

1 **4.13 GEOLOGY, SEISMICITY, AND SOILS**

2 Redevelopment would eliminate structures in the Oakland Army Base sub-district that do not
3 meet current seismic standards; this would be a benefit. Redevelopment could also result in
4 potentially significant impacts related to earthquakes, erosion, and currently unknown
5 subsurface features or facilities. With implementation of measures recommended in this section,
6 all potentially significant impacts would be mitigated to a level that is less than significant.

7 **4.13.1 Study Area**

8 The study area is the approximately 1,800-acre redevelopment project area.

9 **4.13.2 Regulatory Setting**

10 **Federal**

11 Information obtained from two federal agencies contributes to the geologic definition of the area.
12 The U.S. Geological Survey (USGS) performs regional-scale geologic studies and mapping
13 used by numerous agencies and others as background information about soils, geology, surface
14 water, and groundwater. The U.S. Department of Agriculture (USDA) compiles, updates, and
15 maintains information about soils, and presents this information in soil surveys. Soil surveys that
16 contain soil type classifications, leaching characteristics, and other information are used by
17 agencies and others as regulatory input or baseline data.

18 **State/Regional**

19 The California Department of Conservation, Division of Mines and Geology (CDMG) compiles,
20 updates, and maintains information regarding regional and local geologic conditions. This
21 includes mapping potentially active and known active faults and seismic evaluations under the
22 Alquist-Priolo Earthquake Fault Zoning Act (PRC §§ 2621-2630). The CDMG makes this
23 information available to other agencies.

24 The San Francisco Bay Area Regional Water Quality Control Board (RWQCB), Region 2, is
25 involved with groundwater quality and regional hydrogeologic issues around the San Francisco
26 Bay Area.

27 **Local**

28 The San Francisco Bay Plan enables BCDC to regulate certain activities in and near the Bay.
29 The policies established by the BCDC regarding the Safety of Fills include the following:

30 ***Policy 1.** The BCDC has appointed the Engineering Criteria Review Board*
31 *consisting of geologists, civil engineers specializing in geotechnical and coastal*
32 *engineering, structural engineers and architects competent to and adequately*
33 *empowered to: (a) establish and revise safety criteria for bay fills and structures*
34 *thereon; (b) review all except minor projects for the adequacy of their specific*

1 *safety provisions and make recommendations concerning these provisions; (c)*
2 *prescribe an inspection system to assure placement of fill according to approved*
3 *designs and (d) gather, and make available performance data developed from*
4 *specific projects. These activities would complement the functions of local*
5 *building departments and local planning departments, none of which are*
6 *presently staffed to provide soil inspections.*

7 ***Policy 2.*** *Even if the Bay Plan indicates that a fill may be permissible, no fill or*
8 *building should be constructed if hazards cannot be overcome adequately for the*
9 *intended use in accordance with the criteria prescribed by the Engineering*
10 *Criteria Review Board (BCDC 1989).*

11 The *Health and Safety Element* of the Oakland General Plan requires a soils and geologic
12 report be submitted to the Department of Public Works (DPW) prior to issuance of any building
13 permit. This report must evaluate the potential for lateral spreading, liquefaction, differential
14 settlement, and other types of ground failure.

15 The General Plan requires all structures of three or more stories to be supported on pile
16 foundations that penetrate Bay Mud deposits and to be anchored in firm, non-compressible
17 materials unless geotechnical findings indicate a more appropriate design. It also provides for
18 the identification and evaluation of existing structural hazards and abatement of those hazards
19 to acceptable levels of risk.

20 **4.13.3 Regional Setting**

21 The region under consideration is the nine-county San Francisco Bay Area.

22 **Geology**

23 The San Francisco Bay Area is identified as a structural depression within the Coast Range
24 Geomorphic province. The Bay is bordered by nearly parallel mountain ranges, the Diablo
25 Range to the east and the Santa Cruz Mountains to the west, that trend northwesterly along
26 several fault zones. The folding and faulting that produced the mountains and the troughs
27 occurred during late Pliocene to mid-Pleistocene time and continues today.

28 Faults and folds of comparatively recent age dominate the geologic setting of the San Francisco
29 Bay region. The folded nature of the rocks created mountain ranges separated by structural
30 troughs due to the westward (tectonic) movement of the North American plate. As the troughs
31 filled with sediment eroded from the mountains, they continued to subside, resulting in a thick
32 layer of sediment. San Francisco Bay is such a structural trough. Subsidence of the structural
33 trough encompassing the Bay occurred during the Pleistocene (5 million to 10,000 years ago)
34 and Holocene epochs (10,000 years ago to the present). Erosion of the Coast Range
35 contributed much of the sediment deposited in the Bay Area structural trough (Corps 1999).

1 The sedimentary formations in the Bay region can be divided into five distinct units. The oldest
2 of these are the Alameda, San Antonio, and Posey formations, which are predominantly clays
3 but also contain layers of silts and sands. These three formations are collectively referred to as
4 Old Bay Muds.

5 The sea level subsided as a result of glaciation after deposition of the Old Bay Muds. This
6 resulted in exposure and erosion of these deposits. The eroded valleys were then largely filled
7 by eolian (windblown) Merritt Sand, which also blanketed many areas between the eroded
8 valleys. After deposition of the Merritt Sand, the sea level gradually rose to its present level,
9 flooding the Bay and resulting in a marine deposit, known as Young Bay Mud, that covers much
10 of the Bay basin to depths of as much as 120 feet (Corps 1999).

11 **Seismicity**

12 Figure 4.13-1 illustrates the tectonic environment of the San Francisco Bay Area.

13 **Faults and Ground Rupture.** The geology of the San Francisco Bay Area, a seismically active
14 area, is dominated by the San Andreas Fault system. The principal seismically active faults of
15 the San Andreas system in the Bay Area include the San Andreas, San Gregorio, Hayward,
16 Rodgers Creek, West Napa, Calaveras, Concord, and Green Valley faults. Ground or fault
17 rupture occurs when the ground above and earthquake experiences lateral displacement during
18 an earthquake. In essence, the ground surface “tears.”

19 **Ground Shaking.** The entire Bay Area is prone to strong seismic ground shaking. The
20 probability of one or more large earthquakes (Richter magnitude 6.7 or greater) occurring in the
21 San Francisco Bay Area by 2030 is estimated at 70 percent, with an uncertainty of 10 percent
22 (Working Group on California Earthquake Probabilities 1999).

23 **Ground Failure.** Seismic-related ground failure can result from liquefaction, lateral spreading
24 (“lurching”), or differential settlement. Liquefaction occurs when the energy from an earthquake
25 increases the pore-water pressure in loose, water-saturated geologic material to the point that it
26 acts as a liquid rather than a solid. The most likely materials to liquefy are shallow, loose, water-
27 saturated, well-sorted silts and sands with little or no clay-sized particles. Lateral spreading
28 (lurching) occurs when soils liquefy, and the overlying soils move horizontally in the direction of
29 a free slope face. Fissures in nearly flat or gently sloping ground surface are a common feature
30 of lateral spreading. Settlement occurs downward when unconsolidated materials, such as fills
31 or soft muds, consolidate or compress. Bay Mud is often associated with settlement in the Bay
32 Area, as are areas of fill. Settlement often occurs as a result of an earthquake, but may also
33 occur gradually over time.

34 **Landslides.** Landslides or slope failures occur when material on an inclined face moves
35 downward. In the Bay Area, landslides may occur in sloped shoreline areas.

- 1 Insert
- 2 Figure 4.13-1 Tectonic Environment
- 3

1 **4.13.4 Local Setting**

2 The redevelopment project area is located within a seismically active region. The geology
3 underlying the study area consists mostly of recent, man-made fill placed on tidal marshlands
4 and shallow estuarine muds. Sedimentary basin deposits underlie the recent fill, sand, and mud.
5 These overlie sedimentary and metamorphic rocks at greater depth.

6 **Geology**

7 Bedrock underlying the study area is part of the Franciscan Assemblage, which consists of
8 sediments and materials containing blocks of various rock types: sandstone, greenstone, chert
9 and serpentinite. These rocks are typically sheared; a veneer of younger sediments covers the
10 Franciscan Assemblage. These younger sediments range in age from late Cretaceous to
11 Quaternary (up to 144 million years ago). These sediments were primarily derived from the
12 Franciscan Assemblage and frequently include Franciscan metamorphosed chert. Other major
13 components of the younger sediments originated inland and were carried into the Bay by the
14 Sacramento and San Joaquin rivers.

15 Local geologic formations consist of Young Bay Mud and Merritt Sand. With the exception of a
16 small area of native soils within the 16th/Wood sub-district, these formations are covered by
17 approximately 4 to 8 feet of artificial fill.

18 Three distinct stratigraphic units were identified during an environmental investigation
19 conducted south of the Oakland Army Base (OARB) for the Union Pacific Transportation
20 Company, now the Union Pacific Company (Canonie 1989). The three stratigraphic units
21 encountered at the site are described below:

- 22 • The uppermost unit is artificial fill, beginning at ground surface and extending from 4 to 8 feet
23 below ground surface (bgs), underlain by a sand layer.
- 24 • The artificial fill and sand unit are underlain by an approximately 1.5- to 2.5-foot-thick Bay
25 Mud unit encountered at depths of 9 to 13.5 feet bgs.
- 26 • The lowermost unit is a yellow-brown, dense to very dense, fine- to medium-grained silty
27 sand. A regional geologic section developed from soil borings drilled north of the site for the
28 BART system indicates this silty sand unit may be 35 to 50 feet thick in the vicinity of the
29 site. The silty sand stratum encountered at the OARB is similar to the uppermost section of
30 the Merritt Sand Formation.

31 **Seismicity**

32 **Faults and Ground Rupture.** The study area is less than 12 miles from the San Andreas Fault.
33 The nearest active fault is the Hayward Fault, approximately five miles to the east. The study
34 area is not located within an Alquist-Priolo Special Studies zone.

35 **Ground Shaking.** According to the CDMG Probabilistic Iseisismal Map (CDMG 1996), there is
36 a 10 percent probability that the study area could experience earthquake ground acceleration

1 greater than 0.7 gravity (g) within a given 50-year period. The site will be subject to future strong
2 ground shaking because of its proximity to the Hayward and San Andreas faults and its location
3 on unconsolidated Bay Mud and fill materials. The Association of Bay Area Governments
4 (ABAG) predicts the most dangerous earthquake in the study area would originate on the
5 northern segments of the Hayward Fault, that shaking would be “violent,” and that damage
6 would be “heavy” (Mercalli Scale IX) as a result of an earthquake of Richter magnitude 7.1
7 (ABAG 1999). Recorded peak ground accelerations from the Loma Prieta earthquake in the
8 area were more than three times greater than those at nearby bedrock locations such as Yerba
9 Buena Island (Carlisle and Rollins 1994).¹

10 Based on studies conducted by Geomatrix (1997), peak horizontal ground accelerations in the
11 Maritime sub-district corresponding to 50, 20, 10, and 5 percent probabilities of exceedance in
12 50 years (i.e., 72-, 224-, 475-, and 950-year return periods, respectively), are 0.29, 0.45, 0.57,
13 and 0.68 g, respectively. Site-specific design response spectra developed by SCI (1998) for
14 depths of 10 feet for earthquakes having 10, 20, and 50 percent chance of exceedance in 50
15 years have peak ground accelerations of 0.44, 0.37, and 0.25 g, respectively. To put these
16 accelerations in perspective, the Uniform Building Code (UBC) requires structures in the San
17 Francisco Bay Area to be designed to withstand a ground acceleration of 0.4 g.

18 As illustrated by Figure 4.13-2, portions of the study area are subject to damage from strong
19 ground shaking and other earthquake and geologic phenomena described below.

20 **Ground Failure.** Study area geologic and seismic conditions combine with regional seismic
21 conditions to result in a moderate-to-high potential for liquefaction. Site conditions include
22 shallow groundwater (at 4 to 9 feet bgs), heterogeneous non-native fill materials, and underlying
23 unconsolidated Young Bay Muds.

24 As illustrated by Figure 4.13-2, portions of the study area have experienced substantial
25 settlement. This settlement has been both gradual, as fills and Bay Muds consolidate, and
26 sudden, as a result of seismic events.

27 **Landslides.** Most of the study area is flat to gently sloping and not subject to land sliding.
28 However, sloped shoreline areas occur at the Gateway Park area and along the Inner Harbor.

29 **Soils**

30 Over 6.5 million cubic yards of fill were placed in 1939 to create the Army’s Oakland Terminal of
31 the San Francisco Port of Embarkation (Rogers and Figuers 1991). Sand fill was hydraulically
32 placed from the Merritt Sand Formation into adjacent areas of the Bay. Study area soils are
33 generally developed, and do not constitute topsoil. Site soils are classified by the USDA as
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¹ Ground shaking (or ground acceleration) resulting from earthquakes is measured in terms of gravity (g). One “g” is equal to an acceleration of 32.2 feet per second squared (ft/s²).

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Figure 4.13-2 Geologic Conditions

1 urban land. The USDA describes the soil materials as mainly heterogeneous fill. Because of the
2 potential variability of the soil materials, the USDA did not evaluate the various engineering
3 properties.

4 Rock fill for seawalls was imported from quarries at Point Richmond and Point San Pedro. The
5 upper few feet of fill was taken from the Leona Rhyolite (a fine-grain volcanic rock) obtained at
6 quarries near Lake Temescal and Oak Knoll Naval Hospital.

7 **4.13.5 Impact Analysis Methodology**

8 **Significance Criteria**

9 Redevelopment would have a significant impact on the environment if it would:

- 10 • Expose people or structures to substantial risk of loss, injury, or death involving:
 - 11 – Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo
 - 12 Earthquake Fault Zoning Map or Seismic Hazards Map issued by the State Geologist for
 - 13 the area or based on other substantial evidence of a known fault (refer to Division of
 - 14 Mines and Geology Special Publications 42 and 117 and PRC § 2690 *et seq.*);
 - 15 – Strong seismic ground shaking;
 - 16 – Seismic-related ground failure, including liquefaction, lateral spreading, subsidence, and
 - 17 collapse;
 - 18 – Landslides;
- 19 • Result in substantial soil erosion or loss of topsoil;
- 20 • Be located on expansive soil, as defined in Table 18-1-B of the UBC (1994), creating
- 21 substantial risks to life or property;
- 22 • Be located above a well, pit, sump, mound, tank vault, or unmarked sewer line, creating
- 23 substantial risks to life or property;
- 24 • Be located above landfills for which there is no approved closure and post-closure plan, or
- 25 unknown fill soils, creating substantial risks to life or property; or
- 26 • Have soils incapable of adequately supporting the use of septic tanks or alternative
- 27 wastewater disposal systems where sewers are not available for the disposal of waste
- 28 water.

29 Not all criteria listed above apply to redevelopment as proposed. Redevelopment would be
30 served by municipal sewerage systems, and the use of septic systems is not anticipated.

31 Redevelopment would not expose increased numbers of people and structures to substantial
32 risk of loss, injury or death involving the rupture of a known earthquake fault. Based on review of
33 the Alquist-Priolo Fault Zoning map of Oakland West, California, the subject property is not
34 located within an Alquist-Priolo Special Studies zone. The nearest fault, the Hayward Fault, is

1 located approximately five miles to the east of the project area. Therefore, the potential for
2 rupture of a known earthquake fault at the site is very low.

3 **4.13.6 Impacts**

4 **Benefits**

5 Redevelopment could substantially reduce seismic hazards related to buildings in the OARB
6 sub-district. Many OARB buildings were constructed during World War II, and do not comply
7 with current earthquake design and construction standards. As they are, these buildings are
8 potentially subject to failure during a strong seismic event. Demolition of these structures under
9 redevelopment would eliminate seismic hazards. Design and construction of new, modern
10 buildings during subsequent redevelopment activities would occur in accordance with current
11 earthquake standards.

12 **Impacts**

13 **Impact 4.13-1:** Redevelopment could expose increased numbers of people and
14 structures to strong seismic ground shaking.

15 **Significance:** Potentially significant

16 **Mitigation 4.13-1:** Redevelopment elements shall be designed in accordance with
17 criteria established by the UBC, soil investigation and construction
18 requirements established in the Oakland General Plan, the Bay
19 Conservation and Development Commission Safety of Fill Policy, and
20 wharf design criteria established by the Port or City of Oakland
21 (depending on the location of the wharf).

22 **Mitigation 4.13-2:** Redevelopment elements shall be designed and constructed in
23 accordance with requirements of a site-specific geotechnical
24 evaluation.

25 **Residual Significance:** Less than significant

26 The project area is located in an active seismic area, and most of the project area is located on
27 man-made fill. It is therefore potentially subject to strong seismic ground shaking that could
28 expose people or structures to substantial risk of loss, injury, or death. Because the occurrence
29 of this impact depends on a seismic event that may or may not occur, the impact is considered
30 potentially significant. With implementation of Mitigation Measures 4.13-1 and 4-13-2, the
31 impact would be substantially reduced, and the residual impact is considered less than
32 significant.

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1 Because the occurrence of this impact depends on a seismic event that may or may not occur,
2 the impact is considered potentially significant. With implementation of Mitigation Measures
3 4.13-1 and 4.13-2, the impact would be avoided or minimized, and the residual impact is
4 considered less than significant.



6 **Impact 4.13-4:** Under certain conditions, disturbance of soils during construction
7 could result in erosion.

8 **Significance:** Potentially significant

9 **Mitigation 4.13-3:** Prior to ground-disturbing activities, the contractor shall develop and
10 implement a Regional Water Quality Control Board (RWQCB)-
11 acceptable Stormwater Pollution Prevention Plan (SWPPP) that
12 includes erosion control measures.

13 **Residual significance:** Less than significant

14 Soils at the project area are either artificial fill or are over-covered, and do not constitute topsoil;
15 therefore, redevelopment would not have the potential to impact topsoil. Although the project
16 area is relatively level in topographic profile, should rain fall when ground is disturbed for
17 construction, moderate erosion could occur. Because the occurrence of this impact depends on
18 rainfall that may or may not occur, the impact is considered potentially significant. With
19 implementation of Mitigation Measure 4.13-3, the residual impact is considered less than
20 significant.



22 **Impact 4.13-5:** Redevelopment could occur on expansive soils.

23 **Significance:** Potentially significant

24 **Mitigation:** Measures 4.13-1 and 4.13-2, described above.

25 **Residual Significance:** Less than significant

26 Project area soils are classified by the USDA as urban land, and soil materials and described as
27 mainly heterogeneous fill. Because of the possible variability of study area soil materials, the
28 USDA did not evaluate their engineering properties. Portions of the project area could contain
29 expansive soils. Because the presence of expansive soils is not definite, the impact is considered
30 potentially significant. With implementation of Mitigation Measures 4.13-1 and 4.13-2, the impact
31 would be avoided or minimized, and the residual impact is considered less than significant.



1 The Health and Safety element of the Oakland General Plan requires a soils and geologic report
2 be submitted to the Department of Public Works (DPW) prior to the issuance of any building
3 permit. The Oakland General Plan also requires all structures of three or more stories to be
4 supported on pile foundations that penetrate Bay Mud deposits, and to be anchored in firm, non-
5 compressible materials unless geotechnical findings indicate a more appropriate design. The
6 General Plan also provides for the identification and evaluation of existing structural hazards
7 and abatement of those hazards to acceptable levels of risk.

8 To comply with the BCDC safety of fill policy, the plans and specifications for the placement of
9 Bay fill will be submitted to the BCDC Engineering Criteria Review Board for review and approval.

10 The Port of Oakland has developed wharf design criteria to be used in the design, construction,
11 reconstruction, and repairs of existing and future wharf structures, except in the event that
12 current engineering practice requires adjustments or modification of the wharf design criteria. All
13 construction associated with New Berth 21 must adhere to the wharf design criteria established
14 by the Port of Oakland. A licensed engineer should monitor construction activities to ensure that
15 the design and construction criteria are followed.

16 The City shall adopt wharf design criteria and apply them to any wharf in the City's jurisdiction.



18 **Mitigation 4.13-2:** Redevelopment elements shall be designed and constructed in accordance
19 with requirements of a site-specific geotechnical evaluation.

20 This measure applies to Impacts 4.13-1, 4.13-2, 4.13-3, 4.13-5, and 4.13-6, and to Cumulative
21 Impact 5.13-1.

22 Site-specific geotechnical, soils, and foundation investigation reports shall be prepared by a
23 licensed geotechnical or soil engineer experienced in construction methods on fill materials in
24 an active seismic area. The reports shall provide site-specific construction methods and
25 recommendations regarding grading activities, fill placement, compaction, foundation
26 construction, drainage control (both surface and subsurface), and seismic safety. Designers and
27 contractors shall comply with recommendations in the reports. A licensed geotechnical or soil
28 engineer shall monitor earthwork and construction activities to ensure that recommended site-
29 specific construction methods are followed.

30 The Oakland General Plan requires all structures of three or more stories to be supported on
31 pile foundations that penetrate Bay Mud deposits and to be anchored in firm, non-compressible
32 materials unless geotechnical findings indicate a more appropriate design. The General Plan
33 also provides for the identification and evaluation of existing structural hazards and abatement
34 of those hazards to acceptable levels of risk.



1 The contractor shall utilize Underground Service Alert or other subsurface utility locators to
2 identify and avoid underground utilities and facilities during construction of redevelopment
3 elements. The contractor shall keep a record of its contacts regarding underground features,
4 and shall make these records available to the City or Port upon request. This condition shall be
5 enforced through contract specification.



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