3.4 Geology, Soils, and Seismicity

This section of the Final Environmental Impact Statement/Report (referred to throughout as the Final EIS/R) characterizes the existing geology and soils within the Phase 2 project area, and assesses whether implementation of the project would cause a substantial adverse effect on geology and soils. The information presented is based on a review of existing geology and soil conditions within the area, and other pertinent federal, state, and local regulations, which are presented in the regulatory framework setting section. Using this information as context, an analysis of the project's environmental impacts related to geology and soils is presented for each alternative. Programmatic mitigation measures described in Chapter 2, Alternatives, would be implemented as part of the project-level designs. Therefore, this section only includes additional mitigation measures as needed.

3.4.1 Physical Setting

Methodology

The development of the baseline conditions, significance criteria, and impact analysis in this section is commensurate to and reliant on the analysis conducted in the 2007 South Bay Salt Pond (SBSP) Restoration Project Environmental Impact Statement/Report (2007 EIS/R). The baseline condition specific to the Phase 2 area pond clusters is based on the current condition of these areas.

Geologic, seismic, and soil characteristics for the South San Francisco Bay (South Bay) were evaluated using existing published data and other publicly available sources and are summarized in the 2007 EIS/R. The sources and references for that evaluation include maps of general geologic distribution, faults, soils, liquefaction susceptibility, and other characteristics and are listed in that 2007 document.

Regional Setting

The regional setting for the SBSP Restoration Project as a whole was presented in Chapter 3.5 of the 2007 EIS/R. The following excerpts present an overview of key geologic, seismic, soils, and hazards concepts. A discussion of these concepts as they relate to the existing conditions at each Phase 2 pond cluster is provided below.

Geology

The San Francisco Bay Region is located along the boundary between the Pacific and North American plates, two large crustal plates that are separated by the north-northwest-trending San Andreas Fault, within the California Coast Ranges Geomorphic Province. A map showing an overview of geology in the San Francisco Bay Area from the United States Geological Survey is shown on Figure 3.4-1 (Wentworth 1997). The geomorphology of the region includes parts of three prominent, northwest-trending geologic/geomorphic features, which include, from west to east, the Santa Cruz Mountains, the Santa Clara Valley, and the Diablo Range. The Santa Clara Valley forms part of an elongated structural block (the San Francisco Bay block) within the central Coast Ranges that contains San Francisco Bay and its surrounding alluvial margins. This structural block is bounded by the San Andreas Fault to the southwest and the Hayward-Calaveras Fault zone to the northeast.

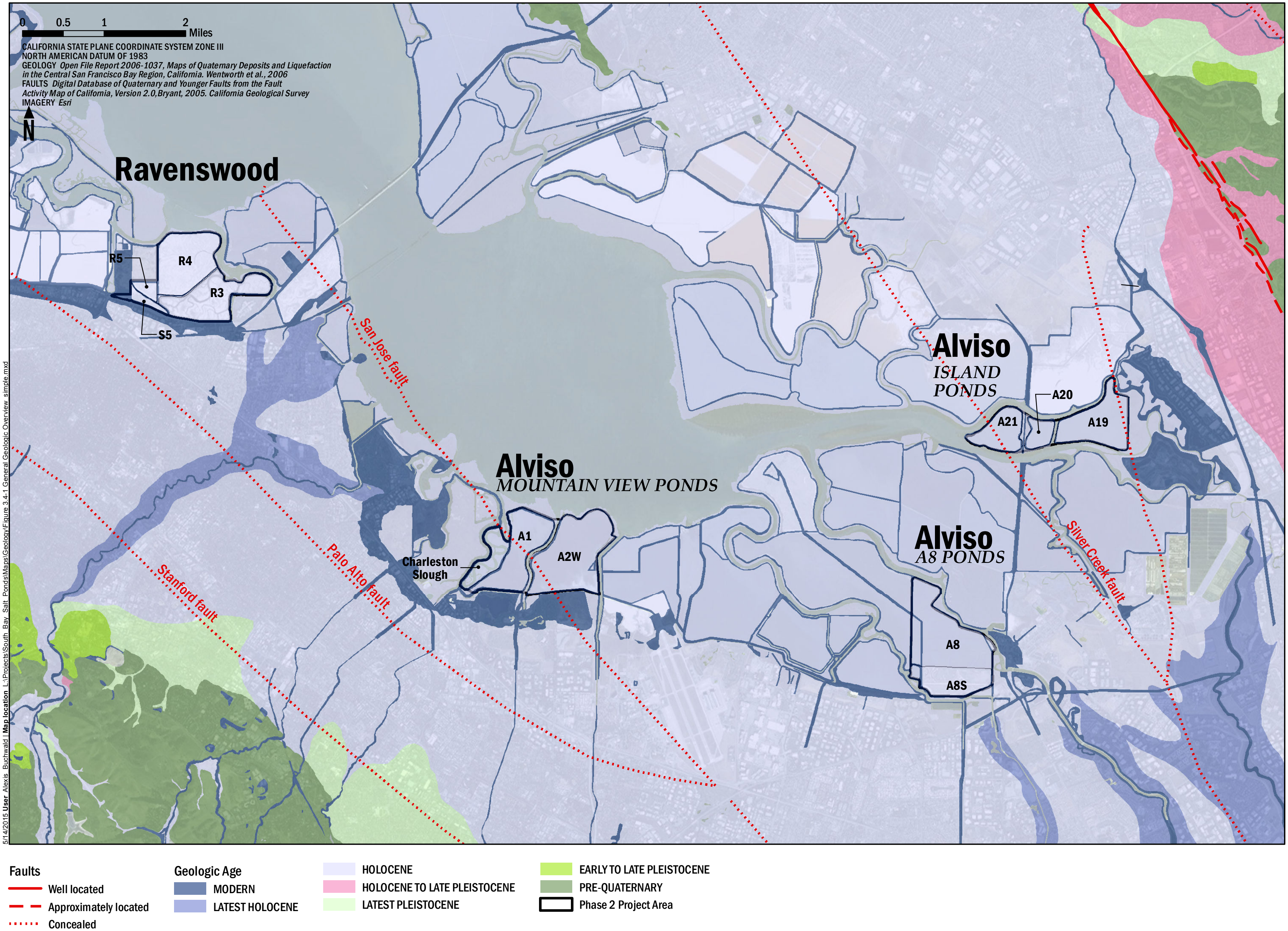

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Figure 3.4-1
General Geological Overview

The oldest rocks in the region belong to the Franciscan Complex of Jurassic to Cretaceous age (205 to 65 million years ago [Ma]). These rocks are intensely deformed (i.e., folded, faulted, and fractured) due to ancient tectonic processes and, to a lesser extent, from more recent tectonic processes associated with the San Andreas Fault system. Franciscan rocks generally comprise the "basement" of the Coast Ranges northeast of the San Andreas Fault; Cretaceous granitic rocks, known as the Salinian block, comprise the basement of the ranges located southwest of the San Andreas Fault. A sequence of Tertiary (65 to 1.8 Ma) marine and nonmarine sedimentary rocks unconformably overlies the granitic and Franciscan basement rocks in the region.

During the Plio-Pleistocene (5 Ma to 11,000 years ago [ka]) epochs, sediments eroded from the uplifting Diablo Range and the Santa Cruz Mountains formed broad alluvial fan complexes along the margins of the Santa Clara Valley. The 5-Ma to 300,000-year-old (Plio-Pleistocene) Santa Clara Formation, which consists of a sequence of fluvial and lacustrine sediments, was deposited unconformably on the older Tertiary and Franciscan rocks along the margins of the Santa Clara Valley during this time and has subsequently folded, faulted, and eroded. The Santa Clara Formation is unconformably overlain by younger Quaternary and Holocene (11 ka to present) alluvial and fluvial deposits (stream channel, overbank, and flood basin environments), which interfinger to the north with estuarine muds of San Francisco Bay (Helley et al. 1979).

South San Francisco Bay is a north-northwest-trending subsiding basin that is filled primarily with Quaternary alluvium (stream) deposits eroded from the surrounding margins and estuarine sources (Bay mud). The Sangamon and Holocene Bay muds are separated by the Quaternary alluvium and eolian (wind-blown) sand deposits. Alluvium deposits consist of sediments eroded from the surrounding Santa Cruz Mountains and Diablo Range uplands. These alluvial sediments were transported and deposited by streams and include a mixture of sands, gravels, silts, and clays with highly variable permeability. In contrast, the fine-grained Bay muds have very low permeability. The youngest Holocene Bay muds underlie almost the entire original Bay (Atwater et al. 1977; Helley et al. 1979). Figure 3.4-2 shows Bay mud thickness in the South San Francisco Bay Area (McDonald et al. 1978). Estuarine (Bay) muds were deposited in San Francisco Bay during high sea level periods of the Sangamon (70,000 to 130,000 years ago) and the Holocene (less than 11,000 years ago) (Atwater et al. 1977).

Soils

According to soil surveys published by the U.S. Department of Agriculture (USDA) Soil Conservation Service, soils along the Bay on the San Francisco Peninsula generally consist of those typically found on bottom lands, and can vary from very poorly drained to well drained (Figure 3.4-3).

Faults

The San Francisco Bay Region is located within a very broad zone of right-lateral transpression (strike-slip faulting and compression) marking a tectonic boundary zone dominated by strike-slip faulting associated with the San Andreas Fault system. The major active components of the San Andreas Fault system that occur in the South San Francisco Bay Region include the proper or main trace of the San Andreas, Hayward, and Calaveras Faults. Fault locations are shown on Figure 3.4-1.

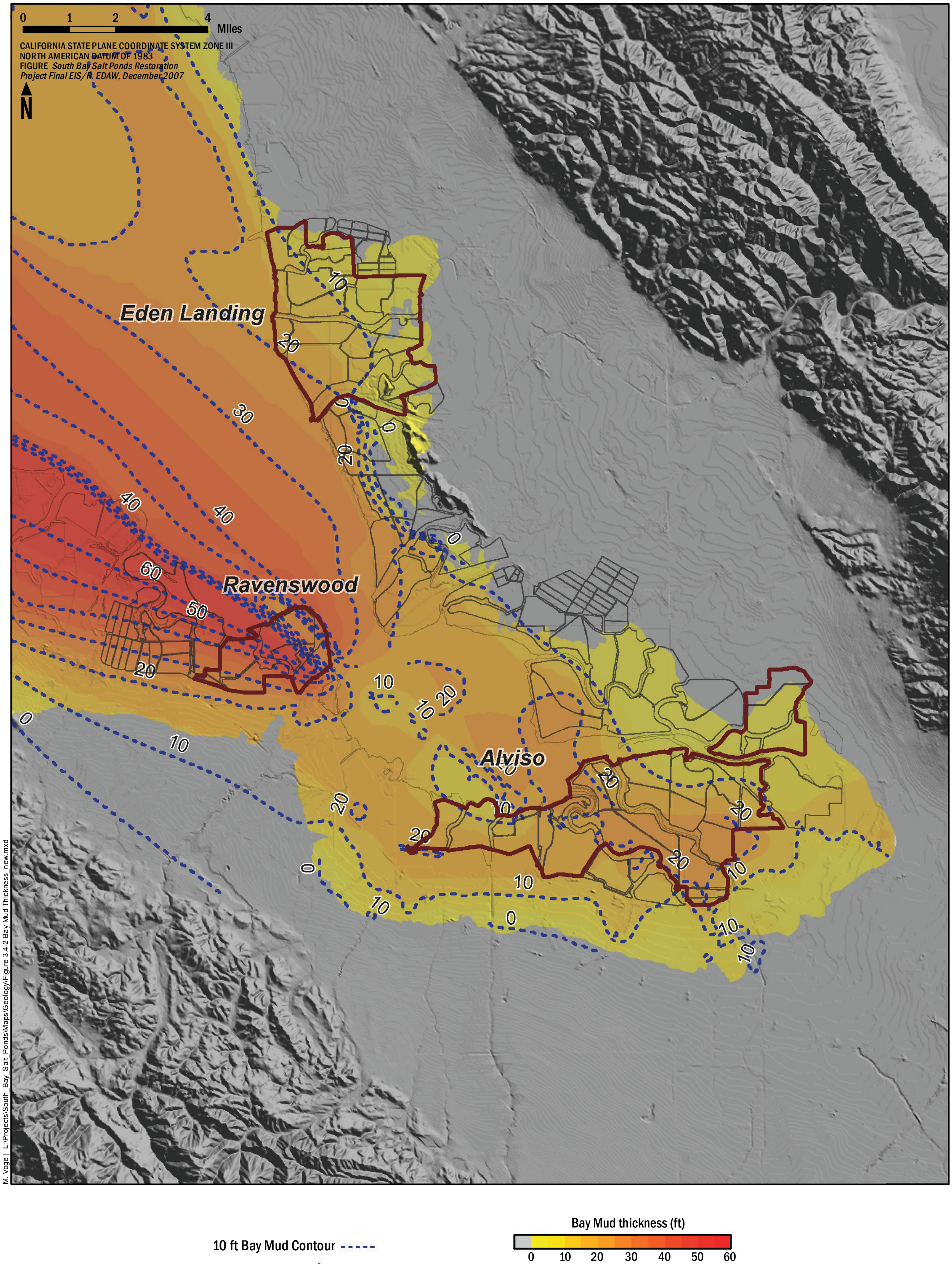

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Figure 3.4-2
Bay Mud Thickness within the SBSP Restoration Project Area

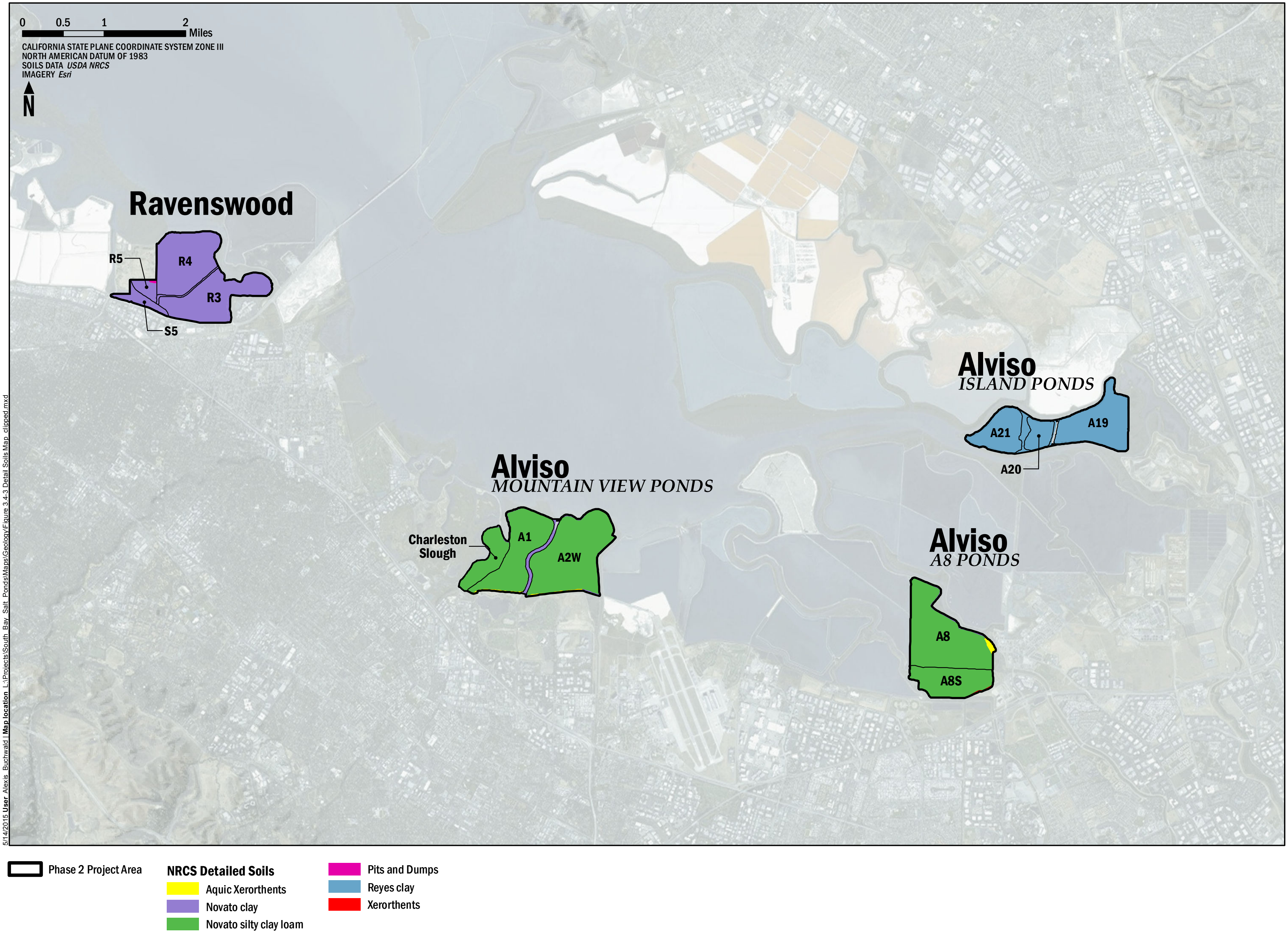

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Figure 3.4-3
Soils

Seismicity and Seismic Hazards

The San Francisco Bay Region is considered to be one of the more seismically active regions in the world, based on its record of historic earthquakes and its position along the San Andreas Fault system. The San Andreas Fault system consists of several major right-lateral strike-slip faults in the region that define the boundary zone between the Pacific and North American tectonic plates. Numerous damaging earthquakes have occurred along the San Andreas Fault as well as other regional faults in historical time.

Seismic or earthquake hazards are generated by the release of underground stress along a fault line and can cause ground shaking, surface fault rupture, tsunami/seiche generation, liquefaction, and earthquake-induced landsliding.

Surface Fault Rupture

Surface fault rupture, which is a manifestation of the fault displacement at the ground surface, usually is associated with moderate- to large-magnitude earthquakes (magnitudes of about 6 or larger). Generally, primary surface fault rupture occurs on active faults having mappable traces or zones at the ground surface. Potential surface fault rupture hazards exist along the known active faults in the greater San Francisco Bay Region. As shown on Figure 3.4-1, the faults that have been identified by the California Geologic Survey as potential surface rupture hazards in close proximity to the South Bay include the San Andreas and Hayward Faults. These faults show historic (last 200 years) displacement associated with mapped surface rupture or surface creep. Other faults in the South Bay include concealed, potentially active Quaternary faults with evidence of displacement sometime during the past 1.8 million years. The San Jose and Palo Alto Faults are mapped on the western boundary of the Bay. The San Jose Fault passes just east of northern portions of the Phase 2 area. The Silver Creek Fault, which is mapped on the eastern margin of the Bay, is located within the Phase 2 area.

Ground Shaking

Ground shaking takes the form of complex vibratory motion in both the horizontal and vertical directions. The amplitude, duration, and frequency content of ground shaking experienced at a specific site in an individual earthquake are highly dependent on several factors, including the magnitude of the earthquake, the fault rupture characteristics, the distance of the fault rupture from the site, and the types and distributions of soils beneath the site. Large-magnitude earthquakes produce stronger ground shaking than small-magnitude events. Sites close to the zone of fault rupture typically experience stronger motion than similar sites located farther away. Site soils can amplify ground motion in certain frequency ranges and can dampen ground motion within other frequency ranges. Soft soils sites, such as the Holocene Bay Mud and Quaternary alluvium, eolian deposits, and older Pleistocene Bay mud could amplify ground motions in the long period range compared to stiff or firm soils sites. This would affect structures having long, natural periods of vibration, such as bridges and tall buildings. Such soft soils are located in the Phase 2 area.

Liquefaction and Related Ground Failures

Liquefaction is a soil behavior phenomenon in which a soil located below the groundwater surface loses a substantial amount of strength due to high excess pore-water pressure generated and accumulated during strong earthquake ground shaking. During earthquake ground shaking, induced cyclic shear creates a tendency in most soils to change volume by rearrangement of the soil-particle structure. The potential for excess pore-water pressure generation and strength loss associated with this volume change tendency is highly dependent on the density of the soil, with greater potential in looser soils like those surrounding South San Francisco Bay including the Phase 2 project area.

The severity of the liquefaction hazard depends on: density of the saturated granular soils, depth and thickness of potentially liquefiable layers, magnitude and duration of the ground shaking, and distance to the nearby free face or ground slope. Generally, looser deposits have the potential to densify more as a result of ground shaking and are subject to larger volumetric changes. Generally thicker deposits would accumulate more volumetric change than thinner deposits.

Figure 3.4-4 shows liquefaction susceptibility based on subsurface conditions, including soil type, soil thickness, and depth to groundwater. Locations of observed ground effects (lateral spreading, sand boil, or settlement) from historic earthquakes (1989 Loma Prieta, 1906 San Francisco, and others) are also shown.

Landslides and Earthquake Triggered Landslides

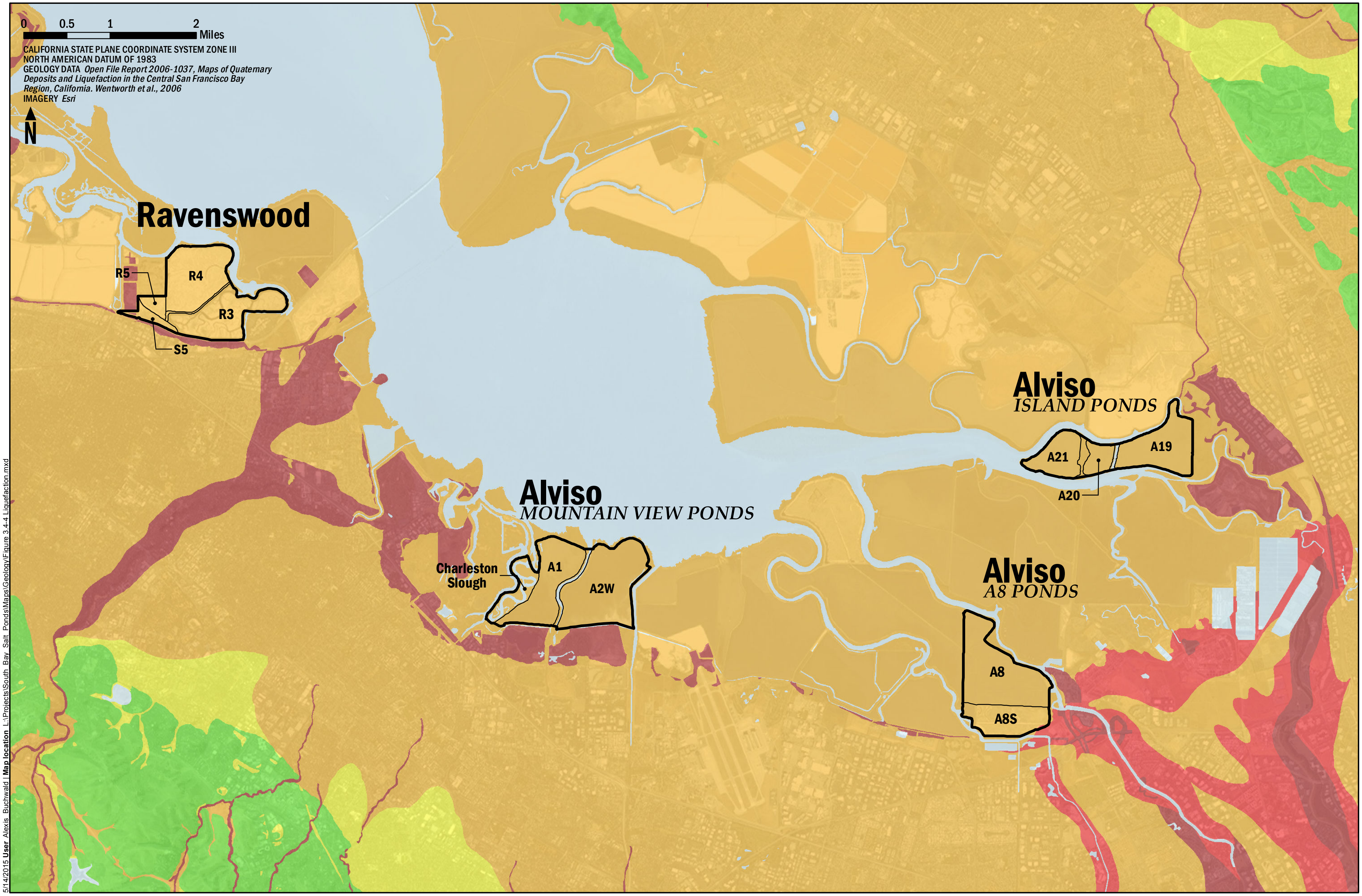
Landsliding is a general term used to describe the gravity-driven downslope movement of weathered earth materials. Landsliding is frequently used to describe rapid forms of flow, slide, or fall, where a mass of rock or weathered debris moves downhill along discrete shear surfaces. Water generally plays an important role in landsliding by oversteepening slopes through surface erosion, by generating seepage pressures through groundwater flow, and by adding weight to a soil mass when it is saturated. Other factors that influence landsliding are: (1) strength of the rock/soil material; (2) degree/depth of weathering; (3) slope angle; (4) the orientation and density of rock structures, such as bedding, joint, and fault planes; and (5) grading activities. Inertial forces from earthquake ground shaking can also reduce the stability of a slope and cause sliding or falling of soil or rock. Landslides may also be triggered by earthquakes and ground shaking.

Subsidence

Within the Phase 2 project area, Bay mud is a very soft, highly compressible material that can cause settlement and ground subsidence. The potential for settlement is correlated to the thickness of the material that underlies a given location. Therefore, a new earthen or structural load constructed in an area that contains a significant thickness of Bay mud can cause consolidation of Bay mud, which would cause ground settlement that would result in lower ground surface elevations.

Phase 2 Project Setting

Local geologic, soils, and hazards conditions in the Phase 2 project area are influenced by the geologic concepts and conditions discussed above. The entire Phase 2 project area is underlain by Holocene Bay mud. The Holocene Bay mud is relatively impermeable to both infiltration and groundwater flow. The Bay muds are generally underlain by (and in some cases overlain by) alluvial deposits.



5/14/2015 **User** Alexis Buchwald | **Map location** L:\Projects\South Bay Salt Ponds\Maps\Geology\Figure 3.4-4 Liquefaction.mxd

Phase 2 Project Area

Liquefaction Susceptibility

- Very High
- High
- Moderate
- Low
- Very Low
- Water

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Figure 3.4-4

Liquefaction

Alviso-Island Ponds

Soils in the Alviso-Island pond cluster (Alviso-Island Ponds or Island Ponds) are labeled on maps as tidal marsh or salt concentration ponds (depending on the age of the map). Soils in the Island Ponds are labeled Reyes Clay and Reyes clay, ponded.

The Island Ponds are underlain by the youngest Holocene Bay mud (Atwater et al. 1977; Helley et al. 1979). Figure 3.4-2 shows the thickness of Bay mud in the Phase 2 area. According to that figure, the thickness of Holocene Bay mud within the Island Ponds is approximately 10 to 15 feet. The thickness of Bay mud is strongly correlated to subsidence.

Some Holocene levee fill and alluvium overlie parts of the Alviso-Island pond cluster. The extent of the Bay muds ends close to the outboard edge of the Island Ponds (Woodward-Lundgren & Associates 1971) (see Figure 3.4-2).

Several faults with potential for surface rupture occur in close proximity to the Island Ponds. Pond A19 is located approximately 2.1 miles southeast of the Hayward Fault. Pond A21 is located approximately 14 miles east of the San Andreas Fault. Other faults in the vicinity of the Island Ponds include the Silver Creek Fault, Palo Alto Fault, and Stanford Fault. All of these faults are concealed, potentially active Quaternary faults that have evidence of displacement sometime during the past 1.8 million years. Pond A19 is located approximately 6 miles east of the San Jose Fault, 8 miles east of the Palo Alto Fault, and 10 miles east of the Stanford Fault. The Silver Creek Fault traverses the western portion of Pond A21 in a north/south-trending direction.

The Island Ponds have a moderate susceptibility for liquefaction. The Island Ponds and their surroundings have gentle surface gradients; therefore, the potential for landslide is limited.

Alviso-Mountain View Ponds

Soils in the Alviso-Mountain View pond cluster (Alviso-Mountain View Ponds or Mountain View Ponds) are labeled as tidal marsh or salt concentration ponds (depending on the age of the map). Soils in this pond cluster are categorized as Novato silty clay loam, with portions categorized as Novato clay.

The Mountain View Ponds are underlain by the youngest Holocene Bay mud (Atwater et al. 1977; Helley et al. 1979). Figure 3.4-2 shows Bay mud thickness in the Phase 2 area. According to that figure, the thickness of Holocene Bay mud within the Mountain View pond cluster varies from 10 to approximately 25 feet. The thickness of Bay mud that underlies a given location is strongly correlated to the potential for subsidence.

Some Holocene levee fill and alluvium overlie parts of the Mountain View pond cluster (Woodward-Lundgren & Associates 1971).

Several faults with potential for surface rupture occur in close proximity to the Mountain View Ponds. Pond A1, Pond A2W, and Charleston Slough are located approximately 8.4 miles west of the Hayward Fault. The Mountain View pond cluster is also roughly 8 miles east of the San Andreas Fault. The San Jose Fault traverses the southwest portion of Pond A2W and continues northwest through Pond A1 and Charleston Slough toward the Ravenswood Complex.

The Mountain View pond cluster is also 1 mile east of the Palo Alto Fault, and 3 miles east of the Stanford Fault. The Silver Creek Fault is 5 miles east of Pond A2W. The San Jose, Palo Alto, Stanford and Silver Creek Faults are concealed, potentially active Quaternary faults that have evidence of displacement sometime during the past 1.8 million years.

The Mountain View pond cluster has a moderate liquefaction susceptibility. The pond cluster has a gentle surface gradient, and potential for landslide is therefore limited.

Alviso-A8 Ponds

Soils in the Alviso-A8 pond cluster (Alviso-A8 Ponds or A8 Ponds) are generally labeled on maps as tidal marsh or salt concentration ponds (depending on the age of the map). Soils in this pond cluster are categorized as Novato silty clay loam.

The A8 Ponds are underlain by the youngest Holocene Bay mud (Atwater et al. 1977; Helley et al. 1979). Figure 3.4-2 shows Bay mud in the Phase 2 area. According to that figure, the thickness of Holocene Bay mud within the A8 Ponds varies from 10 to approximately 25 feet. The thickness of Bay mud that underlies a given location is strongly correlated to the potential for subsidence.

Some Holocene levee fill and alluvium overlie parts of the A8 Ponds (Woodward-Lundgren & Associates 1971) (see Figure 3.4-2).

Several faults with potential for surface rupture occur in close proximity to the Alviso-A8 pond cluster. Ponds A8 and A8S are approximately 5 miles west of the Hayward Fault and 12 miles east of the San Andreas Fault.

Alviso-A8 pond cluster is approximately 9 miles east of the Stanford Fault, 7 miles east of the Palo Alto Fault, and 1.5 miles west of the Silver Creek Fault. All of these faults are considered concealed and potentially active Quaternary faults. Unlike the other Phase 2 pond clusters, no faults underlie either Pond A8 or A8S.

The A8 Ponds have a moderate liquefaction susceptibility. The A8 Ponds have a gentle surface gradient, and the potential for landslide is therefore limited.

Ravenswood Ponds

Soils in the Ravenswood pond cluster (Ravenswood Ponds) are primarily categorized as Novato-Reyes and Reclaimed Urban land-Orthents. Novato-Reyes soils are poorly drained soils located on tidal flats. Reclaimed Urban land-Orthents soils are found on urban land and reclaimed tidal flats.

The Ravenswood Ponds are underlain by the youngest Holocene Bay mud (Atwater et al. 1977; Helley et al. 1979). Figure 3.4-2 shows Bay mud thickness in the study area, the thickness of which is strongly correlated to the potential for subsidence. According to this figure, the thickness of Bay mud below the Ravenswood pond cluster varies from 20 to 60 feet. This relatively variable package of Bay mud thickness is attributed to the close proximity of the pond complex to the long axis of the Bay and the main paleo-drainage.

The San Andreas Fault is approximately 6.5 miles west of the Ravenswood pond cluster, while the Hayward Fault is 10 miles east. Both the San Andreas and Hayward Faults are active, and have the potential to cause surface rupture. Other faults in the vicinity of the Ravenswood pond cluster include the Stanford Fault and Palo Alto Fault, which are 0.5 mile west of Ponds R5 and S5, respectively. The San Jose Fault traverses a portion of both Ponds R3 and R4. The Stanford, Palo Alto, San Jose and Silver

Creek Faults are concealed Quaternary faults, meaning they have less potential for surface rupture but are still considered active faults.

The Ravenswood Ponds are adjacent to an area of very high liquefaction susceptibility. The Ravenswood pond cluster has a gentle surface gradient, and the potential for landslide is therefore limited.

Regulatory Setting

Federal

FEMA regulations govern design and construction of flood control levees that could be affected by geology, soils, and seismicity in the Phase 2 area. These regulations are discussed in Section 3.2, Hydrology, Flood Management, and Infrastructure.

State

State regulations that govern geotechnical and geological aspects of Phase 2 of the SBSP Restoration Project include the Alquist-Priolo Earthquake Fault Zoning Act and Seismic Hazards Mapping Act. The California Building Code (CBC) would apply if a significant, permanent structure is constructed; however, none is proposed. The two primary regulations governing soils and geology are discussed below.

Alquist-Priolo Earthquake Fault Zone Act

The Alquist-Priolo Earthquake Fault Zones are regulatory zones that encompass surface traces of active faults that have a potential for future surface fault rupture. What does it mean to be located within an Earthquake Fault Zone? It means that an active fault is present within the zone, and the fault may pose a risk of surface fault rupture to existing or future structures. If property is not developed, a fault study may be required before the parcel can be subdivided or before most structures can be permitted. If a property is developed, the Alquist-Priolo Earthquake Fault Zone Act requires that all real estate transactions within an Earthquake Fault Zone be disclosed by the seller to prospective buyers.

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. ("Earthquake Fault Zones" were called "Special Studies Zones" prior to January 1, 1994.) The maps are distributed to all affected state agencies, counties, and cities for their use in planning and controlling new or renewed construction. Local agencies must regulate most development projects within the zones. Projects include all land divisions and most structures for human occupancy. Single-family wood-frame and steel-frame dwellings up to two stories that are not part of a development of four units or more are exempt. However, local agencies can be more restrictive than state law requires.

Before a project can be permitted, counties and cities 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 from the fault (generally 50 feet).

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act addresses seismic hazards such as strong ground shaking, soil liquefaction, and earthquake-related landslides. This act requires the State of California to identify and map areas that are at risk for these and other related hazards. Counties and cities are also required to regulate development in the mapped seismic hazard zones.

Permit review is the primary method of regulating local development under the Seismic Hazards Mapping Act. Counties and cities cannot issue development permits in these hazard zones until site-specific soils and/or geology investigations are carried out and measures to reduce potential damage are incorporated in the development plans.

The design of all structures (building and non-building structures) is required to comply with the Uniform Building Code (UBC)[1] and the CBC, which are the applicable building codes. Construction activities are overseen by the immediate local jurisdiction and regulated through a multi-stage permitting process. Projects within city limits typically require permit review by the city, while projects in unincorporated areas require a county permit. Grading and building permits require a site-specific geotechnical evaluation by a state-certified engineering geologist and/or geotechnical engineer. The geotechnical evaluation provides a geological basis from which to develop appropriate construction designs. A typical geotechnical evaluation usually includes an assessment of bedrock and quaternary geology, geologic structure, and soils, and a history of excavation and fill placement. The evaluation may also address the requirements of the Alquist-Priolo Act and the Seismic Hazards Mapping Act when appropriate.

3.4.2 Environmental Impacts and Mitigation Measures

Overview

This section describes environmental impacts and mitigation measures related to geology, soils, and seismicity. It includes a discussion of the criteria used to determine the significance of impacts. Potential impacts were characterized by evaluating direct, indirect, short-term (temporary), and long-term effects. Impact evaluations for the Action Alternatives are assessed based on the existing conditions described in Section 3.4.2 above, and not the proposed conditions that would occur under the No Action Alternative (the National Environmental Policy Act [NEPA] terminology will be used throughout this section). This approach is consistent with the California Environmental Quality Act (CEQA), which requires that project impacts be evaluated against existing conditions. In this case, the No Action Alternative represents no change from current management direction or level of management intensity provided in the Adaptive Management Plan (AMP) and other Refuge management documents and practices.

Significance Criteria

For the purposes of this Final EIS/R, Phase 2 would have a significant effect if it would:

- Be located on a site with geologic features that pose a substantial hazard to property and/or human life (e.g., an active fault, an active landslide); or

[1] Published by the International Conference of Building Officials, the UBC is a widely adopted model building code in the United States. The CBC incorporates by reference the UBC, with necessary California amendments.

- Expose people or property to major geologic hazards that cannot be avoided or reduced through the use of standard engineering design and seismic safety techniques; or
- Cause substantial erosion or siltation.

The first two of these significance criteria are addressed in the impacts discussed below, which are specific applications of the relative positions of the Phase 2 activities and geologic features (e.g., faults, Bay muds). The third bulleted significance criterion above is addressed partly herein and partly in Section 3.2, Hydrology, Flood Management, and Infrastructure. The SBSP Restoration Project, Phase 2 alternatives would not cause substantial erosion or siltation of top soils, so no further discussion of that topic is necessary here. The potential erosion caused by altering existing drainage patterns in the mudflats and sloughs is discussed in Section 3.2, Hydrology, Flood Management, and Infrastructure.

As explained in Section 3.1.2, while both CEQ Regulations for Implementing NEPA and the CEQA Guidelines were considered during the impact analysis, impacts identified in this EIS/R are characterized using CEQA terminology. Please refer to Section 3.1.2 for a description of the terminology used to explain the severity of the impacts.

Program-level Evaluation Summary

The 2007 EIS/R evaluated the potential geologic, soils, and seismic hazards that could affect the three long-term restoration alternatives. At the program level, the decision was made to select Programmatic Alternative C and implement Phase 1 actions. Therefore, a summary of the impacts for Alternative C from the 2007 EIS/R is provided below.

Potential effects from settlement and subsidence (including effects on levees and subsurface utility and surface rail crossings), liquefaction, lateral spreading, and ground and levee faults from fault rupture were found to be less than significant under Alternative C. This is because new and/or improved flood control levees would be designed, constructed, and maintained to address settlement, liquefaction, lateral spreading, and ground failure from a fault rupture. These facilities would be designed to account for the location of existing underground utilities and surface rail lines.

Risk from tsunami and/or seiche were found to be less than significant because Alternative C would not include habitable structures, and warning systems would allow for evacuation of the shoreline in such an event so inundation by tsunamis would not be expected to expose people to potential injury or death. Because impacts from Alternative C were found to be less than significant, no mitigation measures specific to geology and soils conditions are carried forward for Phase 2.

Project-Level Evaluation

Phase 2 Impact 3.4-1: Potential effects from settlement due to consolidation of Bay mud.

Alviso-Island Ponds

Alternative Island A (No Action). Under Alternative Island A, the Island Ponds (Ponds A19, A20, and A21) would continue to be managed through the activities described in the AMP and other Refuge management documents and practices. The existing levees at Ponds A19, A 20, and A21 were breached on their southern sides in March 2006 as part of the Initial Stewardship Plan. These levees (and the Island Ponds as a whole) are underlain by Bay mud of varying thickness. Under Alternative Island A, the existing salt pond levees would be allowed to continue to degrade, and no new structures or weight would be added that could expedite any already occurring rates of subsidence. The Union Pacific Railroad (UPRR) and associated infrastructure would continue to be maintained as needed. Therefore, implementation of Alternative Island A would not increase the risk of any of these hazards and this impact would be less than significant.

Alternative Island A Level of Significance: Less than Significant

Alternative Island B. Actions under Alternative Island B would result in increased hydraulic and habitat connectivity in Ponds A19 and A20 (but not Pond A21), and all ponds would continue to transition into tidal marshes. There would be no acceleration of already occurring subsidence levels caused by Alternative Island B because no new material (i.e., weight) would be added to the levees. The UPRR and associated infrastructure would continue to be maintained as needed. As such, potential effects from settlement due to consolidation of Bay mud are less than significant under Alternative Island B.

Alternative Island B Level of Significance: Less than Significant

Alternative Island C. Similar to Alternative Island B, Alternative Island C would not create an increased risk of flooding or other hazards because no new material (i.e., weight) is proposed that might cause existing rates of settlement to increase. The UPRR and associated infrastructure would continue to be maintained as needed. Potential effects from settlement due to consolidation of Bay mud are less than significant under Alternative Island C.

Alternative Island C Level of Significance: Less than Significant

Alviso-Mountain View Ponds

Alternative Mountain View A (No Action). The Alviso-Mountain View Ponds and Charleston Slough are underlain by Bay mud of varying thickness. Under Alternative Mountain View A, no new design components would be implemented as part of Phase 2, and the United States Fish and Wildlife Service (USFWS) would continue to manage the Mountain View pond cluster through the activities described in the AMP and other Refuge management documents and practices. The outboard levees at Ponds A1 and A2W are high-priority levees that are to be maintained for inland flood protection. These outboard levees would be maintained or repaired upon failure, including failure as a result of background subsidence rates.

Therefore, implementation of Alternative Mountain View A would not increase already existing rates of settlement, and the continued maintenance of outboard levees would ensure that no new risks to neighboring populated areas are created as a result of continued subsidence of the outboard levees. Potential effects from settlement due to consolidation of Bay mud are less than significant under Alternative Mountain View A.

Alternative Mountain View A Level of Significance: Less than Significant

Alternative Mountain View B. Levees and flood control improvements proposed under Alternative Mountain View B would add additional weight to areas underlain by Bay mud, thereby potentially increasing the existing rate of settlement. However, the levees and other improvements would be designed and constructed to compensate for settlement and consolidation, which would prevent tidal overtopping and is intended to prevent flooding. Additionally, the levees would be improved and designed to withstand seismic events to the extent practicable. The long-term settlement of improved levees resulting from increased weight would be offset by required maintenance to ensure minimum elevations are achieved, and potential effects on people and property would be less than significant.

Habitat transition zones would be constructed along the south edge of Ponds A1 and A2W as part of Alternative Mountain View B. The habitat transition zones add additional fill to the ponds, thereby potentially increasing the already occurring rates of settlement. However, the intention of the habitat transition zones and any other pond bottom modification would be to raise the elevation of the deeply subsided pond bottoms, thereby working to offset settlement and consolidation. Further, construction of the habitat transition zones would not create impacts to people or property, and would act as an additional barrier preventing potential impacts from flooding. Therefore, impacts from settlement resulting from consolidation of Bay mud are less than significant under Alternative Mountain View B.

Alternative Mountain View B Level of Significance: Less than Significant

Alternative Mountain View C. Under Alternative Mountain View C, Ponds A1, and A2W would be breached and opened to tidal action, which would begin their transition into tidal marshes. The levee separating Charleston Slough and Pond A1 would be lowered instead of improved. To compensate for this loss of flood protection, which exists under the current conditions, a new flood protection system consisting of raised and improved levees around the western and southern portions of Charleston Slough would be constructed.

These improvements would add additional fill material to areas underlain by Bay mud, thereby potentially increasing the rate of settlement. However, the levees and other improvements would be constructed to prevent tidal overtopping and prevent flooding. They would be designed and constructed to compensate for settlement and consolidation. They would also be improved and designed to withstand seismic events to the extent practicable. Therefore, the settlement of levees as a result of increased weight would be offset by required maintenance to ensure minimum elevations are achieved, thereby preventing potential effects on people and property resulting from potentially accelerated rates of subsidence. This impact would be less than significant.

Habitat transition zones would be constructed along the south edge of Ponds A1 and A2W as part of Alternative Mountain View C. The habitat transition zones would add additional fill to these ponds and could increase background rates of settlement. However, the intention of the habitat transition zones and any other pond bottom modifications would be to raise the elevation of the deeply subsided pond bottoms, thereby working to offset settlement and consolidation. Further, construction of the habitat transition zones would not create impacts to people or property, and would act as an additional barrier preventing potential impacts from flooding. Therefore, under Alternative Mountain View C, impacts from settlement resulting from consolidation of Bay mud compared to the existing conditions in this pond cluster are less than significant.

Alternative Mountain View C Level of Significance: Less than Significant

Alviso-A8 Ponds

Alternative A8 A (No Action). Under Alternative A8 A, Pond A8, and Pond A8S would continue to be managed through the activities described in the AMP and other Refuge management documents and practices. Ponds A8 and A8S were linked in the Phase 1 actions. The A8 Ponds are underlain by Bay mud of varying thickness. Under Alternative A8 A, the existing external salt pond levees would be maintained as they currently are, and no new structures or weight would be added that could expedite background subsidence levels.

Phase 2 project components associated with Alternative A8 A would not cause additional subsidence due to consolidation of Bay mud because no new material (i.e., weight) would be added to existing levees or within the Alviso-A8 pond cluster. As such, potential effects from settlement due to consolidation of Bay mud are less than significant under Alternative A8 A.

Alternative A8 A Level of Significance: Less than Significant

Alternative A8 B. Under Alternative A8 B, habitat transition zones would be constructed in the southwest corner and southeast corner of Pond A8S. Similar to the Action Alternatives described above at the Mountain View Ponds, the habitat transition zones would perform several functions, including adding some flood protection and buffering against sea-level rise.

Construction of these habitat transition zones would add additional weight to areas underlain by Bay mud, thereby potentially accelerating existing background rates of settlement. However, one intention of the habitat transition zones would be to raise the elevation of part of the deeply subsided pond bottoms, thereby working to offset settlement and consolidation. Further, the design of these habitat transition zones will include planning for some degree of consolidation and settlement, so that construction of the habitat transition zones would not create impacts to people or property. Finally, the settlement of habitat transition zones as a result of increased weight would be offset by required maintenance to ensure that minimum elevations are maintained and potential effects on people and property are avoided. As a result, impacts from long-term subsidence under Alternative A8 B would remain less than significant.

Alternative A8 B Level of Significance: Less than Significant

Ravenswood Ponds

Alternative Ravenswood A (No Action). The Ravenswood Ponds are underlain by Bay mud of varying thickness. Under Alternative Ravenswood A, no new design components would be implemented as part of Phase 2, and the USFWS would continue to manage the Ravenswood pond cluster through the activities described in the AMP and other Refuge management documents and practices. The outboard levees at Ponds R3 and R4 are high-priority levees that are to be maintained for inland flood protection. These outboard levees would be maintained or repaired upon failure, including as a result of background subsidence rates.

Therefore, implementation of Ravenswood A would not increase already existing rates of settlement. Furthermore, the continued maintenance of outboard levees would ensure that no new risks to neighboring populated areas are created as a result of continued subsidence of the outboard levees. Potential effects from settlement due to consolidation of Bay mud are less than significant under Alternative Ravenswood A.

Alternative Ravenswood A Level of Significance: Less than Significant

Alternative Ravenswood B. Levee improvements, construction of water control structures, habitat transition zones, and adding recreational facilities under Alternative Ravenswood B would impose new loads on the underlying Bay mud, thereby potentially accelerating existing background rates of settlement. However, the intent of levee improvements and maintenance along the All-American Canal (AAC), combined with regular maintenance of the existing outboard levees on the boundary of Pond R3, would prevent tidal overtopping and preclude potential flooding caused by long-term sea-level rise. The AAC and related improvements would be designed and constructed to compensate for settlement and consolidation.

Construction of the habitat transition zone along the western edge of Pond R4 would prevent scouring of lands associated Bedwell Bayfront Park, thereby protecting higher water levels from exposing or damaging the landfill cap. The potential accelerated settlement and consolidation caused by the addition of material along the AAC, regular maintenance of the outboard levee at Pond R3, and the addition of the habitat transition zone at the eastern edge of Pond R4 would be offset by required maintenance to ensure minimum elevations to protect against flooding are retained. Further, construction of the habitat transition zones would not create impacts to people or structures, as no public access will be provided in these areas. They would also act as an additional barrier preventing potential impacts from flooding. Therefore, the future conditions under Alternative Ravenswood B would not represent a net change from the existing levels of subsidence, and potential effects on people and property from settlement of Bay mud underlying these components over time would remain less than significant.

Alternative Ravenswood B Level of Significance: Less than Significant

Alternative Ravenswood C. Alternative Ravenswood C would be similar to Alternative Ravenswood B with the following exceptions: Ponds R5 and S5 would be converted to a particular type of managed pond that is maintained at mudflat elevation for shore birds; a second water control structure would be installed on Pond R3 to allow for improvement to the habitat for the western snowy plover; and an additional habitat transition zone would be constructed.

The addition of material in the bottoms of Ponds R5 and S5 could potentially accelerate rates of settlement of the underlying Bay mud. This activity would not result in increased exposure of people to changes in the settlement of Bay mud because the activity would not alter the flood protection provided by the ponds.

As with Alternative Ravenswood B, the potential accelerated rates of settlement caused by the addition of material along the AAC, regular maintenance of the outward levee on Pond R3, and the addition of the habitat transition zone at the eastern edge of Pond R4 and along the AAC would be offset by required maintenance to ensure minimum elevations are retained to protect against flooding. Further, construction of the habitat transition zones would not create impacts to people or property, and would act as an additional barrier preventing potential impacts from flooding. Therefore the future conditions under Alternative Ravenswood C would not represent a net change from the existing levels of subsidence, and potential effects on people and property from settlement of these facilities over time would remain less than significant.

Alternative Ravenswood C Level of Significance: Less than Significant

Alternative Ravenswood D. Under Alternative Ravenswood D, potential accelerated rates of settlement caused by the addition of material along the AAC, the Redwood City stormwater interconnection components, regular maintenance of the outboard levee at Pond R3, and the addition of the habitat transition zone at the eastern edge of Pond R4 and along the AAC would be offset by required maintenance to ensure minimum elevations are retained to protect against flooding. Further, construction of the habitat transition zones would not create impacts to people or property, and would act as an additional barrier preventing potential impacts from flooding when compared to existing conditions at this pond cluster. Therefore the future conditions under Alternative Ravenswood D would not represent a net change from the existing levels of subsidence, and potential effects on people and property from settlement of these facilities over time would remain less than significant under Alternative Ravenswood D.

Alternative Ravenswood D Level of Significance: Less than Significant

Phase 2 Impact 3.4-2: Potential effects from liquefaction of soils and lateral spreading.

Alviso-Island Ponds

Alternative Island A (No Action). Based on existing data, the Island Ponds are within an area of moderate liquefaction susceptibility. The Island Ponds are geographically isolated from any urbanized and built-out areas by other waterbodies, other salt ponds, and a landfill. Under Alternative Island A, no new habitable structures would be constructed within the Island Ponds. Additionally, under this alternative, no new improvements or maintenance to existing levees would occur, except those that protect the existing UPRR rail line between Ponds A21 and A20. This alternative would allow the existing breached levees to continue to be scoured from hydraulic action and to naturally degrade over time.

Liquefaction could cause existing levees within the pond cluster to be damaged during an earthquake. Under this scenario, existing levee slopes could be partially damaged/breached or completely fail, allowing them to then be overtopped by tidal action. If this occurred, the Island Ponds would be exposed to frequent tidal inundation. In this scenario, only the levee containing the existing UPRR railroad tracks would be repaired, and all others would be allowed to remain in their damaged state, according to the AMP. Therefore, the existing UPRR line would remain protected.

If the outboard levees surrounding the Island Ponds fail, they would not be replaced; however, this would not create any new impacts from liquefaction. Therefore, impacts from Alternative Island A as a result of liquefaction or lateral spreading would be less than significant.

Alternative Island A Level of Significance: Less than Significant

Alternative Island B. Alternative Island B proposes activities that would continue the transition of these ponds to tidal marsh and enhances the complexity and connectivity of the habitat. Liquefaction could cause existing levees within the Island Pond cluster to be damaged during an earthquake. Under this scenario, existing levee slopes could be partially damaged/breached or completely fail, allowing them to then be overtopped by tidal action. If this occurred, the Island Ponds would be exposed to frequent tidal inundation. In this scenario, as with Alternative Island A, only the levee containing the existing UPRR railroad tracks would be repaired; all others would be allowed to remain in their damaged state, according to the AMP. Therefore, the existing UPRR line would remain protected. The current risks of damage to the UPRR tracks would not be increased under Alternative Island B. Therefore, impacts from Alternative Island B as a result of liquefaction or lateral spreading would be less than significant.

Alternative Island B Level of Significance: Less than Significant

Alternative Island C. Alternative Island C proposes activities that would continue the transition of these ponds to tidal marsh and enhances the complexity and connectivity of the habitat. Impacts resulting from lateral spreading or liquefaction under Alternative Island C would be the same as those described under Alternative Island B. The current risks of damage to the UPRR tracks would not be increased under

Alternative Island C. Therefore impacts from Alternative Island C as a result of liquefaction or lateral spreading would be less than significant.

Alternative Island C Level of Significance: Less than Significant

Alviso-Mountain View Ponds

Alternative Mountain View A (No Action). Based on existing data, the Mountain View Ponds are within an area of moderate liquefaction susceptibility. Most of the pond cluster's southern boundary is adjacent to a closed landfill that is in an area of high to very high liquefaction susceptibility. Liquefaction at the Mountain View Ponds could cause failure and deformation of existing levee or landfill slopes, or levees could also be breached. Liquefaction could cause portions of levees to settle below minimum flood elevations, allowing them to be overtopped by tidal action.

Under Alternative Mountain View A, Ponds A1 and A2W would continue to be managed through the activities described in the AMP and other Refuge management documents and practices. Charleston Slough would continue to be managed by the City of Mountain View. The outboard levees at Ponds A1 and A2W are high-priority levees that are to be maintained for inland flood protection. These outboard levees would be maintained and repaired upon failure. Therefore, impacts to the existing environmental conditions as a result of liquefaction or lateral spreading would be less than significant under Alternative Mountain View A.

Alternative Mountain View A Level of Significance: Less than Significant

Alternative Mountain View B. Under Alternative Mountain View B, the northern perimeter levee and the northern portion of the western perimeter levee at Pond A1, the eastern levee of Pond A1, and the western levee of Pond A2W would not be maintained. Additionally, the replacement or raised and improved levee between Charleston Slough and Pond A1 would be designed and constructed to resist liquefaction and lateral spreading to the extent practicable. The raised levee and other flood protection improvements at the southwest corner of Pond A1 would be similarly designed and constructed to resist lateral spreading or impacts from liquefaction, to the extent practicable. While liquefaction and lateral spreading could still occur under Alternative Mountain View B, any failures of upland flood control levees caused by liquefaction or lateral spreading would be repaired. Armored breaches and viewing platforms would also be designed to account for liquefaction and lateral spreading. The improved levees and other flood control infrastructure would be repaired should it fail as a result of liquefaction, which is similar to what would occur under the management strategy of the AMP and other Refuge management documents and practices. Therefore, Alternative Mountain View B would prevent unnecessary exposure of people and property to flood hazards resulting from liquefaction or lateral spreading. As such, impacts resulting from the selection of Alternative Mountain View B would be less than significant.

Alternative Mountain View B Level of Significance: Less than Significant

Alternative Mountain View C. Impacts resulting from lateral spreading or liquefaction under Mountain View C would be much the same as those described under Mountain View B. The differences occur in the locations where levees and flood control infrastructure would be replaced or raised and improved. Compared to Alternative Mountain View B, under Alternative Mountain View C, the western levee of Charleston Slough (instead of the western levee of Pond A1), and the ground to be raised to tie into the high ground of the landfill under Shoreline Park would extend further around the southern end of Charleston Slough instead of stopping at the corner of Pond A1. Those improvements would also be both higher and wider to address the City of Mountain View's plans for future sea-level rise, so there would be more material placed here than elsewhere. However, equally improved design and engineering standards would be used to make these structures resistant to liquefaction and lateral spreading. Thus, the impacts from Alternative Mountain View C would be less than significant.

Alternative Mountain View C Level of Significance: Less than Significant

Alviso-A8 Ponds

Alternative A8 A (No Action). Based on existing data, the A8 Ponds are within an area of moderate liquefaction susceptibility. Under Alternative A8 A, the pond cluster would continue to be managed through the activities described in the AMP and in accordance with current USFWS practices.

Liquefaction may cause portions of levees to settle below minimum elevations, allowing them to be overtopped. In areas where liquefaction causes failure and deformation of levee slopes, levees may be breached. Corresponding ponds and adjacent areas may be flooded as a result, but these conditions would exist with or without the project. Alternative A8 A would not create a new opportunity to expose people to damage resulting from liquefaction or lateral spreading. As such, impacts resulting from the selection of Alternative A8 A would be less than significant.

Alternative A8 A Level of Significance: Less than Significant

Alternative A8 B. Under this alternative, habitat transition zones would be constructed in Pond A8S's southwest and southeast corners. These habitat transition zones would be designed and maintained to resist liquefaction and lateral failure. While these habitat transition zones could still be affected by liquefaction, liquefaction of the soils under these habitat transition zones would not create a new hazard to people or property from flooding as a result of liquefaction and lateral spreading when compared to existing conditions in this pond cluster. Therefore, impacts resulting from lateral spreading or liquefaction under Alternative A8 B would be would be less than significant.

Alternative A8 B Level of Significance: Less than Significant

Ravenswood Ponds

Alternative Ravenswood A (No Action). Based on existing data, the Ravenswood Ponds are within an area of moderate liquefaction susceptibility. Liquefaction may cause portions of levees to settle below minimum elevations, allowing them to be overtopped. Corresponding ponds and adjacent areas may be flooded as a result, which could impact populated areas. Due to this susceptibility, liquefaction could cause portions of levees to settle below minimum flood elevations, allowing them to be overtopped by tidal action. This could be an issue for nearby populated areas if the outboard levees at Ponds R3 and R4 became liquefied or laterally spread.

The outboard levees at Ponds R3 and R4 are high-priority levees that are to be maintained for inland flood protection and that are a component of the United States Army Corps of Engineers 1995 operations and maintenance permit. These outboard levees would be maintained or repaired upon failure. Furthermore, the nature of maintenance and repair that would take place under Alternative Ravenswood A is such that it would not cause habitable structures to be constructed within the Phase 2 site, nor would it create a new opportunity to expose people to damage resulting from liquefaction or lateral spreading. Therefore, Alternative Ravenswood A would not create a new opportunity to expose people to damage resulting from liquefaction or lateral spreading. As such, impacts resulting from the selection of Alternative Ravenswood A would be less than significant.

Alternative Ravenswood A Level of Significance: Less than Significant

Alternative Ravenswood B. Impacts resulting from lateral spreading or liquefaction under Alternative Ravenswood B may cause portions of the levees to settle below minimum elevations, allowing them to be overtopped. Corresponding ponds and adjacent areas may be flooded as a result, which could impact populated areas. Under Alternative Ravenswood B, the existing outboard levee at Pond R3 would be maintained and repaired. Under Alternative Ravenswood B, a raised and improved levee between Ponds R3 and R4 along the AAC, tying in to high ground at Bedwell Bayfront Park at the western end, is proposed. That improved levee would be designed and constructed so as to prevent impacts from liquefaction and lateral spreading. While liquefaction and lateral spreading could still occur under Alternative Ravenswood B, failures of levees caused by liquefaction or lateral spreading would be repaired at the outboard levee of Pond R3, and harm from such failure would be prevented or minimized through the construction of a new raised levee along the AAC.

The installation of water control structures for enhanced managed ponds in Pond R3 (for western snowy plover) and Ponds R5 and S5 (for dabbling ducks and small shorebirds) would not substantially change the risk or the severity of lateral spreading or liquefaction. The habitat transition zone and the minimal additional material for a viewing platform would not substantially change the risk or the severity of lateral spreading or liquefaction.

Based on the above, Alternative Ravenswood B would prevent unnecessary exposure of people and property to flood hazards resulting from liquefaction or lateral spreading. As such, impacts resulting from the selection of Alternative Ravenswood B would be less than significant.

Alternative Ravenswood B Level of Significance: Less than Significant

Alternative Ravenswood C. Alternative Ravenswood C would be similar to Alternative Ravenswood B with several exceptions: Ponds R5 and S5 would be converted to a particular type of managed pond that is maintained at mudflat elevation for shore birds; a second water control structure would be installed on Pond R3 to allow for additional improvement to the habitat for the western snowy plover; an additional habitat transition zone would be constructed; and additional recreational and public access components would be constructed. None of the specific construction actions or attributes associated with Alternative Ravenswood C would change the potential for liquefaction or lateral spreading when compared to the existing conditions at this pond cluster. Therefore, impacts resulting from lateral spreading or liquefaction under Alternative Ravenswood C would be the same as those described under Alternative Ravenswood B and would be less than significant.

Alternative Ravenswood C Level of Significance: Less than Significant

Alternative Ravenswood D. Alternative Ravenswood D would be similar to Alternative Ravenswood B with a few exceptions. Alternative Ravenswood D would open Pond R4 to tidal flows, improve levees to provide additional flood protection, create two habitat transition zones in Pond R4, establish enhanced managed ponds in Ponds R5 and S5 to improve habitat for diving and dabbling birds, increase pond connectivity, further enhance Pond R3 for western snowy plover habitat, allow stormwater outflow from Redwood City to Ponds R5 and S5, remove the levees within and between Ponds R5 and S5, and improve recreation and public access. None of the specific construction actions or attributes associated with

Alternative Ravenswood D would change the potential for liquefaction or lateral spreading when compared to the existing conditions at this pond cluster. Therefore, impacts resulting from lateral spreading or liquefaction under Alternative Ravenswood D would be the same as those described under Alternative Ravenswood B and would be less than significant.

Alternative Ravenswood D Level of Significance: Less than Significant

Phase 2 Impact 3.4-3: Potential for ground and levee failure from fault rupture.

Alviso-Island Ponds

Alternative Island A (No Action). The concealed quaternary Silver Creek Fault runs through the eastern end of the Alviso-Island pond cluster. Surface faults can result in ground rupture. While no surface faults traverse this pond cluster, in the event of a levee breach caused by fault rupture during an earthquake, there is a potential for flooding within the pond cluster and nearby areas. However, these areas contain no recreational components or other features that could potentially expose people to hazards as a result of the rupture. Therefore, Alternative Island A impacts associated with the potential for ground and levee failure from fault rupture would be less than significant.

Alternative Island A Level of Significance: Less than Significant

Alternative Island B. The concealed quaternary Silver Creek Fault runs through the eastern end of the Alviso-Island pond cluster. Surface faults can result in ground rupture. While no surface faults traverse this pond cluster, in the event of a levee breach caused by fault rupture during an earthquake, there is a potential for flooding within the pond cluster and nearby areas. However these areas contain no recreational components or other features that could potentially expose people to hazards as a result of the rupture. Additionally, this alternative would not construct any features or add infrastructure to the Island Ponds. Therefore, Alternative Island B impacts associated with the potential for ground and levee failure from fault rupture would be less than significant.

Alternative Island B Level of Significance: Less than Significant

Alternative Island C. The concealed quaternary Silver Creek Fault runs through the eastern end of the Alviso-Island pond cluster. Surface faults can result in ground rupture. While no surface faults traverse this pond cluster, in the event of a levee breach caused by fault rupture during an earthquake, there is a potential for flooding within the pond cluster and nearby areas. However these areas contain no recreational components or other features that could potentially expose people to hazards as a result of the rupture. Additionally, this alternative would not construct any features or add infrastructure to the Island Ponds. Impacts from potential ground and levee failure from fault rupture described under Alternative Island C would be the same for Alternative Island B and would be less than significant.

Alternative Island C Level of Significance: Less than Significant

Alviso-Mountain View Ponds

Alternative Mountain View A (No Action). The concealed quaternary San Jose Fault runs through Pond A2W, Pond A1, and Charleston Slough. Surface faults can result in ground rupture. While no surface faults traverse the Alviso-Mountain View pond cluster, in the event of a levee breach caused by fault rupture during an earthquake, there is a potential for flooding within the pond cluster and nearby areas. However, under Alternative A, these areas would contain no new recreational structures or other features that could potentially expose people to hazards as a result of the rupture. As such, potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake would be less than significant.

Alternative Mountain View A Level of Significance: Less than Significant

Alternative Mountain View B. Alternative Mountain View B would not add new recreational facilities on the San Jose Fault trace (though a viewing platform would be added near an existing trail in both Action Alternatives at the Mountain View Ponds). The raised levee between Charleston Slough and Pond A1 would be constructed to withstand failure from fault rupture to the extent practicable. As such, potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake would be less than significant.

Alternative Mountain View B Level of Significance: Less than Significant

Alternative Mountain View C. Unlike Mountain View B, Alternative Mountain View C would add a recreational facility – the trail to be constructed on the remaining outboard levee of Charleston Slough – near the San Jose Fault trace. The trail would not directly traverse the fault trace, and this levee is a relatively recent addition and was designed and built to modern seismic standards. Also, the raised levee between Charleston Slough and the Palo Alto Flood Basin would be constructed to withstand failure from fault rupture to the extent practicable. As such, while Alternative Mountain View C would add recreational facilities near the concealed San Jose Fault trace, these facilities would not be constructed on top of the fault, so the net risk from faulting associated with this project remains the same as the existing conditions. Therefore the potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake would be less than significant.

Alternative Mountain View C Level of Significance: Less than Significant

Alviso-A8 Ponds

Alternative A8 A (No Action). No active or potentially active faults are mapped within the Alviso-A8 pond cluster. As such, the potential for ground and levee failure from fault rupture is less than significant under Alternative A8 A.

Alternative A8 A Level of Significance: Less than Significant

Alternative A8 B. No active or potentially active faults are mapped within the Alviso-A8 pond cluster. As such, the potential for ground and levee failure from fault rupture is less than significant under the Alternative A8 B.

Alternative A8 B Level of Significance: Less than Significant

Ravenswood Ponds

Alternative Ravenswood A (No Action). The concealed quaternary San Jose Fault runs through Ponds R3 and R4. In the event of a levee breach caused by surface fault rupture during an earthquake, there is a potential for flooding within the pond cluster and nearby areas. However, there are no nearby structures or recreational facilities that would be affected by this potential flooding. Therefore, impacts associated with the potential for ground and levee failure from fault rupture from Alternative Ravenswood A would be less than significant.

Alternative Ravenswood A Level of Significance: Less than Significant

Alternative Ravenswood B. Alternative Ravenswood B would not place recreational facilities on the San Jose Fault trace. The improved levee along the AAC would be constructed to withstand failure from fault rupture to the extent practicable. Therefore, potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake under Alternative Ravenswood B would be less than significant.

Alternative Ravenswood B Level of Significance: Less than Significant

Alternative Ravenswood C. Alternative Ravenswood C would not place recreational facilities on the San Jose Fault trace. The improved levee along the AAC would be constructed to withstand failure from fault rupture to the extent practicable. Therefore, potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake under Alternative Ravenswood C would be less than significant.

Alternative Ravenswood C Level of Significance: Less than Significant

Alternative Ravenswood D. Alternative Ravenswood D would not place recreational facilities on the San Jose Fault trace. The improved levee along the AAC would be constructed to withstand failure from fault rupture to the extent practicable. The Redwood City Bayfront Canal and Atherton Channel Project facilities would also be constructed to withstand failure from fault rupture to the extent practicable. Therefore, potential effects on people and property due to a rupture immediately on or adjacent to a fault during an earthquake would be less than significant under Alternative Ravenswood D.

Alternative Ravenswood D Level of Significance: Less than Significant

Phase 2 Impact 3.4-4: Potential effects from consolidation of Bay mud on existing subsurface utility crossings and surface rail crossings.

Alviso-Island Ponds

Alternative Island A (No Action). The existing UPRR runs north-south between Ponds A21 and A20. Under Alternative Island A, limited operations and maintenance activities would occur within the UPRR alignment area; however, no new earthen or structural loads would be placed in this UPRR alignment. Therefore, impacts from consolidation of Bay mud on existing surface rail crossings would be less than significant. No subsurface utility crossings occur in the Alviso-Island pond cluster.

Alternative Island A Level of Significance: Less than Significant

Alternative Island B. The existing UPRR runs north-south between Ponds A21 and A20. Alternative Island B proposes activities that would speed the transition of these ponds to tidal marsh; however, no new earthen or structural loads would be placed in or near the UPRR alignment. Therefore, impacts from consolidation of Bay mud on existing surface rail crossings would be less than significant. No subsurface utility crossings occur in the Island Ponds.

Alternative Island B Level of Significance: Less than Significant

Alternative Island C. Under Alternative Island C, the actions would be similar to those in Alternative Island B, but in more locations. Impacts from consolidation of Bay mud on existing surface rail crossings and subsurface utilities would be the same as those described under Alternative Island B, and would be less than significant.

Alternative Island C Level of Significance: Less than Significant

Alviso-Mountain View Ponds

Alternative Mountain View A (No Action)**.** There are no known existing subsurface utility or rail crossings within the Alviso-Mountain View pond cluster. Therefore no impact to an existing utility or rail crossing would occur from consolidation of Bay mud associated with Alternative Mountain View A.

Alternative Mountain View A Level of Significance: No Impact

Alternative Mountain View B. There are no known existing subsurface utilities or rail crossings within the Alviso-Mountain View pond cluster. Therefore no impact to an existing utility or rail crossing would occur from consolidation of Bay mud associated with Alternative Mountain View B.

Alternative Mountain View B Level of Significance: No Impact

Alternative Mountain View C*.* Under Alternative Mountain View C, impacts from consolidation of Bay mud on existing surface rail crossings and subsurface utilities would be the same as those described under Alternative Mountain View B.

Alternative Mountain View C Level of Significance: No Impact

Alviso-A8 Ponds

The Santa Clara Valley Water District (SCVWD) has a water diversion outflow pipe that empties into the underwater portions of Pond A8S near its western junction with Pond A8. This is the only known subsurface utility in these ponds. The USFWS is committed to coordinating with the SCVWD through 2007 EIS/R Mitigation Measure 3.4-6.

Alternative A8 A (No Action). The current management practices at the A8 Ponds do not impede or impair the intermittent use of this water outflow system by the SCVWD. Under Alternative A8 A, these practices would not change, and there would be no impact.

Alternative A8 A Level of Significance: No Impact

Alternative A8 B. Under Alternative A8 B, the placement of upland fill material to form habitat transition zones would have the potential to impede or impair the use of the existing water diversion outflow system by the SCVWD. However, the proposed location of the western habitat transition zone in Pond A8S was chosen so as to avoid this outflow system. The design and implementation of the habitat transition zone there would avoid it completely, and the impacts on its use would therefore be less than significant.

Alternative A8 B Level of Significance: Less than Significant

Ravenswood Ponds

Alternative Ravenswood A (No Action). There are no known existing subsurface utility or rail crossings within the Ravenswood pond cluster. Therefore no impact to an existing utility or rail crossing would occur from consolidation of Bay mud. There is a Cargill Company brine channel and pipeline that runs along the southernmost edge of the Pond R3-S5 axis, adjacent to the Bay Trail, but it would not be subject to consolidation-related impacts.

Alternative Ravenswood A Level of Significance: No Impact

Alternative Ravenswood B. There are no known existing subsurface utility or rail crossings within the Ravenswood pond cluster. Therefore no impact to existing utility or rail crossing would occur from consolidation of Bay mud associated with Alternative Ravenswood B. There is a Cargill Company brine channel and pipeline that runs along the southernmost edge of the Pond R3-S5 axis, adjacent to the Bay Trail, but it would not be subject to consolidation-related impacts.

Alternative Ravenswood B Level of Significance: No Impact

Alternative Ravenswood C. Under Alternative Ravenswood C, impacts from consolidation of Bay mud on existing surface rail crossings and subsurface utilities would be the same as those described under Alternative Ravenswood B.

Alternative Ravenswood C Level of Significance: No Impact

Alternative Ravenswood D. Under Alternative Ravenswood D, the City of Redwood City's Bayfront Canal and Atherton Channel Project would cross a number of subsurface utilities and/or easements, including cable service and a Cargill pipeline. However, as part of project design and planning, the City of Redwood City would acquire the necessary construction easements to conduct the work and avoid impacts from the installation of the box culverts to connect Pond S5 with Flood Slough and the existing storm drain outfall system. That project would be designed and built in such a way as to avoid impacts from consolidation of Bay mud or other soils on the existing subsurface utilities. The impact would therefore be less than significant.

Alternative Ravenswood D Level of Significance: Less than Significant

Impact Summary

Phase 2 impacts and levels of significance are summarized in Table 3.4-1. The levels of significance are those remaining after implementation of program-level mitigation measures, project-level design features, and the AMP and other Refuge management documents and practices. The geology and soils analysis required no project-level mitigation measures in order to reduce the impacts to a level that was less than significant.

Table 3.4-1 Phase 2 Summary of Impacts – Geology and Soils

IMPACT	ALTERNATIVE											
	ISLAND			MOUNTAIN VIEW			A8		RAVENSWOOD			
	A	B	C	A	B	C	A	B	A	B	C	D
Phase 2 Impact 3.4-1: Potential effects from settlement due to consolidation of Bay mud.	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS
Phase 2 Impact 3.4-2: Potential effects from liquefaction of soils and lateral spreading.	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS
Phase 2 Impact 3.4-3: Potential for ground and levee failure from fault rupture.	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS	LTS
Phase 2 Impact 3.4-4: Potential effects from consolidation of Bay mud on existing subsurface utility crossings and surface rail crossings.	LTS	LTS	LTS	NI	NI	NI	NI	LTS	NI	NI	NI	LTS

Notes:
Alternative A at each pond cluster is the No Action Alternative (No Project Alternative under CEQA).
LTS = Less than Significant
NI = No Impact

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