2 GEOLOGIC, GEOTECHNICAL, AND SEISMIC HAZARD REGULATIONS

As noted above, it is necessary to look at a wide range of potential geology, soils, and seismic related topics in order to comply with State Guidelines for environmental impact reports (EIRs, MNDs), and to provide an adequate understanding of geotechnical and engineering geologic issues affecting land use planning decisions.

2.1 Alquist-Priolo Earthquake Fault Zoning Act

The 1972 Alquist-Priolo Special Studies Zones Act 1971 resulted from the consequences of the Sylmar-San Fernando earthquake and seeks to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault. The Act was renamed in 1994 to the Alquist-Priolo Earthquake Fault Zone (APEFZ) Act. The Sylmar-San Fernando earthquake produced surface fault rupture damage along a zone that might have been identified in advance of the earthquake had the proper studies been mandated.

The best and most feasible surface rupture mitigation is avoidance of the causative fault. Thus, the APEFZ Act mandates that cities and counties (lead agencies) require that within an APEFZ geologic investigations must be performed to demonstrate that potential development sites are not threatened by surface fault displacements from future earthquakes. To aid the various jurisdictions that function as lead agencies for project approvals in California, the California Geological Survey (CGS, formerly the California Division of Mines and Geology-CDMG) must delineate Earthquake Fault Zones on standard U. S. Geological Survey topographic maps (1-inch equals 2,000-foot scale) along faults that are "sufficiently active and well defined" as defined in the Act. Quoting from the implementation guide, Special Publication 42 (Hart and Bryant, 1997; a 2007 interim revision has been updated to reflect changes in the index map and the listing of additional effected cities):

> “Zone boundaries on early maps were positioned about 660 feet (200 meters) away from the fault traces to accommodate imprecise locations of the faults and possible existence of active branches. The policy since 1977 is to position the EFZ boundary about 500 feet (150 meters) away from major active faults and about 200 to 300 feet (60 to 90 meters) away from well-defined, minor faults. Exceptions to this policy exist where faults are locally complex or where faults are not vertical.”

Lead agencies are responsible to regulate most development projects within the APEFZ as described in the Act, but may enact more stringent regulations. Certain smaller residential developments can be exempt. The City currently has no APEFZ within the Project area.

2.2 Seismic Hazards Mapping Act

The 1990 Seismic Hazards Mapping Act (SHMA) addresses the primary earthquake hazard, strong ground shaking, as well as the secondary hazards of liquefaction, earthquake-induced landslides, and in some areas zones of amplified shaking. As with the APEFZ Act, CGS is the primary State agency charged with implementing the SHMA, and CGS provides local jurisdictions with the 1-inch equals 2,000-foot scale seismic hazard zone maps that identify areas susceptible to liquefaction, earthquake-induced landslides, and in some areas amplified shaking. Site-specific hazard investigations are required by the SHMA when a development project is located within one of the Seismic Hazard Mapping Zones (SHMZ) defined as a zone of required investigation.

Lead agencies with the authority to approve projects shall ensure that:

> "The geotechnical report shall be prepared by a registered civil engineer or certified engineering geologist, having competence in the field of seismic hazard evaluation and mitigation. The geotechnical report shall contain site-specific evaluations of the seismic hazard affecting the project, and shall identify portions of the project site containing seismic hazards. The report shall also identify any known off-site seismic hazards that could adversely affect the site in the event of an earthquake."

And:

> "Prior to approving the project, the lead agency shall independently review the geotechnical report to determine the adequacy of the hazard evaluation and proposed mitigation measures and to determine the requirements of Section 3724(a), above, are satisfied. Such reviews shall be conducted by a certified engineering geologist or registered civil engineer, having competence in the field of seismic hazard evaluation and mitigation."

CGS Special Publication 117 (CGS, 2008a) covers the investigation, analysis, implementation, and review processes for liquefaction and earthquake-induced landslides evaluations and reports as updated effective September 2008 in order to provide detailed guidance for lead agencies to review SHMA reports. The overall goal is to protect the public by minimizing property damage and the loss of life.

2.3 Federal Disaster Mitigation Act of 2000

The Disaster Mitigation Act of 2000 provided a new set of mitigation plan requirements that emphasize State and local jurisdictions to coordinate disaster mitigation planning and implementation. States are encouraged to complete a "Standard" or an "Enhanced" Natural Mitigation Plan. "Enhanced" plans demonstrate increased coordination of mitigation activities at the State level, and if completed and approved, will increase the amount of funding through the Hazard Mitigation Grant Program. California's updated State Hazard Mitigation Plan was adopted on October 8, 2007 and approved by the Federal Emergency Management Agency (FEMA) Region IX on December 17, 2007. The City is updating its Local Hazard Mitigation Plan (LHMP) and General Plan Safety Element. This is necessary in order to receive funding from the State and Federal government in the event of a natural disaster. The updated plans are not yet available to the public. However, currently approved versions provide adequate information for this study and have been used herein.

2.4 National Flood Insurance Program

FEMA administers the National Flood Insurance Program (NFIP), and participating jurisdictions must exercise land use controls and purchase flood insurance as a prerequisite for receiving funds to purchase or build a structure in a flood hazard area. The NFIP provides federal flood insurance subsidies and federally financed loans for eligible property owners in flood-prone areas. The City has participated in the program since 1979 and as of 2004, some special (100-year) flood hazard areas were identified in the Project area. Newport Beach is identified on the NFIP Flood Insurance Rate Maps as being within Zone X, areas subject to minimal flooding, Zones AE and A, 100-year flood zones with base elevations determined and not determined, respectively.

2.5 California Environmental Quality Act (CEQA)

The 1970 CEQA ensures that local agencies consider and review the environmental impacts of development projects within their jurisdictions. CEQA requires that an environmental document (e.g., Environmental Impact Report [EIR], Mitigated Negative Declaration [MND]) be prepared for projects that are judged in an Initial Study (IS) to have potentially significant effects on the environment. Environmental documents (IS, MND, EIR) must consider, and analyze as deemed appropriate, geologic, soils, and seismic hazards. If impacts are considered potentially significant, recommendations for mitigation measures are made to reduce geologic and seismic hazards to less than significant. This allows early public review of proposed development projects and provides lead agencies the authority to regulate development projects in the early stages of planning.

2.6 Sanitary Sewer Pipeline Standards

The Orange County Sanitation District (OCSD) and the City have sanitary sewer pipeline standards. For purposes of this document it is assumed that both would provide a satisfactory project; the following refers to the City standards since the Project area is within the City. City Standard Plans and Specifications for the Construction of Sanitary Sewers insure the sewer lines and connections are properly designed and constructed. It has standardized its use of equipment in the pumping stations for ease of maintenance and replacement. City specifications incorporate the Standard Plans and Specifications for Public Works Construction (the “Green Book”), which helps insure proper design and construction of sewer facilities. Specifications identify minimum design standards, submittal requirements and approval or acceptance procedures to be used for wastewater systems that will be maintained and operated by the City. City inspectors are required to have on the job at all times copies of the City’s Design Criteria Standard Provisions and Standard Drawings for Public Works Construction, the Standard Specifications for Public Works Construction Inspection Manual, the Work Area Traffic Control Manual (WATCH), and the CALTRANS Manual for Work upon Highways.

2.7 Building Codes

The City Council adopted the California Building Code 2013 Edition (CBC) based on the 2012 International Building Code (IBC), as published by the International Code Council, in municipal code as Ordinance 2013-24. As of December 10, 2013 all new residential, commercial, and light industrial construction is governed by the CBC. The 2013 California Building Code (defined in CCR Part 2 of Title 24) includes additions to the previous building code that make it more stringent, in particular with regard to seismic and earthquake conditions for critical structures such as essential facilities, public schools and hospitals. The CBC, which is included in Title 24 of the California Administrative Code, is a compilation of three types of building standards from three different origins:

- Those adopted by state agencies without change from building standards contained in national model codes (e.g., the IBC).
- Those adopted from the national model code standards to meet California conditions (e.g., most of California is Seismic Design Categories D and E).
- Those authorized by the California legislature that constitutes extensive additions not covered by the model codes that have been adopted to address particular California concerns (e.g., the specification of Certified Engineering Geologist rather than engineering geologist).

International and national model code standards adopted into Title 24 apply to all occupancies in California except for modifications adopted by state agencies and local governing bodies. Facilities and structures such as pipelines, power plants, freeways, emergency management centers (e.g., traffic management, 911 centers), and dams are regulated under criteria developed by various California and Federal agencies. It is doubtful that the 2013 CBC will apply to the proposed Project unless appurtenant facilities are involved.

3 GEOLOGIC, GEOTECHNICAL, AND SEISMIC CONDITIONS WITHIN THE PROJECT AREA

3.1 Overview of Geologic, Geotechnical, and Seismic Conditions

General geologic and fault conditions in the Project area (CGS, 2002; Morton and Miller, 2006; Figures G-1 and G-4) are shared with other local cities that lie along the southern California coast along the southwestern slope of the Santa Ana Mountains.

Several million years of mountain building have occurred due to uplift above the San Joaquin Hills blind thrust from Newport Beach to south of Laguna Beach (Figure G-1), folding the geologic formations in the San Joaquin Hills into a broad anticline (Figure G-2). Erosion of the metasedimentary, volcanic, and crystalline rocks of the Santa Ana Mountains and sediment transport by water and gravity formed alluvial fans and subsequently dissected these fans creating the numerous southerly trending arroyos and canyons draining to the Newport Beach area (Figure G-3). Natural hillsides are susceptible to landslides due to the relatively weak and clay-rich geologic formations, and young alluvium is susceptible to consolidation/subsidence that can be exacerbated by earthquakes. Man-made water reservoirs and lakes located within, or up slope from, the Project area have the potential to fail and release floodwaters to local areas, in cases where water is impounded behind them. Groundwater basins are located north and west of the Project area, but not under the Project area; historically shallow groundwater is reported within the areas of young alluvium. Where groundwater is shallow and sediments are sufficiently loose, large earthquakes can cause liquefaction of the alluvium and settlement of overlying man-made structures.

3.2 Seismic Conditions

The City has experienced moderately severe to mild earthquake shaking in the historic past, however generally has a somewhat lower potential for strong ground shaking than other areas of southern California. Events centered some distance from the Project area (e.g., Landers/Big Bear and Northridge) caused only minor local disruptions. The 1994 6.7 magnitude (M) Northridge earthquake main shock occurred approximately 100 kilometers northwest of the City and the 1992 Landers M7.3 approximately 130 kilometers northeast each causing Modified Mercalli Intensity of about V and a peak ground acceleration (PGA) of less than 0.1g (g = force of gravity). The 1933 Long Beach earthquake ($M_w = 6.4$) about 24 kilometers to the west of the Project area is estimated to have had a Modified Mercalli Intensity of about V based on contemporaneous reports.

Substantial disruption from these earthquakes occurred closer to the epicenters reminding southern California residents that every several years another area of southern California is vulnerable to a "direct hit.” With earthquake prediction still a distant goal, it is important that each Project area and citizen do what is within its means and power to create policies that will maximize the protection to lives and property.

The potential for damaging earthquakes in the Project area is similar to or greater than what is typical of most southern California cities. Severe local earthquakes (as large or larger than the M6.4 1933 Long Beach, 1994 M6.7 Northridge and 1971 M6.4 San Fernando earthquakes) may occur within a relatively short distance, for example less than 25 miles (Figure G-4). Such earthquakes would most likely occur more or less aligned with major strike-slip or reverse faults having recognizable surface features (e.g., the Newport-Inglewood, Elsinore, Chino-Central Avenue, Whittier, Sierra Madre, and San Andreas faults), but also on less well understood blind thrust faults (e.g., the Puente Hills [1987 M5.9 Whittier Narrows] and San Joaquin Hills [possibly the 1769 ~M7.3?] blind thrust earthquakes) having more subtle surface expressions. The aforementioned documented Newport-Inglewood fault zone and San Joaquin Hills blind thrust fault pose the most substantial threats. Depending upon the type of source fault, the depth of the energy release, and the magnitude of the earthquake, (a) ground displacements may occur on these surface faults very near the Project area causing ruptures and offsets within the near surface geologic and soil formations and (b) there may be co-seismic folding, ground tilting, and uplift above a blind thrust. Such area-wide and regional uplift was associated with the 1987 and 1994 events noted above.

3.2.1 Critical Faults and Related Earthquakes

Two types of fault impacts are important to consider in the Project area. Fault-generated earthquake ground shaking summarized above is the most critical impact due to its widespread effects, and to the severe damage resulting in economic losses and the injury or death of people. The other important impact relates to ground movement, e.g., surface fault rupture, co-seismic uplift, ground lurching, and ground cracking. While these ground movement effects are more limited in extent than strong ground shaking, the impacts on structures can be severe on or near active or potentially active faults.

Faults classified as active and potentially active are considered the most significant in relation to the seismicity of the Project area (Figure G-4). In cases where earthquakes are large or hypocenters are shallow, ground rupture can occur along the source fault plane where it intersects the earth's surface. The classification of the faults discussed below is coincident with the classification by CGS (Hart and Bryant, 1997). “Active” faults (demonstrated offset of Holocene materials [less than 10,000-12,000 years ago] or significant seismic activity) and “potentially active” (Pleistocene [greater than 12,000 but less than 1,600,000 years ago]) faults (as defined by the CGS) must be considered as potential sources for fault rupture. In general, the younger the last movement is on a fault, the higher the potential for future movement on that fault.

Only two faults are documented to directly underlie the Project area of Newport Beach, each having different potential impacts, and each having differing levels of information regarding their degree of activity and damage-generating potential (see Figure G-1 for locations of regional faults). These active and potentially active faults are:

- Newport-Inglewood fault zone (City of Newport Beach, 2006), and
- San Joaquin Hills blind thrust (Grant et al, 1999).

While there are other regional faults that could cause earthquake damage (e.g., Puente Hills, Whittier, Elsinore, San Andreas), consideration of the two aforementioned faults captures a reasonable range of potential ground shaking values and potential impacts.

3.2.1.1 Newport-Inglewood Fault Zone

The active NIFZ (Figure G-1) extends from the southern edge of the Santa Monica Mountains southeastward to the offshore area near the City leaving the coastline at the northwestern corner of the City. Farther southward offshore and onshore extensions continue as the Rose Canyon fault zone. The primary section of the NIFZ that is of interest to the Project is the south Los Angeles Basin segment extending from the Santa Monica Mountains on the north to several miles beyond the City area on the south. It is a structurally complex series of an echelon, vertically dipping, discontinuous northwest-trending right-lateral strike-slip faults with associated folds and shorter normal and reverse faults (Yeats, 1973).

The fault is considered active based on its seismicity record, the youthful geomorphic features along the fault, and evidence of Holocene-age surface ruptures documented in Orange County by various investigators. The NIFZ was the source for the 1933 M6.4 Long Beach earthquake located approximately 3 miles south of present-day Huntington Beach, offshore of the City (City of Newport Beach, 2006). Primary ground rupture was not observed however secondary cracking, minor slumping, lateral movement of unconsolidated sediments, and settlement of road fills placed on marshy land occurred throughout the region.

The Long Beach earthquake occurred at 5:54 p.m. on March 10, 1933 just off the coast of the City on the NIFZ, a system of right-lateral strike-slip faulting with a closest approach to Project area of approximately one mile. The Mw = 6.4 earthquake had a hypocentral depth of 10 kilometers, and from seismic records it was determined that the maximum slip was about 1 meter and the total rupture length was about 15 kilometers, although there was no surface rupture. The earthquake lasted 5 seconds, ground shaking lasted somewhat over twice as long, and the maximum recorded ground acceleration was 0.22g, at a distance of 27 kilometers. Liquefaction features, such as sand boils were observed.

Studies have shown that the onshore portion of the NIFZ has a recurrence interval calculated at 200 to 800 years, with three to five ground rupturing earthquakes in the past 11,700 (+/-700 years; City of Newport Beach, 2006). With a maximum 7.1 magnitude earthquake for the onshore segment, it is possible to generate peak horizontal ground accelerations (PHGA) between 0.65g and 1.1g at the Project site. For a M7.1 earthquake on the offshore segment a PHGA between 0.59g and 0.98g is possible.

3.2.1.2 San Joaquin Hills Blind Thrust

The San Joaquin Hills blind thrust (SJHBT; Figure G-1) is a buried low-angle thrust fault dipping approximately 20- to 30-degrees (Grant et al, 1999; 23-degrees per Wills et al, 2008) to the southwest and underlying the San Joaquin Hills east of the City. Models of the subsurface conditions used to approximate the earthquake fault plane/source suggest the fault is most likely bounded by the offshore Newport-Inglewood fault zone on the southwest, and the surface expression extends roughly between the Santa Ana River and San Juan Creek on the northwest and southeast, The northeastern edge of the SJHBT may lie just beyond the northeast extent of the San Joaquin Hills and partially beneath the City at a depth of about 2 kilometers (Wills et al, 2008).

It is indicated that the SJHBT is a northeast vergent thrust fault (Grant et al, 1999) that pure thrust movement has caused the uplift of the San Joaquin Hills and the formation of the broad anticlinal (up warp) structure roughly paralleling the coastline. Others have suggested that the San Joaquin Hills uplift may be due to (a) strike-slip movement on the Newport-Inglewood fault or (b) movement along a back thrust (SJHBT) above the northeast dipping Oceanside blind trust. Grant et al (1999) determined that San Joaquin Hills have risen at a rate of 0.7 to 0.9 feet per 1,000 years (0.21–0.27 m/k.y.) during the past 122,000 years based on measurements of paleoshoreline elevations and radiometric ages of fossil corals. Using the fault plane geometry and an average uplift per earthquake of 1.3 meters they determined a recurrence interval for this uplift of 1,650 to 3,100 years. Considering the three uplift interpretations the range for the maximum magnitude earthquake was determined to be Mw = 7.3 to 7.5 (Grant and Shearer, 2004). The more likely maximum probable earthquake used by the USGS for its scenario analysis was M6.6.

The USGS (2008) "ShakeMaps" present estimates of the geographic distribution of MMI ground shaking intensity, as well as peak ground acceleration and other ground shaking parameters for both historic earthquakes and for potential future "scenario" earthquakes. An analysis of the San Joaquin Hills blind thrust M6.6 scenario earthquake (USGS, 2003) indicates that for planning purposes the Project area may experience an MMI intensity of VIII (approaching IX) and a PGA of 0.36 to 0.42g. Depending upon the facility or structure being considered it is likely that one of these significant faults would control the earthquake design considerations for the Project area.

3.2.2 Historic Earthquakes and Ground Shaking

Earthquakes generally occur on faults, which are planar features within the earth. Numerous regional and local faults (Figure G-2, Morton and Miller, 2006 and Figure G-1 CGS, 2002) are capable of producing severe earthquakes of magnitude (M) of 6.0 or greater.

Only one instrumentally recorded earthquake of greater than magnitude 6.0 has occurred near the Project area, the 1933 Long Beach earthquake on the NIFZ near the City. It is estimated that this earthquake caused a Modified Mercalli (MMI) shaking intensity effect of between IV and VIII (USGS, 2015; http://earthquake.usgs.gov/earthquakes/states/events/1933_03_11_iso.php) classified as slight to considerable damage. General background seismicity (SCEC, 2015) is considered low for the southern portion of Orange County with earthquake activity concentrated on faults to the east (Elsinore), north (Whittier and Puente Hills), and west (Newport-Inglewood). As documented by Grant et al (1999), the 1769 estimated M7.3 event on the SJHBT was larger and could have been close to the Project area. As described in an earlier section, ground motions, intensity, and damaging effects would likely be much more severe than the 1933 Long Beach event.

3.3 Geologic Conditions in the Project Area

3.3.1 Physiography and Topography

Landforms and topography of the Project area is controlled by the distribution and character of geologic units, and by climate and erosion, all of which contribute to the sculpture of the landscape. An 1875 coastal survey map (U. S. Coast and Geodetic Survey, accessed March 2015; Figure G-3) shows the Project area to be a combination of saltwater marsh, low relief sand and silt deposits (beach/dune sand) bordered by bluffs of bedrock and alluvial terrace deposits. Hilly terrain of the San Joaquin Hills to the east contributes runoff to San Diego Creek and smaller drainages such as Peters Canyon and Bonita Creek, which drain into Upper Newport Bay which connects at the Project area with Newport Bay.

Project area elevations range from approximately 15-20 feet amsl at the alternative Pump Station 3 to minus 15-20 feet amsl beneath the channel under the Bay Bridge. The remaining alternative Pump Stations 1 and 2 are at elevation of 10-13 feet amsl. Pipeline route alternatives are within these elevation ranges.

3.3.2 Surficial and Bedrock Deposits-General Descriptions

As shown on Figure G-2, the Project area is underlain by Quaternary (Holocene) estuary sediments (map symbol Qes) surrounding the Bay Bridge and under Pump Stations 1 and 2, and by Capistrano Formation (Tcs) partially under and north of Pump Station 3. Not shown beneath the water of the channel are very young sediments overlying unnamed older deposits noted in geotechnical borings and discussed below in more detail. In general, the Qes deposits have engineering properties that are less adequate for construction purposes than Tcs bedrock. Though not a true geologic deposit, artificial (man-placed) fill materials may be present beneath the Project area at a scale too small to be mapped at the scale of Figure G-2; such materials consist of reconstituted geologic materials placed either with or without engineering compaction and controls.

The California Building Code geologic subgrade classification system (Site Class A through Site Class F) is used to classify soil properties according to their physical attributes. Under this geologic subgrade site classification, non-engineered artificial fill (af) and the young alluvium (Qes) would likely be classified as Site Class E or possibly Site Class F (a soft to very soft soil profile); younger unnamed units beneath the channel would likely be classified as Site Class D or Site Class E, which is a stiff to soft soil profile; and, bedrock formations (Tcs) would likely be Site Class C or better. These classifications will affect seismic coefficients for earthquake design as shown by geotechnical design reports.

The seismic design coefficients based on Chapter 16 of the 2013 CBC for site class D and E are provided in Tables G-1 and G-2, respectively. These values were obtained from *USGS U.S. Seismic Design Maps* tool, based on 2010 ASCE 7 Standard and 2012 International Building Code (IBC). The parameters shown in Tables G-1 and G-2 were computed based on site coordinates of 33.6167°N and 117.9049°W. MCE_R stands for Risk-Targeted Maximum Considered Earthquake.

Table G-1. Site Coefficients for Site Class D

Categorization/Coefficient	Design Value
Site Soil Classification	S_D
Short Period Spectral Acceleration S_S (g)	1.717
1-sec. Period Spectral Acceleration S_1 (g)	0.633
Short Period (MCE_R) Spectral Acceleration S_{MS}(g)	1.717
1-sec. Period (MCE_R) Spectral Acceleration S_{M1}(g)	0.949
Short Period Design Spectral Acceleration S_{DS} (g)	1.145
1-sec. Period Design Spectral Acceleration S_{D1} (g)	0.633

The above parameters do NOT consider essential facilities

Table G-2. Site Coefficients for Site Class E

Categorization/Coefficient	Design Value
Site Soil Classification	S_E
Short Period Spectral Acceleration S_S (g)	1.717
1-sec. Period Spectral Acceleration S_1 (g)	0.633
Short Period (MCE$_R$) Spectral Acceleration S_{MS}(g)	1.545
1-sec. Period (MCE$_R$) Spectral Acceleration S_{M1}(g)	1.519
Short Period Design Spectral Acceleration S_{DS} (g)	1.030
1-sec. Period Design Spectral Acceleration S_{D1} (g)	1.013

The above parameters do NOT consider essential facilities

The Mapped Peak Ground Acceleration (PGA$_M$) adjusted for site effects at the site was calculated to be 0.707g and 0.636g for site Class D and E, respectively, as defined by ASCE 7-10 Chapter 11.

Based on the Morton and Miller (2006) geologic map, the Project area is underlain by one (exposed Capistrano Formation siltstone, Tcs) and possibly another (Monterey Formation, Tm) siltstone in the subsurface. The Monterey Formation is typically a yellowish-gray, siliceous shale and diatomaceous siltstone, with minor sandstone, sandy limestone, and travertine-limestone near the base. The Monterey Formation is of marine origin and bedding is generally well developed with a locally variable dip orientation in the range of 10 to 25 degrees (Morton and Miller, 2006). This formation has produced a wide variety of plant, marine micro- and macro-fossils, and vertebrate remains.

Capistrano Formation has multiple distinguishable members, one of which is the Capistrano Formation siltstone, which is the bedrock exposed near the Project area. It is composed of 1) marine yellow-gray to light brownish-gray siltstone with interbedded fine grained sandstone and 2) gray to brown siltstone and claystone with sandstone interbeds. The formation generally has well developed bedding features. In addition to the formations discussed above, late Pleistocene (less than about 120,000 years old) deposits are found in areas surrounding the Project area. These surficial deposits consist of relatively recent (geologically young), old, and very old sedimentary formations formed by alluvial and near-shore marine processes in streams, on alluvial fans, in estuaries, and in the marine coastal zone.

These older paralic deposits (units Qop and Qop$_2$ through Qop$_6$) consist of mostly poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits are possibly susceptible to liquefaction, settlement, dynamic consolidation, slope instability, and poor to very good foundation characteristics.

3.3.3 Groundwater Depth

The Project area does not overlie a named groundwater basin. Within the Project area groundwater is very near sea level indicating deposits deeper than about 10-15 feet amsl are saturated. This is discussed further in the section on liquefaction hazards.

3.3.4 Surface Water and Flooding

Some areas of the City are determined to be within a FEMA-designated flood zone; therefore, the City participates in the Federal Flood Insurance Study to determine the mandatory insurance necessary for identified properties.

As shown on Federal Insurance Rate Maps (FIRMs), flood areas that have a 1 percent annual chance of flooding are in the "100-year floodplain." FEMA designated 100-year floodplains and floodways are identified north of, and crossing the Project area in the Newport Channel and upper Newport Bay. Small portions of the Project area on the southwest side and northern edge of the Bay Bridge are within the 500-year floodplain (City of Newport Beach, 2008; Figure G-5). The City coordinates with the OCSD to maintain the necessary flood control and stormwater management.

3.3.5 Dam Failure Inundation

Only one upstream dam potentially retains sufficient surface water in the reservoir to cause flooding within the Project Area; this is Prado Dam located a few miles west of the City of Corona (City of Newport Beach, 2008; Map 7-9). This estimate was made in 2008 before the dam was to be raised about 28.4 ft, therefore the condition should have improved. Based on the 2008 estimate, flood waters would reach the Bay Bridge, but little impact on the Project area is expected.

3.3.6 Tsunami

There are numerous reports with lists of tsunamis that have affected the west coast of the United States and California in particular (Legg, 2004; USC, 2015). The effects indicated are usually wave amplitude, wave height, or wave run-up. For purposes of this report we assume this reported value indicates the increase in the elevation of the sea surface above the tidal elevation at the time. The City (City of Newport Beach, 2008; Map 7-7) indicates 100- and 500-year tsunami inundation zones with inundation elevations (respectively) of 4.9 and 6.5 ft above mean sea level and 7.47-feet and 9.07 feet above mean higher high water (Figure G-6) This would have considered regional/local and distant sources capable of generating damaging tsunamis. For example consideration would be given to such events as the 1960 M9.5 Chile earthquake, the March 11, 2011 M9.0 Honshu, Japan earthquake, a hypothetical magnitude (M) 9.4 earthquake on the Alaska-Aleutians Subduction Zone (AASZ), and from local offshore events from the Catalina fault. The worst-case inundation is estimated at 32 ft above mean sea level for a large landslide occurring offshore along the southern California escarpment (City of Newport Beach, 2008; Map 7.8). Additional potential hazards for the proposed force mains are channel bottom scour in the Bay Bridge area resulting from the retreat of a tsunami wave and impact to the bridge structure/force mains hanging from the bridge.

3.3.7 Oil, Gas, and Mineral Resources

The Project area lies within a portion of the City that has not been associated with the recovery of mineral resources (City of Newport Beach, 2006; Figures 4.5-3 and 4.5-4). The Project Area is almost entirely within a State Mineral Resource Zone 1 (MRZ; Figure G-7) indicating "Areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that there is little likelihood for their presence" (Miller, 1996; City of Newport Beach, 2006; Figure 4.5-4). Small areas near the Project area are within an MRZ-3 classification ("Areas containing mineral deposits, the significance of which cannot be evaluated from available data.") These classifications are related to sand and gravel resource potential due to the nature of the geologic formations described above. With regard to oil, natural gas, and geothermal resources, the West Newport Oil Field and the Newport Oil Field are mapped over a mile west of the Project area, and no active wells are shown within the Project area (City of Newport, 2006; Figure 4.5-3). Considering the MRZ-1 and MRZ-3 areas, and the oil fields, activities within the Project area would not affect future availability or production.

3.4 Project Area Subsurface Conditions

In addition to the regional and local area data discussed above, there are three sources of Project area-specific data that can be used to better understand the subsurface conditions that may impact the construction of the force mains and pump stations at the alternative locations. These sources are:

- Geotechnical Professionals Inc. (GPI, 2014) DRAFT Geotechnical Investigation Proposed Restaurant Balboa Marina, Newport Beach, California; and,
- Leighton Consulting, Inc. (LCI, 2012), Preliminary Geotechnical Engineering Evaluation for the Proposed Back Bay Landing – Mixed-Use Waterfront Development Legislative Approvals (GPA, CLUPA, etc.), Bayside Drive And Pacific Coast Highway, Newport Beach, California.
- Caltrans Log of Test Borings (c1976) related to the construction of the North Arm of the Newport Bay Bridge;

3.4.1 GPI Report 2014

The GPI report is related to the proposed restaurant south of PCH and east of the Newport Bay channel under the Bay Bridge. Exploration consisted of four cone Penetration Test (CPT) soundings, two hollow-stem auger borings, and two Geoprobe borings with depths of exploration of 50 feet, 7.5 feet, and 33 feet, respectively. For purposes of this study CPT C3 is just south of PCH and just east of the channel, therefore is representative of conditions that might be expected for Horizontal Direction Drilling (HDD) or microtunneling, and also of conditions at Pump Station No. 2.

CPT C3 encountered what is described as medium dense to very dense sand over the entire 50 feet, except for a 2-foot thick organic soft clay/medium-dense silty sand zone at 12- to 14-foot depth. Analyses by GPI concluded that the site is subject to strong earthquake ground shaking, shallow groundwater, liquefaction/lateral spreading, compressible soil layers, and subsoils are highly corrosive to metals. Pile foundations were recommended for proposed buildings.

3.4.2 LCI Report 2012

The LCI report is related to the proposed mixed-use waterfront development restaurant north of PCH and east of the Newport Bay channel under the Bay Bridge. Exploration consisted of four Cone Penetration Test (CPT) soundings, three hollow-stem auger borings, and the use of previous CPT exploration on the subject property. CPT and hollow-stem augers reached depths of exploration of 60 feet and 51.5 feet, respectively. For purposes of this study LCPT-3 and LBH-3 are just north of PCH and just east of the channel. LCPT-3 is representative of conditions that might be expected for HDD or microtunneling, and LBH-3 is also representative of conditions at Pump Station No. 1.

LCPT-3 encountered what is described as predominantly medium dense to very dense sand with layers of silty sand and gravelly sand over the 40 feet depth. LBH-3 encountered 6.5 feet of loose to medium-dense silty sand (artificial fill) over 55 feet of predominantly dense sand. Analyses by LCI concluded that the site is subject to strong earthquake ground shaking, shallow groundwater, liquefaction/lateral spreading, compressible soil layers, and shallow subsoils are moderately corrosive to metals. Rammed Aggregate Pier (a version of a pile) foundations were recommended for proposed buildings.

3.4.3 Caltrans Test Borings c1976

The Caltrans Log of Test Borings are related to the construction of the existing Newport Bay Bridge extending across the Newport Bay channel.

Exploration consisted of 24 Cone Penetration Test (CPT) soundings, 41 rotary wash borings, and other borings not considered in this study. CPT and rotary wash borings reached depths of exploration of 120 feet and 150 feet, respectively. Caltrans presented these CPTs and borings in five different vertical sections corresponding to portions of the bridge from west to east. These vertical sections are not ideal for this study since they mix borings from both north and south of the bridge center line making for a "mixed" representation of the lateral continuity. This is not ideal when attempting to evaluate the differences between pipeline alternatives north and south of the Bay Bridge. For purposes of this study two schematic "representative" geologic cross-sections were constructed to approximate the conditions immediately north and south of the bridge. CPTs and borings were selected only north or south, respectively, to provide a better schematic representation of conditions. Since there are five force main alternatives that would involve either HDD or microtunneling, and three of these are several hundred feet north of the Bay Bridge, not all possible conditions can be accurately approximated.

3.4.4 Expected Geologic and Geotechnical Conditions North and South of the Bay Bridge

Three non-bedrock geologic units were defined in the north and south cross-sections. From oldest (deepest) to youngest they are:

- Monterey or Capistrano Formation Bedrock – moderately hard to hard siltstone.
- Unit A – Predominantly Clayey silt and mixed silty clay, clayey sand, and sandy silt, very soft to stiff.
- Unit B – Medium to coarse-grained sand, dense to very dense with layers of shells and gravel and at higher elevations sand and gravelly sand with silty sand, slightly compact to compact (dense?).
- Unit C – Silty sand and sand, very loose to slightly compact with shells and gravel.

3.4.4.1 Bedrock: Monterey and Capistrano Formations

As indicated in Figure G-4 the areas immediately adjacent to the Project area exposed both Pliocene-age Capistrano Formation siltstone (Tcs) and Miocene-age Monterey Formation (Tm). An outcrop due east of the Project area and north of PCH was mapped as Tcs as well as most of the lower bluffs along the west side of the channel and along Dover Dr. adjacent to PS3. East of the Project area and south of PCH, and farther west of the Project area along PCH, is mapped as Tm. On this basis alone it is not readily apparent which formation might be under and adjacent to the Bay Bridge crossing.

Caltrans borings (all except B-25) and some CPTs encountered bedrock as shown in the North and South cross sections (Appendix A). From the visual logging of the borings the bedrock is described as mostly a siltstone and in only one case (B-16 on the South section) with shale interbeds. In most cases bedrock descriptions are limited to color, which is most often brown, then dark brown, gray brown and gray-green. On a few occasions the bedrock is described as friable (easily broken/crushed) or fissile (fine layers), and in one case micaceous and in another sheared with slickensides. Neither the GPI or LCI reports encountered bedrock formations.

Morton and Miller (2006) indicate the Tcs is composed of 1) marine yellow-gray to light brownish-gray siltstone with interbedded fine-grained sandstone and 2) gray to brown siltstone and claystone with sandstone interbeds. The formation generally has well developed bedding features. Descriptions from other reports suggest the Tcs is thinly bedded with partings along bedding planes and is often micaceous, with some examples of beds being highly disturbed and sheared. Though not reported in the cores, the Tcs can have closely-spaced fractures filled with reddish brown iron oxide, and can contain thin interbeds of fine- to medium-grained sandstone.

Typically the Monterey Formation is described as light gray to gray-brown siliceous and/or diatomaceous siltstone. Morton and Miller (2006) describe the Monterey Formation as typically a yellowish-gray, siliceous shale and diatomaceous siltstone, with minor sandstone, sandy limestone, and travertine-limestone near the base. This formation has produced a wide variety of plant, marine micro- and macro-fossils, and vertebrate remains.

Although this conclusion is not certain, we believe based on the bedrock color, friability, bedding/layering characteristics, and proximity to the mapped outcrop to the east that the bedrock in the Project area is Pliocene Capistrano Formation siltstone (Tcs). Although not observed, if faulting exists in the project area some Monterey Formation could be present.

3.4.4.2 North Side of Bay Bridge Centerline

This schematic cross-section considered borings and CPT's north of the bridge, specifically, borings B-40, -7, -27, -8, -10, -13, -33, -14, -29, -18, -31, and -41, and CPTs B-4, -5, -17, -21, and -24. Bedrock ranges in elevation between minus (-) 22 feet and -140 feet, with elevation -50 feet on the west (~Sta. 140), -22 feet just west of center (~Sta. 145), then gradually descending to -140 feet (~Sta. 150). Unit A varies from zero to ~ 60 feet thick, Unit B varies from zero to ~115 feet thick (thicker on the east), Unit C is zero to ~20 feet thick and present west of ~Sta. 143 and east of ~Sta. 147.

3.4.4.3 South Side of Bay Bridge Centerline

This schematic cross-section considered borings and CPT's south of the bridge, specifically, borings B-40, -33, -3, -35, -36, -9, -11, -12, -37, -15, -16, -30, and -20, and CPT B-22. Bedrock ranges in elevation between minus (-) 35 feet and -90 feet, with elevation -50 feet on the west (~Sta. 141.5), -35 feet just west of center (~Sta. 144.7), then gradually descending to -90 feet (~Sta. 149.5). Unit A varies from 5 feet to ~60 feet thick, Unit B varies from 5 feet to ~70 feet thick (thicker on the east), and Unit C is present in three separate shallow channels and varies in thickness from zero to ~30 feet thick.

3.4.4.4 Qualitative Comparison of the North and South Side Alignments

In support of the EIR, Table G-3 uses a set of criteria derived from CGS Note 53 (CGS, 2013) to provide a qualitative comparison between the North and South side alignments, and the Bridge attached alignments, as well as the three Pump Station locations. A simple measure of potential impact to each alignment is stated as None, Low, Moderate, and High. In addition a plus (+) and minus (-) was assigned to each Low, Moderate, and High to provide some room to emphasize relative differences within these three categories. Although not presented here, a numerical value was given to each as follows: None = 0; Low- = 2, the remaining increase by one up to High+ = 10. This provides a "score" that helped separate the alternatives a bit more.

As shown in Table G-3, Pump Stations 1 and 2 impacts rate about the same and Pump Station 3 has slightly more impact due to the adjacent bedrock/terrace deposit bluff which added slope stability concerns not seen in Pump Stations 1 and 2. In our opinion, these concerns can be easily mitigated and would likely show Pump Station 3 to be a slightly superior location from both environmental and constructability viewpoints since bedrock would likely be closer to the surface and provide more foundation alternatives.

Table G-3. Geologic/Geotechnical, Seismic, and Hydrologic Issues and Alternatives Evaluation [1]

GEOLOGIC/GEOTECHNICAL, SEISMIC, AND HYDROLOGY ISSUES										
GENERAL ISSUES	***SPECIFIC ISSUES POTENTIALLY CAUSING CONCERNS***	***RELATIVE IMPACTS TO PUMP STATION LOCATION ALTERNATIVES***			***RELATIVE IMPACTS TO FORCE MAIN LOCATION ALTERNATIVES***					
		1	***2***	***3***	***1***	***2***	***3***	***4***	***5***	***6***
EARTHQUAKE PHENOMENA	Ground Shaking	High+	High+	High+	High+	High+	High-	High+	High+	High+
	Landslides and Rockfalls	Moderate	Moderate	Moderate	None	None	None	None	None	None
	Fault Rupture and Tectonic Warping	Low	Low	Low	Moderate-	Moderate-	Low	Low	Moderate-	Moderate-
	Differential Compaction/ Seismic Settlement	Low+	Low+	Low-	Moderate	Moderate	None	Low-	Moderate	Moderate
	Liquefaction and Lateral Spreads	High+	High+	High-	Moderate-	Moderate-	None	Moderate-	Moderate-	Low+
	Tsunamis and Seiches	High-	High-	High-	Low+	Low+	High+	Moderate	Low+	Low+
	Flooding due to Dam or Levee Failure	Low-	Low-	Low	Low-	Low-	Low+	Low	Low-	Low-
SLOPE AND/OR FOUNDATION	Landslides and Mudflows	None	None	Moderate	Low+	Low+	None	None	Low+	Low+
	Unstable Cut and Fill Slopes	Low-	Low-	Moderate-	Low-	Low-	None	Moderate-	Low-	Low-
	Collapsible and Expansive Soil	Moderate+	Moderate+	Moderate-	Moderate-	Low	None	Low-	Moderate-	Moderate-
INSTABILITY	Trench-Wall Stability	High	High	High	Moderate+	Moderate+	None	Moderate	Moderate+	Moderate+
	Erosion of Graded Areas and Sedimentation	None	None	Low	None	None	None	None	None	None
EROSION, SEDIMENTATION AND FLOODING	Alteration of Existing Runoff	Low-	Low-	Low+	None	None	None	None	None	None
	Increased Impervious Surfaces	None	None	Low-	None	None	None	None	None	None
	Unprotected Drainage Ways	None	None	Low-	None	None	None	None	None	None
	FEMA Flood Zones	Low-	Low-	Low-	Low-	Low-	Low-	None	Low-	Low-
LAND SUBSIDENCE	Extraction of Groundwater, Gas, Oil, or Geothermal Energy	None	None	None	None	None	None	None	None	None
	Hydro-compaction or Peat Oxidation	Low	Low	Low+	Low-	Low-	None	Low-	Low-	Low-
	Fault Rupture / Ground Cracking	Low+	Low+	Low+	Moderate	Moderate	Low+	Low+	Moderate	Moderate
LOSS OF MINERAL RESOURCES	Loss of Access	None	None	None	None	None	None	None	None	None
	Deposits Covered by Changed Land Use	None	None	None	None	None	None	None	None	None
	Zoning Restrictions	None	None	None	None	None	High+	None	None	None
OVERALL IMPACT COMPARISON		Low	Low	Low	Low	Low	Low	Low	Low	Low

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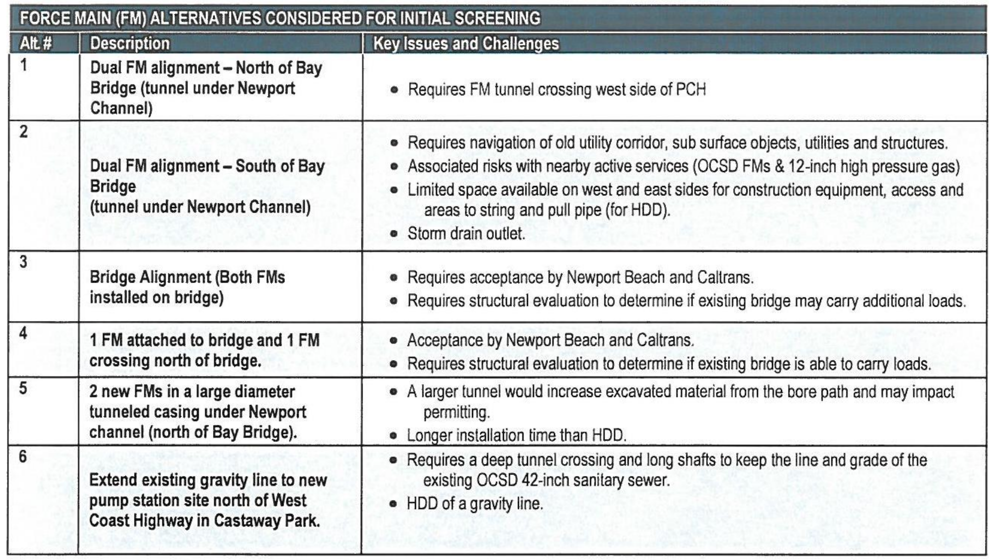
1. Table modified after 2013 CGS Note 52 (Guidelines for Preparing Geological Reports for Regional-Scale Environmental and Resource Management Planning) based on issues applicable to the Project.



FORCE MAIN (FM) ALTERNATIVES CONSIDERED FOR INITIAL SCREENING		
Alt. #	Description	Key Issues and Challenges
1	**Dual FM alignment – North of Bay Bridge (tunnel under Newport Channel)**	• Requires FM tunnel crossing west side of PCH
2	**Dual FM alignment – South of Bay Bridge (tunnel under Newport Channel)**	• Requires navigation of old utility corridor, sub surface objects, utilities and structures. • Associated risks with nearby active services (OCSD FMs & 12-inch high pressure gas) • Limited space available on west and east sides for construction equipment, access and areas to string and pull pipe (for HDD). • Storm drain outlet.
3	**Bridge Alignment (Both FMs installed on bridge)**	• Requires acceptance by Newport Beach and Caltrans. • Requires structural evaluation to determine if existing bridge may carry additional loads.
4	**1 FM attached to bridge and 1 FM crossing north of bridge.**	• Acceptance by Newport Beach and Caltrans. • Requires structural evaluation to determine if existing bridge is able to carry loads.
5	**2 new FMs in a large diameter tunneled casing under Newport channel (north of Bay Bridge).**	• A larger tunnel would increase excavated material from the bore path and may impact permitting. • Longer installation time than HDD.
6	**Extend existing gravity line to new pump station site north of West Coast Highway in Castaway Park.**	• Requires a deep tunnel crossing and long shafts to keep the line and grade of the existing OCSD 42-inch sanitary sewer. • HDD of a gravity line.

The force main alternatives use the same criteria and as such separate mainly by the fully Bridge attached, partial Bridge attached, and all HDD or microtunneling. Because the fully or partially Bridge attached alternatives do not require, or require less, HDD or microtunneling to cross the channel they are higher rated.

Considering that several of the North side alignments are adjacent to the bridge and several hundred feet to the north, one must assume that the geologic unit relationships are similar to the schematic cross-section. The degree of similarity is not known since no data are available to help resolve this. Geotechnical comparison of the North and South alignments would depend upon the selected depth of the excavation. For example, this would determine how much, or if, bedrock would be involved. This comparison of course does not include obstacles (pilings, piers, abutments, debris) that remain from the old Bay Bridge and other existing structures (utilities and pipelines) that could greatly affect the suitability of the South side.

3.4.4.5 Geological Conclusions

Unit C is at a shallow depth and would be unlikely to be encountered in HDD/Microtunneling unless it is found in unstudied areas to the north and south where it would be unstable in excavations. Unit B appears fairly consistent lithologically, has no reported large cobbles or boulders, should be stable in steep slopes on-land, has medium- to coarse-grained sand and some gravel that could be abrasive to metal, and is prevalent in the eastern portions of the cross sections (Appendix A). Unit A is somewhat inconsistent lithologically, would be marginally stable in steep slopes on-land, contains minor sand, gravel, and shells that should be non-abrasive to metal, should shrink/swell if wetted/dried, and is common in the central and western portions of the cross-sections. Presumed Capistrano Formation bedrock is soft to moderately hard, may drill as easily as Unit B, is thinly bedded with beddings likely dipping downward 10 to 20 degrees, is likely somewhat fractured, and being a siltstone, would have low abrasiveness due to grain sizes generally less than about 1/16 of a millimeter. Capistrano Formation has been the subject of some studies for larger tunnels associated with the LOSSAN (Los Angeles to San Diego; Caltrans/USDOT, 2007) high speed rail project, although detailed information was not located. They characterized the Capistrano Formation as moderately consolidated, prone to landsliding, and suggest low to medium excavation difficulty (based on cost and duration).

3.4.4.6 Geotechnical Conclusions

Interbedded layers of sand, silty sand, sandy silt, clayey silt, and silty clay were reported in the boring logs from Caltrans Log of Test Borings shown in the north and south cross sections presented in Appendix A and boring LBH-3 from LCI Report between approximately 10 feet AMSL down to the Qae at 51.5 feet depth. The equivalent SPT blow counts vary between 9 and 200 and 1 and 154 for the north and south cross section locations, respectively. Based on laboratory test results, the in-place moisture content varies between 2 and 24 percent for the north cross section (no data is available for the south cross section). Similarly, the in-place dry unit weight of the soils varies between approximately 79 and 106 pounds per cubic feet (pcf) for the north cross section (no data is available for the south cross section). Soil property characterization data versus elevation is presented in Figure G-8.

4 ANALYSIS OF POTENTIAL GEOLOGIC, GEOTECHNICAL, AND SEISMIC HAZARDS AND POTENTIAL MITIGATIONS

4.1 Overview

Potential hazards have been divided into three categories, geologic, geotechnical, and seismic; non-seismic includes engineering geology and soil hazards that can occur without an earthquake.

The magnitude of a damaging earthquake would likely be at least 5.0 for some significant effects to be triggered, although lesser magnitude earthquakes have activated hazards and caused damage. Geologic and geotechnical hazards are activated due to the nature of the geologic materials, the hydrogeologic regime, or weather. In the Project area, seismic and geotechnical hazards carry with them the most risk to the proposed force main and pump station project components.

Because of the topography/bathymetry and the nature of the geologic units present in the Project area, non-seismic hazards that would be expected are potential weak bedrock (Monterey or Capistrano Formations) and non-bedrock (Units A through C) formations. Geotechnical issues related to weak materials are greatest for Unit C and progressively less for Units C, B, A, and bedrock. Oil, gas, mineral resources, and groundwater resources would not be impacted, nor would they impact the project (e.g., subsidence due to fluid withdrawal or water or oil). Dam failure inundation and flooding potential exist; these could impact the pump station, but would not be significant to the force mains.

Active faults are not known to be present based on the City data bases, therefore fault rupture appears unlikely. However, co-seismic deformation/uplift is possible due to the buried San Joaquin Hills blind thrust. Strong earthquake ground shaking is a potentially significant impact. Tsunami impacts, while unlikely, could have a potentially significant effect from wave impact on the bridge to channel scour. Liquefaction and lateral spreading landslide potential exists for most of the Project area. Landslide potential may exist for the bluff area around Pump Station No. 3. The following subsections describe mitigations that, in addition to regulatory compliance, could reduce potential impacts.

4.2 Seismic Hazards

4.2.1 Overview

4.2.2 Ground Shaking

The potential effects of severe ground shaking can be envisioned given the experience of many citizens with recent earthquakes in southern California. The 1994 Northridge earthquake had a magnitude of 6.7 and occurred on a previously unidentified buried thrust fault beneath the San Fernando Valley. It caused significant structural damage, injury, and loss of life in the San Fernando Valley, Simi Valley, Santa Clarita Valley, Santa Monica, and the northern Los Angeles Basin, with MMI values of VIII-IX. Peak horizontal and vertical ground accelerations exceeded 1g in a few locations. This can also be said for other earthquakes such as the 1933 Long Beach and the 1971 San Fernando. In the Project area local differences in subsurface conditions summarized above (e.g., density, water content, grain size, subgrade soil profile classification) could increase the effective shaking above the levels for these past events. These effects would be greater in areas where ground failure occurred due to liquefaction, lateral spreading, or dynamic consolidation. Therefore, site-specific geology, geotechnical, and earthquake engineering studies are mandatory for evaluating existing conditions and developing design criteria for the force mains and the pumping station. Application of industry standard design and construction measures would reduce impacts to less than significant levels.

4.2.3 Surface Co-Seismic Deformation

The Project area has no mapped APEFZ and no faults mapped through the Project area. Although the current data suggest it would be unlikely, if fault movement were to occur on an unknown "young" fault, damage to the proposed project could be severe.

The San Joaquin Hills blind thrust (SJHBT) fault underlies the Project area and surrounding communities. If movement were to occur on a buried fault, the most likely results would be regional uplift. Shaw et al (2002) studied detailed high-resolution seismic reflection geophysical profiles of the Puente Hills blind thrust (PHBT) that confirmed the fault is active and capable of generating discrete surface fold scarps in areas where the buried leading edge of the main thrust fault is some 2 kilometers deep. Due to the uncertainties associated with the SJHBT location and depth, and the low likelihood of a large magnitude earthquake, such co-seismic surface deformation is unlikely.

Further investigation should be weighed against the probability of significant risks posed to the proposed Project. Research conducted over the past decade or so has demonstrated that it is possible to develop reasonable design mitigation measures to accommodate some level of fault related deformation without compromising the functionality of the structures. This necessitates determining in some detail the consequences of movement on distinct faults and distributed shearing due to bedrock or alluvial deposit warping associated with faulting (e.g., co-seismic uplift, and surface tilting or folding).

Design measures involving specially constructed artificial fill using geogrids and geotextiles, and heavily reinforced foundations and slabs can be developed to accommodate some fault related deformation. Design determinations rely mainly on geologic and geotechnical field data, observations of the performance of similar structures, and some level of numerical modeling.

4.2.4 Earthquake-Induced Landslides and Lateral Spreading

The GPI and LCI geotechnical studies north and south of PCH and east of the Project area defined areas susceptible to earthquake-induced lateral spread landslides. In addition, the City (City of Newport Beach, 2008) defines an earthquake induced landslide hazard north of/adjacent to the Pump Station No. 3 alternate site. The City map does not distinguish level of susceptibility and is not a substitute for geologic and geotechnical study for specific projects. Areas are delineated where there was known earthquake-induced slope failure during historic earthquakes, landslide movement (including both landslide deposits and source areas), and where CGS' analysis indicates ground slope and geologic materials are susceptible to earthquake-induced slope failure. The delineated areas are not necessarily unstable, but the maps provide an opportunity to consider these areas when planning for new projects.

In hillside terrain an appropriate engineering geology and geotechnical investigation (performed by properly licensed professionals), including field data collection, laboratory testing, and slope stability analysis, should be conducted considering both static and dynamic (earthquake) forces. Development projects within a zone susceptible to earthquake-induced landslides and lateral spread landslides must be evaluated using CGS guidelines (CGS, 2008) that describe study methods and mitigation options. Mitigation options include, but are not limited to, building setbacks, landslide debris removal/replacement, slope angle reduction, earth or engineered buttresses, protective barriers, retaining/slough walls, debris fences, and run-out/catchment areas.

4.2.5 Liquefaction

Ground failures associated with saturated deposits (liquefaction) can include an entire suite of effects ranging from simple ground cracking to complex lateral spreading landslides (discussed above). The three key factors that indicate whether an area is potentially susceptible to liquefaction are severe ground shaking, shallow groundwater and low-density granular deposits (mainly sand). Failures can include ground fissures, sand boils, ground settlement, and loss of bearing strength, buoyancy effects, ground oscillation, flow failure, and lateral spread (Bartlett and Youd, 1992). These, in turn, can have effects on surface and subsurface structures.

Ground fissures may be reflected as linear tensional features which open to widths of a few to several inches, but which may or may not exhibit differential vertical movement. *Sand boils* are built-up sand accumulations often up to three feet across that result from ejected sand and water forced from the subsurface under pressure. *Ground settlement* often occurs as liquefied sand deposits reconsolidate following ejection of the water and sand. A *loss of bearing strength* can cause surface structures to settle, either rather evenly or differentially, causing tilting. *Buoyancy* caused by rapid upward movement of water through sandy soils can cause buried structures to rise (float) when they are founded in the liquefied layer. *Ground oscillation* may not cause permanent ground displacement, but may damage rigid structures due to the severe ground shaking in a non-liquefied zone. *Flow failure* is found in steeper terrain where liquefied soils near the ground surface flow as a viscous mass down slope similar to a mudflow in rain-saturated soils. *Lateral spread* is a liquefaction-induced landslide of a fairly coherent block of soil and sediment deposits that moves laterally (along the liquefied zone) by gravitational force, sometimes on the order of 10 feet, often toward a topographic low such as a depression or a valley area.

In addition to having ground shaking parameters, quantitative estimates of liquefaction potential require specific data from geotechnical borings, laboratory testing, and groundwater level information. The City hazard zones maps (City of Newport Beach, 2008) and the GPI and LCI geotechnical reports delineate areas or establish conditions within the Project area and adjacent areas indicating susceptibility for liquefaction (see Figure G-4). This could result in severe settlement of surface facilities and in some cases uplift of buried structures (e.g., large pipelines).

Although there is some potential for deep liquefaction greater than about 50 feet below ground surface, liquefaction potential is substantially higher where water is less than 50 feet deep. Susceptibility also includes sediment type. Liquefaction assessments must be made for important projects. It should be a goal to compile such data as it might exist in Project area, and supplement nearby studies as needed with specific geologic and engineering properties across the Project area. The Seismic Hazards Mapping Program provides published guidelines and implementation procedures for the evaluation and mitigation of liquefaction conditions with a designated liquefaction hazard zone. These guidelines and procedures require registered professionals (California Registered Civil Engineer or Certified Engineering Geologist) to conduct the evaluations, establish the site-specific mitigation, and participate in the implementation process. The evaluation determines the controlling earthquake parameters, the liquefaction depth, the thickness, and lateral extent of the liquefiable layer affecting the proposed development, and the type and estimated amount of vertical and horizontal ground deformation.

Ground improvement (densification and hardening) and structural (foundation) design are the two classes of liquefaction mitigation. Ground densification methods include vibro-compaction, vibro-replacement (also known as vibro-stone columns), deep dynamic compaction, and compaction (pressure) grouting. Hardening methods reduce the void space in the liquefiable soil by introducing grout materials either through permeation grouting, mechanical soil mixing, or jet grouting. Structural mitigation may have little or no effect on strengthening the soil itself.

For heavy structures, the preferred mitigation is deep caissons or pile foundations to penetrate through the liquefiable material, or a mat foundation may be feasible. For lighter structures continuous spread footings having isolated footings interconnected with grade beams, mat foundations, and post-tensioned slabs may be appropriate. Dewatering and drainage systems may be part of the mitigation process. Lateral spread hazards are not as readily mitigated with structural solutions and may require use of retaining structures, removal or treatment of liquefiable soils, modification of site geometry, or drainage to lower the groundwater table. Whether a single type of mitigation technique or a combination of techniques is needed will depend on the site-specific geotechnical conditions.

4.2.6 Dynamic Consolidation and Subsidence

Dry to partially saturated sediments not susceptible to liquefaction may be susceptible to dynamic consolidation and local ground subsidence. This consolidation or densification occurs in loose cohesionless sediments as the void spaces are diminished due to intense seismic shaking. Hazard maps are not normally created for this condition, and there are no specific data in the Project area, which allow prediction of the locations or magnitudes of potential consolidation and subsidence. Considering the Project elements, the buried force mains and pumping stations would be susceptible to these phenomena.

Due to the probable heterogeneous nature of the Unit A through Unit C deposits in the Project area, the amount of dynamic consolidation and subsidence will not be consistent from location to location. Variations in vertical consolidation may occur within a small area which may cause differential settlement of the structure and substantially more damage than if the structure were to settle evenly throughout. Observations reported in the other areas of southern California suggest that earthquake-induced consolidation, ground subsidence, and building settlement may reach a meter (3+ feet) or more; however, settlements of 5 to 30 centimeters (2 to 12 inches) are rather common. The resultant ground failures manifest as ground cracks with relative vertical displacements as indicated above. When structures overlie these local subsidence areas, ground cracking may be translated through foundations and slabs causing severe structural damage.

Earthquake-induced consolidation and structure settlements are normally less severe than liquefaction ground deformations; however the previously described mitigation measures for liquefaction could apply. Based on a thorough geotechnical investigation by licensed professionals, recommendations are provided; for surface structures the most common recommendation may be over-excavation of the loose soils and replacement by compacted soils meeting standard geotechnical specifications. The depth of over-excavation will depend on the nature and thickness of the loose soils, but critical areas are the contacts between formations of varying density where differential settlement is most common. For HDD and microtunneling, softer layers in Units A through D beneath the buried pipeline could be susceptible to consolidation and subsidence depending on actual conditions and design specifics (e.g., excavation depth and diameter).

4.2.7 Dam Failure Inundation, Flooding, and Tsunami Run-up

The past failures (Baldwin Hills and St. Francis) and near-failures (Van Norman) of southern California dams point out the importance of considering dam safety. Dams may fail for seismic or geologic reasons, either of which could lead to the results described in this section. Section 8589.5 of the California Government Code requires dam owners to provide the Governor’s Office of Emergency Services with an inundation map showing the extent of damage to life and property that would occur, given a complete and sudden dam failure at full capacity, the Project area lies downstream from Prado Dam and the predicted inundation hazard would just reach the Project area. In addition, flooding due to precipitation and tsunami occurrence must be considered.

Areas immediately downstream from dam failures would be the most susceptible to damage from rapidly flowing water, severe erosion, and associated floating debris. Areas more distant from the larger reservoirs, higher elevation areas, and those areas farthest from the flood channels could suffer more from minor sheet flow and rising water. Such should be the case in the Project area. The 500-year flood levels would inundate a small portion of the southwest edge of the Bay Bridge. Considering the nature of this hazard, no mitigation measures are required.

The 100 and 500-year earthquake-induced tsunami inundation levels would impact nearly all of the Project area, with the possible exception of the alternate Pump Station No. 3. The offshore continental shelf landslide-induced tsunami (32-foot elevation) would inundate all of the Project area. This tsunami would potentially put substantial forces on the Bay Bridge during run-up and when water recedes. During the receding period substantial water velocities could severely erode the channel bottom where the flow would be concentrated. Depending upon the depth of the HDD or microtunnel, the scour could impact the force mains. Although no standard design measures have been determined, appropriate modeling and calculations would be necessary to develop appropriate mitigation measures if the risk is considered sufficiently probable.

4.3 Geologic and Soil Hazards

4.3.1 Landslides, Mudslides, and Debris Flows

Slope instability under non-earthquake (static) conditions is considered to be a potentially significant hazard in the hillside and mountain areas of the Project area. The distribution of mapped landslides in the City area is shown on Figure G-2 (Morton and Miller, 2006) and none are in the Project area. Figure G-4 shows potential earthquake induced landslides and these are discussed above.

In hillside terrain an appropriate engineering geology and geotechnical investigation (performed by properly licensed professionals), including field data collection, laboratory testing, and slope stability analysis, should be conducted considering both static and dynamic (earthquake) forces. The same mitigation options apply here as for earthquake induced landslides. These include, but are not limited to, building setbacks, landslide debris removal/replacement, slope angle reduction, earth or engineered buttresses, protective barriers, retaining/slough walls, debris fences, and run-out/catchment areas. Surficial slope failure impacts can be mitigated by removing vulnerable deposits (e.g., soil, colluvium, fractured/weathered bedrock), placing structures outside the path of potential slides, constructing debris basins at canyon mouths to catch the slide material, building barriers to stop or divert surficial slide debris (e.g., impact, diversion or deflection structures - walls or channels).

4.3.2 Collapsible and Expansive Soil Hazards

Collapsible and expansive soil issues are recognized in standard geotechnical investigations mandated by the City in the Project area and by other regulatory bodies. Expansive soils are found associated with soils, alluvium, and bedrock formations that contain clay minerals susceptible to expansion under wetting conditions and contraction under drying conditions. Depending upon the type and amount of clay present in a geologic deposit, these volume changes (shrink and swell) can cause severe damage to slabs, foundations, and concrete flatwork. Collapsible soils undergo a volume reduction when the pore spaces become saturated causing loss of grain-to-grain contact and possibly dissolving of interstitial cement holding the grains apart. The weight of overlying structures can cause uniform or differential settlements and damage to foundations and walls.

Expansive and collapsible soil damage can be mitigated by delineation of the soils during a geotechnical investigation, over-excavation of the subject soils and recompaction of new engineered fill material, possibly pre-saturating the subject soils, and provision of proper surface drainage away from structures and building foundations.

4.3.3 Shallow Groundwater

Shallow groundwater is discussed in the liquefaction sections. The concern in this section is the potential to intercept shallow or perched groundwater in subsurface excavations, such a basements, utility trenches, deep foundations, or tunnels. Shallow groundwater exists throughout the Project area and is discussed by GPI and LCI in the context of these geotechnical evaluations. Surface (open cuts and pits) or underground (tunnels, vertical large-diameter borings) excavations can encounter shallow groundwater inflows, which may be perched and local or widespread in extent. This will affect excavation stability, and therefore short- and long-term safety for workers, as well as post-construction stability of structures associated with these excavation areas. The degree of hazard for the Project area is generally high.

Depths to water of less than 15 feet are considered a high hazard because water may be encountered even in routine project excavations; depths of 15 to 30 feet are considered a moderate hazard because only the more significant excavations (e.g., subterranean parking garages) for larger project structures would likely extend to these depths. Because the groundwater is less than 15 feet deep the hazard is considered significant and will be a design issue for the force mains and the pump stations. Such structures must be very carefully studied and where possible dewatering programs can be implemented for construction and as necessary for the life of the structure.

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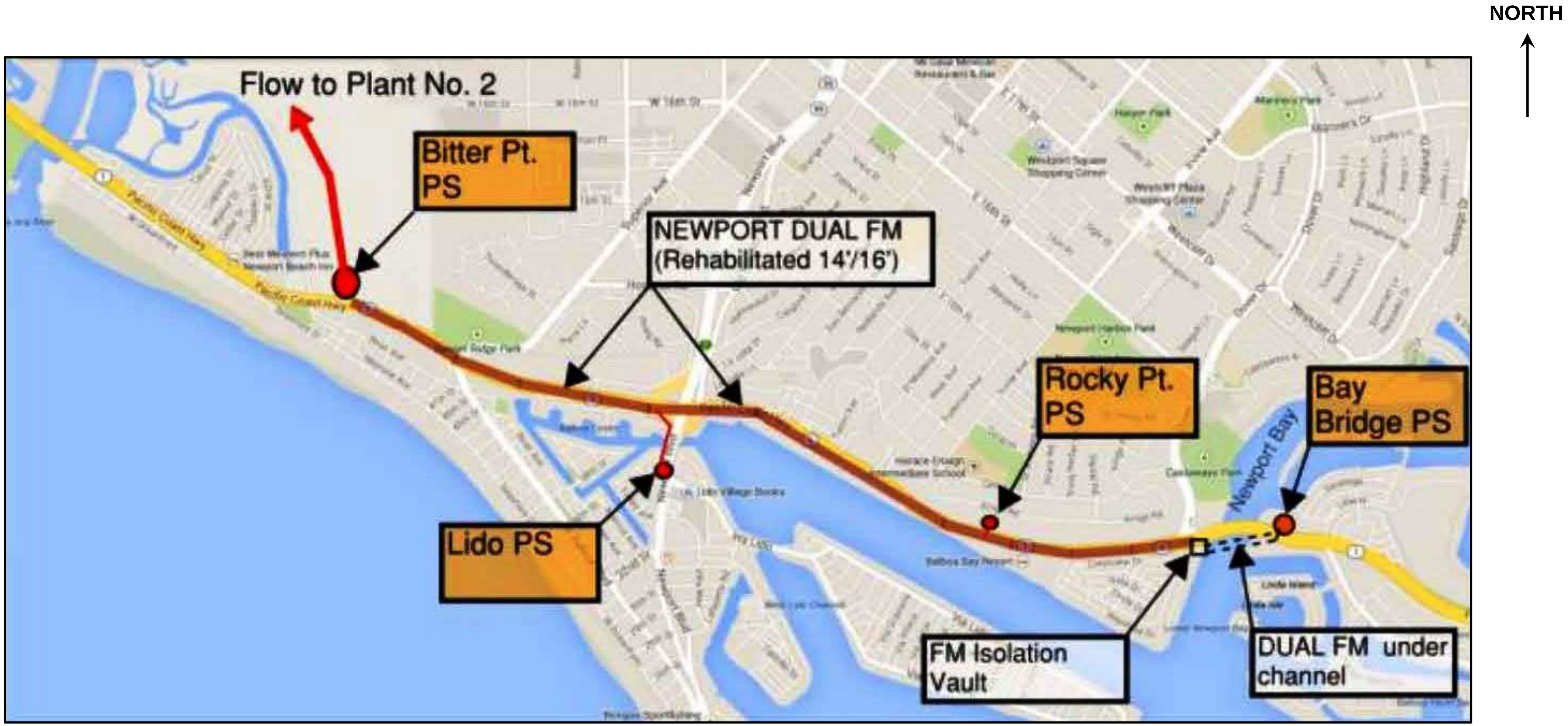
FIGURES



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OCSD NEWPORT FORCE MAIN AND PUMP STATION NETWORK

Figure
G-0

EXPLANATION

Fault traces on land are indicated by solid lines where well located, by dashed lines where approximately located or inferred, and by dotted lines where concealed by younger rocks or by lakes or bays. Fault traces are queried where continuation or existence is uncertain. Concealed faults in the Great Valley are based on maps of selected subsurface horizons, so locations shown are approximate and may indicate structural trend only. All offshore faults based on seismic reflection profile records are shown as solid lines where well defined, dashed where inferred, queried where uncertain.

FAULT CLASSIFICATION COLOR CODE
(Indicating Recency of Movement)

Fault along which historic (last 200 years) displacement has occurred and is associated with one or more of the following:

(a) a recorded earthquake with surface rupture. (Also included are some well-defined surface breaks caused by ground shaking during earthquakes, e.g. extensive ground breakage, not on the White Wolf fault, caused by the Arvin-Tehachapi earthquake of 1952). The date of the associated earthquake is indicated. Where repeated surface ruptures on the same fault have occurred, only the date of the latest movement may be indicated, especially if earlier reports are not well documented as to location of ground breaks.

(b) fault creep slippage - slow ground displacement usually without accompanying earthquakes.

(c) displaced survey lines.

A triangle to the right or left of the date indicates termination point of observed surface displacement. Solid red triangle indicates known location of rupture termination point. Open black triangle indicates uncertain or estimated location of rupture termination point.

Date bracketed by triangles indicates local fault break.

No triangle by date indicates an intermediate point along fault break.

CREEP

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (creep with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occured that has been triggered by an earthquake on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate terminal points between which triggered creep slippage has occurred (creep either continuous or intermittent between these end points).

Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence for Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holocene age deposits: offset stream courses, linear scarps, shutter ridges, and triangular faceted spurs. Recency of faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to that described for Holocene faults except features are less distinct. Faulting may be younger, but lack of younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement sometime during the past 1.6 million years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 1975. See Bulletin 201, Appendix D for source data.

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissnce nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

ADDITIONAL FAULT SYMBOLS

Bar and ball on downthrown side (relative or apparent).

Arrows along fault indicate relative or apparent direction of lateral movement.

Arrow on fault indicates direction of dip.

Low angle fault (barbs on upper plate). Fault surface generally dips less than 45° but locally may have been subsequently steepened. On offshore faults, barbs simply indicate a reverse fault regardless of steepness of dip.

OTHER SYMBOLS

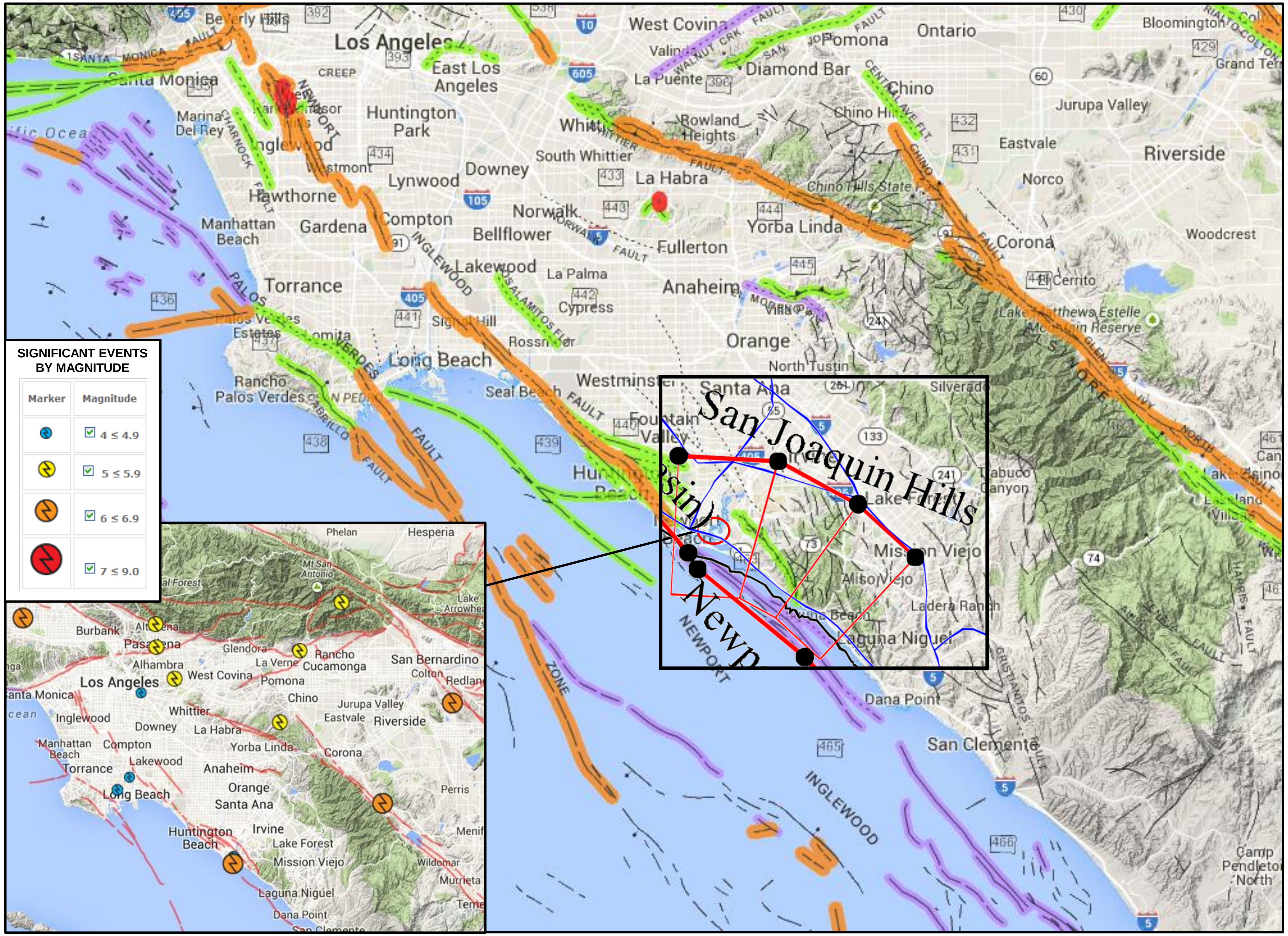
Numbers refer to annotations listed in the appendices of the accompanying report. Annotations include fault name, age of fault displacement, and pertinent references including Earthquake Fault Zone maps where a fault has been zoned by the Alquist-Priolo Earthquake Fault Zoning Act. This Act requires the State Geologist to delineate zones to encompass faults with Holocene displacement.

Structural discontinuity (offshore) separating differing Neogene structural domains. May indicate discontinuities between basement rocks.

Brawley Seismic Zone, a linear zone of seismicity locally up to 10 km wide associated with the releasing step between the Imperial and San Andreas faults.

Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION ON LAND	DESCRIPTION OFFSHORE
Quaternary	Late Quaternary	Historic	200	🟥		Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
		Holocene	11,700	🟧	?	Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
		Pleistocene	700,000	🟩	?	Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
	Early Quaternary		1,600,000*	🟪	?	Undivided Quaternary faults - most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
Pre-Quaternary			4.5 billion (Age of Earth)	—		Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive.	Fault cuts strata of Pliocene or older age.

* Quaternary now recognized as extending to 2.6 Ma (Walker and Geissman, 2009). Quaternary faults in this map were established using the previous 1.6 Ma criterion.



SIGNIFICANT EVENTS BY MAGNITUDE

Marker	Magnitude
●	☑ 4 ≤ 4.9
●	☑ 5 ≤ 5.9
●	☑ 6 ≤ 6.9
●	☑ 7 ≤ 9.0

NORTH

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Source: Department of Conservation, 2010 Fault Activity Map of California, and California Geological Survey, 2002.

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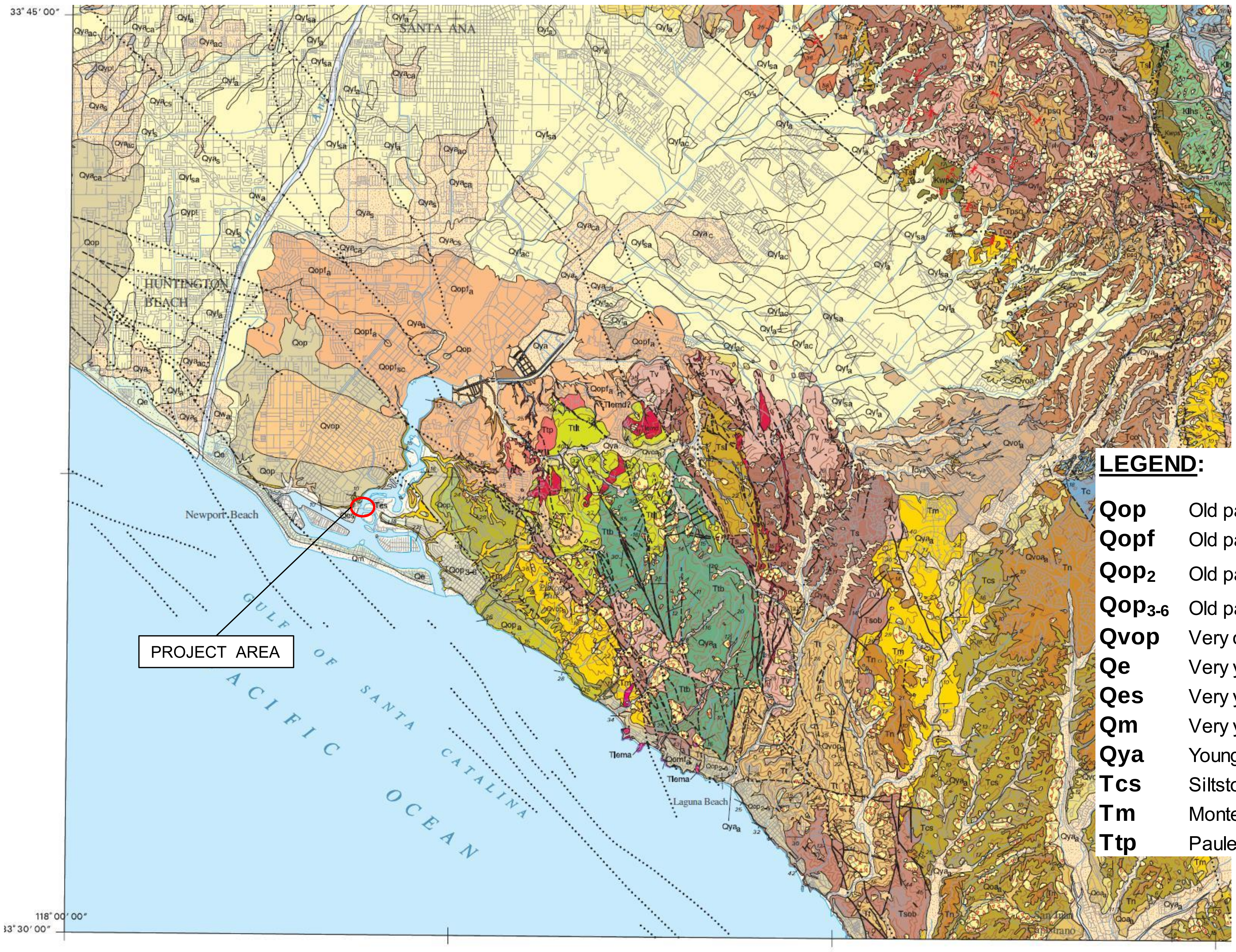
REGIONAL FAULTING AND EARTHQUAKES

Figure
G-1

FINAL DRAFT



LEGEND:

Qop	Old paralic deposits, undivided (late to middle Pleistocene)
Qopf	Old paralic deposits overlain by alluvial-fan deposits (late to middle Pleistocene)
Qop_2	Old paralic deposits, Unit 2
Qop_{3-6}	Old paralic deposits, Units 3-6, undivided
Qvop	Very old paralic deposits (middle to early Pleistocene)
Qe	Very young eolian deposits (late Holocene)
Qes	Very young estuarine deposits (late Holocene)
Qm	Very young marine deposits (late Holocene)
Qya	Young axial-channel deposits (Holocene and late Pleistocene)
Tcs	Siltstone facies
Tm	Monterey Formation (Miocene)
Ttp	Paulerino Formation

NORTH ↑

Source: U.S. Geological Survey, Douglas M. Morton and Fred K. Miller, 2006.

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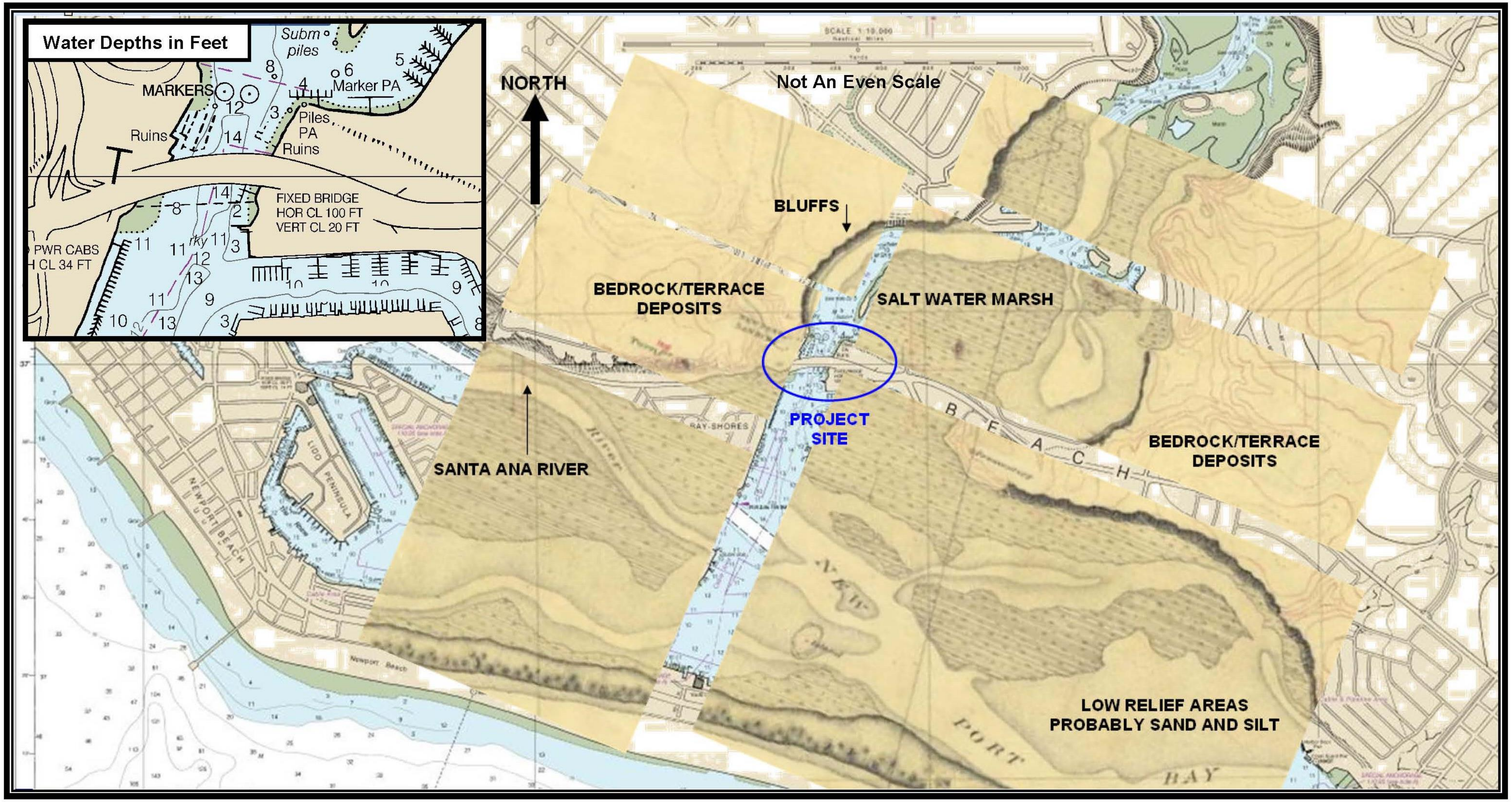
PROJECT REGION GEOLOGY AND FAULTS

Figure
G-2



Sources: Large Map Underlay: U. S. Coast and Geodetic Survey, 2015, Nautical Chart, United States – West Coast – Newport Bay, California, 1:10,000, http://www.charts.noaa.gov/OnLineViewer/18754.shtml ; Smaller Yellowish Overlay Maps, U. S. Coast and Geodetic Survey, 2015, 1875 "Topography in Vicinity Of Newport Bay, California", http://historicalcharts.noaa.gov/historicals/search. (*Disclaimer: The maps are intended to show general relationships, and due to the differences in the map dates and scales cannot be considered suitable for accurate measurements.*)

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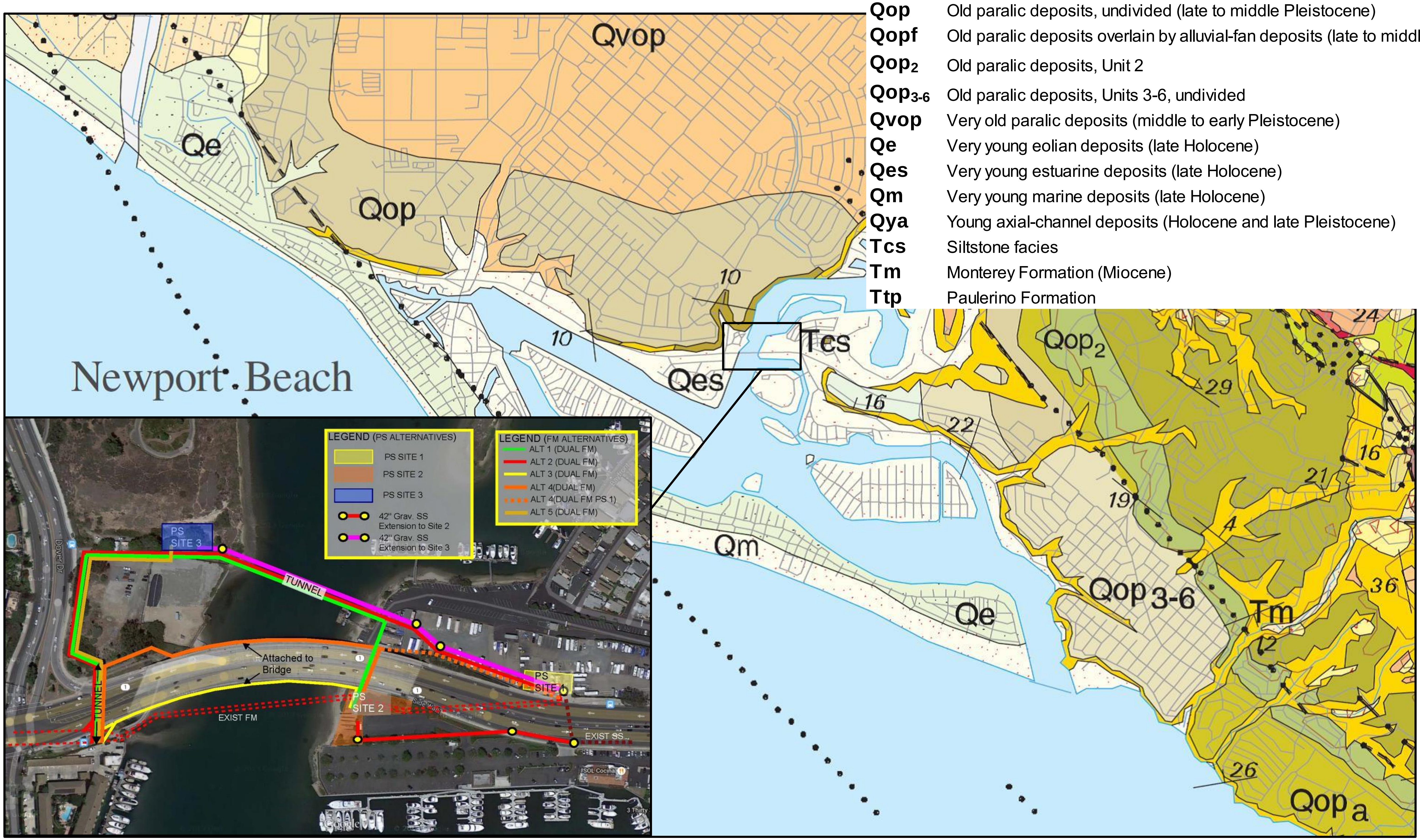
PRE-DEVELOPMENT SURFACE GEOLOGY

Figure
G-3

NORTH

LEGEND:

Qop	Old paralic deposits, undivided (late to middle Pleistocene)
Qopf	Old paralic deposits overlain by alluvial-fan deposits (late to middle Pleistocene)
Qop_2	Old paralic deposits, Unit 2
Qop_{3-6}	Old paralic deposits, Units 3-6, undivided
Qvop	Very old paralic deposits (middle to early Pleistocene)
Qe	Very young eolian deposits (late Holocene)
Qes	Very young estuarine deposits (late Holocene)
Qm	Very young marine deposits (late Holocene)
Qya	Young axial-channel deposits (Holocene and late Pleistocene)
Tcs	Siltstone facies
Tm	Monterey Formation (Miocene)
Ttp	Paulerino Formation



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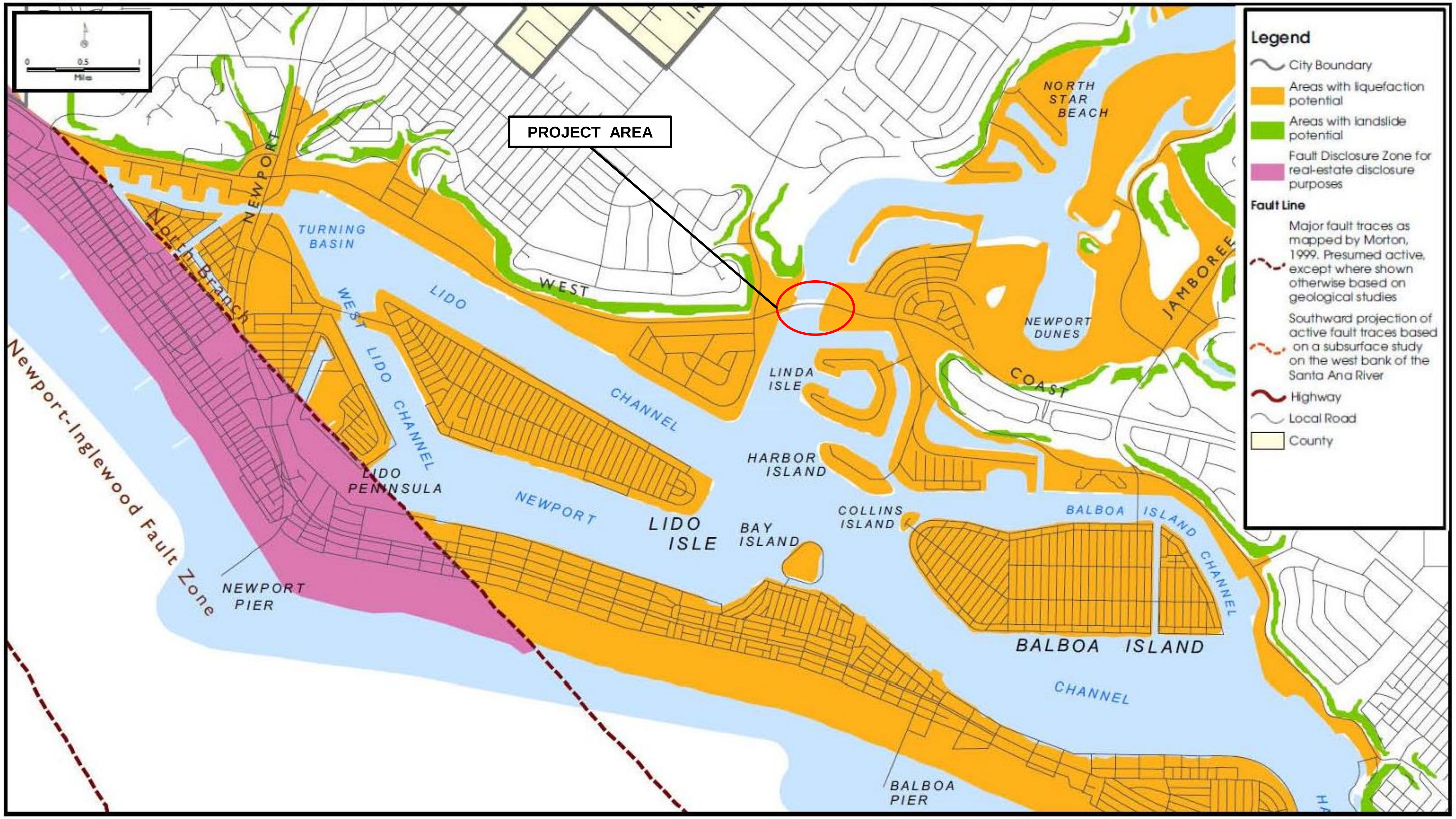

Source: City of Newport Beach General Plan Safety Element, 2006, Figure S2 Seismic Hazards.

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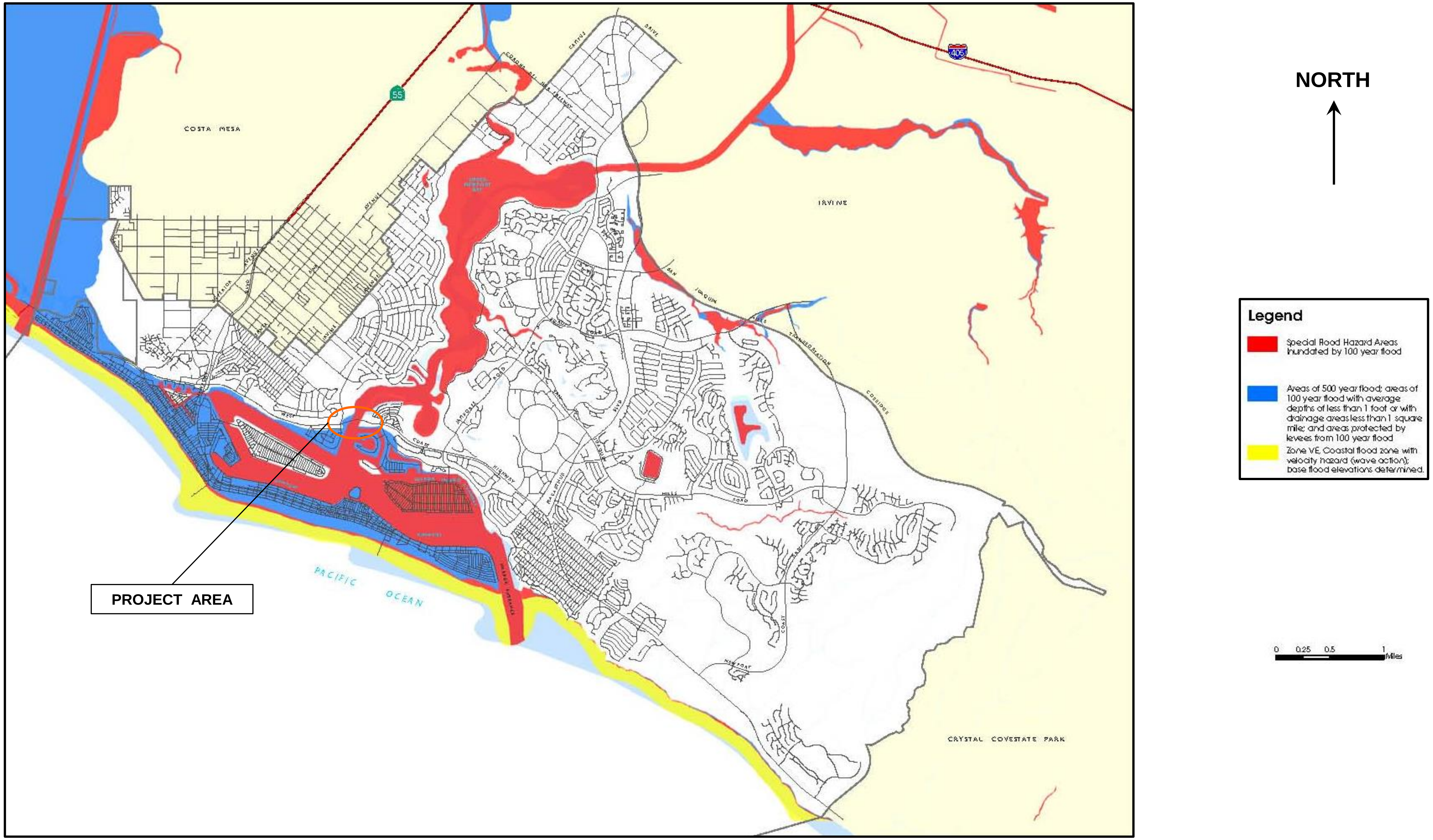
ACTIVE FAULTS, LIQUEFACTION
AND EARTHQUAKE-INDUCED LANDSLIDE AREAS

Figure
G-5



Source: City of Newport Beach, 2006. Project No. 10579-01. Date: 03/17/06.

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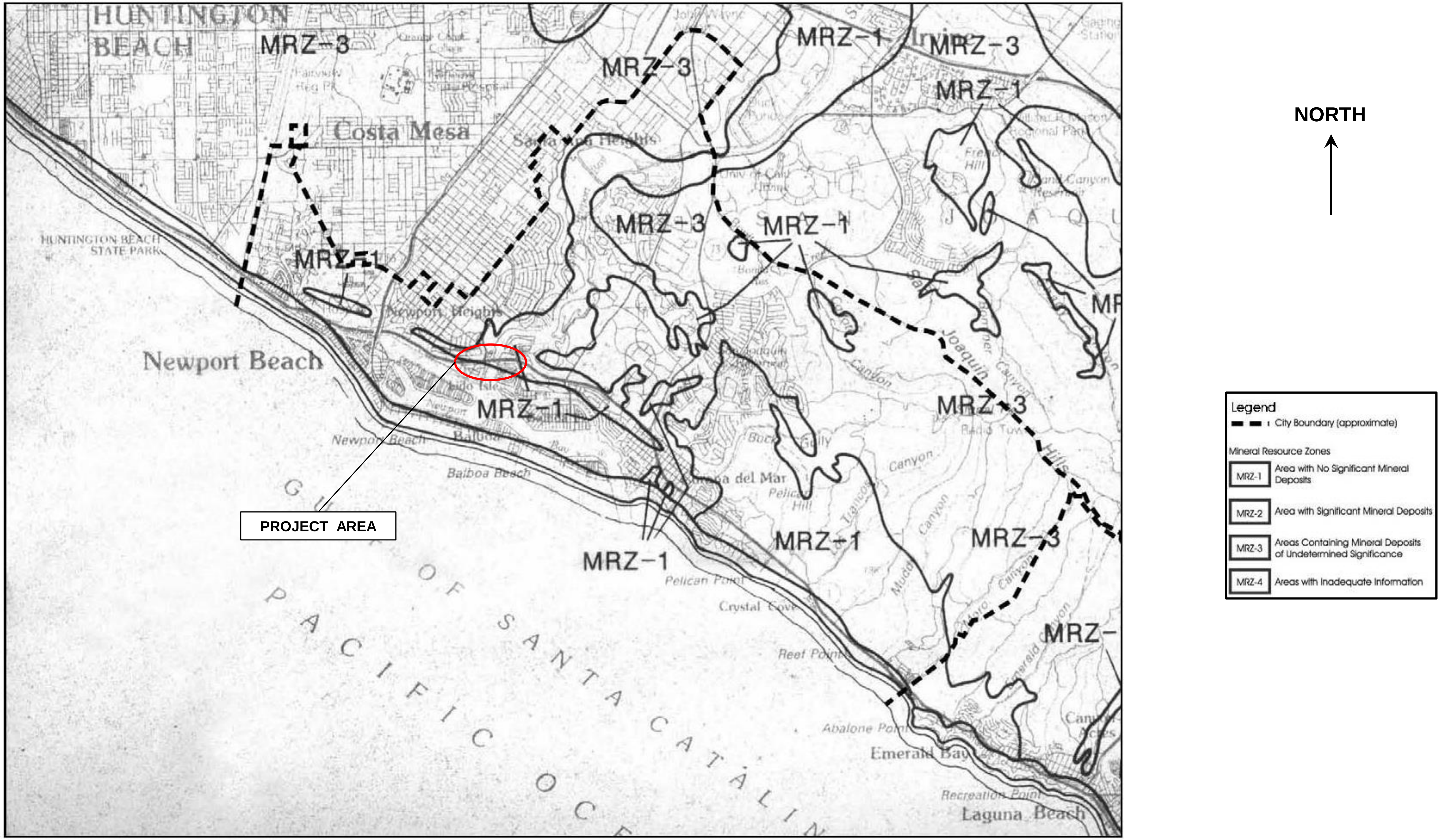
FEMA FLOOD ZONES, DAM INUNDATION FLOODING, AND TSUNAMI RUN-UP POTENTIAL

Figure
G-6



Source: Department of Conservation, Division of Mines and Geology (DMG). Project No. 10579-01. Open File Report 94-15, 1994.

NOT TO SCALE

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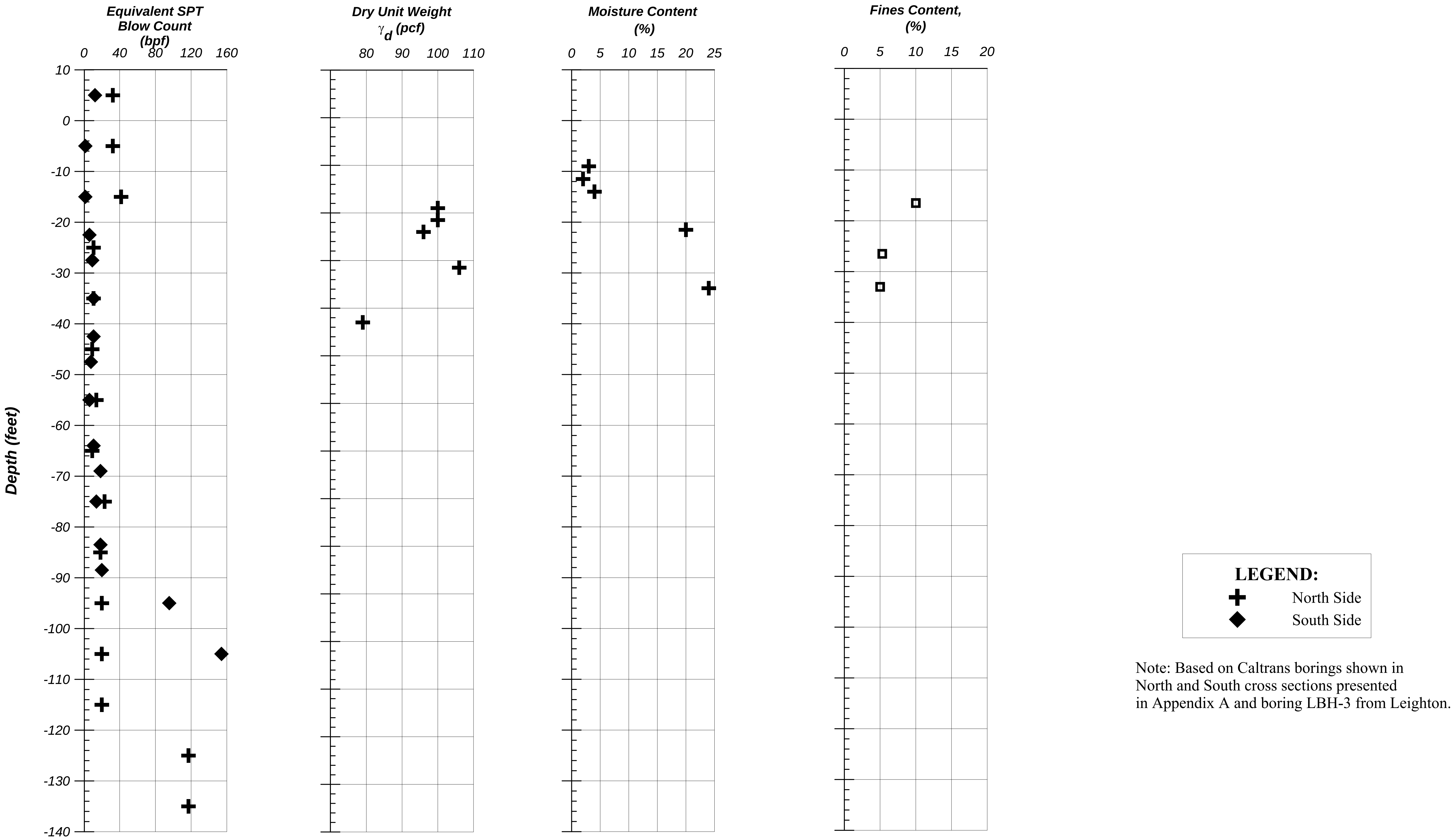
MINERAL RESOURCE ZONES

Figure
G-7



Note: Based on Caltrans borings shown in North and South cross sections presented in Appendix A and boring LBH-3 from Leighton.

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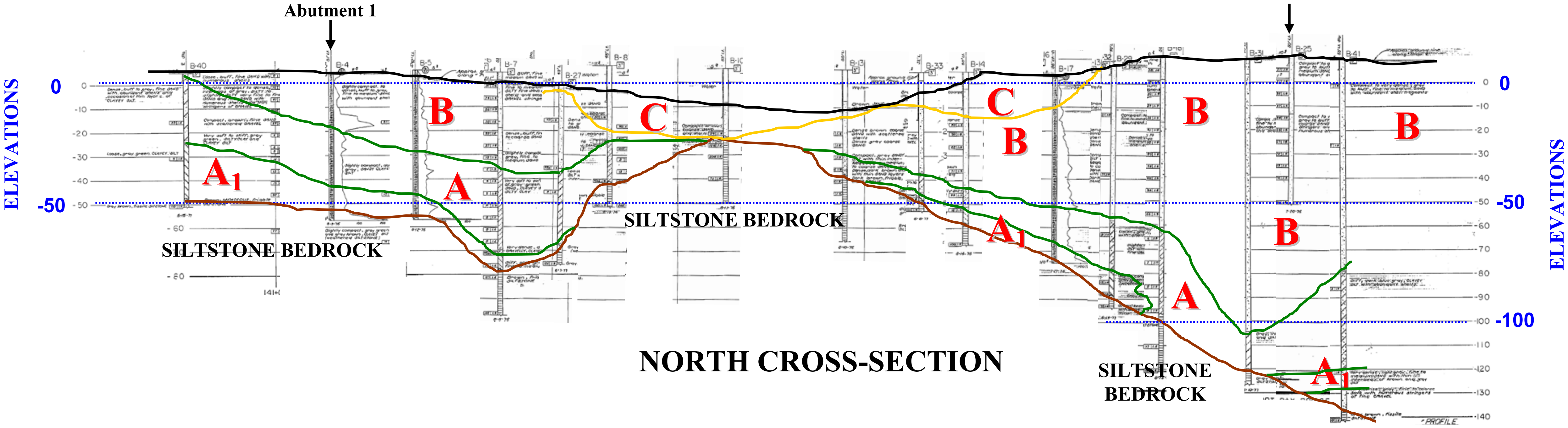
SOIL PROPERTY CHARACTERIZATION DATA VERSUS ELEVATION

Figure
G-8

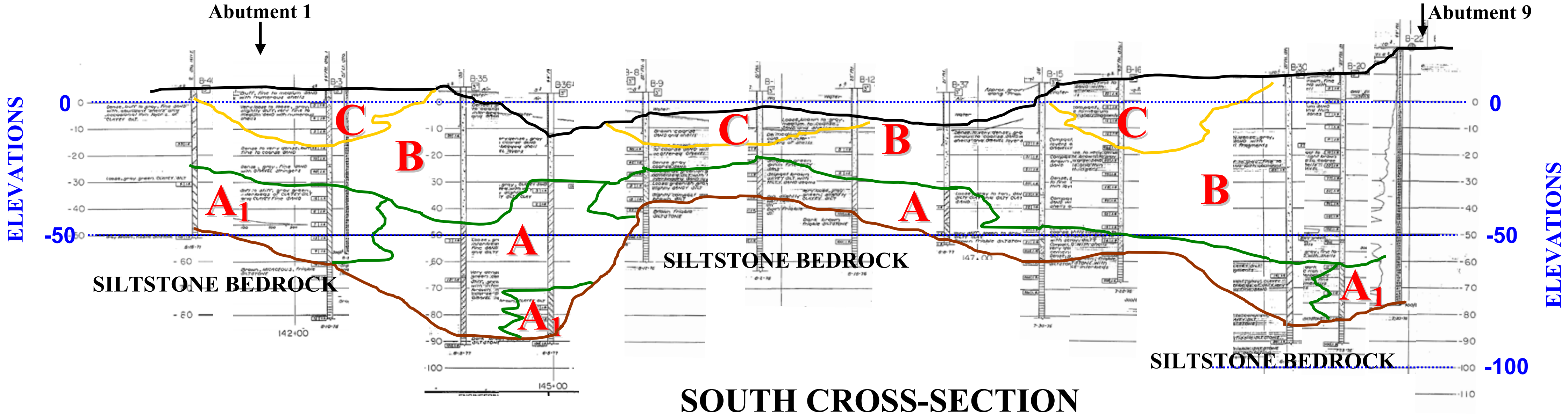
APPENDIX A

FINAL DRAFT

View to the North



NORTH CROSS-SECTION



SOUTH CROSS-SECTION

Geologic Unit Explanation

C Described As: 1) Coarse to Very Coarse Loose Sand w/ Shells; and 2) V. Loose to Loose Fine-Medium Sand w/ Shells

B Described As: Dense to Very Dense Med-Coarse Sand W/ Shell and Gravel Layers; 2) Dense to V. Dense Sand w/ Shells and Gravel Stringers; 3) Compact to Very Dense Sand w/ Shells and Gravel Stringers; and 4) Sand w/ Shells and Clayey Silt Layers. At Higher Elevations Tends to be: 1) Fine to Very Fine, Slightly Compact to Dense Silty Sand w/Shells and Gravel Stringers; 2) Compact to Dense Fine to Medium Sand w/Gravel Layers; and 3) Compact to Very Dense Fine to Medium Sand w/ Abundant Shell Fragments

A Described As: 1) Soft to Stiff and "Loose" Clayey Silt; 2) Loose to Very Stiff Sand, Clayey Silt, Silty Clay; 3) Loose to Dense and Very Soft to Stiff Clayey Sand and Sandy Silt Clay; 4) Soft to Stiff Clayey Silt; and 5) Slightly Compact to Compact Clayey Silt with Silty Fine Sand.

[Note: original Caltrans borings have been used to create schematic cross-sections north and south of the bridge centerline. The user is cautioned that stations are approximated relative to the original "log of test borings". Unit correlations are subject to change based on further analysis. The sections should provide a reasonable representation of possible conditions along an HDD or Microtunnel alignment.]

SCHEMATIC REPRESENTATIVE CROSS-SECTIONS

Approximate Scale 1" = 100-Feet Horizontal and 50-Feet Vertical

See Above

KLW

3-16-15