4.3 GEOLOGY, SOILS, AND SEISMICITY

The purpose of this section is to describe the geologic, soil, and seismic setting of the Project area, identify potential related impacts associated with the proposed Project, and recommend mitigation to reduce the significance of such impacts.

Information in this Section is based on the *Preliminary Geological/Geotechnical Assessment Report for the Dana Point Harbor Revitalization Project*, prepared by GeoPentech (January 15, 2004); the *Preliminary Geotechnical Investigation Report for the Dana Point Harbor Master Plan*, prepared by Leighton & Associates (December 12, 2002); and the *Bulkhead Structural Evaluation*, prepared by BlueWater Design Group (December 17, 2003). The complete reports are included in Appendix G (Geotechnical Study).

4.3.1 EXISTING CONDITIONS

4.3.1.1 GEOLOGIC STRUCTURE

Dana Point Harbor (Harbor) is located within the northwest-trending Peninsular Ranges in southern California. The Peninsular Ranges province is an elongated area characterized by parallel fault-bounded mountain ranges and intervening valleys. The province extends southward from the Transverse Ranges at the northern side of the Los Angeles Basin southward into Mexico. The Project area lies at the southernmost end of the San Joaquin Hills, which are a northwest trending topographically high area that extends southward from Newport Beach to Dana Point.

The Harbor is a coastal reentrant (cove) protected by the Headlands at Dana Point. The protected cove owes its existence to differing resistance to wave erosion of the two bedrock formations exposed along a fault in the steep coastal bluff. Bedrock units include the Capistrano Formation and the San Onofre Breccia, both of which are exposed in the sea cliffs behind the Harbor, which are separated by the Dana Cove Fault. The weaker Capistrano Formation has been preferentially eroded, creating Dana Cove. More youthful sediments have been deposited in the Harbor, including colluvium, alluvium, beach deposits, landslide debris, talus, and artificial fill placed during construction of the modern Harbor in the 1970s.

4.3.1.2 SURFICIAL UNITS

Artificial fill, beach sand, and alluvial deposits underlie the Harbor. The sea cliffs surrounding the Harbor to the north and west are cut into marine sedimentary rocks. The rocks exposed in the sea cliff are capped by marine and nonmarine terrace deposits, and the slopes along the sea cliff consist of landslide debris and talus deposits.

Leighton and Associates (L&A) performed a preliminary geotechnical investigation (2002) of a portion of the Commercial Core area between Dana Point Harbor Drive and the seawall, east of Casitas Place and west of the existing shipyard area, near Embarcadero Place (Planning Areas 1 and2). L&A reported that artificial fills in this area typically range in depth from 15 to 20 feet. The fills were reported to consist of sandy clay, clayey sand, and silty clay. A layer of dense to very dense, gravelly sand alluvium was reported at depths of 20 to 22 feet in one of L&A's borings. Fluvial terrace deposits are reported to be exposed at the extreme eastern portion of the Harbor.

Based on the result of the preliminary field investigation and laboratory testing, the near-surface fill soils within the Project area exhibit a low expansion potential. However, further sampling and testing during preparation of construction plans is recommended to confirm the preliminary findings.

The *Bulkhead Structural Evaluation* prepared by the BlueWater Design Group (December 2003) observed overall area settlement of 1 to 2 inches throughout the site. This includes areas significantly beyond the wall, including the parking areas and concrete drainage swales. Based on the observed uniformity, settlement has likely occurred throughout the entire site, rather than just within the local proximity of the wall. Settlement is suspected because of the use of loose unconsolidated fill material that was subsequently flooded after construction (when the cofferdams were breached). There is also a low-velocity flow of water during tidal fluctuations that may cause some movement of soil. It is not clear, based on field observations, when the settlement occurred over the life of the current facilities. There is evidence of grinding and placement of concrete transition strips on the sidewalks where differential movement has occurred.

The quay wall and revetment slope are designed to retain the earth of the upland side and provide a transition from the uplands area to the marina. Lateral load is imposed by the wedge of soil being retained as well as by surcharge from transient or live loads on the surface (such as vehicles). Additionally, vertical settlement appears to be the primary cause for requiring hardscape maintenance.

The bedrock is mantled by surficial earth units, including talus, beach sands, stream-deposited alluvium, and artificial fill. Artificial fill was encountered from two to 20 feet over the bedrock. Fill thickness increases toward the ocean, with the thickest section of alluvium in Planning Area 2,. Artificial fill generally consisted of sandy clay, clayey sand, and silty clay. Borings taken within Planning Area 3 encountered approximately five feet of alluvium over the bedrock. The alluvium was capped by fill, and consisted of gravelly sand.

4.3.1.3 BEDROCK UNITS

San Onofre Breccia. The San Onofre Breccia is a Middle Miocene-age (approximately 11 to 16 million years old) formation of marine origin. It consists of a very coarse, reddish-brown to blue-gray, massive to crudely bedded breccia with interbeds of coarse, pebbly sandstone and siltstone. The soil is generally an earthy, poorly cemented silt, or a well-cemented angular sand. The San Onofre Breccia is exposed at the western end of the Harbor along the east-facing cliffs, where it is in fault contact with the Capistrano Formation. The San Onofre Breccia is a bedrock unit that is resistant to erosion and forms the headlands at Dana Point.

Capistrano Formation. The Capistrano Formation is a Late Miocene to Early Pliocene-age (approximately 3.6 to 11 million years old) formation of marine origin. In the Dana Point area, the Capistrano Formation is widespread, with a total thickness of nearly 2,400 feet. This marine (ocean-deposited) bedrock formation is divided into a few recognizable subunits: a siltstone facies, a sandstone facies, and sandstone with conglomerate and sedimentary breccia. These three facies of the Capistrano Formation are all exposed in the sea cliffs surrounding the Project area, generally dipping and sloping northward. The siltstone facies is medium to dark gray and brownish gray to dark greenish gray, fine grained, poorly to moderately consolidated and massive to moderately fissile (capable of being split or divided in the direction of the grain or along natural planes of cleavage). The sandstone facies is yellowish brown to pale yellowish brown and medium gray to light gray, fine- to medium-grained, weakly cemented, and massive to poorly bedded. The sandstone and breccia facies is yellowish brown and coarse grained, weakly cemented to friable, with angular to rounded pebbles and cobbles of multiple origins, massive to poorly bedded and with interbeds of well-graded sand and silt. The bedrock encountered is from the siltstone facies of the Capistrano Formation. Capistrano Formation bedrock adjacent to the Dana Cove fault contact is sheared in a zone approximately 70 to 100 feet wide.

4.3.1.4 FAULTING AND SEISMICITY

Orange County, like most regions that border the Pacific Ocean, is a region of high seismic activity and therefore, is subject to potentially destructive earthquakes. Earthquakes are the result of an abrupt release of energy stored in the earth. This energy is generated from the forces that cause the continents to change their relative position on the earth's surface; this process is called "plate tectonics." Large earthquakes are caused by the rupturing of great rock masses under strain within the earth's crust. This usually takes the form of abrupt slipping or sliding along a rupture plane (fault). Each time two segments of the earth's crust suddenly shift past one another along a fault, an earthquake occurs. Major earthquakes are commonly accompanied by foreshocks and aftershocks, which are usually less intense and represent local yielding and adjustments of rock masses along the main zone of faulting.

PRIMARY AND SECONDARY HAZARDS

Earthquakes create two types of hazards: primary and secondary. Primary seismic hazards include ground shaking, ground displacement, subsidence and uplift due to seismic episodes. Primary hazards can, in turn, induce secondary hazards. These include the following: ground failure (lurch cracking, lateral spreading and slope failure), liquefaction, seismically induced water waves (tsunamis and seiches), movement on nearby independent faults (sympathetic fault movement) and dam failure.

ACTIVE FAULTS

Potentially active faults are those believed to have generated earthquakes during the Quaternary period, but prior to Holocene time. These include faults that are currently slipping, those that display earthquake activity, and those that have historical surface rupture. The California Division of Mines and Geology (CDMG) defines active faults as those that have had surface displacement within Holocene time (about the last 11,000 years). Such displacement can be recognized by the existence of sharp cliffs in young alluvium, unweathered terraces and offset modern stream courses.

The location of known active, potentially active and conjectural faults in relation to the Project area is shown on Exhibit 4.3-1 (Regional Fault Map). Descriptions of key faults surrounding the Project area are summarized below (refer to Table 4.3-1, *Summary of Active Nearby Faults*).

LOCAL FAULTS

Dana Cove Fault

This well-defined fault zone passes diagonally through the Harbor, directly under and nearly parallel to the existing West Basin Pier (bearing approximately 43 degrees west of north). The seaward projection is estimated to be approximately 250 feet wide, consisting of sheared breccia and contorted siltstones and sandstones. No seismic activity has been reported along this fault, which has been classified as inactive.

Newport-Inglewood Fault Zone/South Coast Offshore Zone of Deformation

The closest active fault to the Project area is the South Coast Offshore Zone of Deformation (SCOZD), which is approximately 3.4 miles (5.5 kilometers [km]) southwest of the Project area. The identification and characterization of the SCOZD is an ongoing research topic in southern California. The SCOZD represents the likely offshore connection between the Newport-Inglewood Fault Zone located to the northwest and the Rose Canyon Fault Zone located further to the south, forming the Newport-Inglewood – Rose Canyon Fault Zone. The SCOZD was identified on the basis of geophysical investigations as a continuous trace within a zone of en-echelon faults in the acoustic basement. Local northwest-to-west-trending folds in the shallower horizons are also associated with this zone.

The SCOZD extends approximately 42 miles from its northern terminus, located offshore approximately five miles south of Newport Beach, to its southern terminus, located offshore southwest of Oceanside.

The SCOZD appears to reflect a tectonic style similar to that of the onshore portion of the Newport-Inglewood Fault, which extends onshore from the east-west Malibu-Santa Monica Fault zone at the southern front of the Transverse Ranges to the northwest, to offshore between Newport Beach and Laguna Beach at the San Joaquin Hills Structural High. The Newport-Inglewood Fault is characterized by short, discontinuous, northwest-trending en-echelon, right-lateral faults, relatively shallow drag fold anticlines, and subsidiary normal and reverse faults. The Newport-Inglewood Fault was the source of the destructive 1933 Long Beach Earthquake (Maximum Magnitude [Mw] 6.4). Scientists from the U.S. Geological Survey (USGS) also interpret recent faulting at the base of the slope between Dana Point and Oceanside to be related to a strand of the Newport-Inglewood Fault.

Table 4.3-1
SUMMARY OF ACTIVE NEARBY FAULTS

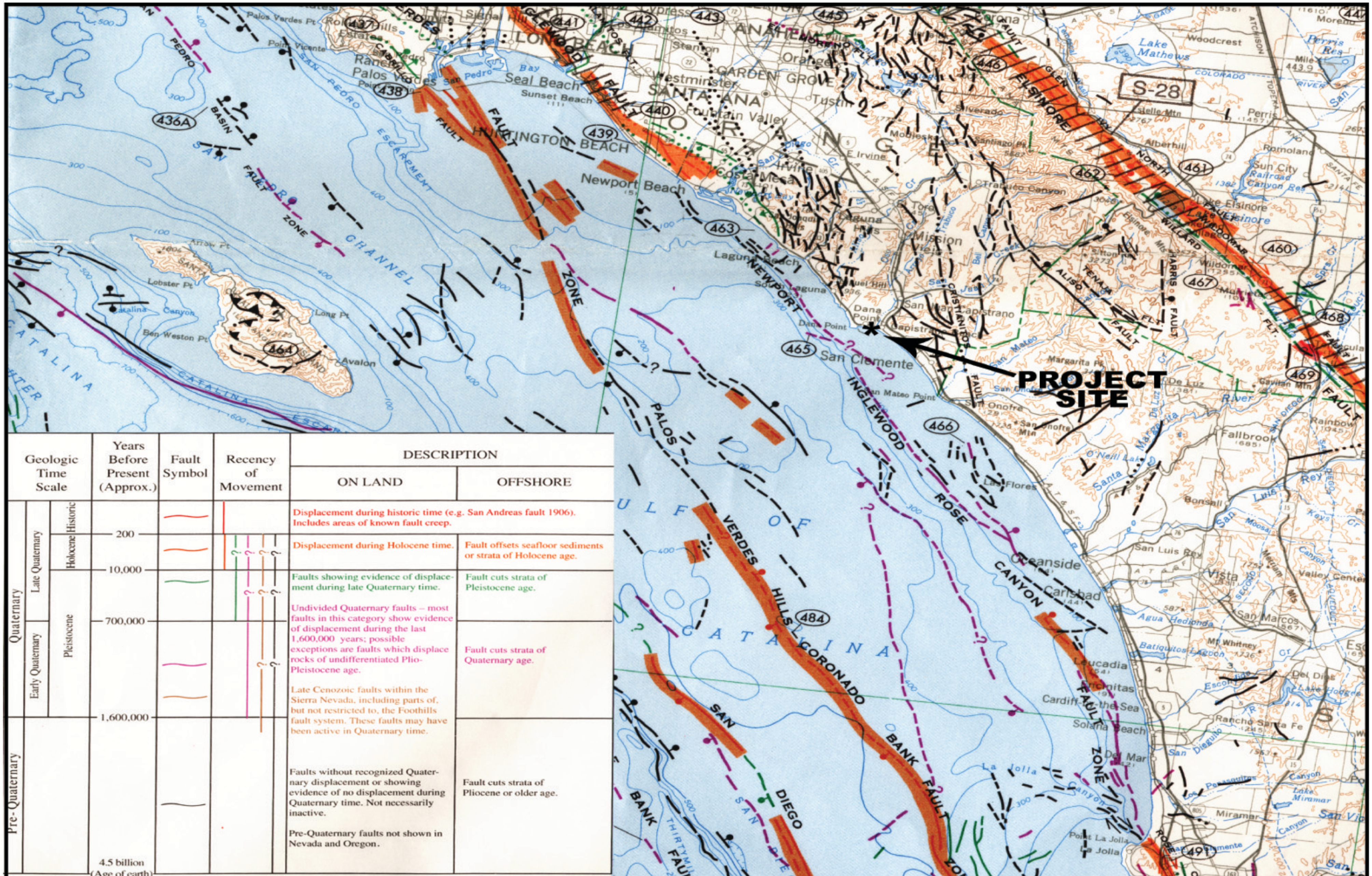
Fault Name	Weight	Slip Rate (mm/year)	Maximum Magnitude (Mw)	Site to Distance (km)
Model 1 Characterization				
Newport-Inglewood (Onshore)	0.5	1.0	6.9	26
Newport-Inglewood – Offshore Zone of Deformation	0.5	1.5	6.9	5 ½
Rose Canyon – Offshore Zone of Deformation	0.5	1.6[1]	6.8[1]	5 ½
San Joaquin Hills Blind Thrust	0.5	0.15[1]	6.8[1]	2.7 [2]
Rose Canyon	0.5	1.5	6.9	45
Model 2 Characterization				
Newport-Inglewood (Onshore)	1.0	1.0	6.9	26
Oceanside Blind Thrust	1.0	0.6[1]	7.2[1]	5 ½
Rose Canyon	1.0	1.5	6.9	45
Model 3 Characterization				
Newport-Inglewood (Onshore)	0.5	1.0	6.9	26
Oceanside Blind Oblique	1.0	1.8[1]	7.6	5
Rose Canyon – Offshore Zone of Deformation	1.0	1.6[1]	6.8[1]	5 ½

[1] Based on weighted average values provided by Hanson, et al. (2002).
[2] Closest Distance = 2.7 km, as reported by L&A (2002); recomputed as 5 ½ km, based on geometry provided by Hanson, et al. (2002).
Source: GeoPentech, *Preliminary Geotechnical Assessment Report for the Dana Point Harbor Revitalization Project*, January 15, 2004.

San Joaquin Hills and Oceanside Blind Thrust Faults

In addition to the mapped surface faults illustrated on Exhibit 4.3-1, blind thrust faults are also believed to exist in the region. The identification and characterization of active, seismogenic blind-fault seismic sources is an ongoing research topic in southern California. These blind-thrust faults are not expressed at the surface, but are inferred to exist based on indirect information, such as seismicity and folded stratigraphy. Two recently postulated fault sources, the San Joaquin Hills Blind Thrust (SJHBT) and the Oceanside Blind Thrust (OBT), are judged to be potentially significant seismic sources in the Project area.

The uplift of the San Joaquin Hills is produced by a southwest-dipping blind thrust fault that extends at least nine miles from northwestern Huntington Mesa to Dana Point, and comes to within 1.2 miles of the ground surface. Research suggests that uplift of the San Joaquin Hills began in the Late Quaternary and continues during the Holocene period. It has been concluded that the San Joaquin Hills are rising in response to a potentially seismogenic, underlying blind fault that should be included in regional seismic hazard models. The SJHBT is the closest active fault to the Project area, located approximately 1.7 miles (2.7 km) from the Harbor and is capable of generating an Mw 6.8 offshore earthquake.



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	10,000			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 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.
						Late Cenozoic faults within the Sierra Nevada, including parts of, but not restricted to, the Foothills fault system. These faults may have been active in Quaternary time.	
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. Pre-Quaternary faults not shown in Nevada and Oregon.	Fault cuts strata of Pliocene or older age.

Scale: N.T.S.
Source: GeoPentech, Preliminary Geological/Geotechnical Assessment Report for the Dana Point Harbor Revitalization Project EIR, January 15, 2004.

REGIONAL FAULT MAP

DANA POINT HARBOR REVITALIZATION PROJECT
PROGRAM ENVIRONMENTAL IMPACT REPORT

EXHIBIT 4.3-1

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Several recent studies have also interpreted offshore seismic data to image a major, east-dipping, low-angle, normal fault that is responsible for tectonic “footwall uplift” in the Miocene time, of high-grade metamorphic rocks now exposed on Catalina Island. This fault is referred to as the Oceanside Detachment. It has been speculated that large portions of these detachments have been reactivated to form the Oceanside and Thirtymile Bank Thrusts, which comprise the Inner California Borderlands Blind Thrust system. It has been noted that seafloor scarps associated with the shallow, east-vergent, fold-and thrust belt above the OBT and between Dana Point and Oceanside may reflect recent activity of the underlying thrust and the complex anticline associated with the SCOZD. However, this is not definitive, because of the lack of precise age control on seafloor sediments.

4.3.1.5 LIQUEFACTION

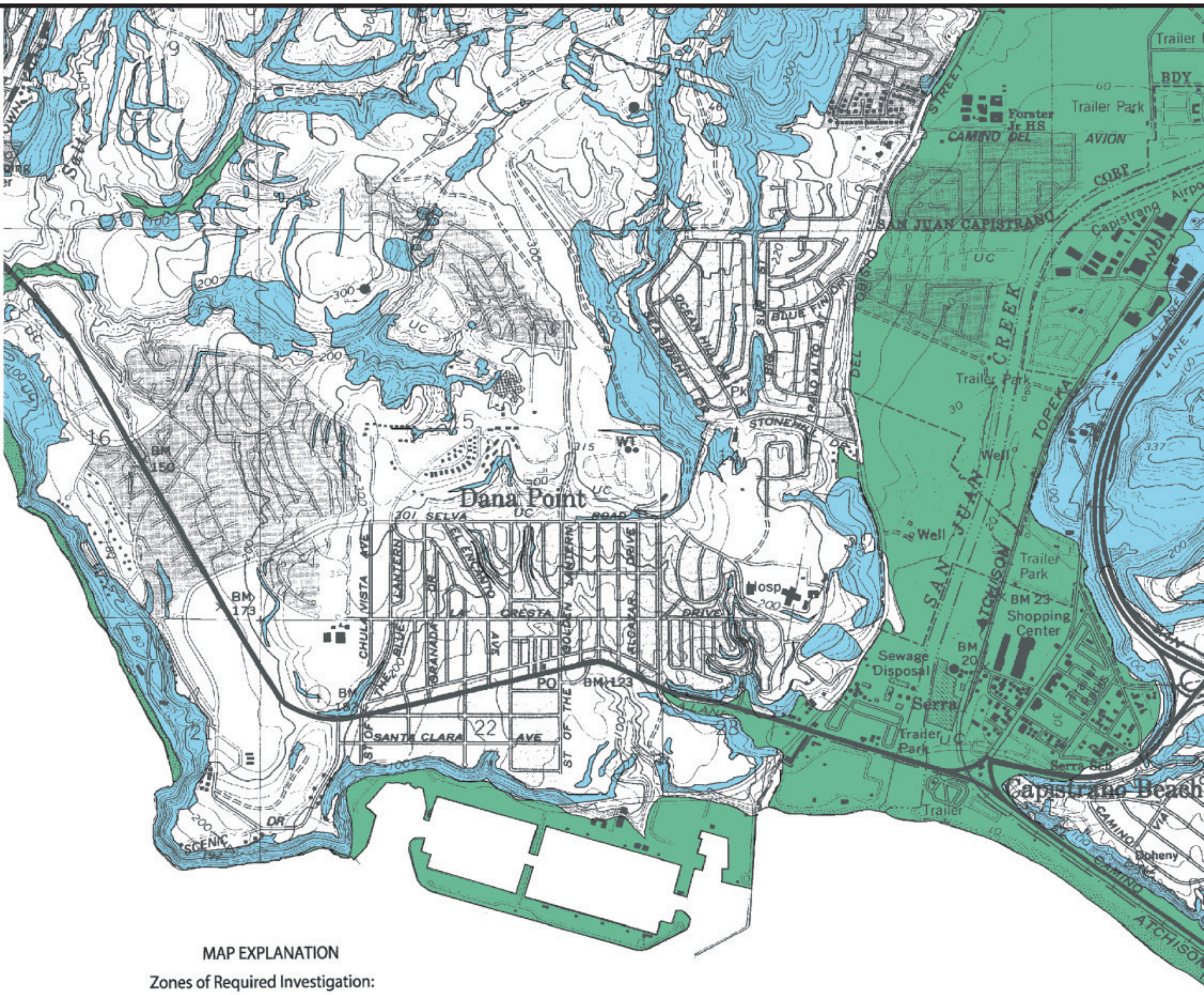
Liquefaction is the loss of strength of cohesionless soils when the pore water pressure in the soil becomes equal to the confining pressure. Liquefaction generally occurs as a “quicksand” type of ground failure caused by strong ground shaking. The primary factors influencing liquefaction potential are groundwater, soil types, relative density of the sandy soils, confining pressure, and the intensity and duration of ground shaking.

When a soil beneath a structure liquefies, the structure loses its integrity as the ground becomes unstable. Surface soils on slopes move downward and ground oscillation occurs on areas of flat topography. Loss of bearing strength under structures is potentially most damaging because it leads directly to losses in the strength of the structure’s foundation and endangers people and property.

As shown in Exhibit 4.3-2 (Seismic Hazard Zones, USGS Dana Point Quadrangle), the Project area is located in a zone designated as having a potential for liquefaction based on the Seismic Hazard Zones Liquefaction Map for the USGS Dana Point 7.5-Minute Quadrangle. However the Seismic Hazard Zone Report (SHZR) 049, notes that “in the Dana Point Quadrangle, artificial fill areas large enough to show at the scale of mapping consist of engineered fill for elevated freeways, the Harbor, and some of the mass graded areas. Since these fills are considered to be properly engineered, zoning for liquefaction in such areas depends on soils conditions in underlying strata.”

4.3.2 METHODOLOGY

The geological/geotechnical impacts have been evaluated in accordance with the California Environmental Quality Act (CEQA) and with the County of Orange RDMD *CEQA Guidelines* for Public Projects. The assessment was prepared based on the documents provided to the geotechnical consultants, Geopentech, by RBF Consulting and available published information. No field exploration or laboratory testing was performed as part of the scope of work for this report. It is noted that this assessment addresses geological/geotechnical impacts pursuant to satisfy CEQA requirements, but further investigation will be required as part of construction plan preparation.



MAP EXPLANATION

Zones of Required Investigation:

Liquefaction

Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Earthquake-Induced Landslides

Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

NOTE: Seismic hazard Zones identified on this map may include developed land where delineated hazards have already been mitigated to city or county standards. Check with your local building/planning department for information regarding the location of such mitigated areas.

DATA AND METHODOLOGY USED TO DEVELOP THIS MAP ARE PRESENTED IN THE FOLLOWING:

Seismic Hazard Zone Report of the Dana Point 7.5-minute quadrangle, Orange County, California
California Division of Mines and Geology, Seismic Hazard Zone Report 049

SCALE 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

Source: GeoPentech, Preliminary Geological/Geotechnical Assessment Report for the Dana Point Harbor Revitalization Project EIR, January 15, 2004.

SEISMIC HAZARD ZONES DANA POINT QUADRANGLE

DANA POINT HARBOR REVITALIZATION PROJECT
PROGRAM ENVIRONMENTAL IMPACT REPORT

EXHIBIT 4.3-2

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4.3.3 SIGNIFICANCE CRITERIA

The following thresholds of significance, based on the criteria contained in Appendix G of the *State CEQA Guidelines*, as amended December 1, 2004 are used to determine whether or not implementation of the proposed Project will result in significant geology, soils, and mineral resources impacts. Accordingly, a project may create a significant environmental impact if it will:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - 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 Impact Statement 4.3-2 (Seismic Impacts);
  - Strong seismic ground shaking; refer to Impact Statement 4.3-2 (Seismic Impacts);
  - Seismic-related ground failure, including liquefaction; refer to Impact Statement 4.3-2 (Seismic Impacts); or
  - Landslides; refer to Impact Statement 4.3-2 (Seismic Impacts);
- Result in substantial soil erosion or the loss of topsoil; refer to Impact Statement 4.3-1 (Surficial Units);
- Be located on a geologic unit or soil that is unstable, or that will become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse; refer to Impact Statements 4.3-1 (Surficial Units) and 4.3-2 (Seismic Impacts);
- Be located on expansive soils, as defined in Table 18-1 B of the *Uniform Building Code* (1994), creating substantial risks to life or property; refer to Impact Statement 4.3-1 (Surficial Units); and/or
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater; refer to Section 7 (Impacts Found Not To Be Significant).

Potential impacts associated with the Project area's topography, soils, and the region's seismic activities are identified below. Mitigation is provided to reduce the significance of impacts.

4.3.4 PROJECT IMPACTS

4.3.4.1 SURFICIAL UNITS

4.3-1 *Soil conditions such as collapsible and expansive soils, soil erosion, and subsidence will have some effect on the t implementation of the Project. Mitigation Measures will include conducting site-specific subsurface investigations, to be verified by the County RDMD as well as further sampling and testing soils during the design phase to confirm the preliminary geotechnical findings. However, implementation of the Project-specific Standard Conditions of Approval (SCAs) and Mitigation Measures (MM) will reduce such impacts to a less than significant level.*

HARBORWIDE

Collapsible and Expansive Soils

As detailed in SCA 4.3-1 and MM 4.3-1 through 4.3-4, potential soil-related constraints and hazards shall be assessed by a geotechnical report that includes an evaluation of potentially expansive soils and recommends construction procedures and/or design criteria to minimize the effect of these soils on the proposed Project. Additionally, adherence to Standard Conditions of Approval pertaining to conformance with the UBC and County Grading and Building Codes and implementation of the recommended Project Design Features will ensure that impacts will be reduced to a less than significant level.

Soil Erosion

The ground surface of the Harbor is relatively flat and therefore, geological hazards related to surface erosion are considered unlikely. The Harbor breakwaters effectively shield the bluff face cliffs behind the Project area from further marine (storm wave) erosion processes. However, due to rainfall, irrigation of the properties within the blufftop residential areas, storm drain outfalls, and relatively poor surface-drainage control conditions, the friable Capistrano Formation sandstones have eroded along the bluffs. This potential hazard to the development has been avoided by a Project Design Feature that positions Dana Point Harbor Drive against the cliff and using a landscaped strip as a barrier between the bluffs and the Harbor facilities. Therefore, the proposed Project is not anticipated to impact or contribute to the factors causing erosion on these slopes. Standard Conditions of Approvals such as SCA 4.3-1 will require further analysis of the site prior to the issuance of any grading permits to ensure soil erosion will not occur. Additionally MM 4.3-2 and MM 4.3-3 requires soil erosion control plans and erosion control measures in addition to further soil sampling and testing during the construction that will ensure that soil erosion impacts will be reduced to a less than significant level.

Subsidence

The Project area is not within an area of known subsidence associated with fluid withdrawal (groundwater or petroleum), peat oxidation, or hydrocompaction. Therefore, impacts in this regard will be less than significant.

While no significant impacts were identified regarding soil conditions within the Project area, it is recommended that further investigation and characterization of the subsurface conditions will be completed with preparation of any plans for new construction. Additionally, adherence to the requirements of the UBC and any specific recommendations by the Project geotechnical consultant regarding grading, soil compaction, and site preparation will ensure that soil impacts will remain at a less than significant level.

COMMERCIAL CORE

No significant impacts were identified regarding collapsible and expansive soils, soil erosion, or subsidence. However, as discussed above, compliance with SCA 4.3-1 as well as MM 4.3-3 and 4.3-5, will require that further investigation shall be included prior to any future construction to verify subsurface conditions and potential soil impacts. Additionally, the proposed Commercial Core will include PDF 4.3-1, which will require the creation of the Festival Plaza and Pedestrian Promenade along the waterfront edge to provide an extended structural setback from the bulkhead area to help prevent soil erosion. PDF 4.3-2 also requires that per further investigation, buildings will comply with structural engineering recommendations. MM 4.3-6 is recommended should pile-driving equipment be required adjacent to the bulkhead, which will require adequate setbacks to prevent failures. New structures Implementation of the recommended Mitigation Measures and Project Design Features will minimize soil impacts within the Commercial Core area to a less than significant level.

OFF-SITE AREAS

The SCWD Lot will be used for boat storage and the Selva Parking Lot will temporarily be used for overflow parking and boat storage during Harbor construction. Specific improvements (fencing, gates, etc.) will be made to allow the existing Selva Lot to be used for temporary storage of boats and employee vehicles. However, there will be no construction activities or subsurface activities within these sites. Therefore, no significant soil impacts are anticipated.

4.3.4.2 SEISMIC IMPACTS

4.3-2 *Because the proposed Project is located in a region that experiences seismic activity, development of the proposed Project will expose people and structures to effects associated with seismic activity. Analysis has concluded that, with compliance with the County Zoning Code, the Uniform Building Code, Standard Conditions of Approval, Project Design Features, and Mitigation Measures, the impact will be less than significant. Mitigation Measures listed below such as requiring additional ground motion assessment of the Project area prior to issuance of* *grading and building permits to ensure impacts will be less than significant.*

HARBORWIDE

Potential seismic hazards include surface fault rupture, seismic shaking, liquefaction, seismically induced settlement, and landsliding. The potential impacts on the Project area are evaluated below.

Fault Surface Rupture

No known active or potentially active faults are mapped through the Project area, and therefore the Project area is not located within a currently designated Alquist-Priolo Earthquake Zone.[1] Based on this consideration, the potential for surface fault rupture at the Project area is considered low. Therefore, such impacts will be less than significant.

Seismic Shaking

The Project area could be subjected to strong ground shaking during a significant earthquake on a nearby or regional fault. Earthquakes that can produce strong shaking at the Project area may occur on mapped active faults (e.g., the Newport-Inglewood Fault Zone) or other postulated active faults (e.g., SCOZD) in the region, or on faults with little or no surface expression, such as the SJHBT and the OBT.

Site-Specific Probabilistic Seismic Hazard Evaluation

A site-specific probabilistic seismic hazard analysis (PSHA) for the Project area was performed. Ground motion at the Project area was modeled using the FRISKSP program. The peak horizontal ground accelerations (PHGA) for the Design Basis Earthquake (DBE) (with a 10-percent probability of exceedance in 50 years) and the Maximum Credible Earthquake (MCE) (with a 10-percent probability of exceedance in 100 years) were estimated using attenuation relationships based on Abrahamson and Silva (1997), Sadigh et al. (1997), and Campbell (1997 Rev.). The PHGA was taken as the average of the PHGAs, computed using each of the three relationships as 0.59 g for the DBE and 0.78 g for the MCE.

Alternative Models of Active Nearby Faults

As indicated above, the estimated PSHA included the SJHBT, Newport-Inglewood, Palos Verdes, Coronado Bank, and Rose Canyon Faults; however, the SCOZD and the OBT were not included. Because of the proximity of the Project area to these two faults, alternative seismic source characterization models have been conducted, considering that the higher postulated slip rate of the SCOZD may represent a greater seismic shaking risk to the Project area.

On the basis of the available information, including Global Positioning System (GPS) data available for the region, possible alternative models of a system of faults

[1] GeoPentech, *Preliminary Geotechnical Assessment for the Dana Point Harbor Revitalization Project,* January 2004.

consisting of the Newport-Inglewood, SCOZD, and Rose Canyon Fault Zones, the SJHBT, and the OBT were developed. As recommended in MM 4.3-7, additional ground motion assessment of the Project area should be conducted and should reflect these alternative models in some fashion. Additionally, appropriate seismic design provisions shall be implemented with Project design and construction in accordance with governing building codes as listed within MMs 4.3-9, 4.3-12, 4.3-13, 4.3-15, 4.3-16. With the implementation of the mentioned Mitigation Measures, impacts regarding seismic shaking are anticipated to be less than significant.

Liquefaction

Review of the available documents indicates a wide range of conclusions regarding the potential for liquefaction at the Project area. The reason for the differing opinions and conclusions is primarily due to the characterization of fill placed during the development of the Harbor.

The following is a summary from previous soil assessments for liquefaction potential:

- The 1973 *Dana Point Harbor Final EIR* (Environmental Sciences, 1973) states *"the interior harbor was constructed in the dry after breakwater placement, with fill material utilized from adjacent cliffs.*" The *Final EIR* also references reports of fill compaction and documentation and concludes that *"Fill areas have been compacted and constructed to standard design values and are suitable for all proposed structures. The materials are dry and have an internal structural makeup not subject to liquefaction in the event of a severe earthquake. The soil materials in the compacted fill areas vary by depth. Coarse granular material is overlain with fine-grained soils above the water level, made up of cut material from the Capistrano Formation."*

- Leighton and Associates (L&A) (2002) characterized the consistency of the 15- to 20-foot-thick fills encountered during its investigation as varying from *"loose to medium dense and firm to stiff"* and stated that *"Engineering analysis suggested that the potential for localized liquefaction of sandy soils in the fill is high during a major earthquake event. The thickness of these potentially liquefiable soils encountered during our exploration varied from a few inches to up to 5 feet."*

The L&A (2002) borings and cone penetration test (CPT) results indicate that the 15- to 20-foot-thick fills are predominantly clayey. In general, compacted fill consisting of predominantly clayey soils will not be expected to pose significant liquefaction hazard. However, based on the variability of the fill soils encountered, including the occurrence of some lenses of silty sand and silt several inches thick, and the possibility that some dredged material may have been used in the apparently compacted fills, the possibility of liquefaction at the Project area cannot be discounted.

Further investigation and evaluation are required to assess the likely extent of the potential for liquefaction at individual sites. Appropriate seismic design provisions shall be implemented with Project design and construction in accordance with governing building codes. Implementation of the MM 4.3-7, which requires additional site-specific subsurface analysis will reduce impacts to a less than significant level.

Lateral Spreading

Lateral spreading tends to occur when a layer of liquefied soils moves laterally toward a slope or an open face. Lateral spreading can move the ground by a few inches to tens of feet, causing ground fissures, grabens (depressed areas), and significant damage to structures on the ground. If the potential for lateral spreading is high, it will be very difficult to design structures to withstand such movements.

The possibility of lateral spreading at the Project area cannot be discounted. Further investigation and evaluation are required to evaluate the potential for lateral spreading at individual sites. MM 4.3-2 shall required that further site-specific subsurface investigations should be conducted to quantify the potential for lateral spreading because the variable fill soils appear to be predominantly clayey and may not be as susceptible to lateral spreading as is indicated by the Project area mapping; refer to Exhibit 4.3-2 (Seismic Hazard Zones, USGS Dana Point Quadrangle). Appropriate seismic design provisions shall be implemented with Project design and construction in accordance with County Building Codes. The incorporation of these features into the Project design and implementation of the recommended Project Design Features and Mitigation Measures will reduce impacts to a less than significant level.

Seismically Induced Settlement

Seismically induced settlement is caused by loose to medium-dense granular soils densified during or after ground shaking, as induced when excess pore water pressures dissipates. Dry and partially saturated soils as well as saturated granular soils are subject to seismically induced settlement. Research indicates that some loose to medium-dense sandy layers were encountered in the fill soils underlying the Project area, and that densification of these layers and associated seismically induced settlements may occur during earthquake shaking. Therefore, further investigation and testing of the subsurface conditions will be required to determine the extent that seismically induced settlement may occur. Appropriate seismic design provisions shall be implemented with Project design and construction in accordance with governing building codes. Implementation of the recommended Project Design Features and such as conducting additional seismic modeling for structures will ensure that seismically induced settlement impacts are reduced to a less than significant level; refer to MM 4.3-6 through MM 4.3-16.

Landsliding

No significant slopes exist within the Project area; however, there are bluffs to the north and northwest, outside the Project area. Therefore, the potential for on-site landsliding is not considered a potential Project-related impact. The cliffs behind the Project area have been historically subject to landsliding. Slope repair and landslide mitigation on the historic landslide area have been accomplished by shotcrete and rock anchors. Periodic slumping of cliff materials may also be anticipated, due to continued erosion of the friable Capistrano Formation sandstones along these bluffs, which have left massive resistant conglomerate interbeds precariously undermined. However, the landsliding hazard related to the proposed Project has been mitigated by positioning Dana Point Harbor Drive against the cliff and using a landscaped strip as a barrier; therefore, these bluffs pose no significant threat.

Factors that have been identified as contributing to the landsliding hazard for these slopes include bluff face instability, seepage, block falls, and adverse bedding. The proposed Project proposes no modification to the bluffs and no structure adjacent to the bluffs, and therefore is not anticipated to impact or contribute to the factors causing a landslide hazard for these slopes and impacts in this regard will be less than significant.

Tsunami

A tsunami is a sea wave generated by a large submarine landslide or an earthquake-related ground deformation beneath the ocean. From south of Palos Verdes peninsula to San Diego, the tsunami hazard has been qualitatively calculated as moderate. A 100-year tsunami event could result in a run up of approximately four feet above mean sea level in the vicinity of Laguna Beach and the Dana Point coast. The Project area is partially shielded from tsunami waves by the headlands, which deflect ocean waves approaching the shore from the west. However, the Project area could incur significant damage if a tsunami generated in the South Pacific struck Dana Point. Inundation maps are currently being developed for California under the U.S. National Tsunami Hazard Mitigation Program; however, no site-specific maps have yet been published. Preliminary estimates for tsunami run-up heights on the southern California coast range from 6 to 18 feet for a tectonically triggered tsunami event.

As a result, the tsunami hazard should be considered during preparation of construction plans for the Project. Further study of the potential impacts of inundation on the existing or proposed building structures along the seawall should be performed with the preparation of construction plans.

Seiches

Seiches are large oscillating waves generated in enclosed bodies of water in response to ground shaking. Because of the partially enclosed configuration of the Harbor, there is a possibility of seiche occurring on-site. Further study of wave run up near the Harbor during a major seismic event should be performed during the construction plan preparation phase.

COMMERCIAL CORE

Potential geological conditions that may impact the Commercial Core include strong seismic ground shaking, liquefaction, and lateral spreading.

Seismic Shaking

Impacts of strong ground shaking may include:

- Potential architectural and structural damage to existing and proposed buildings and utilities; and/or
- Seismically induced ground failures.

Seismic ground shaking hazard is common in southern California and the effects of ground shaking can be mitigated if the proposed structures are designed in conformance to current building codes and engineering practices. Ground motion assessments for design should reflect the recently developed alternative models for potential faults in the vicinity of the Commercial Core. As with the Harborwide improvements, appropriate seismic design provisions shall be implemented with Project design and construction in accordance with Country Building Codes. Implementation of the recommended Project Design Features and Mitigation Measures will reduce impacts to a less than significant level.

Liquefaction

Impacts of potential liquefaction within the existing fill may include:

- Bearing capacity failures;
- Settlement and damage to existing and proposed structures, utilities, and surface improvements (such as pavements);
- Damage due to differential settlements and uneven surfaces; and/or
- Damage to utilities and rigid pipes due to dislocation at connections and joints.

Further, the potential for liquefaction could result in significant impacts in regards to the existing bulkhead. Liquefaction may result in a large increase in the lateral pressures and loss of vertical and lateral support for bulkheads, piling, and deadman anchors. This could cause vertical settlement at the ground surface and lateral spread of the soils at the free face of the bulkhead structure. Global stability under seismic ground shaking of both the revetment slope and the quay wall soil-structure system is a concern for this type of waterfront facility. Locations where buildings are in close proximity to the bulkhead will require more stringent seismic design criteria and considerations.

Further investigation and detailed characterization of the existing fill conditions is required to identify the extent of the potential for liquefaction, as specified in the Project Mitigation Measures.

Additionally, appropriate seismic provisions shall be implemented as Project Design Features and construction shall be in accordance with governing building codes. Implementation of the recommended Project Design Features and Mitigation Measures will reduce impacts to a less than significant level.

Lateral Spreading

Due to the proximity of the proposed and existing structures to the existing bulkheads, new and proposed landside facilities and improvements will be severely impacted in the event of lateral spreading of the supporting and retained fill soils. Damage due to bearing-capacity failures, ground fissuring, excessive horizontal and vertical displacements, and slope failures may be anticipated. Therefore, further evaluation of lateral spreading potential is required.

As with the Harborwide improvements, appropriate seismic design provisions shall be implemented with Project design and construction in accordance with County Building Codes. Implementation of the recommended Project Design Features and Mitigation Measures will reduce impacts to a less than significant level.

OFF-SITE AREAS

Potential geological conditions that may impact the South Coast Water District (SCWD) Lot and the Selva Parking lot are strong seismic ground shaking, liquefaction, and lateral spreading.

Seismic Shaking — SCWD Lot

Impacts of strong ground shaking may include potential damage to existing and proposed structures and utilities, and/or seismically induced ground failures.

Seismic ground shaking is a common hazard in southern California and the effects of ground shaking can be mitigated if the proposed structures are designed in conformance to current building codes and engineering practices. Ground motion assessments for design should reflect the recently developed alternative models for potential faults in the vicinity of the SCWD Lot. However, no structures are proposed for the SCWD site; therefore, impacts will be less than significant.

Liquefaction — SCWD Lot

Based on the CDMG maps, the SCWD Lot may be susceptible to liquefaction. No specific site information was readily available. Consequences of liquefaction may include bearing-capacity failures and damage to facilities, utilities, and pavements due to seismically induced settlements. However, because the SCWD site will be used primarily for surface lot boat storage, impacts will be less than significant.

Lateral Spreading — SCWD Lot

Potential for lateral spreading at the SCWD Lot will depend on the site-specific soil conditions and topography. However, as the SCWD Lot is not bounded by open-faced slopes, the potential for lateral spreading is considered low. Nonetheless, site-specific geotechnical investigation is required to characterize the subsurface condition and the potential for lateral spreading. If the potential for lateral spreading is identified upon further investigation, mitigation will be required to reduce impacts to a less than significant level.

Seismic Shaking — Selva Parking Lot

Because no structures or utilities exist on the Selva Parking Lot and, based on the proposed use of this site as overflow parking, no significant impact due to ground shaking is anticipated. No mitigation will be required, as impacts are anticipated to be less than significant.

Liquefaction — Selva Parking Lot

The Selva Parking Lot is not located in an area identified as having the potential for liquefaction, based on the CDMG Seismic Hazard Zones Map for the USGS Dana Point Quadrangle. No mitigation will be required, as impacts are anticipated to be less than significant.

Lateral Spreading — Selva Parking Lot

Due to the subsurface conditions at the Selva Parking Lot, the potential for lateral spreading at this area is remote. No mitigation will be required, as impacts are anticipated to be less than significant.

4.3.5 CUMULATIVE IMPACTS

4.3-3 *The proposed Project, combined with future development, will result in increased short-term impacts such as erosion and sedimentation, and long-term seismic impacts within the area. Mitigation has been incorporated to reduce impacts to a less than significant level.*

For geology, soils, and seismicity, cumulative impact of the projects cited within Section 4.0 consists of (1) the area that could be affected by the proposed Project activities and (2) the areas affected by other projects whose activities could directly or indirectly affect the geology and soils of that proposed Project site. Neither the proposed Project nor any of the identified projects with potential cumulative impacts entail activities that will affect geology, soils, and seismicity at significant distances from the site (i.e., projects requiring significant structural blasting or drilling, high-vibration activities, deep excavation, etc.).

The analysis indicated that there will be no significant cumulative impact of the proposed Project related to geology, soils, and seismicity based on the following:

- The construction activities related to the proposed Project entail only impacts on the Project site and immediately offshore;
- There are no real or special geological features or soil types on the Project site that will be affected by Project activities; and
- There are no other known activities or projects with activities that affect the geology and soils of the site.

4.3.6 PROJECT DESIGN FEATURES

The proposed Project includes features that reduce or eliminate potential impacts to environmental resources. The following Project Design Features (PDFs) are specified to be implemented.

PDF 4.3-1 Creation of the Festival Plaza and Pedestrian Promenade along the waterfront's edge also provides for extended structural setbacks from the bulkhead area.

PDF 4.3-2 All new structures and the Commercial Core area parking deck will be supported with piles to provide adequate resistance to long-term settlement if recommended.

PDF 4.3-3 Foundation setback requirements will be implemented for proposed Project improvements, as specified in the geotechnical report. Setback distances will reflect geologic and structural engineering evaluations of the site and recommendations included in the geotechnical report, subject to the review and approval of the Manager, RDMD/Subdivision and Grading.

4.3.7 STANDARD CONDITIONS OF APPROVAL

Controls are imposed on new developments through the permitting process via the adoption of conditions of approval or through enforcement of existing ordinances and regulations. The County has developed extensive guidelines for development that will be implemented as the proposed Project is carried out. Existing applicable County of Orange Standard Conditions of Approval (SCA) are identified below.

SCA 4.3-1 Prior to the issuance of a grading permit, a geotechnical report shall be submitted to the Manager, RDMD/ Subdivision and Grading, for approval. The report shall include the information and be in the form as required by the County Grading Code and Manual.

4.3.8 MITIGATION MEASURES

4.3.8.1 HARBORWIDE

SURFICIAL UNITS

MM 4.3-1 The Project shall conduct site-specific subsurface investigations, to be verified by the Manager, RDMD/Subdivision and Grading, to quantify the potential for lateral spreading (because the variable fill soils appear to be predominantly Clayey and may not be as susceptible to lateral spreading as the mapping of the Project area may indicate). If the potential for lateral spreading to occur is identified, SCAs shall be included to reduce impacts to a less than significant level.

MM 4.3-2 Further sampling and testing during the design phase is recommended to confirm the preliminary geotechnical findings. If results from further testing indicate the possibility for soil erosion, expansive/collapsible soils or subsidence, Mitigation Measures shall be included to reduce impacts to a less than significant level.

MM 4.3-3 The County of Orange Dana Point Harbor Department shall submit erosion control plans for Project grading and site preparation for review and approval by the Manager, RDMD/Subdivision and Grading. The Dana Point Harbor Department shall exercise special care during the construction phase of the Project to prevent off-site siltation. The Dana Point Harbor Department shall provide erosion control measures as approved by the County of Orange, RDMD, RDMD/Subdivision and Grading. The erosion control measures shall be shown and specified on the grading plan and shall be construction to the satisfaction of the County of Orange, RDMD prior to the start of any other grading operations. Prior to the removal of any erosion control devices so constructed, the area served shall be protected by additional drainage facilities, slope erosion control measures, and other methods as may be required by the County of Orange, RDMD. The Dana Point Harbor Department shall maintain the erosion control devices shall remain in place until the County of Orange, RDMD approves of the removal of said facilities.

MM 4.3-4 Site safety requirements shall address specifications of the Occupational Safety and Health Administration (OSHA). Applicable specifications prepared by OSHA related to earth resources consist of Section 29 CFR Part 1926, which are focused on worker safety in excavations.

MM 4.3-5 Paved lot structural sections shall be constructed with a minimum of 3-inches of asphaltic concrete over a minimum of 6-inches of aggregate base in accordance with the recommendations of a soils engineer and as approved by the Manager, RDMD/Subdivisions and Grading.

MM 4.3-6 If cranes and pile-driving equipment are required, adequate setbacks shall be observed from bulkhead areas to prevent failures due to increased lateral loads.

SEISMIC IMPACTS

MM 4.3-7 The Project shall assess the likely extent of the potential for soil liquefaction at individual sites to be verified by the Manager, RDMD/Subdivision and Grading. If the potential for liquefaction to occur is identified, Project Design Features (PDFs) shall be included that reduce impacts to a less than significant level.

MM 4.3-8 Additional ground-motion assessment of the Project area shall be conducted prior to Grading Permit approval. Possible alternative models of a system of faults consisting of the Newport-Inglewood, SCOZD, and Rose Canyon Fault Zones, the San Joaquin Hills Blind Thrust, and the Oceanside Blind Thrust shall be reflected within the analysis.

MM 4.3-9 Conformance with the latest Uniform Building Code and County Ordinances can be expected to satisfactorily mitigate the effect of seismic groundshaking. Conformance with applicable codes and ordinances shall occur in conjunction with the issuance of building permits in order to insure that over excavation of soft, broken rock and clayey soils within sheared zones will be required where development is planned.

MM 4.3-10 All grading and improvements on the subject property shall be made in accordance with the Orange County Grading Ordinance and to the satisfaction of the Manager, RDMD/Subdivisions and Grading. Grading plans shall be in substantial conformance with the approved Dana Point Harbor Revitalization Plan.

MM 4.3-11 Prior to issuance of a grading permit, the County of Orange Dana Point Harbor Department shall provide a plan showing the placement of applicable underground storage tanks for the approval of the County Manager, RDMD/Building Permits, in consultation with the Manager, RDMD/ Environmental Resources.

MM 4.3-12 The potential damaging effects of regional earthquake activity shall be considered in the design of each structure. The preliminary seismic evaluation shall be based on basic data including the Uniform Building Code Seismic Parameters. Structural design criteria shall be determined in consideration of building types, occupancy category, seismic importance factors and possibly other factors.

MM 4.3-13 The descriptions of proposed Project activities and governing measures described in this section refer to the requirements of the currently adopted Uniform Building Code (UBC) (ICBO, 1997, as updated by subsequent adoptions), and especially those sections of the UBC dealing with seismic design and construction requirements, site grading, site drainage, soils properties and soils removal and recompaction. Adherence to the requirements of the UBC is assumed in this analysis to render less than significant any potential environmental impacts related to geology and soils that will otherwise expose people or structures to potential substantial adverse effects, including risk of loss, injury or death.

MM 4.3-14 Engineering design for all structures shall be based on the probability that the Project area will be subjected to strong ground motion during the lifetime of development. Construction plans shall be subject to the County of Orange Review and shall include applicable standards, which address seismic design parameters.

MM 4.3-15 Mitigation of earthquake ground shaking shall be incorporated into design and construction in accordance with Uniform Building Code requirements and site-specific design.

MM 4.3-16 Construction work performed within public roadways or public properties adjacent to the Project site will require compliance with specifications presented in the latest edition of Standard Specifications for Public Works Construction (the Greenbook).

CUMULATIVE IMPACTS

No mitigation is required.

4.3.8.2 COMMERCIAL CORE

SURFICIAL UNITS

MM 4.3-17 Refer to Mitigation Measures MM 4.3-1 through MM 4.3-6.

SEISMIC IMPACTS

MM 4.3-18 Refer to Mitigation Measures MM 4.3-7 through MM 4.3-16.

MM 4.3-19 Further investigation and detailed characterization of the existing fill conditions is required to identify the extent of the potential for liquefaction. Mitigation Measures shall include:

- Recommended new building setback distances from the quay wall ranging from 2 to 3 times the height of the bulkhead wall for localized liquefaction and lateral spreading failure to several times the height of the revetment slope and bulkhead system for global seismic instability, to be considered during the master planning and conceptual design phase of the Project;
- Supporting proposed structures on deep foundations extending into bedrock;
- Stiffened floor slab designs;
- Total or partial removal of the potentially liquefiable soils and replacement with compacted fill;
- Soil remediation and site improvement.

MM 4.3-20 Further evaluation of lateral spreading potential is required. If it is found that the lateral spreading potential is high, then Mitigation Measures shall include:

- New building setback distances from the quay wall ranging from 2 to 3 times the height of the bulkhead wall;

- Repair or replacement of existing seawall for site containment;
- Total/partial removal of the potentially liquefiable soils and replacement with compacted fill; and/or
- Soil remediation and site improvement.

CUMULATIVE IMPACTS

No mitigation is required.

4.3.8.3 OFF-SITE AREAS

SCWD LOT

No mitigation is required.

SELVA PARKING LOT

No mitigation is required.

4.3.9 LEVEL OF SIGNIFICANCE AFTER MITIGATION

No significant impacts related to geology, soils, and seismicity have been identified following implementation of Mitigation Measures and/or compliance with applicable standards and policies of the County of Orange Zoning Code.