

5.10 GEOLOGY

5.10.1 Significance Criteria

Impacts would be considered significant if they:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving surface fault rupture, earthquake ground shaking, liquefaction, subsidence, uplift, expansive soils, mass wasting, erosion and tsunami or seiche;
- Situate terminals on a geologic unit or soil that is unstable, or that could become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse; or
- Prevent future access to geologic features and resources of economic or scientific value.

The following section discusses potential impacts to the geologic environment from the proposed WTA alternatives. Geologic hazards considered include surface fault rupture, earthquake ground shaking, liquefaction and lateral spreading, uplift and subsidence, expansive soils, mass wasting, erosion, and tsunamis. Major active faults in the Bay Area are summarized in Table 3.10.1. The potential exposure of transit terminals to geologic hazards is summarized in Table 3.10.2. Mitigation measures required to overcome the various geologic hazards are also presented. Lastly, the impacts of the program on the geologic environment are discussed.

5.10.2 Impacts and Mitigation

Impact G-1 **Potential new terminals and facilities could be exposed to surface faulting. There is a potential for substantial damage and risk of injury or loss of life at facilities located on or near active faults.**

The state of California delineates zones around active faults under the AP Earthquake Fault Zone Act (Hart 1994) to mitigate for the effects of surface faulting. Any development within an AP Zone requires detailed geologic investigation to accurately delineate active fault strands such that they can be avoided. Fault rupture beneath engineered structures can, if the fault displacement is large enough, lead to damage and in extreme conditions catastrophic collapse. Even minor fault displacements can cause significant structural damage.

With the exception of the potential for a Half Moon Bay terminal location (Alternative 1), none of the potential shore-based facilities are located within an AP Zone. Therefore, the potential for surface faulting is low for all other terminals (Table 3.10.2). The San Gregorio fault comes onshore at Pillar Point, near the potential Half Moon Bay transit terminal location. The San Gregorio fault poses a potential surface faulting hazard, therefore the potential for surface faulting at Half Moon Bay is considered high (Table 3.10.2).

Summary of Impact G-1

- For Alternative 1, the Half Moon Bay terminal could be within or near the AP Zone for the San Gregorio fault and could be exposed to potential surface fault rupture effects. Other

terminal locations have a low likelihood of exposure. This is a potentially significant impact for Half Moon Bay.

- Alternative 2 has no new terminal locations within AP Zones. The potential for this impact is low and considered not significant.
- Alternatives 3 and 4 would not include new terminals. No impact would occur.

Mitigation G-1.1: Significant risk of exposure to surface faulting for Alternative 1 can be avoided if the Half Moon Bay terminal location is dropped from further consideration.

Mitigation G-1.2: Any potential development at Half Moon Bay would have to be carried out in accordance with the regulations detailed in the Alquist-Priolo Act. This will involve detailed, site-specific subsurface geologic investigations to accurately locate the active trace(s) of the fault and adoption of a suitable setback distance in order to mitigate for the effects of potential future fault rupture.

Based on the information above and the generalized locations of WTA facilities presented in this EIR, the hazard from surface faulting rupture is negligible at all potential transit terminal localities except for Half Moon Bay. Therefore, no mitigation measures are recommended for other locations. The proximity of terminals to active fault zones should, however, be verified when specific terminals and routes are proposed.

Impact After Mitigation: The impact from surface faulting after mitigation is low and considered not significant.

Impact G-2 **Potential new terminals and other facilities could be exposed to strong ground shaking. There is a potential for substantial damage to facilities and risk of injury or loss of life at incorrectly designed or constructed facilities.**

The Bay Area is seismically active and all sites have a reasonably high potential of experiencing significant strong earthquake shaking in the future (Working Group on California Earthquake Probabilities 1999).

A number of attenuation relationships have been developed from recordings of earthquake shaking that relate earthquake size, distance from the earthquake source, and geologic conditions to the amount of shaking that can be expected at a site. The amount of shaking is expressed in terms of “Peak Horizontal Acceleration” measured in percent of acceleration of gravity (g) (approximately 9.81 feet per second per second or 10 m/s²). However, because no specific projects are proposed at this time, no site-specific ground motions were calculated for any sites during this study. Rather, relative levels of earthquake shaking were estimated based on the proximity of each terminal site to known active faults (Table 5.10.1). Sites located less than 5 km from an active fault could experience “very high” shaking. Sites located 5 to 10 km from an active fault could experience “high” levels of shaking. Sites located 10 to 20 km from active faults could experience “moderate” shaking. In cases where ground conditions are likely to amplify the effects of earthquake shaking (deep, soft sediment), there is an increase in the likely shaking hazard ranking (i.e., a site on soft Bay Mud located 7 km from an active fault would likely experience “very high” levels of earthquake shaking).

The levels of earthquake shaking expected from a large earthquake on any of the Bay Area faults would likely result in structural damage and possible injury or loss of life at poorly constructed structures. Areas where foundation conditions have not been sufficiently engineered could experience a loss of bearing capacity, leading to significant structural damage and even collapse.

Summary of Impact G-2

- Alternatives 1 and 2 include new terminals. If the new structures and facilities are not properly designed or constructed for site-specific conditions, they could suffer substantial damage from seismic activity and pose potential risk of injury or loss of life to occupants.
- Alternative 3 could involve expansion of existing terminals. If the expansion was not properly designed, substantial damage could occur from seismic activity.
- Alternative 4 does not include new structures. No impacts would occur.

Mitigation G-2.1: Terminal facilities should be designed and constructed at a minimum to the seismic design requirements for ground shaking specified in the Uniform Building Code for Seismic Zone 4. Additionally, to satisfy the provisions of the 1998 California Building Code, these facilities must be designed to withstand ground motions equating to approximately a 500-year return period (10 percent probability of exceedence in 50 years). For design purposes, site-specific ground motions will have to be calculated for all project sites.

Impact After Mitigation: Impact G-2 would be less than significant with implementation of Mitigation G-2.1.

***Impact G-3* Potential new terminals are in areas of potentially liquefiable soils. There is a potential risk for destruction of structures.**

A map of liquefaction susceptibility in the seven-county Bay Area, prepared by Knudsen et al. (2000), was used to assess risk for the potential ferry terminal locations (Table 5.10.1). The majority of the terminal locations around the Bay Area are in areas of soft, potentially liquefiable soils (Knudsen et al. 2000). Liquefaction is likely to be triggered by strong shaking from an earthquake on one of the Bay Area's active faults. When liquefaction occurs, the strength of the soil decreases and, the ability of soil to support building foundations is reduced. Liquefied soil also exerts higher pressure on retaining walls, which can cause them to tilt or slide. This movement can cause settlement of the retained soil and destruction of structures on the ground surface. Increased water pressure can also trigger landslides. Liquefaction can be minimized or even prevented by adopting appropriate ground improvement techniques, such as soil densification and dewatering, or designing foundations that will accommodate differential ground movement during liquefaction.

Summary of Impact G-3

- Alternatives 1 and 2 would involve potential new terminals located within areas ranked with high to very high susceptibility to liquefaction. The only terminal that might not include soils with these conditions is Fort Baker (Table 5.10.1). This is a potentially significant impact.

- Alternative 3 could involve expansion of existing facilities. This is a potentially significant impact only if building foundations are not designed correctly for potentially liquefiable conditions.
- Alternative 4 involves existing terminals and service. Therefore, there would be no impacts.

Mitigation G-3.1: A program of site-specific exploratory borings and accompanying laboratory testing will be required to delineate any potentially liquefiable materials underneath potential terminal sites. These geotechnical investigations will also be required for consideration prior to foundation design. Potentially liquefiable deposits will either have to be removed or engineered (dewatered or densified) to reduce their liquefaction potential.

Impact After Mitigation: Impact G-3 would be reduced to less than significant with implementation of Mitigation G-3.1 for potential new terminals.

Impact G-4 **Subsidence is ongoing in portions of the Bay Area. The potential geohazard presented by subsidence to potential new terminals is likely low to moderate.**

Although subsidence is ongoing in areas of the Bay (Ogden Beeman and Associates 1992), it does not appear to pose a significant hazard during the lifetime of the project. Significant land level changes generally occur on geologic time scales ($>10^3$ years). There may be some localized settlement associated with liquefaction (Impact G-3), however, this can be avoided if appropriate mitigation measures (Mitigation G-3.1) are implemented.

Summary of Impact G-4

- Alternatives 1 and 2 would involve potential new terminals located in areas of low to moderate potential for subsidence. The potential for this impact is low and not considered significant.
- Alternatives 3 and 4 involve only existing terminals. Therefore, there would be no impacts from these alternatives.

Mitigation G-4.1: Based on the information above, the hazard from subsidence is likely negligible at potential transit terminal localities. Verification of this condition should be verified when site-specific exploratory investigations are performed.

Impact After Mitigation: Impact G-4 can be avoided or reduced to less-than-significant levels with implementation of Mitigation G-3.1, above.

Impact G-5 **Expansive soil behavior is associated with wetting and drying of soils containing mixed-layer clays. Expansive soils can lead to structural damage.**

The high groundwater table along the margins of the Bay and along the coast at Half Moon Bay indicate that soils at these localities are permanently saturated, therefore there is a very low risk of expansive soil behavior.

Summary of Impact G-5

- Alternatives 1 and 2 would involve potential new terminals located along the shore, where soils are permanently saturated. Alternative 3 could involve expansion of existing facilities. The hazard of expansive soils is considered negligible, and no mitigation is required.
- Alternative 4 involves an existing terminal, and no changes would occur under the WTA program. Therefore, there would be no impacts.

Based on the information above, the hazard from expansive soils is negligible at potential transit terminal localities and, therefore, no mitigation measures are identified.

Impact G-6 **Slope movements have the potential to cause a range of impacts from minor structural damage (building impacts from rock fall) to major damage and injury/loss of life from building collapse.**

Project sites located adjacent to any areas of steep topography are potentially prone to slope instability, depending on source materials, when subject to a triggering mechanism such as heavy rainfall or seismic shaking. Slope instability ranging from rock falls to block sliding is possible on any steep slope around the Bay Area. Particularly prone areas are underlain by rocks of the Great Valley Group or the Franciscan Complex (Table 5.10.1).

Summary of Impact G-6

- Alternatives 1 and 2 include terminals that are not on relatively flat topography (Sausalito, Angel Island, and Fort Baker). These three terminal locations could present potential impacts depending on the actual siting of terminal facilities with regard to slope and source materials.
- Alternative 3 includes Sausalito, which is not on relatively flat topography. Any expansion of the terminal could present potential impacts.
- Alternative 4 does not include new or expanded terminals. Therefore, no impacts would occur.

Mitigation G-6.1: The hazard from mass wasting can be reduced by siting facilities away from steep and unstable slopes. For sites located adjacent to areas of steep topography, site-specific geologic and geotechnical investigations and laboratory testing will determine the stability of slopes and their parent material. Using these data, appropriate slope strengthening and stabilizing designs can be developed.

Impact After Mitigation: Impact G-6 would be considered less than significant after implementation of Mitigation G-6.1.

Impact G-7 **Erosion due to wind and water action could lead to the deterioration of terminal structures.**

Wind and water are the primary agents of erosion, leading to the weathering and subsequent transportation of rock and soils. In coastal and shoreline environments, both agents work in conjunction, often augmented by tidal and current action, to cause removal and/or redeposition

of sediments and soft, easily erodable rock. In addition, erosion of soils and soft rock along the margins of river channels can be significant due to high velocity flows.

Comparison of pre-1900 and post-1900/pre-fill topographic maps of San Francisco Bay indicates that the greatest amount of erosion has occurred along the East Bay shoreline in the area south of the Bay Bridge (<http://anchor.ncd.noaa.gov/states/ca.htm>). This erosion is the result of wave action, driven by the prevailing winds that cross the Bay from the west. The western shoreline, in the lee of the Peninsula Hills and San Bruno Mountain, has remained essentially unchanged during this period. Thus, potential terminal facilities located along the eastern shoreline of the South Bay at San Leandro Marina may be subject to some degree of erosion.

Other areas that may be subject to erosion are located along the banks of rivers, including Pittsburg, Antioch, Martinez, and Benicia along the main channel of the Sacramento River through Suisun Bay, where relatively high velocity flows are achieved during flood stage.

Coastal localities, including those at the entrance to San Francisco Bay, may be subject to tidal and wave erosion. The amount of erosion at these, or any other sites, is essentially unknown at this time. Erosion potential will have to be calculated from detailed site-specific sedimentologic and hydrodynamic studies.

Significant erosion could result in undermining of seawalls, foundations, and other constructed facilities located adjacent to the affected coast or river channel.

Summary of Impact G-7

- Alternatives 1 and 2 would involve potential new terminals. Alternative 3 could involve expansion of existing terminals. Some of these terminals, particularly those located in the East Bay shoreline of the South Bay, could be subjected to a high degree of erosion, which could affect terminal structures. This is a potentially significant impact.
- Alternative 4 involves existing terminals, and no changes would occur under the WTA program. Therefore, there would be no impacts.

Mitigation G-7.1: As stated above, the erosion potential of each site will have to be determined by detailed, site-specific studies. Once this has been determined, appropriate mitigation measures can be adopted.

In general terms, erosion can be prevented by armoring the coastline with rip-rap or concrete seawalls. Defensive measures such as groins that modify or deflect flow and circulation patterns are not desirable as they merely transfer the erosion problem elsewhere.

Impact After Mitigation: Impact G-7 would be less than significant after implementation of Mitigation G-7.1.

Impact G-8 **Tsunami- and seiche-generated waves have the potential to inundate shoreline sites and damage terminal facilities. This potential impact would range from potentially significant at oceanside terminals (Half Moon Bay) to low and or not significant at most of the Bay terminals.**

Ritter and Dupre (1972) show that for a tsunami originating outside San Francisco Bay, the amount of inundation based on tsunami run-up decreases to 50 percent of its maximum at the

Golden Gate by the time it passes the Bay Bridge to the south and the Richmond-San Rafael Bridge to the north. By the time the tsunami reaches the Carquinez Strait to the north or Alviso in the south, the run-up would only be approximately 10 percent of its maximum at the Golden Gate. This model was used to assess hazards related to tsunamis and seiche in San Francisco Bay.

Tsunami-generated waves have the potential to inundate low-lying coastal areas and cause extensive erosion and/or deposition of sediment. Poorly constructed facilities can also be damaged by both the incoming and outgoing waves. As stated above, by the time a tsunami enters the Bay, its impacts will be dramatically reduced compared to those on the open coast. Therefore, the impact of a tsunami to facilities along the Bay shoreline would be minimal, possibly involving a meter or so of potential inundation. The terminal site at Half Moon Bay could be subject to larger tsunami waves from distant sources, including subduction zones surrounding the northern Pacific. Such tsunamis have inundated coastal California on numerous occasions. Most notably, the tsunami generated by the 1964 Alaska earthquake caused damage along the coast of northern California.

Summary of Impact G-8

- Alternative 1 would involve a potential new terminal in Half Moon Bay. This impact would be potentially significant.
- Alternatives 2, 3, and 4 do not involve oceanside terminals. No impact is anticipated.

Mitigation G-8.1: The impacts of future tsunamis can be lessened or mitigated completely by the application of appropriate engineering design. Detailed hydrodynamic modeling may be necessary for coastal locations in order to determine the likely extent of potential inundation. The behavior of tsunami waves is dependent on local bathymetry. Optimal siting of shoreline facilities and breakwaters would lessen the impact of incoming waves. The placement of concrete seawalls and rip-rap will assist in minimizing erosion during wave incursion and withdrawal.

Impact After Mitigation: Impact G-8 would be reduced to a less-than-significant level after implementation of Mitigation G-8.1.

Impact G-9 **The WTA ferry expansion program could potentially impact the geologic environment, including energy or mineral resources. At a program level of review, none of these issues present any potentially significant impacts.**

Hydrocarbon Resources. There are no known hydrocarbon (oil and gas) resources within the immediate area of the project with the exception of a gas field located adjacent to the Antioch Ferry Terminal location (DOGG 2001). However, the WTA project is not expected to have an impact on this resource.

Geothermal Resources. There are no known geothermal resources within the immediate area of the program expansion (DOGG 2001). The WTA project would have no impact on geothermal resources.

Crushed Rock Aggregate Resources. The majority of the terminal locations are classified by California Division of Mines and Geology (now California Geological Survey) as being Mineral

Resource Zone (MRZ)-1 or MRZ-4 areas (Stinson et al. 1987). MRZ-1 describes “areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence.” MRZ-4 describes “areas where available information is inadequate for assignment to any other MRZ zone.” Based on this information, the majority of potential terminal locations would have no impact on economic mineral resources. However, Rodeo and Crockett were classified as MRZ-3 areas containing crushed aggregate resources. MRZ-3 describes “areas containing mineral deposits, the significance of which cannot be evaluated from available data.” Therefore, there is a possibility that the Rodeo and Crockett sites may impact future use of these crushed aggregate resources.

Activities involved in the ferry terminal construction would likely require crushed rock aggregate for the manufacture of concrete elements (e.g., piles, retaining wall structures, surface facilities). Considerations of transportation cost mean that this material will have to come from local sources. This will result in increased production of crushed rock aggregate at local source sites, but this has not been a major constraint for other Bay Area projects.

Sand and Gravel Resources. Half Moon Bay and Antioch are classified as MRZ-3 areas containing sand and gravel resources. This indicates that the siting of shore facilities at these locations could restrict future development of these sand and gravel resources. The Bay Area has other available sources for these materials.

Unique or Outstanding Geologic and Geomorphic Features. The area of San Francisco Bay surrounding potential terminal sites does not contain any unique geological formations, geological features, or geomorphological features that would be adversely impacted by the various WTA project alternatives.

Summary of Impact G-9

- Alternatives 1 and 2 would not have regionwide significant impacts to other mineral or energy resources. There is potential for terminal locations, once selected or determined, to potentially affect these resources.
- Alternative 3 does not include new terminals. No impact would occur.
- Alternative 4 would not impact these resources or features.

Mitigation G-9.1: The presence of geologic, energy, or mineral resources would be identified in the course of site investigations performed for selected terminal or facility features. Avoidance or design measures can mitigate these impacts and can be defined at that time.

Impact After Mitigation: These impacts are not considered significant on a regionwide basis. They can also be avoided during specific terminal planning and design.

References

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- Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M., and E.J. Helley. 2000. Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region: A Digital Database, U.S. Geological Survey, Open-File Report 00-444, 60 p.
- Ogden Beeman and Associates. 1992. Sediment Budget Study for San Francisco Bay, Final Report. Prepared for US Army Corps of Engineers, San Francisco District, 25 p.
- Ritter, J.R. and W.R. Dupre. 1972. Maps Showing Areas of Potential Inundation by Tsunamis in the San Francisco Bay Region, California, U.S. Geological Survey, Miscellaneous Field Studies Map MF-480, 1:125,000
- Stinson, M.C., Manson, M.W., and J.J. Plappert. 1987. Mineral Land Classification: Aggregate Materials in the San Francisco - Monterey Bay Area Part II: Classification of Aggregate Resource Areas South San Francisco Bay Production-Consumption Region, California Division of Mines and Geology, Special Report 146, 74 p.
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**Table 5.10.1
Geohazard Exposure for Potential WTA Terminal Sites**

Terminal Site	Alt. 1	Alt. 2	Alt. 3	Potential Geohazards							
				Earthquake Shaking ¹	Fault Rupture ²	Liquefaction ³	Subsidence / Uplift ⁴	Landsliding ⁵	Erosion ⁶	Expansive Soils ⁷	Seiche / Tsunami ⁸
Vallejo	X	X	X	Very High	Low	High – Very High	Low	Low	Moderate	Low	Low
Larkspur	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low
Tiburon	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low
Sausalito	X	X	X	High	Low	Very High	Low	Moderate	Low	Low	Low
Pier 41/43	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low – Moderate
Ferry Building	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low – Moderate
Jack London Square	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low
Alameda	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low
Harbor Bay Isle	X	X	X	High	Low	Very High	Low	Low	Low	Low	Low
Pittsburg	X	X		High	Low	High	Low	Low	Moderate	Low	Low
Martinez	X	X		High	Low	Very High	Low	Low	Moderate	Low	Low
Benicia	X	X		High	Low	Very Low	Low	Low	Moderate	Low	Low
Port Sonoma / Gness Field / North Bay	X	X		Very High	Low	High	Moderate	Low	Moderate	Low	Low
Richmond	X	X		High or Very High**	Low	Very Low or Very High**	Low	Low	Low	Low	Low
Berkeley / Albany	X	X		Very High	Low	Very High	Low	Low	Low	Low	Low
Angel Island	X	X		Moderate	Low	Very Low	Low	Low or Moderate**	Low	Low	Low
Treasure Island	X	X		High	Low	Very High	Low	Low	Low	Low	Low - Moderate
Ft. Baker	X	X		High	Low	Moderate or Very Low**	Low	Moderate	Low	Low	Moderate
Alameda Point	X	X		Very High	Low	Very High	Low	Low	Low	Low	Low
Oakland International / Coliseum	X	X		Very High	Low	Very High	Low	Low	Low	Low	Low
East Bay / San Leandro Marina	X	X		Very High	Low	Very High	Low	Low	Moderate	Low	Low
Moffett Field	X	X		Very High	Low	High – Very High	Moderate	Low	Low	Low	Low
Redwood City	X	X		High	Low	High	Low	Low	Low	Low	Low
San Francisco Airport	X	X		Very High	Low	Very High	Low	Low	Low	Low	Low
Oyster Point	X	X		Very High	Low	Very High	Low	Low	Low	Low	Low
Mission Bay	X	X		High	Low	Very High	Low	Low	Low	Low	Low
China Basin / PacBell Park	X	X		High	Low	Very High	Low	Low	Low	Low	Low
Ft. Mason	X	X		Moderate or High**	Low	Very High or Very Low**	Low	Low	Low	Low	Moderate
Antioch	X			High	Low	Moderate – Very High	Low	Low	Moderate	Low	Low
Mare Island	X			Very High	Low – Moderate	High – Very High	Low to Moderate	Low	Moderate	Low	Moderate
Crockett	X			Very High	Low	Very High	Low	Low	Low	Low	Moderate
Rodeo	X			High	Low	High	Low	Low	Low	Low	Moderate
San Rafael	X			High	Low	High – Very High	Low	Low	Low	Low	Low
Bay Model	X			Very High	Low	Very High	Low	Low	Low	Low	Low
Point Molate	X			High or Very High**	Low	Very Low or Very High**	Low	Low or Moderate**	Low	Low	Low
Oakland Army Base	X			Very High	Low	Very High	Low	Low	Low	Low	Low
East Palo Alto	X			High	Low	High or Very High**	Low	Low	Low	Low	Low
Foster City	X			High	Low	High or Very High**	Low	Low	Low	Low	Low
Coyote Point	X			Very High or High**	Low	Very High or Very Low**	Low	Low	Low	Low	Low
Candlestick Park	X			Very High	Low	Very High	Low	Low	Low	Low	Low
Hunters Point	X			High	Low	Very High	Low	Low	Low	Low	Low
Pier 43	X			High	Low	Very High	Low	Low	Low	Low	Moderate
Presidio	X			Very High	Low	Very High	Low	Low	Low	Low	Moderate
Half Moon Bay	X			Very High	High to Moderate	Low to Very High**	Moderate	Low	Moderate	Low	High

¹Earthquake Shaking: Site-specific earthquake ground motions were not calculated. Ranking is based on proximity to major active faults. Very High – located 5 km or less from active fault; High – located 5-10 km from active fault; Moderate – located 10-20 km from active fault.

²Fault Rupture: High – located within and Alquist-Priolo (AP) Earthquake Fault Zone; Moderate – Located adjacent to an AP Zone; Low – Located away from known AP Zones.

³Liquefaction: Hazards designations based on ranking of Knudsen *et al.* (2000).

⁴Subsidence/Uplift: Ranking relates to potential for tectonic uplift/subsidence during lifetime of the project. Subsidence due to liquefaction and/or lateral spreading is not considered. High – Area of known ongoing subsidence/uplift; Moderate – Area of historical uplift/subsidence; Low – Area with no history of geologically recent uplift/subsidence.

⁵Landsliding: High – History of landsliding/debris flows; Moderate – Area of steep slopes with landslide-prone materials; Low – Flat or relatively flat topography.

⁶Erosion: High – Area of significant active erosion; Moderate - Site located adjacent to river channel, open ocean, or coastline exposed to wind/wave fetch; Low – Site sheltered from agents of erosion.

⁷Expansive Soils: the expansive soil hazard at all localities is considered low as the coastal location of these sites ensures that the soils will almost always be saturated and, therefore, not subject to shrink/swell wetting and drying.

⁸Seiche/Tsunami: High – exposed to open ocean tsunami waves; Moderate – exposed to reduced height tsunami waves or smaller local tsunamis; Low – sheltered from potential tsunami waves.

** Actual hazard ranking is dependent on the exact location of the shore based facility.