4.5 GEOLOGY AND SOILS

4.5.1 Introduction

This section discusses existing RBC site geology and soils resources and analyzes the potential for development under the proposed 2014 LRDP to affect those resources. The section also describes RBC's regional geologic and seismic setting and analyzes potential geologic and seismic hazards that may affect the proposed project based on the site conditions and location. The analysis focuses on increased exposure of people and structures to hazards such as groundshaking, liquefaction, and erosion. Section information and analysis is based on existing project site documentation.

One NOP public comment related to geology and soils was received. This comment noted the liquefaction potential from a large earthquake along the Hayward or San Andreas Faults due to the presence of loose sandy fill at the RBC site.

4.5.2 Environmental Setting

Regional Geology

The San Francisco Bay Area geology is dominated by the San Andreas fault system that includes the San Andreas fault, the San Gregorio fault, the Hayward fault, the Calaveras fault, and other faults that have been active during approximately the last 30 million years. Bay Area geology is quite complex, owing to the relative movement of the North American continental and Pacific Ocean crustal plates. The terrain was created by tectonic forces that compressed ancient sedimentary deposits into a sub-parallel series of anticlines (concave downward) and synclines (concave upward). These folds were subsequently right-laterally faulted, uplifted, and eroded into their present configuration. The bedrock underlying the sediments in the San Francisco Bay basin, and exposed in some of the hills surrounding the Bay, consists of a complex of partially metamorphosed sedimentary and volcanic rocks belonging to the Franciscan Formation. The region was apparently well above sea level until about 1 million years ago when a combination of subsidence of the basin and rising sea levels from melting of continental ice caps led to deposition of sediments on the Franciscan bedrock surface.

Richmond is underlain by the Franciscan Formation. The Franciscan Formation consists of sedimentary and volcanic rocks that accumulated to a thickness of more than 50,000 feet, probably in a deep part of the oceanic basin beyond the continental slope, during Late Jurassic to Late Cretaceous time. Most of the Franciscan rock types are dense, hard, resistant, and form ground that will be generally stable during earthquake shaking. Where intensively sheared or weathered, these rocks disintegrate into much less stable ground, and the slopes underlain by these sheared materials are much less stable than areas of outcropping hard rock.

Above the Franciscan Formation lie tertiary marine and non-marine sedimentary and volcanic rocks. Outcrops of marine sedimentary rocks that formed when the sea invaded the area south of Santa Rosa in Miocene and Eocene time (24 million to 5 million years ago), are very limited in Richmond. Miocene and Eocene rocks comprise a sequence of hardened sandstone and shale. On the surface in shallow areas and under the bay waters is a combination of alluvium and bay mud.

Site Specific Geology

The Franciscan bedrock (primarily greywacke, black shale and slate, greenstone, and chert) underlies the site at depths between 80 to 160 feet or more. Depth to bedrock generally increases to the southwest. The groundwater table is about 10 feet below existing grade; tidal fluctuation will affect the groundwater elevation.

Historically, artificial fill was placed on the RBC site to reclaim the original low-lying lands and marshlands. In addition, pyrite cinders from the adjacent Stauffer Chemical facility were placed on the site. Much of the original pyrite has been removed and replaced with other imported fill soil, but some is still present. The native near surface geology consists of Holocene alluvial fan and alluvial fan levee deposits. The alluvial fan deposits consist of stiff to dense silty clay with interbedded sand and gravel lenses.

Faults and Seismic Hazards

The Hayward fault, approximately 2 miles northeast of the RBC site, is the closest active fault to the site (Figure 4-9). Based on the soil type, the relatively young age of the soil, and the shallow depth to groundwater, the sandy areas on the site could be susceptible to liquefaction during an earthquake. The areas dominated by clay would be less susceptible to liquefaction. Liquefaction hazard maps produced by ABAG indicate that the eastern portion of the project site is susceptible to liquefaction (ABAG 2011).

Repeated tectonic events in the San Francisco Bay Area resulted in a complex geologic structure with numerous folds, faults, and cross faults. Today, the most significant manifestations of these forces with respect to the project site are the San Andreas fault system and Hayward fault zone.

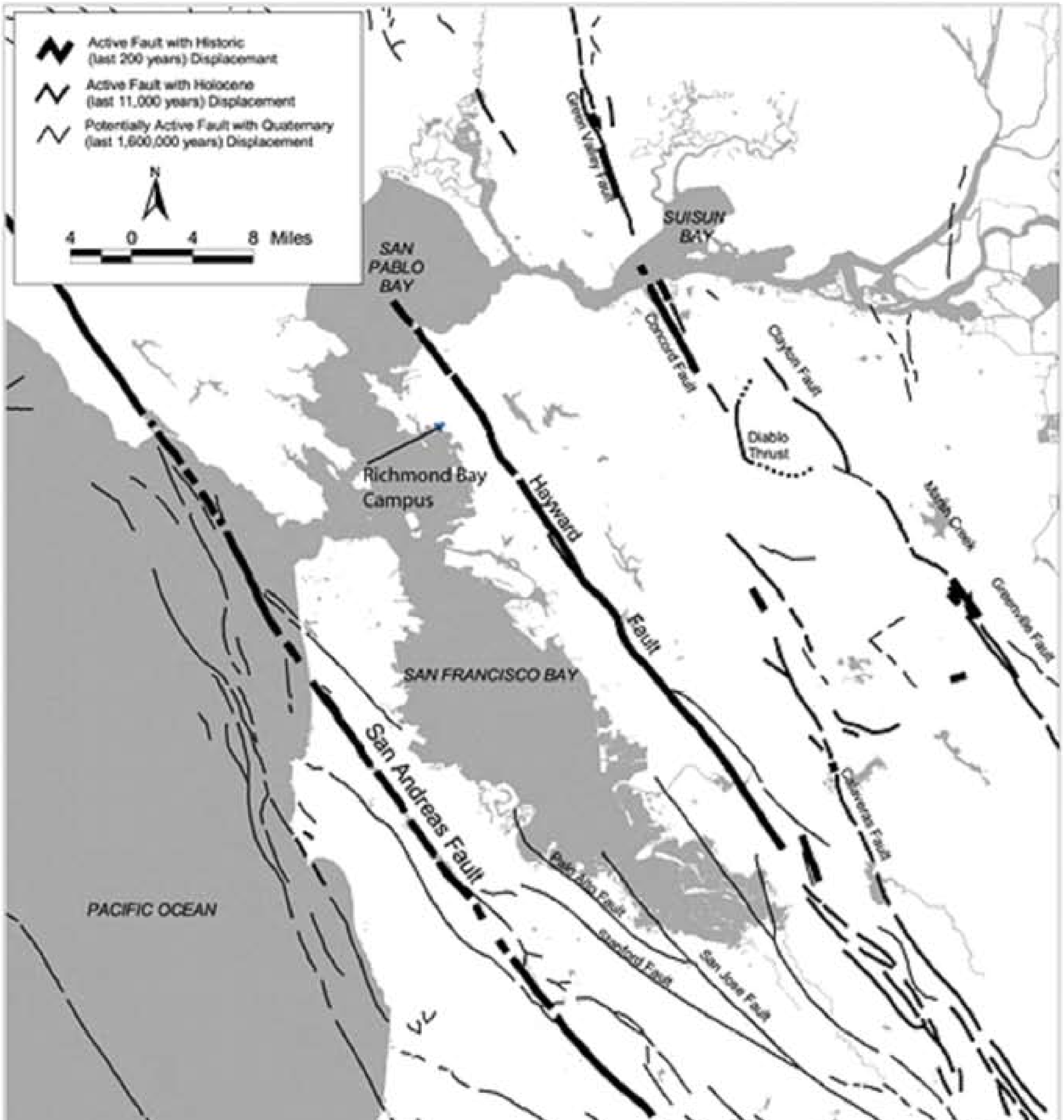
The Hayward fault is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault. A characteristic feature of the fault is its well-expressed and relatively consistent fault creep. Although large earthquakes on the Hayward fault have been rare since 1868, slow fault creep has continued to occur and has caused measurable offset. Fault creep on the East Bay fault segment is estimated at 0.35 inches per year. There have been two recorded incidents of major earthquakes along the Hayward fault. A magnitude 6.5 earthquake occurred on June 10, 1836, and a magnitude 6.9 occurred on October 21, 1868.

The San Andreas fault, 15 miles to the west, could produce significant groundshaking at the RBC site. The greatest Bay Area region earthquake in historic times occurred along the San Andreas fault on April 18, 1906, with a magnitude of 7.8.

The magnitude 6.9 Loma Prieta earthquake occurred in October 1989 with its epicenter about 70 miles south of Richmond. The damage in Richmond was relatively slight compared to that in San Francisco and Oakland. Older buildings were damaged, cracking appeared in residences and commercial buildings, and there was damage in the industrial areas near the Port. City staff relocated from City Hall, which was declared unsafe. There were no bridge or building collapses and no significant fire damage. The energy released during the Loma Prieta earthquake was just 3 percent of the amount of energy released during the 1906 earthquake.

Three moderate earthquakes occurred along the Calaveras fault, 20 miles to the southeast, in 1980. The Morgan Hill Earthquake of April 24, 1984, occurred on this fault. The effects of these earthquakes on Richmond were insignificant. The maximum credible earthquake on this fault is approximately magnitude 6.3.

During the recent historical period, six significant earthquakes have occurred in the San Francisco Bay Area, commencing with the 1868 earthquake. Other earthquakes between 1868 and 1906 were estimated as being in the range of magnitude 6.0 to 6.5.



Fault Zones

Richmond, California

TETRA TECH

Figure 4-9

After the 1989 Loma Prieta earthquake, the US Geological Survey and other scientists estimated that there is a 62 percent probability of at least one magnitude 6.7 or greater earthquake, capable of causing widespread damage, striking somewhere in the San Francisco Bay region before 2032 (USGS 2003). The region is defined as extending north-to-south from Healdsburg to Salinas. The probability of such earthquakes occurring on the Hayward and Rogers Creek faults is estimated at 27 percent. They projected that there was at least an 80 percent chance of one or more magnitude 6 to 6.6 earthquakes occurring in the Bay region before 2032.

Ground Shaking

Ground movement during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and type of affected geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. For this reason, earthquake intensities are also measured in terms of their observed effects at a given locality. The Modified Mercalli intensity scale (Table 4.5-1) is commonly used to measure earthquake damage from ground shaking. The intensity values in that scale range from I (earthquake not felt) to XII (damage nearly total), and intensities ranging from IV to X could cause moderate to significant structural damage. The intensities of an earthquake will vary over the region of a fault and generally decrease with distance from the epicenter of the earthquake.

Table 4.5-1
Modified Mercalli Scale of Earthquake Intensities

Earthquake Intensity	Effects Observed	Average Peak Acceleration
I	Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.	< 0.0015 g
II	*Effect on people:* Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.	< 0.0015 g
III	*Effect on people:* Felt by most people indoors. Some people can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake: the shaking is like that caused by the passing of light trucks.	< 0.0015 g
IV	*Other effects:* Hanging objectives swing. *Structural effects:* Windows or doors rattle. Wooden walls and frames creak.	0.015 g-0.02 g [a]
V	*Effect on people:* Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls. *Other effects:* Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. *Structural effects:* Doors close, open, or swing. Windows rattle.	0.03 g-0.04 g
VI	*Effect on people:* Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. *Other effects:* Hanging objectives swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objectives displaced or upset. *Structural effects:* Weak plaster and Masonry D* crack. Windows break. Doors close, open, or swing.	0.06 g-0.07 g

Table 4.5-1
Modified Mercalli Scale of Earthquake Intensities

Earthquake Intensity	Effects Observed	Average Peak Acceleration
VII	*Effect on people:* Felt by everyone. Many are frightened and run outdoors. People walk unsteadily. *Other effects:* Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle. *Structural effects:* Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced pampers and architectural ornaments fall. Concrete irrigation ditches damaged.	0.10 g-0.15 g
VIII	*Effect on people:* Difficult to stand. Shaking noticed by auto drivers. *Other effects:* Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver. *Structural effects:* Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off.	0.25 g-0.30 g
IX	*Effect on people:* General fright. People thrown to ground. *Other effects:* Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees. *Structural effects:* Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.	0.50 g-0.55 g
X	Effect on people: General Panic. *Other effects:* Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into small craters, and, in muddy areas, water fountains are formed. *Structural effects:* Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.	> 0.60 g
XI	*Effect on people:* General panic. *Other effects:* Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. *Structural effects:* General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.	> 0.60 g
XII	*Effect on people:* General panic. *Other effects:* Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air. *Structural effects:* Damage nearly total, the ultimate catastrophe.	> 0.60 g

Notes:
a. g is gravity = 32 feet per second squared.
* Masonry A: Good workmanship and mortar, reinforced, designed to resist lateral forces;
* Masonry B: Good workmanship and mortar, reinforced;
* Masonry C: Good workmanship and mortar, unreinforced;
* Masonry D: Poor workmanship and mortar, weak materials like adobe.

Predicted ground shaking for a large event on the Hayward fault would be severe to violent along the length of the fault. Hayward fault rupture would generate structurally damaging ground motions in Richmond ranging from Modified Mercalli intensity VII to X.

Liquefaction

Liquefaction may occur when loose, unconsolidated, saturated fine- to medium-grained sandy soils are subjected to ground vibrations during a seismic event. This usually occurs in areas where the groundwater table is within 50 feet of the ground surface, and it is generally associated with uncompacted, saturated, or nearly saturated, non-cohesive sandy and silty soils. During liquefaction, loose soil sediments are shaken. This creates a sudden increase in pore water pressure and loss of shear strength and causes the soils to behave like a liquid. If the liquefying layer is near the ground surface, the effects may resemble those of quicksand. If the layer is deep below the ground surface, it may provide a sliding surface for the material above it or cause differential settlement of the ground surface that may damage building foundations by altering weight-bearing characteristics. Liquefaction can affect soils to 50 feet deep during prolonged periods of ground shaking.

The State has not designated any liquefaction hazard areas in the City of Richmond under the Seismic Hazard Zones Mapping Program, although as noted above, liquefaction hazard maps have been produced by ABAG indicating that the eastern portion of the RBC site is susceptible to liquefaction.

Tsunami and Seiche

Tsunamis (seismic sea waves) are long period waves typically caused by underwater disturbances (landslides), volcanic eruptions, or seismic events. Areas highly susceptible to tsunami inundation tend to be in low-lying coastal areas such as tidal flats, marshlands, and former bay margins that have been artificially filled but are still at or near sea level. There have been 19 recorded tsunamis in the Bay Area from 1868 to 1968. The maximum wave height associated with these tsunamis was just less than 15 feet at the Golden Gate Tide Gage in 1868. After natural attenuation across the Bay, estimates are that the wave height was approximately half that on the Richmond shoreline and negligible by the Carquinez Strait.

The West Coast and Alaska Tsunami Warning Center in Alaska and the Pacific Tsunami warning Center in Hawaii monitor potential tsunamis. The Centers currently issue “warnings” to particular locales when a 7.5 magnitude earthquake or greater occurs within 3 hours tsunami travel time to those locations, and issue “watches” when tsunami travel time is within 3 to 6 hours of particular locations. Information is transmitted to the Governor’s Office of Emergency Services Warning Control Center and local emergency managers.

There are no State or other officially designated tsunami evacuation zones in the City of Richmond.

A seiche is an earthquake-generated wave in enclosed or restricted bodies of water such as lakes and reservoirs caused when an earthquake ground wave matches the natural period of oscillation of the body of water. Seiche risk in the shoreline areas would be minimal because there are no large confined bodies of water with sufficient depth to resonate with earthquake generated shaking. Catastrophic earthquake damage also can result from dam failure or from large masses of earth breaking loose and sliding into a reservoir or the Bay.

Landslides

Landsliding is a form of ground failure where there is a relatively rapid downslope movement of a mass of soil, rock, and rock debris. The term is used here to include mudslides and earthflows. Landsliding is affected by the degree of water saturation, strength of rocks, slope angle, mass and thickness of deposit, and type and extent of vegetative cover. Landslides occur from shearing between layers of soil below the ground surface. In clay, the ground slumps or drops in a mass, whereas in Bay Mud, the ground spreads laterally. Soil flows occur when the cohesion of the soil fails, generally after heavy rainfall. Rainfall saturates the soil, adding weight and decreasing friction. Most landslides occur on slopes greater than 15 percent. Slopes at the RBC site range from 0 to 5 percent. Soils at the RBC site consist of artificial fill, alluvial fan deposits, a mix of stiff to dense silty clay with interbedded sand and gravel lenses, bay sediments, and Yerba Buena Mud (Older Bay Mud). Bay sediments may exist in the site's upper 18 feet. The bay sediments consist of fine- to very fine-grained sediments, while the Yerba Buena mud is a fine-grained unit that behaves as a regionally extensive aquitard.

4.5.3 Regulatory Considerations

Federal

In October 1977, the US Congress passed the Earthquake Hazards Reduction Act to reduce earthquake risks to life and property in the United States. To accomplish this, the Act established the National Earthquake Hazards Reduction Program. This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction Program Act by refining the description of agency responsibilities, program goals, and objectives. The mission of the program includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The Act designates the Federal Emergency Management Agency as the program lead agency and assigns several planning, coordinating, and reporting responsibilities. Other program agencies include the National Institute of Standards and Technology, National Science Foundation, and US Geological Survey.

State

The Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Sections 2621-2630) was passed in 1972 to mitigate surface faulting hazards to structures designed for human occupancy. The Act's main purpose is to prevent the construction of buildings for human occupancy on the surface trace of active faults. The law addresses only the hazard of surface fault rupture and not of other earthquake hazards. The Act 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 planning efforts. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, cities and counties must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.

The Seismic Hazards Mapping Act of 1990 (Public Resources Code Sections 2690–2699.6), addresses earthquake hazards from nonsurface fault rupture, including liquefaction and seismically induced landslides. The Act established a mapping program for areas that have the potential for liquefaction, landslide, strong ground shaking, or other earthquake and geologic hazards. The Act specifies that project lead agencies may withhold development permits until site specific geologic or soils investigations are conducted and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.

The State of California provides building design standards through the California Building Code (CBC, California Code of Regulations, Title 24). Where no other building codes apply, Chapter 29 regulates excavation, foundations, and retaining walls. The CBC applies to building design and construction in the state and is based on the federal Uniform Building Code (UBC) used widely throughout the country (generally adopted state-by-state or district-by-district). The CBC has been modified for California conditions with numerous more detailed or more stringent regulations. The state earthquake protection law (California Health and Safety Code Section 19100 et seq.) requires that structures be designed to resist stresses produced by lateral forces from wind and earthquakes. Specific minimum seismic safety and structural design requirements are in Chapter 16 of the CBC. The CBC identifies seismic factors that must be considered in structural design. CBC Chapter 18 regulates the excavation of foundations and retaining walls; Appendix Chapter A33 regulates grading activities, including drainage and erosion control, and construction on unstable soils, such as expansive soils and areas subject to liquefaction.

Local

The RBC would be a University of California property where work within the University's mission is performed. As a state entity, the University is exempt under the state constitution from compliance with local land use regulations, including general plans and zoning. The University seeks to cooperate with local jurisdictions to reduce to the extent feasible any physical consequences of potential land use conflicts. The RBC is in the City of Richmond. The following section summarizes the UC Seismic Safety Policy as it relates to geology and soils.

University of California Seismic Safety Policy

The University of California Seismic Safety Policy (UC 2011) requires "The design and construction of buildings on University premises shall comply, at a minimum, with the current seismic provisions of CBC for new or existing buildings as appropriate."

City of Richmond General Plan

The 2030 General Plan EIR determined that future General Plan development effects on geology, soils, and minerals would be less than significant. Future development would not expose people or structures to seismic hazards, soil spreading, land subsidence, soil erosion, or landslide hazards beyond an acceptable level of risk. Development would adhere to the California Building Code to minimize risk. No mitigation measures would be required. Cumulative impacts would be less than significant.

4.5.4 Impacts and Mitigation Measures

Standards of Significance

The 2014 LRDP implementation impacts on geology and soils would be considered significant if they would exceed the following Standards of Significance listed below, in accordance with Appendix G of the *State CEQA Guidelines* and the UC CEQA Handbook:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
    - Strong seismic groundshaking;
    - Seismic related ground failure, including liquefaction; and
    - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

- Be on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994 or most current edition), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

CEQA Checklist Items Adequately Addressed in the Initial Study

The Initial Study analysis circulated with the NOP concluded that further analysis of the following issues was not required in the EIR.

- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
- Landslides.
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

A portion of the Hayward fault zone occurs in the City of Richmond, about 2 miles northeast of the site. No fault is present on the RBC site and there is no potential for fault rupture.

The RBC site is relatively flat, at the distal end of an alluvial plain, so there is no potential for landslide risk.

The Richmond properties are served by the City of Richmond wastewater treatment system, and RBC would not be served by septic systems or alternate wastewater disposal systems.

Analytical Methods

This section describes the potential geology and soils impacts resulting from development under the proposed 2014 LRDP and assesses them based on the Standards of Significance. Potential impacts were analyzed based on existing site data and the generalized scope of facility development analyzed in this EIR.

A project site's geotechnical characteristics determine its potential for structural and safety hazards that could occur during proposed project construction or operation. The conditions presented in the Richmond General Plan Update Final Environmental Impact Report, supplemented as necessary with widely available industry sources, were used to document regional and local geology in this EIR. Site assessment studies characterizing geotechnical conditions at each future proposed building site would be required prior to specific project approvals.

RBC 2014 LRDP Policies

The RBC 2014 LRDP policies related to geology and soils include the following:

- S3 – Sustainability Policy on Site Development: Embody environmental stewardship and respect the unique character of the RBC in site development.
  - Draw on the neighborhood context and prominently feature the natural assets including climate, wetlands, and proximity to the San Francisco Bay and the Bay Trail.
  - Actively promote sustainability as a core value at the campus and provide practical opportunities for innovation and education in sustainable design.

- Manage soil contamination as a component of each construction project.
- Control construction dust by implementing the best management practices (BMPs) defined in the BAAQMD CEQA Guidelines.

LRDP Impacts and Mitigation Measures

LRDP Impact GEO-1: Development under the 2014 LRDP would not expose people and structures to substantial adverse effects from seismic hazards such as ground shaking and earthquake-induced ground failure at the RBC site. (*Less than Significant*)

The RBC site is in an area potentially subject to strong seismic ground shaking from earthquakes along several active Bay Area faults. Due to its proximity to Hayward fault, the RBC site is subject to levels of ground shaking ranging up to very strong to violent (Modified Mercalli Intensity IX). Ground shaking intensities from a major Hayward Fault seismic event could approach or exceed a peak ground acceleration of 0.60 g. The RBC site area has not been officially assessed by the State of California for its liquefaction potential, but based on the soil type, the relatively young soil age, and the shallow groundwater depth, the sandy areas on the RBC site could be susceptible to liquefaction during an earthquake.

Seismic ground shaking could damage the proposed buildings, roadways, retaining walls, and other ancillary facilities and the development of the proposed campus would expose future campus population to risk from seismic ground shaking.

UC Seismic Safety Policy implementation would ensure that people or structures would not be exposed to a significant risk from ground shaking. The 1995 University policy on seismic safety, revised in 2011, requires that all new construction at the RBC site comply with the current seismic provisions of the California Code of Regulations, Title 24, California Buildings Standards or local seismic requirements, whichever is the most stringent. Adherence would include:

- Use of CBC seismic standards as the minimum seismic-resistant design for all proposed facilities;
- Seismic-resistant earthwork and construction design criteria based on the site-specific recommendations of a California-licensed professional civil engineer in cooperation with the project's California-licensed professional geotechnical and structural engineers (section 1802 ff and 1802A ff);
- An engineering analyses that demonstrates satisfactory performance of alluvium or fill where either forms part or all of the support, especially where the possible occurrence of liquefiable soils exists; and
- An analysis of soil expansion potential and appropriate remediation (compaction, removal/replacement) prior to using any expansive soils for foundation support.

With adherence to the University Seismic Safety Policy, all campus development would be designed and constructed to current seismic standards. Although conformance to the highest seismic standards does not guarantee avoidance of structural damage in the event of a maximum credible earthquake, it is reasonable to expect that structures built in compliance with the seismic requirements would not collapse or cause loss of life in a major earthquake. There are seismic shaking hazards beyond that associated with building collapse, including falling debris, fire, gas leaks, and others that are difficult to quantify given the potential magnitude and unpredictable nature of seismic events. The UC Seismic Safety Policy dictates stringent standards intended to limit the impacts of such hazards. For all of these reasons, the impact related to seismic ground shaking would be less than significant.

Mitigation Measure: No mitigation measure is required.

LRDP Impact GEO-2: **Development under the 2014 LRDP would result in construction on soils that could be subject to erosion and instability. (*Potentially Significant; Less than Significant with Mitigation*)**

RBC site soils consist of artificial fill; alluvial fan deposits, a mix of stiff to dense silty clay with interbedded sand and gravel lenses; bay sediments; and Yerba Buena Mud (Older Bay Mud). Bay sediments may exist in the upper 18 feet. The bay sediments consist of fine- to very fine-grained sediments, while the Yerba Buena Mud is a fine-grained unit that behaves as a regionally extensive aquitard. Because of this soil lithology, there is potential for expansive soils and settlement at the RBC site. Expansion occurs in clay soils and results in soil swelling and shrinking with change in moisture conditions. Such shrinking and swelling can cause problems with building foundations, slab on-grade, and pavement unless adequately addressed during design and construction. Settlement is the gradual downward movement of an engineered structure (e.g., a building) from the compaction of the unconsolidated material below the foundation. Structures built on Bay Mud are prone to settlement that can damage the building's foundation and structural integrity unless identified and addressed during design and construction. Erosion potential at the RBC site is relatively low because the area is flat with slopes between 0 and 5 percent and clay-bearing soils encountered are likely to be cohesive.

LRDP MM GEO-2

GEO-2a: A site-specific, design-level geotechnical investigation shall be completed during the design phase of each new building project and prior to construction approval on the RBC site. This investigation shall be conducted by a licensed geotechnical engineer and shall include an evaluation of potential soils hazards and appropriate measures to minimize these hazards. Geotechnical recommendations shall subsequently be incorporated into building design.

GEO-2b: Construction under the LRDP shall comply with ABAG's Manual of Standards for Erosion and Sediment Control Measures, and the California Stormwater Quality Association's Stormwater Best Management Practice Handbook for Construction (CASQA 2003) (or subsequent editions thereof). Construction under the LRDP shall use construction BMPs and standards to control and reduce erosion. These measures could include, but are not limited to, restricting grading to the dry season, protecting all finished graded slopes from erosion using such techniques as erosion control matting and hydroseeding, or other suitable measures.

GEO-2c: All LRDP construction projects shall include, as appropriate, revegetation of disturbed areas (including slope stabilization projects) using native shrubs, trees, or grasses.

Cumulative Impacts and Mitigation Measures

LRDP Cumulative Impact GEO-1: **Development under the 2014 LRDP together with cumulative development in the region would not result in significant cumulative impacts related to geology and soils. (*Less than Significant*)**

Development under the proposed 2014 LRDP would attract an increased number of people to an area exposed to potential seismic effects such as ground shaking or liquefaction. Development under the 2014 LRDP would allow an increase in the size and number of structures subject to the effects of expansive soils or other soil constraints that could affect structural integrity, roadways, or underground utilities. Site preparation and development would create temporary or permanent ground surface changes that could alter erosion rates. Other reasonably foreseeable future development in Richmond would also be exposed to similar seismic hazards or be affected by expansive soils and erosion. Potentially adverse environmental effects associated with seismic hazards, expansive soils, topographic alteration, and erosion are site-specific and generally do not aggregate. Implementation of the UC Seismic Safety Policy, the National Pollutant Discharge Elimination System permit requirements, and the UC safety policies would help ensure that potential site-specific geotechnical and soil conditions would be adequately addressed and that potential impacts to future City development would be maintained at less-than-significant levels. Therefore, the proposed 2014 LRDP would result in less than significant cumulative geologic, seismic, and soil impacts.

4.5.5 References

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