3.14 GEOLOGY AND SOILS

This section describes the geology and soils setting and regulatory setting and discusses the potential effects of the EA Alternatives on geology and soils.

3.14.1 Regulatory Framework

Clean Water Act

The Clean Water Act (CWA) (33 U.S. Code [USC] 1251 et seq.) includes provisions for reducing soil erosion for the protection of water quality. The CWA prohibits the discharge of pollutants from a point source to navigable waters, unless a permit was obtained under the CWA's provisions. Regulation of discharges under the CWA also pertains to construction sites where soil erosion and stormwater runoff and other pollutant discharges could affect downstream water quality. The CWA is described in greater detail in Section 3.2 (Water Resources).

Executive Order 12699

Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," was signed by President George H. W. Bush on January 5, 1990, to further the goals of Public Law 95-124, the Earthquake Hazards Reduction Act of 1977, as amended. The executive order applies to new construction of buildings owned, leased, constructed, assisted, or regulated by the Federal government. Guidelines and procedures for implementing the order were prepared in 1992 by the Federal Interagency Committee on Seismic Safety in Construction. The guidelines establish minimum acceptable seismic safety standards, provide evaluation procedures for determining the adequacy of local building codes, and recommend implementation procedures. Each Federal agency is independently responsible for ensuring that appropriate seismic design and construction standards are applied to new construction under its jurisdiction.

Under Executive Order 12699, the original model code for the West Coast was the Uniform Building Code, developed by the International Conference of Building Officials. In 1994, the International Conference of Building Officials joined with other similar organizations in the Southeast and on the East Coast to form the International Code Council (ICC). In 2000, the ICC published the first International Building Code (IBC) based on the reassessment of earlier codes and the combined updated experience of ICC member organizations. The current (2006) IBC is the result of nearly 100 years of building code improvement.

International Building Code

The IBC, which encompasses the former Uniform Building Code, is published by the ICC to provide standard specifications for engineering and construction activities, including measures to address geologic and soil concerns (ICC, 2009). Specifically, these measures encompass issues such as seismic loading (e.g., classifying seismic zones and faults), ground motion, and engineered fill specifications (e.g., compaction and moisture content). The referenced guidelines, though not formal regulatory requirements per se, are widely accepted by regulatory authorities and are routinely included in related standards such as grading codes. The IBC guidelines are updated regularly to reflect current industry standards and practices, including criteria from sources such as the American Society of Civil Engineers and ASTM International (ASTM, formerly known as the American Society for Testing and Materials).

Earthquake Hazards Reduction Act

In October 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act (42 USC 7701 et seq.) to "reduce the risks to life and property from future earthquakes in the United States [U.S.] through the establishment and maintenance of an effective earthquake hazards and reduction program" (42 USC 7702). To accomplish this, the act established the National Earthquake Hazards Reduction Program. The National Earthquake Hazards Reduction Program Act (NEHRPA) substantially amended this program in November 1990 by refining the description of agency responsibilities, program goals, and objectives. The NEHRPA designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns FEMA several planning, coordinating, and reporting responsibilities. Other NEHRPA agencies include the National Institute of Standards and Technology, the National Science Foundation, and U.S. Geological Survey (USGS).

Veterans Health Administration Directive 2005-019

The purpose of Veterans Health Administration (VHA) Directive 2005-019 is to establish a policy regarding the seismic safety of VHA buildings. Because facilities identified as essential must remain in operation after a seismic event, VHA Directive 2005-019 assists VA in providing adequate life-safety protection to veterans, employees, and other building occupants. Under VHA Directive 2005-019, all new buildings must be structurally designed and constructed in compliance with VA Seismic Design Requirements H-18-8 and the IBC. A major update of the VA Seismic Design Requirements H-18-8 (formerly known as H-08-8) was implemented in 1995. The current VA Seismic Design Requirements H-18-8 closely aligns with the IBC, and the VA Seismic Design Requirements are applicable to the Proposed Action.

Alquist-Priolo Earthquake Fault Zoning Act

The California Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act) was passed in December 1972 to mitigate the hazard of surface faulting to structures for human occupancy. Surface rupture is the most easily avoided seismic hazard. The main purpose of the Alquist-Priolo Act is to prevent the construction of buildings used for human occupancy on the surface trace of active faults.

The Alquist-Priolo Act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. The California Seismic Hazards Mapping Act, passed in 1990, addresses earthquake hazards caused by non-surface fault rupture, including liquefaction and seismically induced landslides. The law requires the State Geologist to establish regulatory zones, known as earthquake fault zones, around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning and controlling new or renewed construction. Local agencies regulate most development projects within the zones. Projects include all land divisions and most structures for human occupancy. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back 50 feet from the fault trace.

Because no active fault zones are known to exist in the City of Alameda, no earthquake fault zones are mapped on the VA Transfer Parcel under the Alquist-Priolo Act.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act of 1990 addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides, and its purpose is to protect public safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and other hazards caused by earthquakes. This law requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects with these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the project design. Seismic Hazard maps have been completed for much of the San Francisco Bay Area.

3.14.2 Affected Environment

Regional Geologic Setting

The VA Transfer Parcel is located in the City of Alameda on the east side of San Francisco Bay in the Coast Ranges geomorphic province, a relatively young geologically and seismically active region on the western margin of the North American Plate. The Coast Ranges are characterized by discontinuous northwest to southeast–trending mountains and valleys, and is dominated by northwest-trending faults, folds, and geologic structures (California Geological Survey [CGS], 2002). The VA Development Area is bordered on the west by San Francisco Bay, a northwest-trending structural depression. The Bay and much of its margins are underlain by the Late Mesozoic Age rocks of the Franciscan Complex. The Franciscan Complex rocks commonly consist of sheared shale and interbedded sandstone, with serpentinite and other metamorphic rocks. Tertiary and Quaternary formations occur locally in unconformity on the Franciscan Complex, while other Mesozoic formations occur in fault contact with the Franciscan Complex (CGS, 2002).

Beneath San Francisco Bay and its margins, the Franciscan bedrock is overlain by a young, geologically unconsolidated sedimentary sequence, which in places exceeds 400 feet in thickness. The sequence is divided into three units, older Bay sediments of the Yerba Buena Formation, Merritt sands of the San Antonio Formation, and younger Bay Mud. Artificial fill of variable thickness, quality, and density has been placed along the margins of San Francisco Bay to reclaim marshland and land once covered by shallow water.

Faulting and Seismicity

VA Transfer Parcel

The major regional active faults considered likely to produce damaging earthquakes at the VA Transfer Parcel are the San Andreas, San Gregorio, Hayward, and Calaveras Faults (Figure 3.14-1). Table 3.14-1 lists the proximity of the closest of the active faults to the VA Transfer Parcel and the estimated maximum moment magnitude[1] for

[1] Seismologists now use a moment magnitude (MN) scale, since it provides a more accurate measurement of the size of major and great earthquakes given that earthquake magnitudes readings greater than MN 7.0 on the moment magnitude scale are slightly greater than a corresponding Richter magnitude. Maximum moment magnitude is the most severe earthquake that could occur on a particular fault.

Source: Data compiled by AECOM in 2012

Figure 3.14-1: Major Faults and Earthquake Epicenters in the San Francisco Bay Area

Table 3.14-1: Regional Faults and Seismicity

Fault Name	Distance (km) from VA Transfer Parcel	Direction from Site	Maximum Moment Magnitude
Hayward—Total	10	Northeast	7.1
San Andreas—1906 Rupture	19.5	Southwest	7.9
San Andreas—Peninsula	19.5	Southwest	7.2
San Andreas—North Coast South	24	West	7.5
San Gregorio North	25	West	7.3
Mount Diablo Thrust	26	East	6.7
Northern Calaveras	27.5	East	7.0
Concord	32	Northeast	6.5
Rodgers Creek	33	North	7.1
Southern Green Valley	36	Northeast	6.5
Northern Greenville	39	Northeast	6.6
Monte Vista	40	South	6.8
West Napa	42	North	6.5
Great Valley—6	45	Northeast	6.7
Central Greenville	45.5	East	6.7
Point Reyes	47.5	West	6.8
Great Valley—5	50	Northeast	6.5

Notes: km = kilometers; VA = U.S. Department of Veterans Affairs
Source: WGCEP, 1999

each fault. Alameda Point is not located within an "earthquake fault zone" as delineated by the CGS, and as shown in Figure 3.14-1, no active faults exist on the VA Transfer Parcel (see "Alquist-Priolo Earthquake Fault Zoning Act," above).

Surrounding Area

The Bay Area is located in a seismically active region near the boundary between two major tectonic plates, the Pacific Plate to the southwest and the North American Plate to the northeast. These two plates move relative to each other in a predominantly lateral manner, with the San Andreas Fault Zone at the junction. The Pacific Plate, on the west side of the fault zone, is moving north relative to the North American Plate on the east. Since approximately 23 million years ago, about 200 miles of right-lateral slip has occurred along the San Andreas Fault Zone to accommodate the relative movement between these two plates (USGS, 2002). The relative movement between the Pacific and North American Plates generally occurs across a 50-mile zone extending from the San Gregorio Fault in the southwest to the Great Valley Thrust Belt to the northeast. In addition to the right-lateral slip movement between tectonic plates, a compressional component of relative movement has developed between the Pacific Plate and a smaller segment of the North American Plate at the latitude of San Francisco Bay during the last 3.5 million years. Strain produced by the relative motions of these plates is relieved by right-lateral strike-slip faulting on the San Andreas Fault and related faults, and by vertical reverse-slip displacement on the Great Valley Fault and other thrust faults in the central California area.

The region's seismic faults can be classified as historically active, active, sufficiently active and well-defined, or inactive, as defined below (CGS, 2007):

- *Historically active* faults are faults that have generated earthquakes accompanied by surface rupture during historic time (approximately the last 200 years) or that exhibit a seismic fault creep (slow incremental movement along a fault that does not entail earthquake activity).
- *Active* faults show geologic evidence of movement within Holocene time (approximately the last 11,000 years).
- *Sufficiently active and well-defined* faults show geologic evidence of movement during the Holocene along one or more of their segments or branches, and their trace may be identified by direct or indirect methods.
- *Inactive* faults show direct geologic evidence of inactivity (that is, no displacement) during all of Quaternary time or longer.

Although it is difficult to quantify the probability that an earthquake will occur on a specific fault, the preceding classification is based on the assumption that if a fault has moved during the last 11,000 years, it is likely to produce earthquakes in the future.

Ground Shaking

VA Transfer Parcel

Earthquakes occurring on faults closest to the VA Transfer Parcel would have the potential to generate the largest ground motions at the site.

Surrounding Area

The USGS has predicted that there is a 63% chance of a moment magnitude 6.7 earthquake or greater occurring in the Bay Area over a period of 30 years, between 2003 and 2032 (USGS, 2007). The intensity of the seismic shaking during an earthquake depends on the distance and direction to the earthquake's epicenter, the magnitude of the earthquake, and the area's geologic conditions.

Topography and Soils

VA Transfer Parcel

The VA Transfer Parcel is located on Alameda Point, which is located on the western portion of Alameda Island. The existing VA Transfer Parcel ranges from 0 msl to approximately 10 feet above msl (CH2M Hill, 2011).

The VA Transfer Parcel is underlain by approximately 15–30 feet of artificial fill consisting of loose to medium dense sands, overlying a range of 30–65 feet of very soft, compressible younger Bay Mud deposits. The younger Bay Mud is underlain by about 30 feet of dense to very dense sands of the San Antonio Formation, including Merritt and Posey sands. These sands are overly stiff to very stiff, older Bay Mud (clay) deposits with a similar origin as the younger Bay Mud (AECOM, 2009). The VA Development Area for both Alternative 1 and Alternative 2 is located within an area that is mapped as a liquefaction hazard zone (CGS, 2003).

Surrounding Area

Alameda Island is characterized by a low topographic profile with surface elevations from mean sea level (msl) to approximately 30 feet above msl.

Like other areas around San Francisco Bay, Alameda Point was created with artificial fill to create developable land (Figure 3.14-2). Historical records indicate that Alameda Point was formerly a shallow mudflat consisting of young Bay Mud with depths generally ranging from 20-feet to more than 100-feet thick. Over an extended period of time, from 1906 to about 1956, the area was filled to create land. The artificial fill sequence consisted of periodic placement of sandy fills in several phases, using hydraulic dredging methods.

The westerly fill at Alameda Point consists of heterogeneous landfill materials consisting of a wide variety of waste materials and construction debris. In the eastern portion of Alameda Point, a Marsh Crust Horizon, approximately 2–6 inches thick, exists just under the artificial fill. The Marsh Crust was not encountered during soil borings near the VA Transfer Parcel (CH2M Hill, 2011).

3.14.3 Environmental Consequences

Assessment Methods

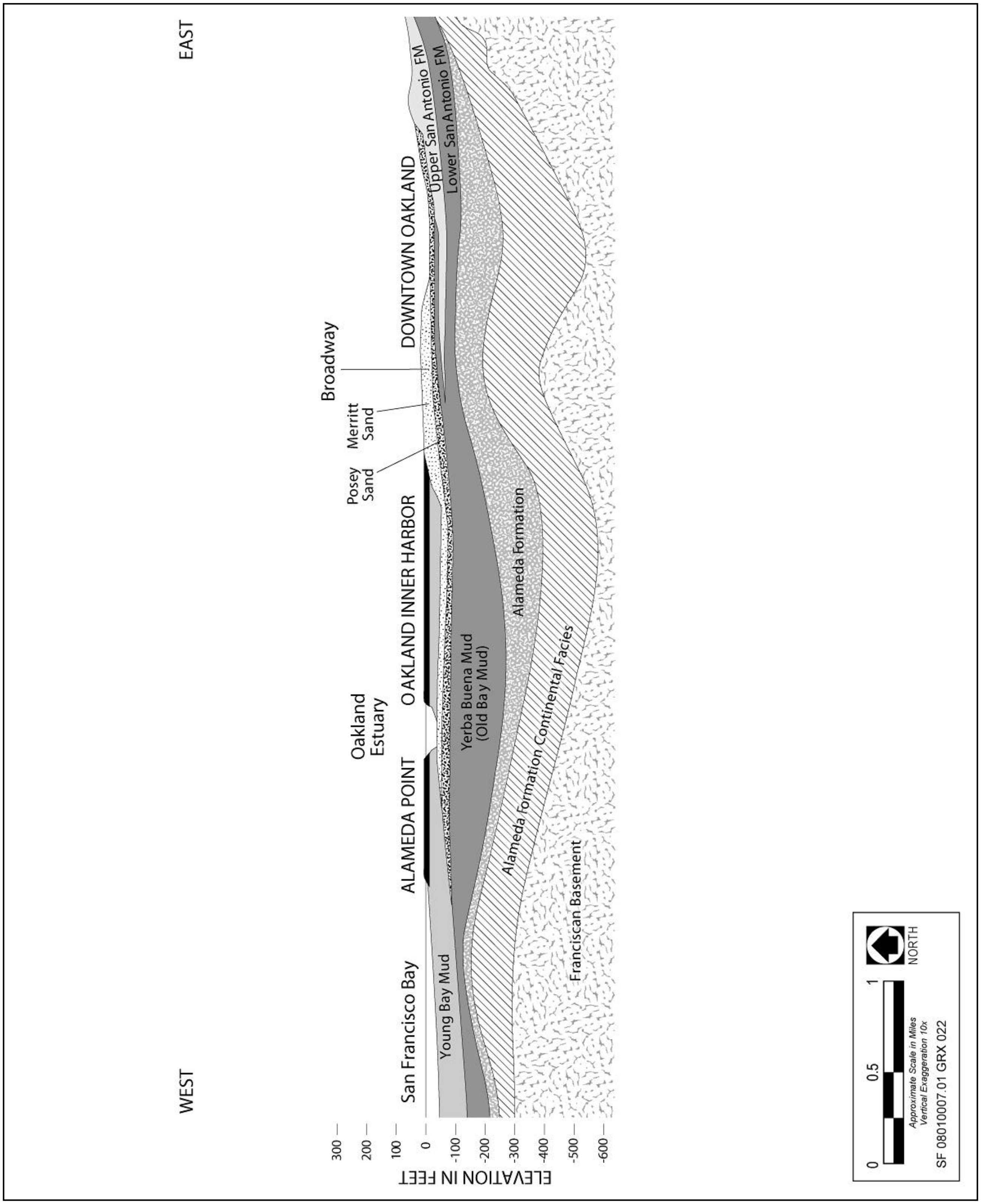
The significance of impacts associated with faulting, ground acceleration, and ground shaking was evaluated based on distance to known fault zones and the seismic characteristics of fault zones. Adverse impacts could occur on soils possessing moderate to severe potential for erosion and liquefaction. Soil erosion impacts are also discussed in Section 3.2 (Water Resources). As noted above, the City of Alameda is not located within an earthquake fault zone, as delineated by CGS, and no active faults exist on Alameda Point; thus, exposure of people or structures to surface fault rupture is not evaluated below. The analysis below is based on site-specific geotechnical reports that are provided in Appendix H (Geotechnical Assessment Report).

Alternative 1

Construction

<u>Erosion and Loss of Topsoil</u>

Construction of the proposed VHA OPC, the Conservation Management Office, and the first phase of the NCA Cemetery during initial construction of Alternative 1 would involve site grading and preparation that would disturb exposed artificial fill. Despite previous development on the former NAS Alameda, erosion and loss of topsoil could occur as a result of construction activities. Excavation, grading, import of fill, and facility construction in the VA Development Area would require temporary disturbance of surface soils and removal of existing on-site pavements, five existing bunkers, and existing subsurface infrastructure. Exposed fill materials would be susceptible to erosion during construction-related excavation. Stormwater runoff could cause erosion during project construction, although most loosened and eroded soil would remain within the excavation pits.



Source: Rogers and Figuers, 1991

Figure 3.14-2: Geologic Cross Section

VA would be required to obtain a National Pollutant Discharge Elimination System (NPDES) general permit for stormwater discharges associated with construction activities (Construction General Permit; State Water Resources Control Board Order No. 99-08-DWQ) before construction could proceed. To complete construction activities that would disturb 1 acre or more where drainage would flow to the separate sewer system, VA must comply with the Construction General Permit and must prepare and implement a storm water pollution prevention plan (SWPPP) that meets the permit's conditions. See the discussion of a SWPPP in Section 3.2 (Water Resources) which evaluates erosion in further detail. With implementation of a SWPPP, the construction-related impact of initial construction related to erosion and loss of topsoil would not be significant.

Under subsequent construction of the cemetery phases of Alternative 1 through the year 2116, potential erosion impacts would be similar to those identified for initial construction. Therefore, the construction-related impact of Alternative 1, for the subsequent cemetery phase construction related to erosion and loss of topsoil would not be significant.

Alteration of Topography

Construction of Alternative 1 would not involve any below-grade development or substantial change in the current topography of the VA Development Area. However, as part of the construction of proposed VA facilities and through the import of 440,000 cubic yards of fill, the ground elevation would be raised to 12.5 feet above msl for the proposed roadways and to 13.5 feet above msl for the proposed VHA OPC, Conservation Management Office, and NCA National Cemetery. As noted previously, the VA Transfer Parcel is primarily flat. The topography in the VA Development Area would be altered to include areas raised above the current topography to 12.5 to 13.5 feet above msl, but these changes in topography would be contoured gradually over the approximately 111-acre, on-site development area. Thus, the construction-related impact of Alternative 1 related to alteration of topography would not be significant.

Operation

Seismically Induced Ground Shaking and Associated Ground Failure

Liquefaction typically occurs when saturated, clean, fine-grained loose sands near the surface (usually in the upper 50 feet) are subject to intense ground shaking and the groundwater table is shallow. One of the major types of liquefaction-induced ground failures is lateral spreading of mildly sloping ground. Lateral spreading is a failure within a nearly horizontal soil zone (possibly from liquefaction) that causes the overlying soil mass to move toward a free face or down a gentle slope.

As noted above, the VA Development Area is located within an area that is mapped as a liquefaction hazard zone (CGS, 2003). As required by VA, a report to identify engineering geologic hazards (geotechnical investigation) and site-specific ground responses was prepared by the Allegiance Group, LLC in April 2012 for the project area (Allegiance Group, 2012). The liquefaction analysis performed by the Allegiance Group indicated high liquefaction potential in the VA Development Area from the surface to 40 feet below ground surface. Borings during the geotechnical site investigation encountered groundwater between 1.0 and 4.5 feet below ground surface (Allegiance Group, 2012). Because the VA Development Area is located between two major active faults (the Hayward and San Andreas Faults) and the top 25–40 feet of soil consists of loose to very loose saturated sand, the potential for liquefaction and lateral spreading during a seismic event is high (Allegiance Group, 2012).

Two options for engineering and design of the proposed facilities—stone columns and deep dynamic compaction—were recommended to address the potential for seismically induced ground shaking and associated ground failure at the VA Development Area. The VA would design and construct the facilities proposed by Alternative 1 utilizing the engineering and design specifications identified in either option, as well as VA Seismic Design Requirements H-18-8 and the IBC. Current design plans include the installation of approximately 800 stone columns, 3.5 feet in diameter, to a depth of 40 feet below ground surface (bgs). These columns would be installed along the main access road located along the northern portion of the VA Development Area (Figure 3.14-3). The stone columns would be installed using a direct push methodology where a probe is "pushed" into the ground using vibration techniques and then the resulting hole is filled with crushed stone. The columns then would work as vertical drainage to prevent the buildup of excess pressure. Stone columns would only prevent lateral spreading; thus, piles for protection from liquefaction also would be required.

Subsidence, the sinking or settling of land, is caused by compaction of unconsolidated soils during a seismic event, soil compaction by heavy structures, erosion of peat soils, or groundwater depletion. Subsidence usually occurs over a broad area, and therefore is not detectable at the ground surface. Placing additional fill or constructing buildings with shallow foundations in the VA Development Area would place additional weight on the Bay Mud. This additional weight would cause consolidation of the Bay Mud layer, resulting in settlement at the ground surface. Consolidation would occur relatively slowly as excess pore pressures dissipate. The amount of consolidation settlement would depend on the thickness of the existing fill, thickness of the soft Bay Mud, and the imposed loads from the new fill and buildings (AECOM, 2009). The estimated 444,000 cubic yards of import was calculated based on the geologic constraints of Bay Mud consolidation, and no additional fill would be required to raise ground elevation for the proposed VHA, OPC, and first cemetery phase.

The VA Development Area is not mapped in a subsidence zone (Allegiance Group, 2012). However, with the addition of approximately 440,000 cubic yards of fill for Alternative 1, Phase 1, which would include construction of the VHA OPC, the Conservation Management Office, the access road, and the initial phase of the cemetery, potential settlement effects may occur.

As described above, the project design would be required to include seismic safety–related features to mitigate the potential for seismically induced ground failure. Therefore, operational impacts of Alternative 1 related to seismically induced ground shaking and ground failure would not be significant.

Seismically Induced Landslides or Slope Failures

Landslides and other slope failures are common occurrences during or soon after earthquakes. The VA Development Area is not located within a designated landslide hazard zone (CGS, 2003), and no potential exists for landslides because the area is flat. No operational impact related to seismically induced landslides or slope failures would occur under Alternative 1.

Expansive or Corrosive Soils

Expansive soils generally result when specific clay minerals in the soil expand when saturated and shrink in volume when dry. Expansive soils can occur in any climate; however, arid and semiarid regions are subject to more extreme cycles of expansion and contraction than more consistently moist areas. As noted previously and shown in Figure 3.14-2, the VA Development Area is underlain by both young and old Bay Mud. The site-

Source: Allegiance Group, 2013

Figure 3.14-3: Location of Proposed Stone Columns

specific geotechnical investigation states that using one of the two options for seismic mitigation (stone columns or deep dynamic compaction) and subsurface engineering, and following standard VA seismic design recommendations for the proposed facilities, would help accommodate any potential expansion of Bay Mud (clay). Therefore, the operational impact of Alternative 1 related to expansive or corrosive soils would not be significant.

Alternative 2 (Preferred Alternative)

Construction

Alternative 2 would involve the same project components as Alternative 1; however, under Alternative 2, the VA Development Area would be located farther north and would extend into an area referred to as the Northwest Territories (Figure 2-3 in Chapter 2.0 [Alternatives]). Under VHA Directive 2005-019, all new buildings would be structurally designed and constructed in compliance with VA Seismic Design Requirements H-18-8 and the IBC.

Erosion and Loss of Topsoil

The effects of constructing buildings, parking lots, and a cemetery as proposed under Alternative 2 would be similar to those of Alternative 1. As under Alternative 1, VA would be required to obtain a NPDES general permit for stormwater discharges associated with construction activities (Construction General Permit; State Water Resources Control Board Order No. 99-08-DWQ) and to implement a SWPPP that meets the conditions of the Construction General Permit. With implementation of a SWPPP, the construction-related impact of Alternative 2 related to erosion and loss of topsoil would not be significant.

Alteration of Topography

Like Alternative 1, Alternative 2 would not result in any below-grade development or any substantial change in the current topography of the VA Development Area. The area's topography would not be substantially altered, and the proposed buildings would be constructed following applicable VA Seismic Design Requirements H-18-8 and the IBC. Therefore, the construction-related impact of Alternative 2 related to alteration of topography would not be significant.

Operation

Seismically Induced Ground Shaking and Ground Failure

Alternative 2 would involve the same project components as Alternative 1; however, under Alternative 2, the VA Development Area would be located farther north. Thus, the effects related to seismically induced ground failure discussed above for Alternative 1 also would apply to Alternative 2. The two options for seismic mitigation (stone columns and deep dynamic compaction) would apply to Alternative 2, and VA would design and construct facilities under this alternative utilizing the engineering and design specifications for either option, the VA Seismic Design Requirements H-18-8, and the IBC. Therefore, the operational impact of Alternative 2 related to seismically induced ground shaking and ground failure would not be significant.

<u>Seismically Induced Landslides or Slope Failures</u>

Alternative 2 would involve the same project components as Alternative 1; however, under Alternative 2, the VA Development Area would be located farther north, which is also flat, like the rest of Alameda Point. Therefore, no operational impact related to seismically induced landslides or slope failures would occur under any phase of Alternative 2.

<u>Expansive or Corrosive Soils</u>

Alternative 2 would involve the same project components as Alternative 1; however, under Alternative 2, the VA Development Area would be located farther north. The site-specific geotechnical investigation states that using one of the two options for seismic mitigation (stone columns or deep dynamic compaction) and subsurface engineering, and following standard VA seismic design recommendations for the proposed facilities, would help accommodate any potential expansion of Bay Mud (clay). Therefore, the operational impact of Alternative 2 related to expansive or corrosive soils would not be significant.

No Action Alternative

Construction

Under the No Action Alternative, the Fed-to-Fed transfer would not take place, and no VA facilities would be constructed. Therefore, no significant construction-related geology and soil impacts would occur.

Operation

Under the No Action Alternative, the Fed-to-Fed transfer would not take place, and no VA facilities would be operated on the property. The property would be retained by Navy in caretaker status until another action on the property is taken. Therefore, no significant operational-related geology and soil impacts would occur.

3.14.4 References

AECOM. 2009 (May 13). Geotechnical Assessment Report, Proposed VA Facilities NAS, California.

Allegiance Group, LLC. 2012 (April 5). Interim Geotechnical Investigation Report, Alameda Point Veterans Administration Project Alameda, California. Prepared for HDR Architecture, Inc.

———. 2013 (June 10). Geotechnical Investigation Report, Alameda Point Veterans Administration Project Alameda, CA.

California Geological Survey (CGS). 2002. *California Geomorphic Provinces*. Note 36. Sacramento, CA.

———. 2003 (February 14). State of California Seismic Hazard Zones, Oakland West Quadrangle. Sacramento, CA.

———. 2007. *Fault-Rupture Hazard Zones in California*, Interim Revision 2007. Special Publication No. 42. Sacramento, CA.

CH2M Hill. 2011 (January). Final Site Inspection Report Transfer Parcels FED-1A, FED-2B, and FED-2C Alameda Point Alameda, California. Prepared for U.S. Department of the Navy.

Graymer, R. W., B. C. Moring, G. J. Saucedo, C. M. Wentworth, E. E. Brabb, and K. L. Knudsen. 2006. Geologic Map of the San Francisco Bay Region. Available: <http://pubs.usgs.gov/sim/2006/2918/sim2918_geolposter-stdres.pdf>. Accessed March 27, 2012.

International Code Council (ICC). 2009. International Building Code.

Rogers, J. D., and S. H. Figuers. 1991 (December). Engineering Geologic Site Characterization of the Greater Oakland-Alameda Area, Alameda and San Francisco Counties, California.

U.S. Geological Survey (USGS). 2002. *Rocks and Geology in the San Francisco Bay Region*. Bulletin 2195.

———. 2007. Working Group on California Earthquake Probabilities, 2008, The *Uniform California Earthquake Rupture Forecast, Version 2* (UCERF 2). U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 203.

Working Group on California Earthquake Probabilities (WGCEP). 1999. *Earthquake Probabilities in the San Francisco Bay Region: 2000 to 2030—A Summary of Findings.* Open-File Report 99-517.