Caltrans would collaborate with the NPS and the Trust to develop feasible stormwater treatment measures for implementation. If more than one type of Caltrans-approved BMP is determined to meet the MEP requirement, Caltrans would select the preferred BMP in consultation with the NPS and the Trust.

3.3.2 Geology/Soils/Seismic /Topography

This section presents a general overview of soils and geologic resources in the study area. A more comprehensive analysis can be found in the *South Access to the Golden Gate Bridge: Doyle Drive Revised Preliminary Geotechnical Report*, September 2004.

Regulatory Setting

The California Department of Transportation (Caltrans) has developed guidelines for investigating soils and geologic conditions and designing transportation facilities accordingly. Examples include: *Guidelines for Foundation Investigations and Reports* (Caltrans, 2000); *Corrosion Guidelines for Foundation Investigations, Version 1.0* (Caltrans, 2003); and *Seismic Design Criteria* (Caltrans, 2001).

The *Presidio Trust Management Plan* (PTMP) Geologic Resources - The Presidio Trust will protect and monitor geologic resources and functions. Natural soils and soil processes will be managed to minimize loss and disturbance. Wherever feasible, soils affected by construction will be salvaged for reuse in other Presidio site restoration activities.

The National Park Service's (NPS) *Management Policies*, 2001 provide information regarding geologic resources. In addition, NPS provides additional guidance for management of geologic materials in national parks through NPS policies set forth in the following Director's Orders:

- *Director's Order 13A – Environmental Management Systems*
- *Director's Order 77-9 In-park Borrow Material (under development).*

Affected Environment

The San Francisco Bay Area, as it is known today, was formed in the mid- to late Pleistocene period (approximately 1,000,000 to 10,000 years ago). Like all other areas of California, a long record of seismic activity characterizes the geologic history of the San Francisco area. In addition, the area has been strongly influenced by the melting of Pleistocene glaciers in the Sierra Nevada Mountains and the San Francisco Bay trough. The resulting topography is characterized by variable thicknesses of recent deposits of soft to medium stiff clays (Bay Mud), older stiffer Pleistocene clay (Old Bay Clay), and sand deposits.

Topography and Natural Features

Generally the topography of the Presidio in the project study area is divided by the various bluffs into the upper hilly inland portion and the lower flat costal area. Areas of natural topography were identified by comparing the earliest available survey date from 1871 with the current topography. The comparison indicates that the portion of the Western Bluff that is with the project study limits has been extensively graded to accommodate the existing Park Presidio interchange.

The existing Doyle Drive high viaduct spans between the Western and Eastern Bluffs that rise steeply to about twenty-five meters (eighty feet) above Crissy Field to the northeast. The area of Cavalry Hollow between the two bluffs is approximately eighteen meters (sixty feet) deep and 460-meters (1,500 feet) wide. This valley appears relatively unchanged from its natural state but the area has been graded to accommodate the stable buildings and access roads. The face of the Eastern Bluff appears relatively undisturbed and features natural exposed outcrops of fractured bedrock down slope from the National Cemetery. However the top of the bluff was re-graded during the construction of the historic batteries and further modified when the existing facility was built. Also evident in the same general area is a slide repair, immediately north of the west abutment of the low-viaduct.

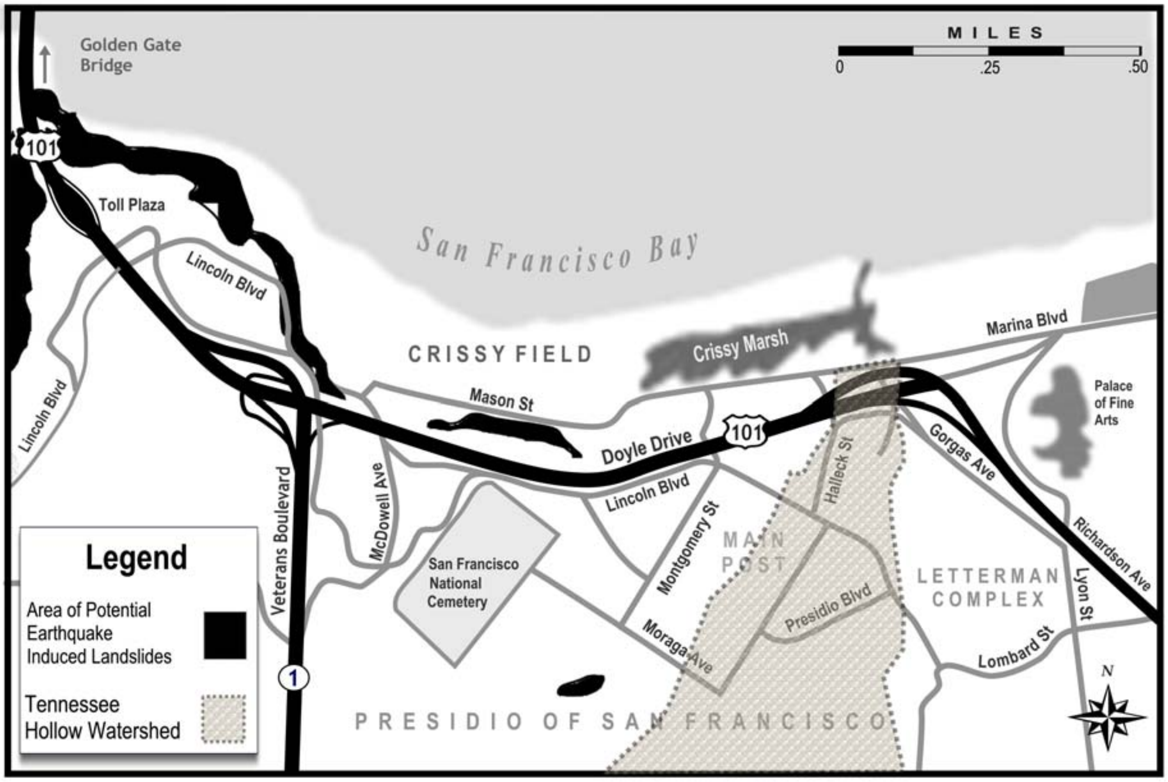
To the east of the Eastern Bluff, the slope under the existing facility is similar to the natural landform but was excavated and backfilled during the construction of the existing low-viaduct. The lower bluff north of the Main Post still creates a vertical separation at the east end of the project but the bluff face itself is not the natural bluff depicted on the 1871 survey. East of Halleck Street, the original bluff has been obscured due to the construction of a large number of military buildings and the placement of artificial fill, and the route is relatively flat. It follows the southern boundary of the Crissy Field area, with elevations ranging from 2.7 to 3.7 meters (nine to twelve feet), and ends near the Exploratorium which is generally flat, and located on fill. Extensive fill material was placed along the shoreline prior to the 1915 Pan Pacific Exposition and additional minor amount was placed in the 1960s.

The Eastern Bluff is an important feature. The *Presidio Trust Management Plan* (PTMP) states, "The Presidio contains some fragile geologic resources, including the Colma Formation dunes, and the serpentine outcrops and bluffs at Inspiration Point and south of Crissy Field." The general location of the Eastern Bluff, and other key topographic features, are illustrated in **Exhibit 3-40**.

Regional Seismic Setting

The major faults mapped in the Bay Area are all part of the northwest-trending San Andreas Fault system. Although no known fault specifically crosses the project study area, three major faults are located within twenty-five kilometers (15.5 miles) of the project site. They are the San Andreas Fault located nine to 10.5 kilometers (5.5 to 6.5 miles) west of the project area; the San Gregorio Fault located thirteen to 14.5 kilometers (eight to nine miles) west of the project area; and the Hayward Fault located 19.5 to 21 kilometers (twelve to thirteen miles) to

Exhibit 3-40
General Location of Topographic Features



the east of the project area. Historically, both the San Andreas and Hayward Faults have generated large earthquakes.

A map of *Seismic Hazard Zones for the City and County of San Francisco* (CDMG, 2000) indicates landslide potential at the following two locations:

- on the Western Bluff, starting from near the western end of the high-viaduct, going westward; and
- in a narrow zone along the northern edge of the Eastern Bluff, about sixty-one meters (200 feet) from the present Doyle Drive alignment.

There is also a slide repair on the Eastern Bluff slope face immediately north of the west abutment of the low-viaduct. Based on communication with the Presidio Trust and Caltrans, the slide of this manmade slope was caused by failure of a storm drain.

Site Specific Geologic and Soils Conditions

Within the Doyle Drive corridor, the topography is the result of various geologic conditions. Shallow bedrock of the Franciscan Formation, a heavily folded and sheared assemblage of greywacke, shale, sandstone, chert, and serpentine, generally dominate the higher elevations at the western end and to the south of the project corridor. Overburden soils in these regions consist of artificial fill, slop debris, ravine fill, and/or Colma Formation. The Colma Formation consists of clay layers intermixed with unconsolidated to weakly consolidated fine- to medium-grained sand. Lower elevations on the eastern portion of the Doyle Drive corridor, such as south of the Crissy Marsh, reflect an estuarine deposition environment, where the bedrock is considerably deeper. Surface soils in this area are dune and beach sands and soft clayey silt layers. These soils are generally underlain by the Colma Formation, which rests on bedrock.

Bedrock consists of greywacke which has been intruded by igneous rocks like serpentine and belong to the Franciscan Formation. West of Station 10+84 (west of McDowell Avenue), the bedrock is exclusively serpentine and is exposed along the Western Bluff slopes.

Another defining feature within the project area is the presence of an extensive historic tidal marsh separated from San Francisco Bay by a beach and dunes. The area, which extends from Crissy Field in a southeasterly direction towards Lombard Street and underlies Doyle Drive east of the Post Commissary Building, was filled in 1912. Soil borings within the area show very soft clay-rich silt deposits interlayered with thicker beach/dune sand layers. The overlying fill material consists of loose sands with variable amounts of silt and clay.

Soil Liquefaction[23]

In the Doyle Drive Project study area, the soils most susceptible to liquefaction are the soft deposits from the historic tidal marsh. Soft soils are present throughout the travel corridor, particularly east of Station 20+00. Soil borings confirm the presence of relatively thin layers of soft clayey silts and loose sands from around Station 17+00 to Station 28+00. **Exhibit 3-41** presents the general location of these stations, which are linear reference points along a proposed alignment. Each station number indicates a specific location on the alignment.

The deposits are interbedded layers of silty sands, sandy silts and clayey silts. The maximum depth of these soft materials was found to be about six meters (twenty feet), except for a well boring beyond Station 23+50 towards Marina Boulevard, where soft clayey silt was encountered to ten meters (thirty-five feet) in depth. This layer appears to extend deeper going north towards San Francisco Bay. **Exhibit 3-42** shows potential areas of soil liquefaction. Another portion of the project study area that has potential for liquefaction is between Stations 9+50 and 11+30 in the vicinity of the high-viaduct.

[23] Soil liquefaction is the loss of strength that can occur in loose, saturated soil during or following an earthquake or other rapid loading. Liquefaction occurs most readily in sand deposits. In the liquefied zones, the strength of the soil decreases and the ability of the soil to support foundations for buildings and bridges is reduced.

Exhibit 3-41
General Location of Project Stations

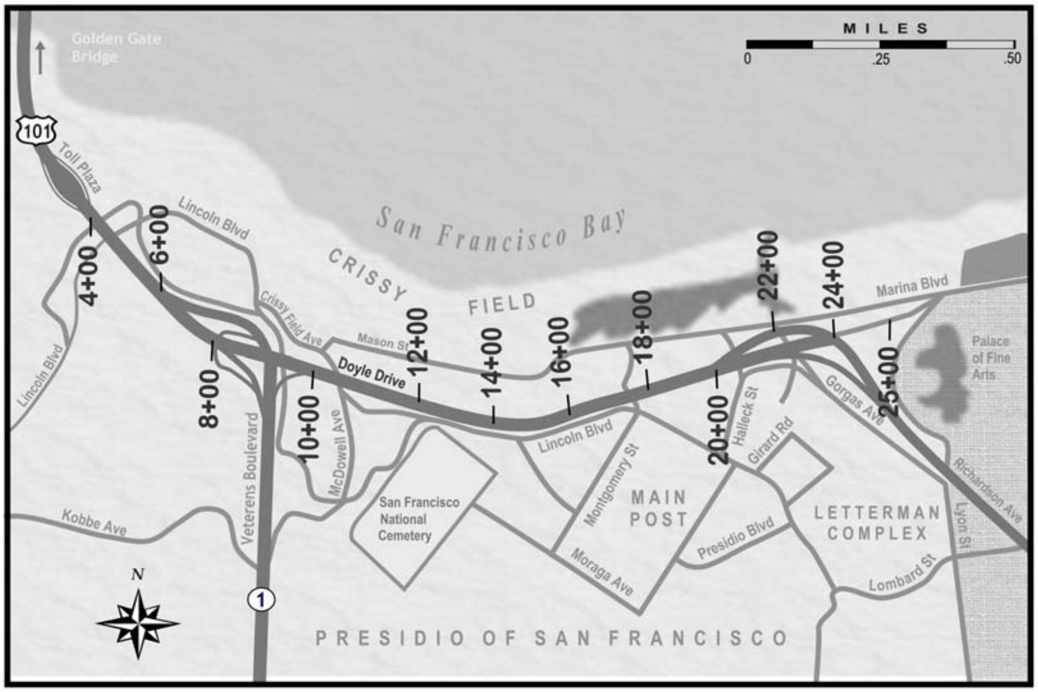
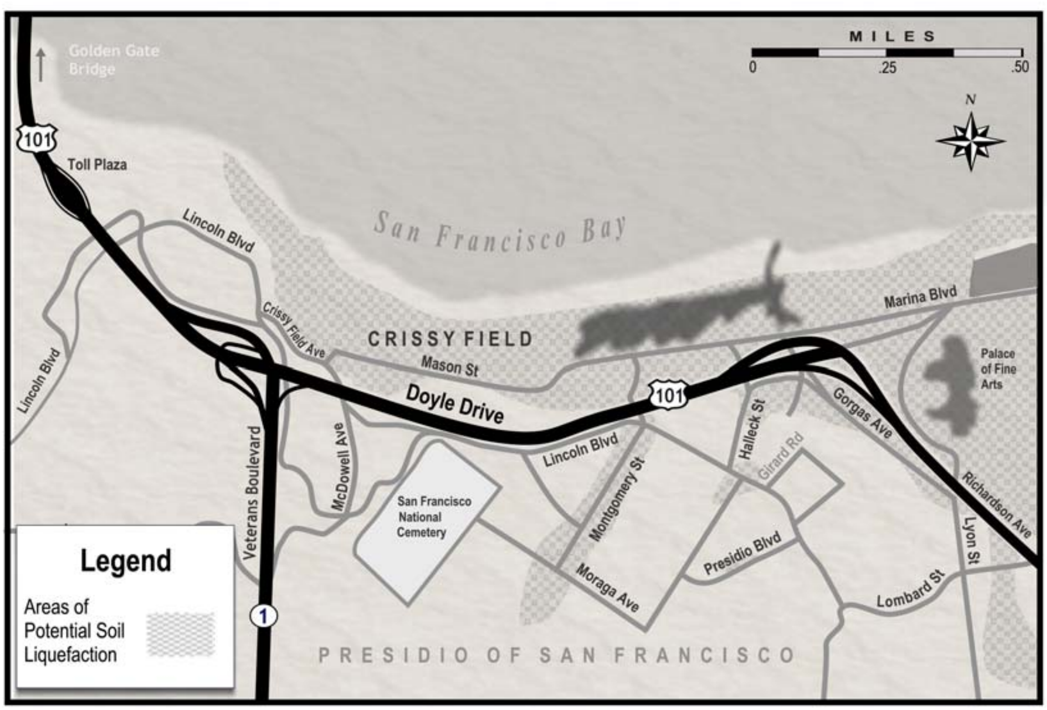


Exhibit 3-42
Potential Areas of Soil Liquefaction



Excessive Settlements and Land Movements

Landslides have been a problem on the Eastern Bluff slopes immediately north of the west abutment of the low viaduct. There were two failures in 1998. One was due to a culvert failure, which caused extensive erosion in the bluff directly under the eastbound structure. The second failure occurred on the north side of the west abutment of the low-viaduct. It was cased by water infiltrating a poorly compacted slide mass. Uncontrolled dumping at this site in the past was a contributing factor. The slope was rebuilt with underdrains and recompacted.

Borings drilled to investigate the depth and quality of the rock in the Eastern Bluff area indicate that intensely weathered and intensely fractured sandstone with siltstone is present 3.5 meters (11.5 feet) below ground surface. Another boring further east indicates intensely weathered and intensely fractured metasedimentary rock at around eighteen meters (fifty-nine feet) below ground surface.

Temporary Impacts

The following section presents potential temporary impacts to soils and geology due to construction activities in the project study area.

Alternative 1: No-Build

Based on the *Final Preliminary Geotechnical Report*, October 2004, the existing structure would remain unchanged, hence, under the No-Build Alternative, there would be no temporary impacts to geological/earth resources

Alternative 2: Replace and Widen

Temporary impacts resulting from Alternative 2 are the same for both build alternatives. Impacts are discussed below.

Alternative 5: Presidio Parkway

Temporary impacts resulting from Alternative 5 are the same for both build alternatives. Impacts are discussed below.

Alternative 2: Replace and Widen and Alternative 5: Presidio Parkway

During construction of either of the Doyle Drive Build Alternatives, topographic grades and non-vegetated, exposed ground would be created that would be susceptible to wind and water erosion.

In addition, development of the Doyle Drive Project may expose construction workers to hazardous concentrations of naturally-occurring asbestos present in serpentinite bedrock. Serpentinite was encountered west of Station 9+26 in soil borings at depths ranging from 0.3 to seven meters (one to twenty-three feet). The rock will therefore be encountered during the pile cap excavations and during cast-in-drilled-holes[24] (CIDH) pile drilling for the high-viaduct and the

[24] *CIDH piles are reinforced concrete piles cast in holes drilled to predetermined elevations.*

viaducts for the Park Presidio Interchange. Serpentinite is a source of fibrous asbestos (chrysotile), which is a known carcinogen and may cause scarring of the lungs. Although intact bedrock itself poses no risk, drilling, blasting, and removal of serpentinite could expose workers to airborne asbestos.

Permanent Impacts

Long-term impacts to soil and geologic resources are expected. The proposed Doyle Drive facility has been designed to avoid disruption of slopes, liquefaction, and other geologic/soils conditions. In addition, standard construction procedures include measures to avoid and/or minimize potential impacts. Controls would be implemented to prevent erosion, including temporary slope protection to stabilize cut slopes, and temporary shoring structures during the excavation of tunnels under Alternative 5. A Stormwater Pollution Prevention Program (SWPPP) would be implemented and Best Management Practices (BMPs) followed to minimize erosion during construction.

Exhibit 3-43 compares the estimated volume of different material type excavated for each proposed alternative. In general, native material is removed only in the western portion of the project site. Excavation of the Main Post tunnels and the low viaduct is generally limited to within the artificial fill. Therefore, only the volume of native material excavated for the high viaduct and the Battery Tunnel are listed in **Exhibit 3-43**.

The following is a discussion of potential permanent impacts which could for each project alternative.

Exhibit 3-43

Summary of Disturbance of Native Soil and Rock

Alternative	Material Type	High Viaduct Excavation	Battery Tunnel Excavation	Subtotal Excavation	Total Excavation
		m^3 ($yard^3$)	m^3 ($yard^3$)	m^3 ($yard^3$)	m^3 ($yard^3$)
Alternative 2 - Replace & Widen	Soil[1]	2,000 (2,600)	n/a	2,000 (2,600)	5,900 (7,700)
	Bedrock[2]	3,900 (5,100)	n/a	3,900 (5,100)	
Alternative 5 - Parkway - Loop Option	Soil	2,700 (3,500)	68,900 (90,100)	71,600 (93,600)	92,200 (120,600)
	Bedrock	5,500 (7,200)	15,100 (19,800)	20,600 (27,000)	
Alternative 5 - Parkway - Hook Option	Soil	2,600 (3,400)	68,900 (90,100)	71,500 (93,500)	91,850 (120,200)
	Bedrock	5,250 (6,900)	15,100 (19,800)	20,350 (26,700)	

[1] Soil includes dune and beach sands and soft clayey silt layers.

[2] Bedrock includes Franciscan Formation which is dominated by greywackes. The greywackes are interbedded with dark shale and occasional limestone. Bedrock also includes sandstones, shale and serpentine.

Alternative 1: No-Build

The existing roadway was constructed using the best available engineering technology at that time. However, portions of the alignment do not meet current earthquake standards. Due to its general conditions, it was not considered feasible to retrofit the low-viaduct structure for "No-Collapse" after the Maximum Credible Earthquake25 (MCE). Based on the Working Group on California Earthquake Probabilities (USGS, 1999), the estimated probability of a major earthquake occurring in the San Francisco Bay Area before 2030 is 70%. Earthquakes are an unavoidable geologic hazard at the Presidio and it could lead to the failure of the low-viaduct.

Alternative 2: Replace and Widen

The alignment of Alternative 2 follows that of the existing facility and does not further modify the remaining area of natural topography along the face of the Eastern Bluff. In areas where the natural topography has already been modified, the project will generally restore the existing grades. The Park Presidio interchange will remain in the existing location and the topography of Cavalry Hollow will be restored to its existing state. The slope to the east of the Eastern Bluff will be excavated and restored as it was during the construction of the existing facility. The eastern portion of Alternative 2 aligns over the artificial fill areas and will not further disturb the natural topography.

The loss of native geologic material associated with construction in this alternative is summarized in **Exhibit 3-43**. Since serpentine only occurs on the Western Bluff, the estimated volume of excavated serpentine in Alternative 2 is only the amount listed under High Viaduct Excavation in **Exhibit 3-43**.

Alternative 5: Presidio Parkway

Alternative 5 does not further modify the remaining area of natural topography along the face of the Eastern Bluff. Generally only areas that have already been modified from their natural state would be affected. The replacement of the Park Presidio interchange will cause additional disturbance to the already heavily modified topography of the Western Bluff. The existing topography of Cavalry Hollow will be modified to accommodate the realignment of Lincoln Boulevard and Crissy Field Avenue. The slope to the east of the Eastern Bluff will be replaced with a retaining wall to accommodate the new facility. The low bluff north of the Main Post will be covered by the fill placed over the Main Post tunnel and a gentle slope down to Mason street north of the new facility would be created.

The loss of native geologic material associated with construction in this alternative is summarized in **Exhibit 3-43**. Since serpentine only occurs on the

[25] The Maximum Credible Earthquake (MCE) is the largest ground motion expected to occur at the project site once every 1,500 years.

Western Bluff, the estimated volume of excavated serpentine in Alternative 5 is only the amount listed under High Viaduct Excavation in **Exhibit 3-43**.

Avoidance, Minimization, and/or Mitigation Measures

Avoidance, minimization, and mitigation measures for geological and earth-related impacts are summarized in this section.

The disturbance and removal of geologic resources to permit the construction of any of the build alternatives is unavoidable. Other geologic concerns would be addressed as described below, through appropriate subsurface investigation and design considerations.

Design and Engineer for Earthquake Activity

Seismic design for the structures would be based on the *Caltrans Seismic Design Criteria* (Caltrans, 2001). Recommendations are provided in the criteria to modify designs to incorporate the effects of the fault type; fault proximity; and structures on deep (greater than seventy-six meters [250 feet]) soil sites. Road structure designs would be based on a Magnitude 8 earthquake on the San Andreas Fault. The San Andreas Fault segment is the governing fault for this project.

Design and Install Foundations Resistant to Soil Liquefaction and Settlement

Special design features would be incorporated into structures that would be placed in soils vulnerable to liquefaction. The high-viaduct, low-viaduct, tunnels, and the causeway foundations will be required to resist complex loads and seismic activity, particularly large earthquakes. To mitigate for complex loading, seismic activity, and potential soil liquefaction and settlement, deep foundations would be required for the viaducts. The most common forms of deep foundations are piles. Different types of piles offer different advantages and are better suited for different geologic settings. CIDH piles are recommended for the High Viaduct foundations where the bedrock is shallow as is expected for the western half of the high-viaduct. Driven Cast in Steel Shell (CISS)[26] or CIDH piles are recommended for the low-viaduct under the Replace and Widen Alternative. Driven piles are recommended for the rest of the viaduct foundations. Piles would be placed to a level below the liquefaction zone to provide proper foundation support. In addition, stronger sections would be used for the upper portions of the piles in order to resist the lateral loads which would occur during a seismic event.

Additional subsurface investigations (via borings or cone penetrometer testing (CPT)) for each structural component (High-Viaduct and Park Presidio Interchange, Low-Viaduct, Battery Tunnels, Main Post Tunnels, Low Causeways, Girard Road Overpass, and remaining areas) would be necessary to obtain site-specific information to adjust piling and foundation design along the entire alignment. Borings or CPTs would also be required on surface roads to aid

[26] *CISS piles consist of driven open ended steel shells filled with reinforced cast-in-place concrete.*

proper design of the pavements. Recommended scope and type of additional subsurface investigations are presented in the *South Access to the Golden Gate Bridge: Doyle Drive Project Final Preliminary Geotechnical Report*, September 2004.

Large soil settlements are likely in the event of liquefaction in former areas covered by the historic tidal marsh, such as in the area of the Main Post Tunnels and the causeways. Such settlements would be of minor consequence to the causeways and tunnels, if measures are taken in the design of the pile foundations to appropriately incorporate the effects of the liquefied layers.

In 'soft soil' areas, such as the Main Post tunnels, the soils are inadequate for supporting the tunnels and backfilled soil cover. While it is proposed that the tunnels be supported on piles penetrating into the dense sandy substrate underlying the soft upper soils, alternative measures to improve the 'soft soils' could be investigated, whereby the need for pilings may be eliminated. Soil improvement technique could be incorporated if it does not have impact on the hydrogeologic regime.

Identify Potential Serpentinite Bedrock Disturbance Areas and Implement Safety Plan

Prior to project construction, geotechnical borings from the site would be reviewed to identify areas of serpentinite bedrock that will be disturbed during project construction. An *Asbestos Dust Mitigation Plan* would be prepared and submitted to Bay Area Air Quality Management District (BAAQMD), in accordance with the Asbestos Airborne Toxic Control Measure for Construction, Grading, Quarrying, and Surface Mining Operations. The *Asbestos Dust Mitigation Plan* would include BMPs to minimize dust during grading and other earthmoving operations. BAAQMD would also be notified at least fourteen days prior to construction activities at the site. Workers would have appropriate training and equipment to detect and handle the material when encountered. All work involving handling and disposal of asbestos, as well as worker health and safety arising out of the serpentine should be performed with strict adherence to all applicable Caltrans, federal, state and local laws and regulations.

Use/Manage Excavation Materials and Implement Geotechnically-Stable Grades

All earthwork for the project would conform to the requirements of Section 19 (Earthwork) of the most current Caltrans Standard Specifications. Soils excavated in one location would be reused as fill or backfill in another location to the extent possible, provided it meets the appropriate requirements. Unsuitable materials such as contaminated soils or soils with high plasticity or excessive organic content would be appropriately disposed of offsite. Soils identified with serpentine would have to be tested to determine suitability for on-site use as fill materials. An earthwork management plan would be developed in coordination with Trust and the National Park Service (NPS).

If archaeological materials not subject to scientific study are redeposited elsewhere on the Presidio, the project proponent will consult with the land manager to ensure that the secondary nature of the materials is documented appropriately and that the primary and secondary locations of such materials are plotted on appropriate maps and documented in such as way to inform future researchers.

3.3.3 Hazardous Waste/Materials

Hazardous materials and wastes can be encountered unexpectedly during the construction and operation of public projects. Examples of common hazardous materials include asbestos, lead-based paint, and volatile organic compounds[27], and, without proper handling, removal, and containment, can pose dangers to the public. Identifying potential waste sites prior to construction is important because it can substantially reduce the possibility of exposure to people and the environment. In the event unexpected encounters do occur, having proper plans and procedures in place further reduces that risk.

This section presents a summary of the hazardous materials and wastes which are located in the Doyle Drive Project study area. More information can be found in the *South Access to the Golden Gate Bridge: Doyle Drive Project Revised Preliminary Site Investigation,* October 2004.

Regulatory Setting

Federal, state, and local laws and regulations govern the use, storage, transportation, and disposal of hazardous materials, as well as including management of contaminated soils and groundwater. The U.S. Environmental Protection Agency (EPA) is the Federal-administering agency for hazardous waste regulations. State and regional agencies are responsible for administering and enforcing California laws and regulations. These include the California Environmental Protection Agency (Cal EPA) Department of Toxic Substances Control (DTSC), the San Francisco Bay Regional Water Quality Control Board (SFRWQCB), the California Air Resources Board (CARB), and the Bay Area Air Quality Management District (BAAQMD). Locally, the San Francisco Department of Public Health (SFDPH) is responsible for certain hazardous material regulation enforcement within the city and county of San Francisco. The San Francisco Fire Department (SFFD) acts as first responder for hazardous material incidents within the study area. The U.S. Department of Transportation (USDOT) is the Federal-administering agency for hazardous materials transportation safety.

Additional laws, regulations, policies, and programs regulate the investigation of Federal properties, such as the Presidio, which are affected by hazardous materials. One of the primary laws affecting Federal properties is the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA).

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[27] *This term is generally applied to organic solvents, certain paint additives, aerosol spray-can propellants, fuels (such as gasoline and kerosene), petroleum distillates, dry cleaning products, and many other industrial and consumer products ranging from office supplies to building materials.*