APPENDIX P

Geo Report

Geotechnical and Geologic Hazard Evaluation
Mission Bay Park Improvements Projects
San Diego, California

Prepared For:
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PREPARED BY:
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Subject: Geotechnical and Geologic Hazard Evaluation Report
Mission Bay Park Improvements PEIR
San Diego, California

Dear Mr. Valerio,

We are pleased to submit our updated Geotechnical and Geologic Hazard Evaluation Report for the Mission Bay Park Improvement PEIR in San Diego, California. This report identifies geotechnical and geologic hazards that have the potential to affect Project elements.

Respectfully submitted,

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EXECUTIVE SUMMARY

This Updated Geotechnical and Geological Hazard Evaluation (Study) has been prepared for the City of San Diego on behalf of Dudek as part of an Environmental Impact Report (EIR) for the Mission Bay Park Improvements Program (Program) in San Diego, California. The Program is inclusive of site-specific project elements and bay-wide programmatic elements (Dudek 2025). The Program location consists of the Mission Bay Park Improvement Zone (Improvement Zone and Study Area), as defined in City of San Diego Charter Section 55.2 and shown on Figure 1.

This Study identifies geotechnical and geological hazards that could have potentially adverse effects on manmade improvements within the Improvement Zone. Materials reviewed include relevant geological maps and guidelines published by the City of San Diego, State of California, and the United States Geologic Survey; and in-house resources. The Study also included a brief site reconnaissance. A summary of the geology and geological hazards is provided below.

- The geological units exposed in the Study Area consists of artificial fill (dredged hydraulic fill), young marine beach deposits, and Old paralic deposits (Unit 6). Although not exposed in the Study Area, it is believed that the artificial fill is underlain locally by young alluvium, and young estuarine deposits. Artificial fill, and young alluvium/estuarine deposits may be subject to consolidation under additional fill or structural loads.
- A small portion of the northeastern Study Area is underlain by active and potentially active faults. Ground rupture on the active fault will affect only a very small portion of the Study Area. The closest known active fault is the Rose Canyon fault, which is located approximately 0.25 miles east of centroid of the Study Area. The Study Area, like the rest of San Diego, is in a region of local and regional active faults and will be subject to strong ground motion in the event of an earthquake on these faults.
- Liquefaction occurs in soft, saturated soil during moderate to severe ground shaking during earthquakes. According to City of San Diego maps, the Study Area is defined as having a high potential for liquefaction.
- Coastal flooding will occur following tsunami events caused by large offshore earthquakes or submarine landslides. Seiches may cause flooding during large earthquakes on the nearby Rose Canyon fault zone.
- Landslide hazards have not been mapped in the Study Area. The lack of steep or high slopes precludes landslides. Local lateral spreading during liquefaction should be expected due to shallow submarine slopes or surcharged submarine slopes from fills placed during revitalization of the Study Area.
- Most of the Study Area is blanketed with soils that range from low expansion potential to non-expansive in nature.
- Potentially corrosive soils may be present in some localized areas due to shallow, salty groundwater. The groundwater in most of the site originates from the salt water in Mission Bay.
- Infiltration rates in shallow soil will be affected by shallow groundwater (within 10 feet of the current ground surface).

The geological hazards that are encroached by planned improvements in the Study Area and identified above can be addressed through avoidance or by engineering design in accordance with established State of California and City of San Diego requirements and codes. It is our understanding that combination of sea level rise and tsunami inundation will be considered in the design of the Oceanfront Walk seawall bulkhead structure. The bulkhead restoration will protect the walkway but is not intended to protect structures east of Oceanfront Walk from flooding or damage following a tsunami.

There are no policies or recommendations of the Mission Bay Park Improvement Projects that will have a direct or indirect significant environmental effect with regards to geological hazards. The proposed land uses are compatible with the known geological hazards. Storm water infiltration into soils may be limited by shallow ground water and alternative systems like bioswales or bioretention basins may be needed. Geotechnical investigations are recommended for any settlement sensitive construction adding additional loads (structural or fill) to settlement prone soil.

1. INTRODUCTION

The Bodhi Group has updated the previously prepared Geotechnical and Geological Hazards Study (Study) of the Mission Bay Park Improvement Projects (Study Area) for the City of San Diego (City) on behalf of Dudek as part of an Environmental Impact Report (EIR) for the Mission Bay Park Improvements Program (Program) in San Diego, California. The Program is inclusive of site-specific project elements and bay-wide programmatic elements (Dudek 2025). The Program location consists of the Mission Bay Park Improvement Zone (Improvement Zone and Study Area), as defined in City of San Diego Charter Section 55.2 and shown on Figure 1.

The Study was limited to a “desktop” California Environmental Quality Act (CEQA)-level evaluation of the Study Area, which does not include field investigation or engineering analysis. The purpose of the Study is to identify geotechnical and geological conditions and hazards that might affect future development and/or redevelopment within the Study Area. The scope of the “desktop” Study is listed below.

- Reviewed relevant published geological information including; State of California-issued geological and hazard maps, the City of San Diego Seismic Safety Study Geologic Hazards and Faults maps (City of San Diego 2008a), and the City of San Diego Guidelines for Geotechnical Reports (City of San Diego 2018).
- Reviewed draft documents of the Mission Bay Park Improvement Program prepared by the City showing the location and description of planned improvements in the Mission Bay Park Improvement Zone. The improvements have been updated from the previously published report.
- Reviewed and summarized regional and local geology and identified potential geotechnical and geological hazards (see Section 15 for multiple references).
- Researched and identified relevant geological hazards listed in the “Guidelines for Geologic/Seismic Consideration in Environmental Impact Reports,” by the California Geological Survey (California Division of Mines and Geology) Note 46 (CGS 1986), and “Guidelines for Preparing Geologic Reports for Regional-Scale Environmental and Resource Management Planning,” by the California Geological Survey (California Division of Mines and Geology) Note 52, as amended or updated (CGS 2013).
- Researched other City and County of San Diego resources, and our in-house library of historical vertical aerial photographs, for geotechnical and geological hazards such as faulting, seismicity, and liquefiable soils (see Section 15 for multiple references).
- The brief site reconnaissance performed on November 23, 2018, was updated with additional site visits. Similar to 2018, access to some areas was limited by private property and locked fences.
- Updated this technical report, which identifies geotechnical and geological hazards. Included in this report is a location map (Figure 1), a map of the regional and Study Area geology showing distribution of surficial deposits and geological units (Figure 2); a map of the active regional faults in southern California (Figure 3) and a geological hazards map identifying areas susceptible to the potential geological hazards described in this report (Figure 4).

1.1. Significant Assumptions

Documentation and data provided by the client or from the public domain, and referred to in the preparation of this Study, are assumed to be complete and correct and have been used and referenced with the understanding that the Bodhi Group assumes no responsibility or liability for their accuracy. The conclusions contained herein are based upon such information and documentation. Because Study Area conditions may change, and additional data may become available, data reported, and conclusions drawn in this report are limited to current conditions and may not be relied upon on a significantly later date or if changes have occurred at the Study Area.

Reasonable CEQA-level efforts were made during the Study to identify geological hazards. “Reasonable efforts” are limited to information gained from information readily-accessible to the public. Such methods may not identify Study Area geological or geotechnical issues that are not listed in these sources. No other warranties are made to any third party, either expressed or implied.

1.2. User Reliance

This report was prepared for the use solely and exclusively by Dudek and the City of San Diego. The report is not for the use or benefit of, nor may it be relied upon by, any other person or entity for any purpose without the advance written consent of the Bodhi Group. In the preparation of this report, the Bodhi Group has used the degree of care and skill ordinarily exercised by a reasonably prudent professional in the same community in the same time frame given the same or similar facts and circumstances.

2. PROJECT LOCATION AND DESCRIPTION

The Mission Bay Park Improvement Zone/Study Area is located in the City of San Diego, between Interstate 5 to the east and the Pacific Ocean to the west, generally bounded by the communities of Pacific Beach on the northern side and Ocean Beach on the southern side, as shown on Figure 1. The Improvement Zone encompasses the 4,235-acre Mission Bay Park as well as several additional nearby areas. Specific project areas ("elements") are located within the Improvement Zone, as shown on Figure 1.

Topographically, the Study Area is situated on flat to gently sloping marshlands and dredged artificial fill supporting the Study Area improvements. A summary of the major project improvements and project elements is provided in Table 1, below.

Table 1 – Summary of Proposed Improvements

Project Element and Location	Nature of Proposed Improvements
Wetland and Water Quality Improvements	
North Fiesta Island	Approximately 315,000 cubic yards of soil will be excavated for wetland improvements and used in other projects
Tecolote Creek and Fiesta Island Causeway	Earthwork and grading to create a channel under the Fiesta Island Causeway and create 12 acres of wetlands and construction of a forebay at the mouth of Tecolote Creek. Import of 180,000 cubic yards of material into the proposed wetland footprint at the existing location of the Tecolote Creek mouth and east Mission Bay.
Cudahy Creek	Create wetlands area including oyster bags, berm, riprap revetment; import of approximately 58,000 cubic yards of soil
Shoreline Restoration	
Vacation Island NW	Restore and stabilize sandy beach with sand replenishment; install boardwalk
Vacation Island NE	Beach nourishment/stabilization; riprap revetment
Vacation Island SW	Repair and improve riprap revetment to create a perched beach
Ventura Cove	Repair riprap revetment
Crown Point	Construct a seawall for shoreline protection
West Sail Bay	Beach nourishment
Bonita Cove	Beach nourishment; sidewalk relocation
Bahia Point	Beach nourishment and stormwater improvements
Upland Habitat and Preserve Expansion	
Fiesta Island Site No. 1 South	Habitat restoration, including removal of non-native plants, berm grading, temporary irrigation system; fencing
Fiesta Island Site No. 3 Near Youth Camping	None at this time
Fiesta Island Site No. 4 North	Berm modification and establishment; reconfigure trails

Project Element and Location	Nature of Proposed Improvements
Fiesta Island Site No. 5 Least Tern Preserve	Berm revegetation and import of sand and shells
Sea World Drive / San Diego River Site No. 1a Cloverleaf	Removal of non-native plants; import of sand and shells; minor topographic variation and mounding
Sea World Drive/San Diego River Site No. 3c Triangle	Remove non-native plants; installation of native container plants and seeds
Sea World Drive/San Diego River Site No. 4d South Shores	Remove non-native plants; import of soil/sand; installation of native container plants and seeds
Bicycle and Pedestrian Improvements	Remove and replace existing pavement (3 inches of concrete over 9 inches of crushed aggregate base)
Rose Creek Bike Path	Extend several storm drain systems; lower some portions of bike path for clearance
Fiesta Island Causeway	No utilities impacted
Ocean Beach Bike Path	No utilities impacted
Robb Field/Gateway Connectivity Path	Relocate utility cabinet; install retaining wall with footings
Restoration of Seawall Bulkhead – Mission Beach – Pacific Beach	New wall placed on top of existing pile caps; grouting to fill voids under boardwalk; new wall with spread footings to Crystal Pier; replace stairways to beach; create vehicle access at Thomas Road
Deferred Maintenance – Bay-wide	Varied; may include repairs to parking lots, lighting, comfort stations, playgrounds, fire pits, stormwater infrastructure
Signage Update – Bay-wide	De minimis

3. HISTORY

Mission Bay was developed from the 1940s through the 1960s. The Bay was named “False Bay” by Juan Rodriguez Cabrillo in 1542 due to a northern shift of the San Diego River Terminus from San Diego Bay to “False Bay”. In 1852 the United States Army constructed the first dike along the south side of the river to prevent it from shifting back to San Diego Bay and created an estuary outlet for the river drainage (which failed soon after construction was completed). During the late 1800s, recreational development took place, but the facilities were destroyed by flooding years later. In the late 1940s, dredging and filling operations began converting the marsh into Mission Bay Park which is almost entirely man-made. Approximately one-half of the park was once tidelands. Today levees are present on the north and south sides of the San Diego River and it no longer drains to Mission Bay (City of San Diego 2018).

4. GEOLOGY

San Diego is located within the western (coastal) portion of the Peninsular Ranges Geomorphic Province of California. The Peninsular Ranges encompass an area that roughly extends from the Transverse Ranges and the Los Angeles Basin, south to the Mexican border, and beyond another approximately 800 miles to the tip of Baja California (Harden 1998). The geomorphic province varies in width from approximately 30 to 100 miles, most of which is characterized by northwest-trending mountain ranges separated by subparallel fault zones. In general, the Peninsular Ranges are underlain by Jurassic-age metavolcanic and metasedimentary rocks and by Cretaceous-age igneous rocks of the southern California batholith. Geological cover over the basement rocks in the westernmost portion of the province in San Diego County generally consists of Upper Cretaceous-, Tertiary-, and Quaternary-age sedimentary rocks. Figure 2, Regional Geologic Map, modified from Kennedy and Tan (2008), shows the regional geology.

Structurally, the Peninsular Ranges are traversed by several major active faults. The Elsinore, San Jacinto, and the San Andreas faults are major active fault systems located northeast of San Diego and the Rose Canyon, San Diego Trough, Coronado Bank and San Clemente faults are major active faults located within or west-southwest of San Diego. Major tectonic activity associated with these and other faults within this regional tectonic framework is generally right-lateral strike-slip movement. These faults, as well as other faults in the region, have the potential for generating strong ground motions in the Study Area. Figure 3 – Regional Fault map shows the proximity of the Study Area to nearby mapped Quaternary faults.

4.1. Local Geology

The geological units exposed in the Study Area consist of artificial fill (dredged hydraulic fill), young beach deposits, and Old paralic deposits (Unit 6). Although not exposed in the Study Area, it is believed that the artificial fill is underlain locally by young alluvium, and young estuarine deposits. The young deposits are likely underlain by Old paralic deposits (Unit 6). Older Pliocene and Eocene sedimentary rocks unconformably underlie the Old paralic deposits. Artificial fill, beach deposits, and young alluvium/estuarine deposits may be subject to consolidation under additional fill or structural loads (Figure 2). Descriptions of the general characteristics of these units are presented below.

- Af – Artificial fill (late Holocene). The Study Area is underlain by a variable thickness of artificial fill consisting of dredged, hydraulically place materials sourced from Mission Bay. Based on old topographic maps (United States Coast & Geodetic Survey 1895), the fill likely ranges from 5-feet-thick along the shore line to about 20-feet-thick in the northern portions of the Study Area. The fill likely consists of loose to medium dense sand (SCST 2018, Bodhi Group 2025). Portions of the fill may have been compacted during construction of existing streets and building pads, although there is no readily-available documentation of compaction. The artificial fill may be subject to settlement under building or additional fill loads.
- Qya – Young alluvial and estuarine deposits (Holocene and late Pleistocene). The young alluvial and estuary (estuarine) deposits are not exposed at the ground surface in the Study Area. Young alluvial and estuarine deposits likely underlie the artificial fill and are characterized as poorly consolidated, sand, silt and clay layers. The alluvium is loose to soft and saturated. The young alluvial and estuarine deposits are subject to settlement under building or additional fill loads and are liquefiable.
- Qmb – Young marine beach sediments (Holocene). The beach deposits are located west of the Oceanfront Walk seawall bulkhead and consist of unconsolidated, clean, fine to medium grained sand. The thickness of the sediments is dependent on seasonal variations in swell direction and intensity. Large storm surf has eroded the beach down to the underlying Old paralic deposits (Unit 6) and

exposed the bulkhead foundations during El Nino episodes. The beach sediments are compressible and erodible.

- Qop6 – Old paralic deposits, Unit 6 (middle to early Pleistocene). The Old paralic deposits are exposed in the Crown Point area and are believed to underlie the young alluvial, beach, and estuarine deposits. The Unit 6 deposits consist of poorly sorted, moderately permeable, well consolidated, reddish brown, interfingered strandline, beach, estuarine, and colluvial deposits composed of siltstone, sandstone, and conglomerate. These paralic deposits are well consolidated and might be sufficient to support deep foundations for light structural loads.

4.2. Local Structural Geology

The older geology (Pliocene and Eocene sedimentary rocks) underlying the Study Area dips (tilts) gently to the west and east forming a north-south trending syncline (Figure 2). The Old paralic deposits are flat lying or dip gently to the west. The older geology, including the Old paralic deposits have been tilted and faulted just east of the Study Area by the Rose Canyon fault zone.

5. TECTONICS AND SEISMICITY

San Diego is affected by the boundary between the North American and Pacific tectonic plates. The boundary, in southern California. is characterized by a wide zone of predominantly northwest-striking, right-slip faults that span the Imperial Valley and Peninsular Range to the offshore California Continental Borderland Province (from the California continental slope to the coast). The San Clemente fault zone located 60 miles west of San Diego and the San Andreas fault zone 70 miles east of San Diego define the plate boundary that affects the Study Area. The most active faults based on geodetic and seismic data are the San Andreas, San Jacinto, and Imperial faults. These faults take up most of the plate motion. Smaller faults, however, are active enough to create damaging earthquakes and these include the Elsinore, Newport-Inglewood-Rose Canyon, and the offshore Coronado Banks, San Diego Trough, and San Clemente fault zones (Figure 3).

5.1. Local and Regional Faults

Table 2 summarizes the local and regional fault characteristics for the active faults that will affect the Study Area. A Quaternary fault is defined by the State of California (2007) as a fault that shows evidence of movement in the last 1.6 million years. Quaternary (Holocene and Pleistocene) faults can be classified as either active or potentially active faults. Active faults are those Quaternary Holocene faults which have been shown to have ruptured in the last 11,000 years. Potentially active faults are those Quaternary Pleistocene faults which have been shown to have ruptured during the 1.6 million years but not within the last 11,000 years. Potentially active faults have a much lower probability for future activity than active faults. The Study Area is not underlain by active or potentially active faults. Earthquakes on the faults summarized below will, however, create ground shaking that can affect the Study Area.

The nearest active fault capable of causing ground rupture and strong earthquake shaking is the Rose Canyon fault zone located 1000 feet east of the centroid of the Study Area. A buried active trace of the fault zone has been mapped to underlie North Mission Bay Drive in the northeast corner of the Study Area. The Rose Canyon fault zone is the southernmost portion of the Newport-Inglewood fault zone which extends from Long Beach to the north to the Descanso fault, offshore of Baja California. A Magnitude 6.3 earthquake occurred on the Newport-Inglewood fault in 1933 and caused serious damage in the Los Angeles area. There have been no historical damaging earthquakes documented on the Rose Canyon fault nor has there been historical fault rupture. Fault trenching on the Rose Canyon fault has shown that the fault has ruptured the ground surface several times in the last 10,000 years (Rockwell 2010). The previously mapped traces of the Rose Canyon fault zone are located beneath the Interstate 5 freeway or east of the freeway.

Table 2 - Fault Characteristics for Active Faults in the Region

Fault Name	Approximate Distance to Study Area (mi)	Slip Rate (millimeters/ year)	Fault Length (miles)	Estimated Magnitude (Maximum Moment Magnitude (Mw))
Newport-Inglewood-Rose Canyon Fault Zone	0.2 mi	1.5	130	7.2
Coronado Bank Fault Zone (offshore)	14	3.0	115	7.6
San Diego Trough Fault Zone (offshore)	20	1.5	106	7.5
San Miguel-Vallecitos Fault Zone (Northern Baja California)	30	0.2	100	6.9
Elsinore Fault Zone	41	5.0	190	7.0
San Clemente Fault Zone (offshore)	23		129	7.7
San Jacinto Fault Zone	63	4.0	152	6.8
Southern San Andreas Fault Zone	90	25	140	7.2

Table References include: CDMG 2002; CGS 2010; Hirabayashi and others 1996; Kahle and others 1984; Ryan and others 2012; and California Department of Conservation 2008.

The nearest potentially active fault to the Study Area is an unnamed fault associated with the Rose Canyon fault zone located beneath North Mission Bay Drive along the eastern boundary of the Study Area. The fault extends from the southern portion of Mount Soledad, southward where it is observed joining Rose Canyon fault proper. The fault is observed offsetting Pliocene San Diego Formation but not early Pleistocene Very Old paralic deposits.

5.2. Historical Earthquakes

The available record of historical (dating back to the late 1700s) earthquakes larger than Magnitude 6 in the coastal San Diego area is as complete as other regions in the State of California (Anderson et al. 1989). Only a small number of earthquakes have been reported in coastal San Diego whereas other portions of southern California and Baja California, Mexico, have experienced many moderate to large earthquakes in the same historical window.

Strong shaking and minor damage has occurred in the coastal San Diego region as a result of large earthquakes on distant faults or smaller earthquakes on local faults (Agnew et al. 1979; Toppozada et al. 1981). Earthquakes in Imperial County and northern Baja California in 1800, 1862, and 1892 are believed to have produced the strongest intensities in the San Diego area.

In the 1930s seismographs were established in San Diego. Since that time, swarms of small to moderate magnitude earthquakes have been recorded in San Diego Bay. In 1964, a swarm of small earthquakes was reported generally in south San Diego Bay (Simmons 1977). In 1985 a swarm of earthquakes with a maximum magnitude of M4.7 occurred just over one-half mile south of the Coronado Bay Bridge (Reichle et al. 1985). A magnitude M5.3 earthquake and a series of aftershocks occurred about 44 miles west of Oceanside in 1986 (Hauksson and Jones 1988). The 1986 earthquake was widely felt but did not cause significant damage.

6. LANDSLIDES AND SLOPE STABILITY

The Study Area is relatively flat. Landslides and slope stability will not affect the Study Area unless new slopes are created during development.

7. SOILS AND INFILTRATION

The artificial fill at the site is predominantly granular and unconsolidated, which should create high infiltration rates. Shallow groundwater may affect artificial storm water recharge systems. Other factors that should be considered in evaluating storm water infiltration feasibility including lateral migration of water and groundwater mounding. A full list of criteria is enumerated in the City of San Diego Storm Water Standards, Part 1, 2017 Edition (City of San Diego 2017).

8. HYDROGEOLOGY

Groundwater conditions are dominated by the adjacent Mission Bay. The groundwater is saline to brackish and is typically found at sea level. Groundwater depths will vary with the tides.

9. DRAINAGE AND FLOODING

The Study Area is situated on a mixed recreation and residential land use area. Current drainage is into streets, storm drains, and gutters that flow into Mission Bay. Grassy park land sheet flows into the bay. Rose Creek flows in a rip-rap lined dredged channel into the Bay. The Study Area is within Zone-X of the San Diego County Flood Insurance Rate Map (FIRM). The most recent FIRM maps were downloaded from the San Diego Geographic Information Source regional data warehouse. The Study Area has a 1% chance of flood with average depths of less than 1 foot.

10. MINERALOGIC RESOURCES

Data from the USGS Mineral Resource Data System show that there are no mineral resources in the Study Area (USGS 2015a).

11. GEOLOGICAL HAZARDS AND IMPACTS

This section identifies geological hazards that may affect proposed policies, programs, and land use for the Mission Bay Improvement Projects. The planned improvements consist mostly of Building Type Land Use VI (City of San Diego 2008b), shoreline restoration, stabilization, habitat and wetland creation and restoration. These types of improvements are generally immune to most geological hazards because they are not sensitive to settlement or seismic hazards. The improvements that are sensitive to geological hazards are those with hard elements (concrete, steel, pipelines) that might be damaged or fail due to settlement or seismic effects. The geological hazards that may affect Projects in the Study Area include seismicity and ground motion; ground rupture; liquefaction; seismically-induced settlement; and flooding due to long-term sea-level rise, tsunamis, and seiches.

These hazards can be addressed through administrative controls (e.g., avoiding building in hazard-prone areas or structure setback) and/or engineering improvements (e.g., ground improvement, ground restraints, or appropriate structure foundation). Site-specific and hazard-specific geotechnical investigations would be required to evaluate the appropriate mitigation measure or combination of measures.

The City of San Diego Seismic Safety Study documents the city’s known and suspected geological hazards and faults (City of San Diego 2008a). The Geologic Hazards and Faults Maps in the Seismic Study show potential hazards and rates them by relative risk, on a scale from nominal to high. The Seismic Safety Study is intended as a tool to determine the level of geotechnical review to be required by the City for planning, development, or building permits. The Study Area occupies portions of Map grids 20 and 25. Identified hazards and others are described below. Figure 3 shows active faults in the study area. Figure 4 shows other geological hazards. The Study Area is designated Geologic Hazard Category 31; “high potential for liquefaction due to high groundwater...and hydraulic fills”. The northeastern most portion of the Study Area is shown to be underlain by potentially active and active buried faults.

11.1. Seismicity and Ground Motion

An active fault is defined by the State Mining and Geology Board as one that has experienced surface displacement within the Holocene epoch, i.e., during the last 11,000 years (CGS 2007). The Study Area is subject to potential ground shaking caused by activity along faults located near the Study Area.

Ground shaking during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and the type of geological material underlying the area. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. Areas that are underlain by bedrock tend to experience less ground shaking than those underlain by unconsolidated sediments such as artificial fill or unconsolidated alluvial fill.

As noted, the Study Area is subject to ground shaking hazards caused by earthquakes on regional active faults (Figure 3). Based on a Probabilistic Seismic Hazards Ground Motion Interpolator provided by the California Department of Conservation (2008), the Study Area (Longitude -117.229562, Latitude

32.776084) is located in a zone where the horizontal peak ground acceleration having a 10 percent probability of exceedance in 50 years is 0.57g (where g represents the acceleration of gravity)[1].

11.2. Ground Rupture

Large earthquakes (usually in excess of Magnitude M5) often rupture the ground surface, shifting the ground up or down or shearing sideways on either side of the fault. The active Rose Canyon fault zone trace mapped beneath North Mission Bay Drive (Figure 3) could possibly cause a combination of sideways (right lateral) and vertical rupture (up on the west side of the fault) on the order of several inches to a foot if a large magnitude earthquake occurred on that specific trace. The precise location of the fault is not well documented and was based on 1929 aerial photographs and older topographic maps.

11.3. Liquefaction, Seismically Induced Settlement, and Lateral Spreading

The entire Study Area is underlain by liquefiable soil (Figure 4). Liquefaction is a phenomenon whereby unconsolidated and/or near-saturated soils lose cohesion as a result of severe vibratory motion. The relatively rapid loss of soil shear strength during strong earthquake shaking results in temporary, fluid-like behavior of the soil. Soil liquefaction causes ground failure that can damage roads, pipelines, underground cables, and buildings with shallow foundations. Research and historical data indicate that loose granular soils and non-plastic silts that are saturated by a relatively shallow groundwater table are susceptible to liquefaction.

Among the potential hazards related to liquefaction are seismically induced settlement and lateral spreads. Seismically induced settlement is caused by the reduction of shear strength due to loss of grain-to-grain contact during liquefaction and may result in dynamic settlement on the order of several inches to several feet. Other factors such as earthquake magnitude, distance from the earthquake epicenter, thickness of the liquefiable layers, and the fines content and particle sizes of the liquefiable layers will also affect the amount of settlement. While slopes in the Study Area are very gentle, there is sufficient gradient along the shoreline to create conditions for lateral spreading, in which the ground surface moves laterally during liquefaction. The potential for lateral spread can increase in areas where fills placed for improvement create an artificial gradient (slope).

11.4. Tsunamis, Seiches, and Dam Failure

A tsunami is a sea wave generated by a submarine earthquake, landslide, or volcanic action. Submarine earthquakes are common along the edge of the Pacific Ocean, thus exposing all Pacific coastal areas to the potential hazard of tsunamis. Seiches are seismically induced waves within enclosed bodies of water such as Mission Bay. A seiche could be created by a large magnitude earthquake occurring on the Rose Canyon fault zone. Data from the San Diego Geographic Information Source regional data warehouse shows portions of the Study Area within the inundation zone (Figure 4). The inundation zone does NOT consider sea level rise (sea level rise is being addressed by other technical studies).

An earthquake-induced dam failure can result in a severe flood event. When a dam fails, a large quantity of water is suddenly released with great potential to cause human casualties, economic loss, lifeline

[1] Peak ground acceleration is used to measure the effect of an earthquake on the ground. For example, 0.001 g is perceptible by people, 0.02 g causes people to lose their balance, and 0.5 g is very high, but buildings can survive if the duration is short and if the mass and configuration has enough damping.

disruption, and environmental damage. Based on data from the San Diego Geographic Information Source regional data warehouse, a major portion of Study Area is in the inundation zone from failure of upstream dams (Figure 4).

11.5. Shallow Groundwater

Groundwater elevation will affect excavations and below ground structures. Excavations (basements, utilities, foundation excavations) will require stabilization measures during construction. Below ground structures will need to take groundwater levels into consideration for drainage.

11.6. Subsidence

Subsidence typically occurs when extraction of fluids (water or oil) cause the reservoir rock to consolidate. Water extraction is minimal in the Study Area and the geological materials area well consolidated. Subsidence is not a hazard in the Study Area.

Settlement of unconsolidated soil (fill or alluvial/estuarine sediments) may occur locally where new loads are imposed on previously uncompacted fill or unconsolidated alluvium.

11.7. Infiltration

The soil under the Study Area is predominantly granular and will likely exhibit high infiltration rates. On-site storm water infiltration facilities will need to consider shallow groundwater (mean higher high tide elevation) during design.

11.8. Expansive or Corrosive Soils

The soil in the Study Area is granular and is not expected to be expansive. Because the groundwater under the Study Area is derived from Mission Bay, it will be salty or brackish. Corrosion of metal will occur if the metal is in contact with ground water.

11.9. Summary

In summary, the major geohazards in the Study Area are effects of seismic events such as liquefaction, settlement, lateral spreading, and inundation from tsunamis and dam failure. As indicated previously, the hazards can be addressed through administrative controls and/or engineering improvements.

12. IMPACT MITIGATION

The impacts summarized above may be addressed through administrative controls (e.g., avoiding building in hazard-prone areas or structural setback areas) and/or engineering improvements (e.g., ground improvement, ground restraints, remedial grading or foundation design). Site specific geotechnical investigations are required to recommend the appropriate mitigation measure(s).

12.1. Seismicity and Ground Motion

The entire Study Area will be affected by seismicity and ground motion. Most of the proposed land use is park, wetland creation, or habitat that will not be adversely affected by ground shaking. Culverts, bridges, and the bulkhead will be affected by ground shaking. Mitigation can be accomplished by geotechnical and structural engineering design. Geotechnical investigations should be conducted in accordance with City of San Diego Guidelines for Geotechnical Reports (City of San Diego 2018) and State of California requirements (CGS 2013). Most mitigation measures will involve foundation and structural design and ground improvement.

12.2. Liquefaction, Seismically Induced Settlement

Liquefaction and seismically induced settlement will not likely impact park, wetland and habitat improvements. Culverts, bridges, and the bulkhead will be affected by ground shaking. Mitigation can be accomplished by geotechnical and structural engineering design. Geotechnical investigations should be conducted in accordance with City of San Diego Guidelines for Geotechnical Reports and State of California requirements. Most mitigation measures will involve foundation design and ground improvement. Repair of damage to pavements from liquefaction is not considered significant.

12.3. Fault Rupture

Ground rupture on active faults may affect North Mission Bay Drive and the easternmost Study Area. Damage to pavements will be repairable. No improvements are planned in this area for the Mission Bay Park Improvement Projects.

12.4. Flooding due to Tsunamis and Seiches

Flooding of parks, wetland, and habitat improvements are not considered significant and do not require mitigation. For other improvements, sea level rise and tsunami inundation levels will be considered in design. It is assumed that the bulkhead restoration along Oceanfront Walk will be designed to protect the walkway and not the residential buildings east of the walkway. The impact of flooding due to tsunamis on the residential structures is not within the scope of the planned improvements. Docks or other recreational facilities may need to be replaced following flooding events.

12.5. Shallow Groundwater

Construction of below-ground structures and excavations for foundations and utilities will need to take groundwater elevations into consideration in design and construction. Geotechnical investigations should be performed in accordance with City of San Diego Guidelines for Geotechnical Report. Mitigation measures typically include temporary shoring, casing, use of drilling muds for excavations and drains, or waterproofing of below ground structures.

12.6. Subsidence

Construction of improvements in areas underlain by alluvium or fill should be designed to withstand settlement of unconsolidated soil. Geotechnical investigations for design of settlement resistant structures should be conducted in accordance with City of San Diego Guidelines for Geotechnical Reports. Mitigation measures typically include ground improvement and/or foundation design.

12.7. Corrosive Soil

Corrosive soil should be evaluated by a Corrosion Engineer for recommendations for soil replacement or cathodic protection.

12.8. Infiltration

Infiltration potential should be evaluated in accordance with City of San Diego Storm Water Standards (City of San Diego 2024).

13. THRESHOLDS OF SIGNIFICANCE

In accordance with Appendix G of the CEQA Guidelines, the project will have significant effect on the environment if:

G-1 Expose people to potential substantial adverse effects, including the risk of loss, injury or death involving: a) fault rupture, b) seismic shaking, c) seismic ground failure, d) landsliding.

G-2 Result in substantial soil erosion or loss of top soil.

G-3 Be located in a geological unit or soil that is unstable (landsliding, settlement, lateral spreading) or that would become unstable as a result of the project.

G-4 Be located on expansive soil causing substantial risk to life or property.

G-5 Having soils incapable of supporting the use of septic tanks where sewers are not available.

13.1. Threshold G-1 a) Fault Rupture

No significant effect. While there are active and potentially active faults in the Study Area, no rupture-sensitive improvements are proposed for these areas.

13.2. Threshold G-1 b) Strong Seismic Ground Shaking

Less than significant effect. Construction of culverts, bridges and bulkheads will be required to use seismic resistant designs in accordance with California and City standards and codes.

13.3. Threshold G-1 c) Seismic Ground Failure

Less than significant effect. Most improvements are not susceptible to damage due to ground failure (parks, wetland, and habitat improvements). Construction of culverts, bridges and bulkheads will be required to use designs resistant to ground failure in accordance with California and City standards and codes.

13.4. Threshold G-1 d) Seismic Induced Landsliding

Less than significant effect. The Study Area is relatively flat and low lying. Any slopes planned for the improvements should constructed in accordance with City of San Diego standards and codes and should be stable under static and pseudostatic conditions.

13.5. Threshold G-2 Substantial Soil Erosion and Loss of Topsoil

Less than significant effect. Most of the Study Area is made of dredged fill where gradients are very low. As a result, the potential for erosion is very low. Since construction will be required to follow City of San Diego standards and code that stipulate protection against temporary and permanent erosion, the impact of erosion and loss of topsoil is less than significant.

13.6. Threshold G-3 Unstable Soil (Landslide, Settlement, Lateral Spreading)

<u>Landslides</u>: Less than Significant. Landslide prone geological formations and tall, steep slopes are not present in the Study Area.

<u>Settlement</u>: Less than Significant. Most of the improvements underlain by settlement prone soil are not susceptible to damage due to settlement (parks, wetland, and habitat improvements). Construction of

culverts, bridges, bulkheads, and substantial fills will be required to use designs resistant to settlement in accordance with California and City standards and codes.

Lateral Spreading: Less than Significant. Most of the improvements in areas underlain by liquefiable soil area not susceptible to damage due to lateral spreading. Where culverts and bridges are constructed in areas susceptible to lateral spreads or where fill embankments will be required, will be designed and constructed to geotechnical standards that reduce lateral spread impacts to acceptable levels.

13.7. Threshold G-4 Expansive Soil

Less than Significant. Expansive soils are generally not present in the Study Area.

13.8. G-5 Soil Unsuitable for Onsite Sewage Disposal Systems

Less than Significant. Shallow groundwater will preclude the use of onsite sewage disposal systems in the Study Area.

14. CONCLUSIONS

The conclusions from this Study are listed below.

- There are no geological hazards that cannot be avoided or addressed.
- There are no policies or recommendations of the Mission Bay Park Program EIR that will have a direct or indirect significant environmental effect with regard to geological hazards.
- The proposed land uses are compatible with the known geological hazards.
- There are no potential impacts related to geological hazards from the implementation of the Mission Bay Park Improvement Projects that can't be avoided, reduced to an acceptable level of risk, or reduced below a level of significance through mandatory conformance with applicable regulatory requirements and the recommendations of this technical report
- The impact of unstable soil can be reduced to less than significant levels by requiring geotechnical investigations on settlement sensitive projects (culverts, bridges, bulkheads and areas where substantial amounts of fill may be placed).

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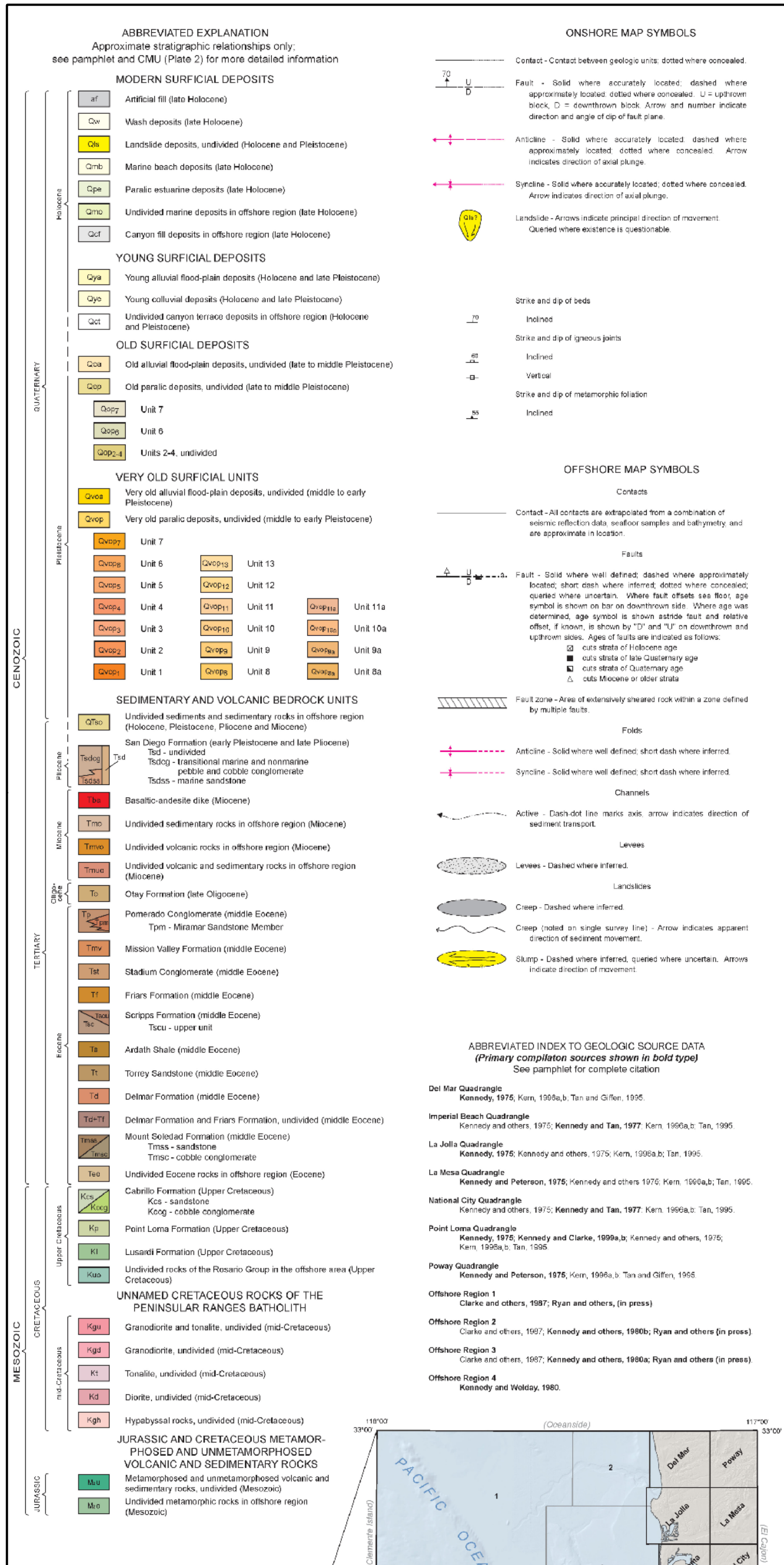
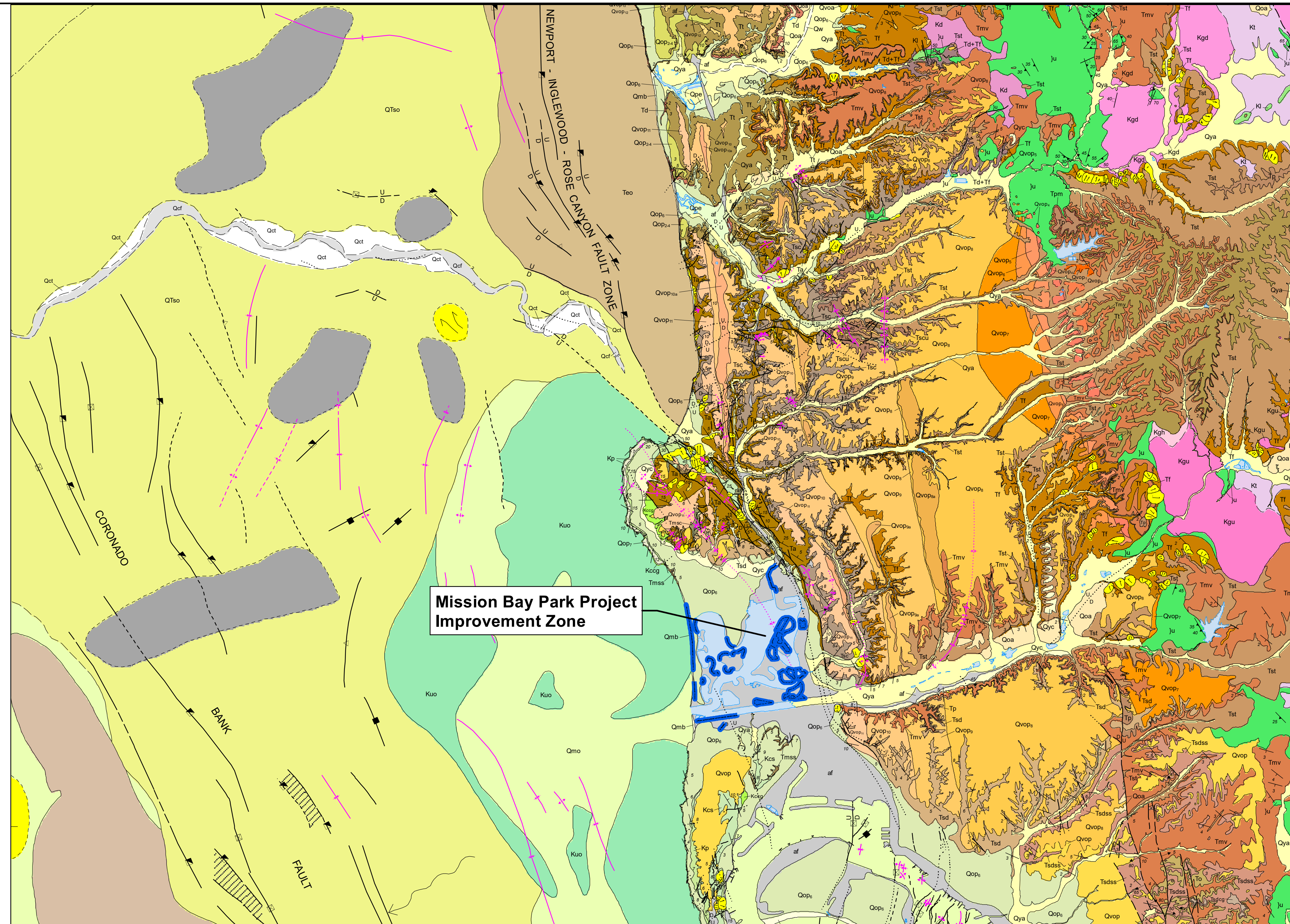
Figures

Mission Bay Park Improvement Zone and Project Elements
Mission Bay Programmatic EIR

FIGURE 1





Mission Bay Improvement Zone Project Element

N
W E
S

0 7,500 15,000 Feet

Project No. 9127010

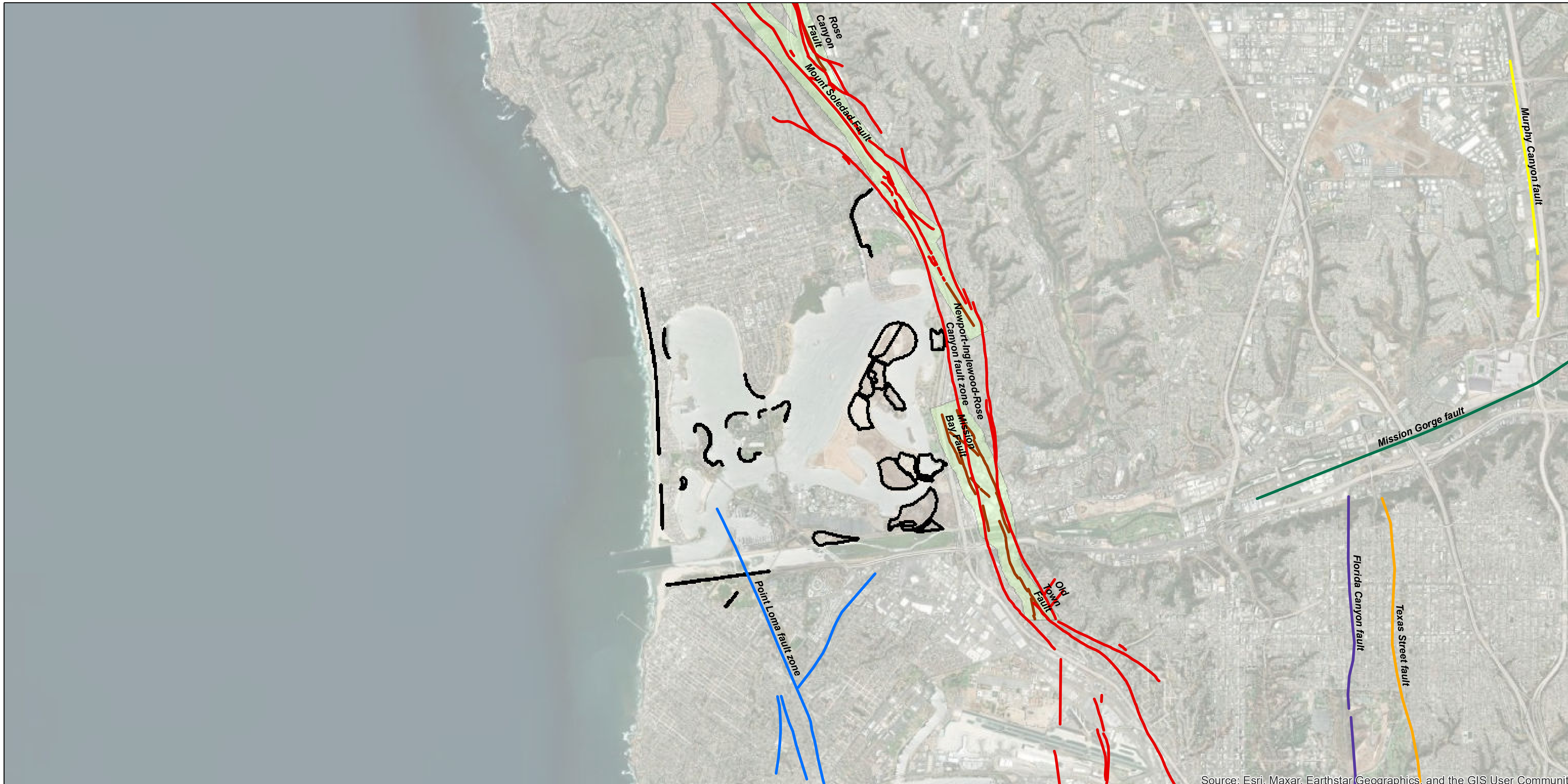
Date: 06/2025

Drawn By: SG

Regional Geology
Mission Bay Park Project Improvement Zone
Mission Bay Programmatic EIR

Mission Bay
San Diego, California

Figure 2



Legend

- Florida Canyon fault
- Mission Gorge fault
- Murphy Canyon fault
- Newport-Inglewood-Rose Canyon fault zone
- Point Loma fault zone
- Texas Street fault
- Active Fault Trace in the Alquist-Priolo Earthquake Fault Zone
- Alquist-Priolo Earthquake Fault Zone
- Mission Bay Improvement Zone Project Element

N W E S

Project No. 9127010

Date: 06/2025

Regional Fault Map

Mission Bay Park Project Improvement Zone

Mission Bay Programmatic EIR

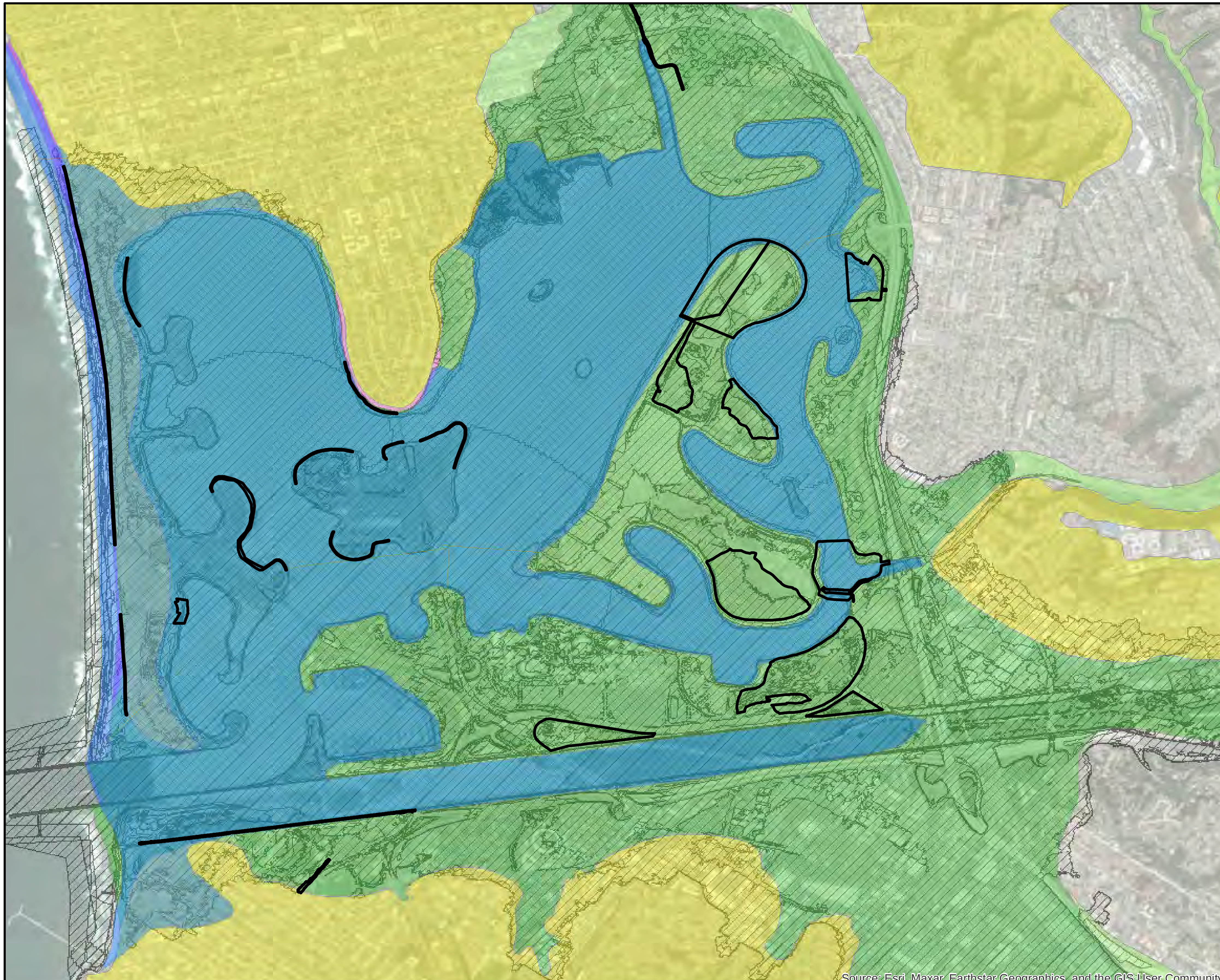
THE BODHI GROUP — INNOVATING | SUSTAINING | SOLVING

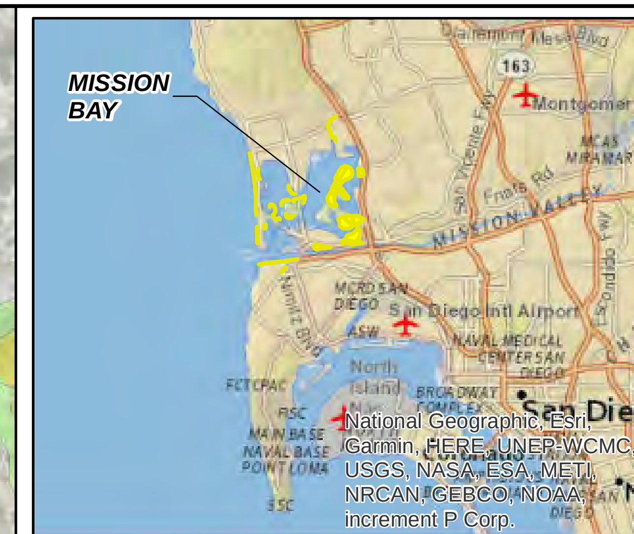
Not To Scale

Drawn By: SG

Mission Bay
San Diego, California

Figure 3





Geohazards

- LIQUEFACTION-High Potential-shallow groundwater major drainages, hydraulic fills
- LIQUEFACTION-Low Potential-fluctuating groundwater minor drainages, hydraulic fills
- COASTAL BLUFFS-Generally stable. Broad beach areas, developed harbor
- COASTAL BLUFFS-Generally stable. Favorable geologic structures, minor or no erosion, no landslides
- ALL OTHER CONDITIONS:other level areas; gently sloping to steep terrain, favorable geologic structure low risk
- Inundation area from dam failure
- Tsunami-seiche inundation area
- Mission Bay Improvement Zone Project Element

0 2,250 4,500 Feet

1 inch = 2,250 feet

N

THE BODHI GROUP
INNOVATING | SUSTAINING | SOLVING

Summary of Geohazards
Mission Bay Park Improvement Zone
Mission Bay Programmatic EIR

FIGURE 4