3.6 Geology and Soils

3.6.1 Introduction

This section includes an evaluation of the potential for the project to result in adverse impacts related to geologic, seismic, and soils hazards. The analysis is based on review of available geologic and geotechnical reports and maps of the project area and vicinity, including site-specific investigations conducted for the project. This section also includes relevant regulations, a discussion of potential project impacts, and appropriate mitigation measures, where necessary.

3.6.2 Scoping Comments

Comments related to geologic and soils hazards were received during the public scoping process. These comments and the location where they are addressed in the geology and soils analysis are provided in Table 3.6-1.

Table 3.6-1 Geology and Soils Scoping Comments

Agency/Entity	Comment	Location in Geology and Soils Section that Comment is Addressed
Garril Page	Marin's Countywide Plan is a resource: maps and geological reports as well as data collected during annual creek maintenance and dredging should be part of this EIR.	The Geology, Mineral Resources and Hazardous Materials Technical Background Report for Marin Countywide Plan has been reviewed during preparation of the Draft EIR. Relevant information is incorporated into Section 3.6.3 Environmental Setting of this Section.
Garril Page	Adding 11 -17 new larger fish resting pools to the channel bottom has unknown effect on the existing concrete structure's stability and safety.	Section 3.6.6, Impact 3.6-3
Garril Page	The new larger fish resting pools in the channel bottom creates unknown effect on the existing concrete structure's stability, coefficient of roughness, profile at the time of any given flood event.	

3.6.3 Environmental Setting

Geology

Regional Geology

Marin County is located in the central portion of the Coast Ranges Geomorphic Province[1] (CGS, 2002). The Coast Ranges province extends about 600 miles along the western edge of California and is bounded on the south by the Transverse Ranges, on the north by the Klamath Mountains, and on the east by the Great Valley. This province is marked by northwest-trending elongated ranges and narrow valleys that roughly parallel the coast and the San Andreas Fault Zone (SAFZ). Much of the Coast Ranges province is composed of marine sedimentary deposits, metamorphic rocks, and volcanic rocks.

The SAFZ separates the Point Reyes Peninsula in western Marin County from the eastern portion of Marin County. The bedrock east of the SAFZ consists of Mesozoic rocks unconformably overlain by Tertiary (Miocene and younger) deposits. The Mesozoic rocks consist of the Great Valley complex and the Franciscan complex. The Great Valley complex consists of accreted and deformed remnants of Jurassic oceanic crust and a thick sequence of turbidites (disturbed deep ocean sediments). The Franciscan complex rocks were probably Jurassic oceanic crust and Jurassic to Cretaceous pelagic deposits (marine sediments) overlain by Upper Jurassic to Upper Cretaceous turbidites. During the Late Cretaceous time, the Franciscan complex was subducted beneath the Coast Ranges, which resulted in deformed and sheared rocks. During late Miocene time, the regional tectonic regime changed and became dominated by the transform boundary of the San Andreas Fault system and deposition of sediments on the older complexes (USACE, 2010). As a result of this geologic activity, the region is characterized by narrow valleys flanked by steep-sided, almost parallel ridges, trending northwest and approximately parallel to the Pacific Ocean coastline. Most ridges are below 5,000 feet and many are below 3,000 feet. The most prominent feature within the Corte Madera Creek watershed is Mount Tamalpais (2,604 feet) (USACE, 2010). The Corte Madera Creek watershed's western boundary is a steep, forested ridge. Numerous creeks that drain steep upland areas onto relatively steep and laterally confined alluvial valley flats combine as San Anselmo Creek in Ross Valley at San Anselmo. San Anselmo Creek then flows southeast through Ross Valley along the Cretaceous sandstone ridge running southeast along the eastern edge of the basin (Stetson Engineers Inc., 2000). San Anselmo Creek flows into Corte Madera Creek west of Greenbrae at the confluence with Ross Creek. Ross Valley can be loosely characterized as a long, narrow, alluvial-filled trench carved by Corte Madera Creek (USACE, 1966, in USACE 2010).

---

[1] A geomorphic province is a regional area that possesses similar bedrock, structure, history, and age. California has 11 geomorphic provinces.

Local Geology
The geologic units underlying the project area consist primarily of valley fill/alluvium. Artificial fill overlying bay mud occurs in the lower portion of Unit 2, and Franciscan Complex is located north of Lagunitas Road as shown on Figure 3.6-1. A geotechnical investigation conducted for Corte Madera Creek concrete channel from College of Marin to Kentfield Hospital (Units 3 and 2). The results of the geotechnical investigation indicate that the soils within Unit 2 beneath the concrete channel consists of an upper layer of sand, and beneath it are silty and clayey soils (GHD, 2019).

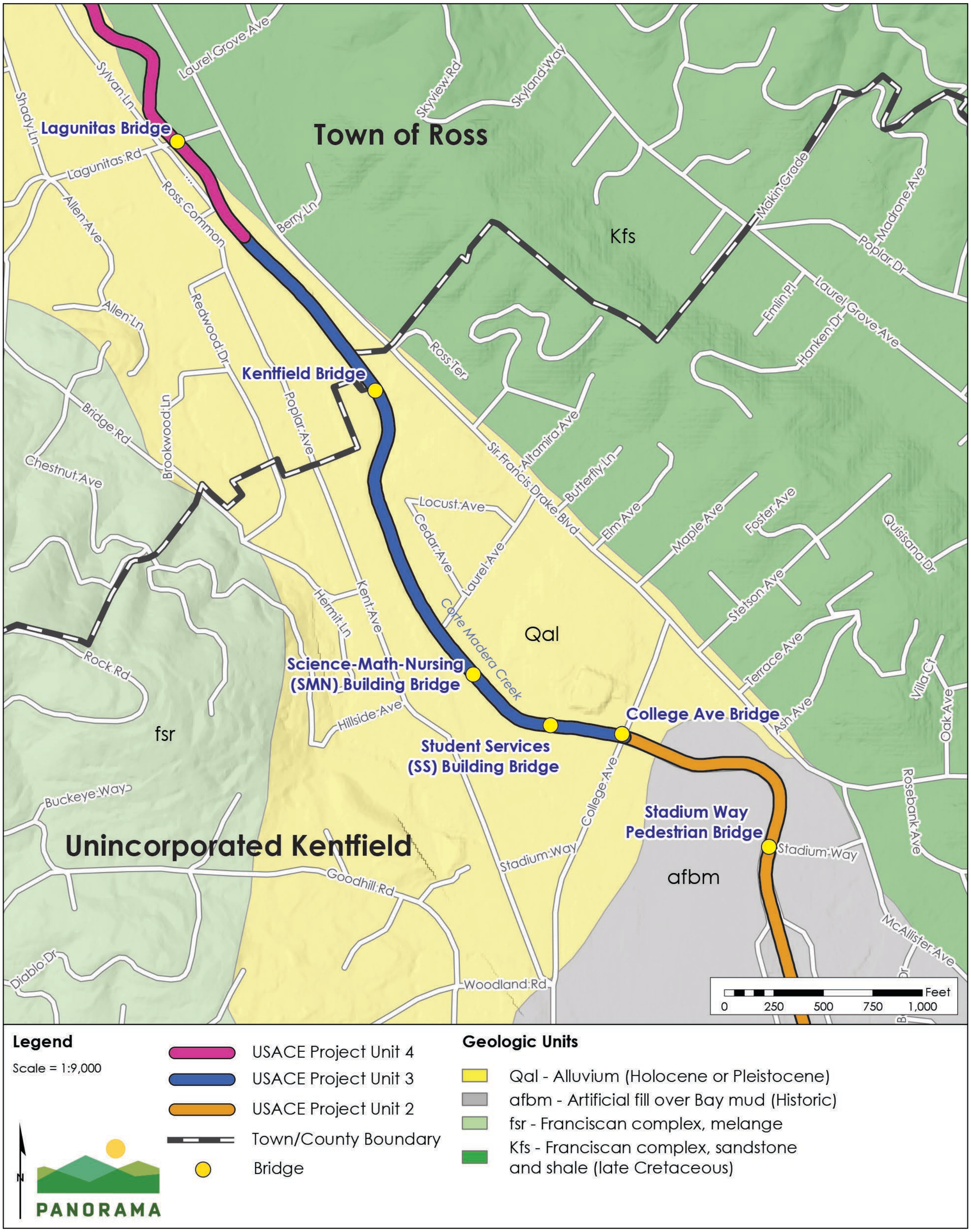
Franciscan Formation
Bedrock underlying the Corte Madera Creek drainage is part of the Jurassic-Cretaceous Franciscan Formation. The Franciscan formation in this area consists of hard sandstone (greywacke) with minor amounts of shale and chert and occasional serpentinite and greenstone. These rocks have been folded into a series of complex anticlines and synclines during the latest episode of crustal deformation during mid-Pleistocene time, and were subsequently or contemporaneously highly fractured and faulted. In general, the trend of these geologic structures is northwestward. Present physical and topographical expression in the Corte Madera Creek basin is aligned along and controlled by this trend (USACE, 1966, in USACE 2010).

Near the upstream end of the project, at the Lagunitas Road Bridge, boring logs indicate the shallowest depth to bedrock is approximately 35 to 40 feet below ground surface (URS Corporation, 2009, in USACE 2010). The depth of bedrock is approximately 40 feet below ground surface near Kentfield and increases in depth towards the Bay (Stetson Engineers Inc., 2000). Sandstone bedrock has been reported 650 feet downstream of Stadium Way pedestrian bridge in Unit 2 at 63 feet below mean sea level (USACE, 1967, in USACE 2010).

Bay Mud
The watershed continues to experience ongoing tectonic uplift and faulting. Following the Pleistocene-Holocene transition (about 10,000 to 12,000 years ago), rising sea level and continuing tectonic uplift caused lower portions of eroding V-shaped upland valleys in Marin County watersheds to fill with sediment, creating u-shaped valleys (Stetson Engineers Inc., 2000). San Francisco Bay waters encroached upon and drowned the lower 2.5 miles of the ancestral Ross valley. The deposition of soft marine sediments formed the present-day tidal marshlands and mudflats (USACE, 1966, in USACE 2010). Holocene sea level rise probably influenced valley filling and flattened the valley slope in the alluvial channel network approximately below the City of San Anselmo (Stetson Engineers Inc., 2000).

The marine sediments are referred to as the "Buy Mud" formation, which attains a maximum thickness of approximately 125 feet in the center of Ross valley near U.S. Highway 101 (USACE, 2010). Bay Mud consists of silts and clays that are very soft to soft, wet, sticky, and structurally weak (USACE, 1966, in USACE 2010). The thickness of the Bay Mud ranges from 10 to 15 feet thick 850 feet downstream of Stadium Way pedestrian bridge and thins rapidly to 50 feet

Figure 3.6-1 Geologic Units



Sources: (Tele Atlas North America, Inc. 2019, GHD 2020, USGS 2019, USGS 2009, US Geological Survey 2013) downstream of Stadium Way pedestrian bridge. Upstream from Stadium Way pedestrian bridge, Bay Mud is reportedly absent and valley fill overlies bedrock. The geologic contact between Bay Mud and underlying valley fill materials is irregular and reflects the meandering nature of Corte Madera Creek in the past (USACE, 1967, in USACE 2010).

Valley Fill/Alluvium

Upstream of the marshland, the valley fill is composed of various mixtures of alluvial soils and slope-wash from the adjoining hills. The valley fill consists of interbedded sand and gravel, firm to stiff silt and clay, and lesser lenses of soft clay. The valley fill materials are generally stiff to dense and comparatively competent foundation materials (USACE, 1966, in USACE 2010; USACE, 1967, in USACE 2010).

Faults and Seismicity

This section characterizes the region's existing faults, describes historical earthquakes, estimates the likelihood of future earthquakes, and describes probable groundshaking effects.

Earthquake Terminology and Concepts

Earthquake Mechanisms and Fault Activity

Faults are planar features within the earth's crust that have formed to release strain caused by the dynamic movements of the earth's major tectonic plates. An earthquake on a fault is produced when these strains overcome the inherent strength of the earth's crust, and the rock ruptures. The rupture causes seismic waves that propagate through the earth's crust, producing the groundshaking effect known as an earthquake. The rupture also causes variable amounts of slip along the fault, which may cause displacement at the earth's surface.

Geologists commonly use the age of offset rocks as evidence of fault activity—the younger the displaced rocks, the more recently earthquakes have occurred. To evaluate the likelihood that a fault would produce an earthquake, geologists examine the magnitude and frequency of recorded earthquakes and evidence of past displacement along a fault. The California Geological Survey (CGS) defines an active fault as one that has had surface displacement within Holocene time (within the last 11,000 years; the U.S. Geological Survey (USGS) uses within the last 15,000 years). A Quaternary fault is defined as a fault that has shown evidence of surface displacement during the Quaternary period (the last 1.6 million years), unless direct geologic evidence demonstrates inactivity for all of the Holocene or longer. This definition does not mean that a fault lacking evidence of surface displacement is necessarily inactive. The term "sufficiently active" is also used to describe a fault if there is some evidence that Holocene displacement has occurred on one or more of its segments or branches (CGS, 2018).

For the purpose of delineating fault rupture zones, the CGS historically sought to zone faults defined as potentially active, which are faults that have shown evidence of surface displacement during the Quaternary period. In late 1975, the State Geologist made a policy decision to zone only those faults that had a relatively high potential for ground rupture, determining that a fault should be considered for zoning only if it was sufficiently active and "well defined." Blind faults are faults that do not show surface evidence of past displacement, even if they occurred in the recent past. Faults that are confined to pre-Quaternary rocks are considered inactive and incapable of generating an earthquake.

Earthquake Magnitude
When an earthquake occurs along a fault, its size can be determined by measuring the energy released during the event. A network of seismographs records the amplitude and frequency of the seismic waves that an earthquake generates. The Richter magnitude (ML) of an earthquake represents the highest amplitude measured by the seismograph at a distance of 100 kilometers from the epicenter. Richter magnitudes vary logarithmically with each whole-number step, representing a tenfold increase in the amplitude of the recorded seismic waves and 32 times the amount of energy released. While Richter magnitude was historically the primary measure of earthquake magnitude, seismologists now use Moment Magnitude (Mw) as the preferred way to express the size of an earthquake. The Mw scale is related to the physical characteristics of a fault, including the rigidity of the rock, the size of fault rupture, and the style of movement or displacement across the fault. Although the formulae of the scales are different, they both contain a similar continuum of magnitude values, except that Mw can reliably measure larger earthquakes and do so from greater distances.

Peak Ground Acceleration
A common measure of ground motion at any particular site during an earthquake is the peak ground acceleration (PGA). The PGA for a given component of motion is the largest value of horizontal acceleration obtained from a seismograph. PGA is expressed as the percentage of the acceleration due to gravity (g), which is approximately 980 centimeters per second squared. In terms of automobile acceleration, one "g" of acceleration is equivalent to the motion of a car traveling 328 feet from rest in 4.5 seconds. For comparison purposes, the maximum peak acceleration value recorded during the Loma Prieta earthquake was in the vicinity of the epicenter, near Santa Cruz, at 0.64 g. Unlike measures of magnitude, which provide a single measure of earthquake energy, PGA varies from place to place and is dependent on the distance from the epicenter and the character of the underlying geology (e.g., hard bedrock, soft sediments, or artificial fills).

Faults and Probable Earthquake Activity
The project area is in a seismically active region of California. The San Francisco Bay Area contains both active (Holocene age, or within the last 11,000 years) and potentially active (Quaternary age, or within the last 1.6 million years) faults and there is the potential for damage resulting from movement along any one of a number of the active faults throughout the area. The Working Group on California Earthquake Probabilities concluded there is a 72 percent probability of at least one magnitude 6.7 or greater earthquake before 2044 within the San Francisco Bay area (USGS, 2015). This earthquake is likely to occur on one of the seven major fault systems in the bay area. It was determined that the Hayward-Rodgers Creek, San Andreas and Calaveras fault systems have the highest probabilities of generating a magnitude 6.7 or greater earthquake before 2044. The Northern San Andreas (6.4 percent probability) and the Hayward-Rodgers Creek (14.3 percent probability) fault systems could have the greatest impacts on Marin County because of their proximity to population centers

within Marin County and the fact that they have the highest probability of rupture in the San Francisco Bay Region. There is also a 98 percent probability for a magnitude 6.0 or greater earthquake before 2044 in the San Francisco Bay region (USGS, 2015).

The project area is approximately 9 miles equidistant between the San Andreas and Hayward-Rodgers Creek Faults Zone, discussed below. The locations of these faults and their geographic relationship to the project area are shown in Figure 3.6-2.

San Andreas Fault Zone

The San Andreas Fault Zone is a major structural feature in the region and forms a boundary between the North American and Pacific tectonic plates (USGS, 2002) . The San Andreas Fault is a major northwest-trending, right-lateral, strike-slip fault that extends for about 600 miles from the Gulf of California in the south to Cape Mendocino in the north. The San Andreas is not a single fault trace but rather a system of active faults that diverges from the main fault south of the City of San Jose, California. The San Andreas Fault has produced numerous large earthquakes, including the 1906 San Francisco earthquake. That event had an estimated ML 8.3 or Mw 7.8 (WGCEP, 2008) and was associated with up to 21 feet of displacement and widespread ground failure (Lawson, 1908). The project area is about 9 miles from the San Andreas Fault Zone. The San Andreas Fault Zone has a 6.4 percent probability of generating an earthquake with a magnitude equal to or greater than 6.7 Mw before 2044 (USGS, 2015).

Hayward-Rodgers Creek Fault Zone

The Hayward-Rodgers Creek Fault Zone is approximately 118 miles in length, located mostly along the base of the hills along the east side of San Francisco Bay and running parallel to the San Andreas Fault Zone. Similar to the San Andreas, it is composed of a system of active faults. The Hayward-Rogers Creek Fault has also produced numerous large earthquakes, including the 1868 earthquake with an estimated magnitude of about 7.0. The project area is about 10 miles from the Hayward-Rodgers Creek Fault Zone. The Hayward-Rodgers Creek Fault has a 14.3 percent probability of generating an earthquake with a magnitude equal to or greater than 6.7 Mw before 2044 (USGS, 2015).

The project area is not within an Alquist-Priolo Earthquake Fault Zone, and the area is not near any known active faults (USACE, 2010). Although no faults cross the project area, other faults in the region capable of producing earthquakes that could affect the project area include the Calaveras, San Gregorio, Concord-Green Valley, Greenville, and Mount Diablo faults (Marin County, 2005).

Geologic Hazards

Seismic Conditions

The San Andreas and Hayward faults are designated by the California Seismic Hazard Map with Maximum Credible Earthquake (MCE) magnitudes of 8.0 and 7.5, respectively. The California Seismic Hazard Maps for the region indicates that the closest mapped fault to the project area is the San Andreas Fault. The project area is in an area subject to severe to violent perceived ground shaking and expected damage to structures is moderate heavy to heavy from a San Andreas Fault earthquake; and very strong to severe perceived ground shaking and expected damage to structures is moderate to moderate heavy from a North Hayward-Rogers Creek Fault earthquake (Marin County, 2005).

Liquefaction, Settlement, and Lateral Spreading

Strong ground shaking caused by large earthquakes can induce ground displacement and/or failure such as liquefaction, compaction settlement, and slope movement. A site's susceptibility to these hazards relates to the site topography, soil conditions, and depth to groundwater. In general, a relatively high potential for liquefaction exists in loose, sandy soils that are within 50 feet of the ground surface and are saturated (below the groundwater table). Liquefaction can result in loss of foundation support and settlement of overlying structures, ground subsidence and translation due to lateral spreading, and differential settlement of affected deposits. Lateral spreading occurs when a soil layer liquefies at depth and causes horizontal movement or displacement of the overburden mass on sloping ground or toward a free face such as a stream bank or excavation, or toward an open body of water. Settlement can occur as a result of the relatively rapid rearrangement, compaction, and settling of subsurface materials, particularly loose, uncompacted, and variable sandy sediments. Settlement can occur both uniformly and differentially (i.e., where adjoining areas settle at different rates). Areas are susceptible to differential settlement if underlain by compressible sediments, such as poorly engineered artificial fill. The liquefaction susceptibility in the project area ranges from moderate to very high (USGS, 2006). The soil types underlying the project area include Tocaloma-McMullin-Urban Land Complex and Xerorthents-Urban land complex (USDA, 2020). These soils have a depth to water table of more than 80 inches (USDA, 2020). The project area is likely to be subject to liquefaction and lateral spreading during large seismic events due to the high groundwater levels and alluvial deposits (consists of loose and unconsolidated silt, sand, clay, and gravel) onsite (USACE, 2018a).

Landslides

Typically, landslides and other slope stability hazards are activated in response to an increase in subsurface and surficial water content, earthquake shaking, the addition of load on a slope, or the removal of downslope support. The project area lies upon relatively flat ground, with the exception of the west and east headwalls on the banks of Corte Madera Creek. Landslide hazards are likely limited to potential slope instability. Excess sediment supply resulting from the February 2017 storms triggered numerous landslides in Unit 4 and creek bank slides appear to be continuing to work through the system (geomorphDESIGN, 2019). Bank instability or localized sloughing has also been reported by residents in Unit 4; however, these are small scale events resulting from the incised channel, instability from development along the creek, and the flashiness of the watershed (USACE, 2018b).

Figure 3.6-2 Faults in the Local Region

Sources: (Tele Atlas North America, Inc. 2019, GHD 2020, USGS 2019, U.S. Geological Survey and California Geological Survey 2010, US Geological Survey 2013)

Paleontological Resources

Paleontological resources are the fossilized remains or impressions of plants and animals, including vertebrates (animals with backbones; mammals, birds, fish, etc.), invertebrates (animals without backbones; starfish, clams, coral, etc.), and microscopic plants and animals (microfossils). Paleontological resources are nonrenewable, scientific resources that may be valuable in documenting the existence of extinct life forms and reconstructing the environments in which they lived. Fossils can be used to determine the relative ages of the depositional layers in which they occur and of the geologic events that created those deposits. The age, abundance, and distribution of fossils depend on the geologic formation in which they occur and the topography of the area in which they are exposed. The geologic environments within which the plants or animals became fossilized usually were quite different from the present environments in which the geologic formations now exist.

The Society of Vertebrate Paleontology published Standard Guidelines in response to a recognized need to establish procedures for the investigation, collection, preservation, and cataloguing of fossil bearing sites (SVP, 2010). The Standard Guidelines are widely accepted among paleontologists, followed by most investigators, and identify the two key phases of paleontological resource protection: (1) assessment and (2) mitigation. Assessment involves identifying the potential for a project site or area to contain significant nonrenewable paleontological resources that could be damaged or destroyed by project excavation or construction. Mitigation involves formulating and applying measures to reduce such adverse effects, including pre-project survey and salvage, monitoring and screen washing during excavation to salvage fossils, conservation and inventory, and final reports and specimen curation. The Society of Vertebrate Paleontology defines the level of potential as one of four sensitivity categories for sedimentary rocks: high, undetermined, low, and no potential as listed below.

1. **High Potential** – Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered are considered to have a high potential for containing additional significant paleontological resources. Rocks units classified as having high potential for producing paleontological resources include, but are not limited to, sedimentary formations and some volcaniclastic formations (e.g., ashes or tephras), and some low grade metamorphic rocks which contain significant paleontological resources anywhere within their geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils (e.g., middle Holocene and older, fine grained fluvial sandstones, argillaceous and carbonate rich paleosols, cross bedded point bar sandstones, fine grained marine sandstones, etc.). Paleontological potential consists of both (a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and (b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units which contain potentially datable organic remains older than late Holocene, including deposits associated with

animal nests or middens and rock units which may contain new vertebrate deposits, traces, or trackways are also classified as having high potential.

2. **Undetermined Potential** – Rock units for which little information is available concerning their paleontological content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential to contain significant paleontological resources. A field survey by a qualified professional paleontologist to specifically determine the paleontological resource potential of these rock units is required before a paleontological resource impact mitigation program can be developed. In cases where no subsurface data are available, paleontological potential can sometimes be determined by strategically located excavations into subsurface stratigraphy.
3. **Low Potential** – Reports in the paleontological literature or field surveys by a qualified professional paleontologist may allow determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections or, based on general scientific consensus, only preserve fossils in rare circumstances and the presence of fossils is the exception not the rule, e.g., basalt flows or recent (i.e., Holocene) colluvium. Rock units with low potential typically will not require impact mitigation measures to protect fossils.
4. **No Potential** – This designation is assigned to geologic formations that are entirely plutonic (volcanic rocks formed beneath the earth's surface) in origin and therefore have no potential for producing fossil remains.

In the context of CEQA, fossils of land dwelling and marine vertebrates, their environment, and associated geological, stratigraphical, taphonomical, and geographical data are considered important (i.e., significant) paleontological resources. Such fossils typically are found in river, lake, and bog deposits, although they may occur in nearly any type of sedimentary sequence.

A search of the University of California Museum of Paleontology collections database indicated one invertebrate fossil has been recovered from the Franciscan Formation (bedrock) in Corte Madera (UCMP, 2020).

Late Pleistocene and Holocene fossils have been recovered from marine sediments (Bay Mud) elsewhere in the San Francisco Bay area. For example, near the Bay Bridge San Francisco anchorage, remains of petrified wood, marine mollusks and mammals, bony fishes, amphibians, reptiles, birds, a diversity of extinct land mammals such as ground sloths, mammoth, mastodon, deer, horse, camel, and bison, and microfossils such as radiolaria, foraminifera, diatoms, pollen, and spores have been found in older Bay Mud. Fossil mollusk shells were reported in cores of Holocene younger Bay Mud from depths of approximately 20 and 25 feet near Candlestick Point in San Francisco (City and County of San Francisco , 2009).

Upstream from Stadium Way pedestrian bridge, Bay Mud is reportedly absent and valley fill overlies bedrock (refer to Figure 3.6-1). In the vicinity of the Lagunitas Road

Bridge within the upper reach of Unit 4, the sandy, lean clay and sandy gravel have no to low potential to contain unique paleontological resources (Town of Ross, n.d., in USACE 2010).Typical valley fill/alluvium in the project area consists of mixtures of alluvial soils and slope wash from the adjoining hills.

Unique Geologic Features

A unique geologic feature embodies distinctive characteristics of any regional or local geologic principles, provides a key piece of information important to geologic history, contains minerals not known to occur elsewhere in the county, and/or is used as a teaching tool. No unique geologic features were identified near or within the project area.

3.6.4 Regulatory Setting

The following laws, statutes, regulations, codes, and policies would apply to the project and are defined as standard conditions for the project.

Federal Regulations

Although there are a number of federal laws, statutes, and regulations that would generally apply to the project, the federal government and its agencies have delegated the authority to implement and satisfy those requirements relevant to geology, seismicity, and soils to the state of California and its agencies, as discussed below.

State Regulations

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to protect structures for human occupancy from the hazard of surface faulting. In accordance with the Alquist-Priolo Earthquake Fault Zoning Act, the State Geologist has established regulatory zones—called earthquake fault zones—around the surface traces of active faults and has published maps showing these zones.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was passed in 1990 following the Loma Prieta earthquake to reduce threats to public health and safety and to minimize property damage caused by earthquakes. This Act requires the State Geologist to delineate various seismic hazard zones, and cities, counties, and other local permitting agencies to regulate certain development projects within these zones (CGS, 2019). The CGS is in the process of producing official maps based on USGS topographic quadrangles.

California Building Code

The California Building Code (CBC), which is codified in Title 24 of the California Code of Regulations, Part 2, was promulgated to safeguard the public health, safety, and general welfare by establishing minimum standards related to structural strength, means of egress to facilities (entering and exiting), and general stability of buildings. The purpose of the CBC is to regulate and control the design, construction, quality of materials, use/occupancy, location, and maintenance of all buildings and structures within its jurisdiction. Title 24 is administered by the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable. The provisions of the CBC apply to the construction, alteration, movement, replacement, location, and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures throughout California.

The 2016 edition of the CBC is based on the 2015 International Building Code published by the International Code Council, which replaced the Uniform Building Code. The code is updated triennially, and the 2016 edition of the CBC was published by the California Building Standards Commission on July 1, 2016, and took effect starting January 1, 2017. The 2016 CBC contains Appendix J Grading, which has been adopted by the County of Marin and includes the following provisions.

Section J101.2 requires that work in flood hazard area requires the preparation of an engineering analysis prepared by a registered design professional that demonstrates the work will not result in any increase in the level of the base flood.

Section J104.3 requires the preparation of a geotechnical report prepared by a registered design professional that shall describe the nature and distribution of existing soils; conclusions and recommendations for grading procedures; soil design criteria for any structures or embankments required to accomplish the proposed grading; and slope stability studies, where necessary.

Section J110.1 requires the faces of cut and fill slopes shall be prepared and maintained to control erosion. The control shall be permitted to consist of effective planting.

National Pollutant Discharge Elimination System Construction General Permit

Projects that disturb more than one acre of land during construction are required to comply with the National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities (Order 2009-0009-DWQ, NPDES No. CAS000002; as amended by Orders 2010-0014-DWQ and 2012-006-DWQ). The Construction General Permit regulates discharges of pollutants in stormwater associated with construction activity to waters of the U.S. from construction sites that disturb one or more acres of land surface, or that are part of a common plan of development or sale that disturbs more than one acre of land surface. In the project area, the Construction General Permit is implemented and enforced by the San Francisco Bay Regional Water Quality Control Board, which administers the stormwater permitting program. The permit regulates stormwater discharges associated with construction or demolition activities, such as clearing and excavation; construction of buildings; and linear underground projects, including installation of water pipelines and other utility lines.

The Construction General Permit requires the development and implementation of a Stormwater Pollution Prevention Plan (SWPPP) that includes specific construction best management practices (BMPs) designed to prevent sediment and pollutants from contacting stormwater from moving offsite into receiving waters. The BMPs fall into several categories, including erosion control, sediment control, waste management and good housekeeping, and are intended to protect surface water quality by preventing the off-site migration of eroded soil and construction-related pollutants from the construction area. Routine inspection of all BMPs is required under the provisions of the Construction General Permit. The SWPPP must be prepared before the construction begins. The SWPPP must contain a site map(s) that delineates the construction work area, existing and proposed buildings, parcel boundaries, roadways, stormwater collection and discharge points, general topography both before and after construction, and drainage patterns across the project area. In addition, the SWPPP is required to contain a visual monitoring program, a chemical monitoring program for non-visible pollutants, and a sediment monitoring plan if the site discharges directly to a water body listed on the 303(d) list for sediment. Corte Madera Creek is not listed on the 303(d) list for sediment.[2]

Regional and Local Regulations

Marin Countywide Plan
The following goals and policies in the Marin Countywide Plan are relevant to the project (Marin County , 2007).

Water Resources
Goal WR-1: Healthy Watersheds. Achieve and maintain proper ecological functioning of watersheds, including sediment transport, groundwater recharge and filtration, biological processes, and natural flood mitigation, while ensuring high-quality water.

> ***Policy WR-1.3: Improve Infiltration.*** Enhance water infiltration throughout watersheds to decrease accelerated runoff rates and enhance groundwater recharge. Whenever possible, maintain or increase a site's predevelopment infiltration to reduce downstream erosion and flooding.
>
> > *Implementing Program: WR-1.b Establish Development Standards for Infiltration.* Establish qualitative standards to maximize groundwater infiltration and minimize surface water runoff based on criteria developed by the Bay Area Stormwater Management Agency Associates. Standards should regulate the amount of impervious surfaces; vary by project type, land use, building-site placement, soils, and area characteristics; and provide for water impoundments, protecting and planting vegetation, cisterns, and other measures, such as restricting wet weather grading to increase groundwater recharge and reduce sedimentation.
> >
> > *Implementing Program: WR-1.f Require Stream Restoration Projects.* Require restoration of streams in conjunction with associated land use approvals to

[2] Corte Madera Creek is currently being addressed for diazinon with a U.S. Environmental Agency approved Total Maximum Daily Load (Regional Water Board, 2017).

improve groundwater recharge and filtration and to ensure high-quality water. Restoration projects should follow the design principles of natural channel restoration utilizing geomorphic concepts.

Goal WR-2: Clean Water. Ensure that surface and groundwater supplies are sufficiently unpolluted to support local natural communities, the health of the human population, and the viability of agriculture and other commercial uses.

Policy WR-2.3: Avoid Erosion and Sedimentation. Minimize soil erosion and discharge of sediments into surface runoff, drainage systems, and water bodies. Continue to require grading plans that address avoidance of soil erosion and on-site sediment retention. Require developments to include on-site facilities for the retention of sediments, and, if necessary, require continued monitoring and maintenance of these facilities upon project completion.

Implementing Program: WR-2.b Integrate Bay Area Stormwater Management Agencies Association Stormwater Quality Protection Guidelines into Permitting Requirements for All Development and Construction Activities. All projects should integrate stormwater pollution prevention design features for water quality protection to the extent feasible, such as those included in the Bay Area Stormwater Management Agencies Association Start-at-the-Source manual and the Tools Handbook.

The above-listed goals, policies, and implementing programs are implemented in the Marin County Stormwater Pollution Prevention Program, discussed further below.

Environmental Hazards

Goal EH-2: Safety from Seismic and Geologic Hazards. Protect people and property from risks associated with seismic activity and geologic conditions.

Policy EH-2.1 Avoid Hazard Areas. Require development to avoid or minimize potential hazards from earthquakes and unstable ground conditions.

Implementing Program: EH-2.a Require Geotechnical Reports. Continue to require any applicant for land division, master plan, development approval, or new construction in a geologic hazard area to submit a geotechnical report prepared by a State-certified Engineering Geologist or a Registered Geotechnical Engineer that:

a. evaluates soil, slope, and other geologic hazard conditions;
b. commits to appropriate and comprehensive mitigation measures sufficient to reduce risks to acceptable levels, including post-construction site monitoring, if applicable;
c. addresses the impact of the project on adjacent lands, and potential impacts of off-site conditions; and

d. meets the requirements of other agency regulations with jurisdiction in the hazard area, such as Bay Conservation and Development Commission requirements for the safety of fills consistent with the Bay Plan.

Implementing Program: EH-2.b Require Construction Observation and Certification. Require any work or construction undertaken to correct slope instability or mitigate other geologic hazard conditions to be supervised and certified by a geotechnical engineer and/or an engineering geologist.

Marin County Municipal Code

The following code of Marin County Municipal Code is relevant to the project (Marin County , 2020).

Chapter 22.16 Discretionary Development Standards

22.16.030 General Standards.

J. Site preparation.

5. Geologic hazards. Construction shall not be permitted on identified seismic or geologic hazard areas such as on slide, on natural springs, on identified fault zones, or on bay mud without approval from the Department of Public Works, based on acceptable soils and geologic reports.

Town of Ross General Plan

The following policies of the Ross General Plan related to geology and soils are applicable to the project (Town of Ross, 2007).

Goal 5. Protecting Community Health and Safety, and Preparing for Emergencies

5.2 Geologic Review Procedures. At the time a development is proposed, Ross geologic and slope stability maps should be reviewed to assess potential geologic hazards. In addition, suitability for development must be based on site-specific geotechnical investigations.

Town of Ross Municipal Code

The following codes of the Town of Ross Municipal Code related to geology and soils are applicable to the project (Town of Ross, 2020).

Chapter 12.28 Urban Runoff Pollution Prevention

12.28.090 Reduction of Pollutants in Urban Runoff. (1) Best Management Practices for Construction, New Development, and Redevelopment.

(A) Any person performing construction, development or redevelopment activities in the town that require a permit or approval under the Ross Municipal Code, including but not limited to approvals under Titles 15, 17 and 18, shall implement appropriate BMPs to prevent the discharge of construction wastes or contaminants from construction materials, tools and equipment from entering a town storm drain or watercourse.

(B) Construction-phase BMPs include erosion and sediment controls and pollution prevention practices. Erosion control BMPs may include, but are not limited to, scheduling and timing of grading activities, timely revegetation of graded areas, the use of hydroseed and hydraulic mulches, and installation of erosion control blankets. Sediment control may include properly sized detention basins, dams, or filters to reduce entry of suspended sediment into the storm drain system and watercourses, and installation of construction entrances to prevent tracking of sediment onto adjacent streets. Pollution prevention practices may include designated washout areas or facilities, control of trash and recycled materials, tarping of materials stored on-site, and proper location of and maintenance of temporary sanitary facilities. The combination of BMPs used, and their execution in the field, must be customized to the site using up-to-date standards and practices. The agency will provide references to current guidance manuals and BMP information on request.

3.6.5 Impact Assessment Methodology

Significance Criteria

Consistent with State CEQA Guidelines Appendix G (Environmental Checklist) and Marin County Environmental Review Guidelines, the project could have a significant impact if it would:

a. Directly or indirectly cause potential substantial adverse effects, including the risk or loss, injury, or death involving:
    i. 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. Refer to Division of Mines and Geology Special Publication 42.
    ii. Strong seismic ground shaking.
    iii. Seismic-related ground failure, including liquefaction.
    iv. Landslides.
b. Result in substantial soil erosion or the loss of topsoil.
c. Be located 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.
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.

e. 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.
f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

Approach to Impact Analysis

The following analysis discusses the potentially significant impacts of the project related to changes in geology and soils. The impact evaluation is based on the potential for the project to change geologic and soil conditions or expose facilities or people to unstable geologic conditions during project activities, using existing site conditions as a baseline for comparison. This section includes an analysis of potential short-term (construction) and long-term (operation) impacts of the project. Impact evaluations are assessed based on the existing conditions described earlier in this section.

3.6.6 Impact Discussion

Impacts Avoided

Due to the nature of the project, there would be no impacts related to the following criterion; therefore, no impact discussion is provided for the reasons described below:

1. **Criterion (e):** Implementation of the project would not involve installation of septic tanks or alternative wastewater disposal systems. No impacts would occur.

Impact Analyzed

Impact 3.6-1: The project could directly or indirectly cause potential substantial adverse effects, including the risk or loss, injury, or death involving: **i. 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. Refer to Division of Mines and Geology Special Publication 42.** **ii. Strong seismic ground shaking.** **iii. Seismic-related ground failure, including liquefaction.** **iv. Landslides.**	**Significance Determination**
	Construction: Less than Significant
	Operation and Maintenance: Less than Significant with Mitigation

Rupture of a Known Earthquake Fault

The project area is not located within an earthquake fault zone as defined by the Alquist-Priolo Earthquake Fault Zoning Act, and no active or potentially active faults exist on or in the immediate vicinity of the site. Although fault rupture could occur on unknown faults, fault rupture is not expected in the project area. Project construction would only last seven months and would not introduce a substantial number of people to the area. Operation and maintenance of the project would not introduce additional people or structures to the area that would increase the risk of loss, injury or death in the unlikely event of fault rupture. The concrete channel removal in Frederick Allen Park and lower Unit 2 would reduce the risk of structural failure from fault rupture because the earthen channel would be less susceptible to failure than the concrete channel. The new segments of floodwalls in Units 2 and 3 would be located along the existing floodwalls and would be generally 2 to 4 feet tall. The new segments of floodwall would not increase the risk of loss, injury, or death from fault rupture. The impact would be less than significant.

Seismic Ground Shaking

The project is not within a designated seismic hazard zone and is not subject to the Seismic Hazards Mapping Act. The nearest fault to the project site is the San Andreas Fault, which is located approximately 9 miles to the west of the project area. The Hayward Fault is approximately 10 miles east of the project area and the Rodgers Creek Fault is approximately 15 miles northeast of the project area. Ground shaking is the primary cause of earthquake damage to man-made structures, strong ground shaking could cause shearing, differential settlement, or heave of structures, causing damage to buildings and structures. The project is located in an area of high seismicity where severe to violent ground shaking could result from a large earthquake on the San Andreas Fault Zone and very strong to severe ground shaking could result from earthquakes on either the North Hayward or Rodgers Creek Faults.

Construction

In the event of an earthquake, construction workers could be exposed to hazards from strong seismic ground shaking. Project construction would not substantially increase these risks of exposure over typical risks of exposure throughout the region. Earthquake safety training pursuant to Occupational Safety and Health Administration (OSHA) regulations would minimize potential for impacts to workers. Due to the short duration of construction (seven months), the low probability of a strong seismic event occurring during the construction timeframe, and safety training for construction crews, the potential construction impact would be less than significant.

Operation A significant seismic event is likely to occur over the lifetime of the project. Shaking associated with a seismic event could cause damage to built features of the project, including the new segments of floodwall, streambank stabilization structures, and the stormwater pump station.

Unit 4

The grading and streambank stabilization improvements to the natural creek channel would have the overall effect of increasing stability by incorporating bank stabilization and vegetation into the design that would limit erosion. The streambank stabilization measures would reduce susceptibility of the creek banks to failure caused by seismic shaking and seismically induced ground failures. Because the project would increase the channel stability in Unit 4 through implementation of streambanks stabilization measures, the impact on risk of loss, injury, or death from seismic shaking would be less than significant.

Frederick Allen Park

The existing flood control channel wall is a concrete structure that is prone to damage under strong seismic events, whereas the proposed natural vegetated channel in Frederick Allen Park would be less prone to damage and loss under a strong seismic event. The new segments of retaining wall within Frederick Allen Park (at the transition to Unit 4 and at the transition to the concrete channel in lower Unit 3) would be up to 10 feet tall and could be prone to damage and loss in the event of strong seismic shaking if appropriate geotechnical evaluation and recommendations were not implemented. The damage or loss of the retaining wall in Frederick Allen Park due to strong seismic shaking would be a significant impact. The District would implement **Mitigation Measure 3.6-1: Geotechnical Investigation Report**, which requires a site-specific geotechnical investigation and implementation of the geotechnical recommendations that would address risk of seismicity. Because the mitigation requires implementation of the geotechnical recommendations, the impact from strong seismic shaking would be less than significant with mitigation.

Unit 3 and Unit 2 Floodwalls and Stormwater Pump Station

The new segments of floodwall in Units 3 and 2 would be generally 2 to 4 feet tall. The floodwall would be designed in accordance with the U.S. Army Corps of Engineers (USACE) design requirements and is subject to USACE approval under Section 408. The floodwall would be designed to meet current design standards to avoid increased risk of structural failure in the event of strong seismic shaking. While the floodwall would be short (2 to 4 feet tall) and not in proximity to people or other structures, failure of the floodwall as a result of seismic shaking could result in risk of loss, injury or death if the floodwall were not repaired prior to a major storm/flood event. If the floodwall were damaged and not repaired, increased flooding and damage could occur in areas that are being protected by the floodwall, which would be a significant impact. **Mitigation Measure 3.6-1: Geotechnical Investigation Report** requires a site-specific geotechnical investigation and implementation of the geotechnical recommendations in final design of the floodwalls to address the risk of structural damage due to seismicity. The new floodwall segments in Units 2 and 3 would have less-than-significant impacts with mitigation related to risk of loss, injury, or death from seismic shaking.

The stormwater pump station would be below grade with the exception of a utility cabinet that would extend approximately 6 feet above grade. The utility cabinet would be an isolated structure that would not be located near any homes or people. The belowground pump station components have been engineered and are located adjacent to the existing concrete flood control channel wall. The additional concrete and pump station components would not increase the risk of floodwall failure. The stormwater pump station would not increase risk of loss, injury or death due to seismic shaking because the pump station would not be located near people or other structures and would not be vulnerable to collapse; therefore, the impact would be less than significant.

Lower College of Marin Concrete Removal

The concrete removal in lower Unit 2 would result in a natural channel that would have reduced risk of failure from strong seismic shaking because the channel would be gently sloped and vegetated. The concrete removal in Unit 2 would not introduce any infrastructure that could result in risk of loss, injury, or death from seismic shaking. The operation of the Unit 2 concrete channel removal would have a less-than-significant impact on risk of loss from seismic shaking.

Seismic-Related Ground Failure

Liquefaction is the phenomenon in which saturated granular sediments temporarily lose their shear strength due to increases in pore pressure during periods of earthquake-induced strong groundshaking. The susceptibility of a site to liquefaction is a function of the depth, density, and water content of the granular sediments and the magnitude and frequency of earthquakes in the surrounding region. Saturated, unconsolidated silts, sands, and silty sands within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction-related phenomena include lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects.

Lateral spreading is a seismically induced ground deformation failure in which near surface soil layers typically break into blocks that progressively move downslope or toward a nearby free face such as a stream channel, river embankment, or a shoreline. Structural elements (e.g., concrete channel, grade control, and slope protection, etc.) that extend through or across a zone of lateral spreading may be pulled apart or sheared.

The project area is in an area mapped by U.S. Geological Survey as having "very high" liquefaction susceptibility (USGS, 2006). Potentially liquefiable materials within the project area include loose sandy layers in the valley fill and soft sandy silt in the creek sediments. Groundwater in the channel is approximately 5 feet below grade in Unit 3. The Bay Mud underlying the downstream of Stadium Way pedestrian bridge in Unit 2 has low potential for liquefaction.

Construction

Construction would introduce construction workers to the area for up to seven months. The construction period would involve grading, removal of concrete, planting, and installation of new concrete floodwalls. Construction would not introduce large structures to the area that would put people at risk of injury or death from liquefaction. Due to the low number of workers (less than 100) that would be required during construction, short duration of construction, and low height of project structures, project construction would have a less-than-significant impact on liquefaction.

Operation

Liquefaction-induced lateral spreading could occur along the floodwalls and slopes with valley fill. Removal of the concrete flood control channel in Frederick Allen Park and lower Unit 2 and the rocks and riprap proposed in Units 4 and 2, and Frederick Allen Park would improve stability of the channel banks and reduce the potential for impacts related to lateral spreading. Because the project would reduce the area of concrete structures that could be subject to damage in the event of liquefaction or lateral spreading, and the project would be designed to meet stringent federal and state seismic design standards, the project would be less prone to damage form liquefaction and lateral spreading than the existing conditions. As such, the project would not expose persons or structures to substantial adverse effects or exacerbate existing conditions related to ground failure, including liquefaction and the impact would be potentially beneficial and less than significant.

Landslides

The project area is located mostly within flat lands with surrounding slopes identified as containing few if any landslides. A search of the U.S. Landslide Inventory indicated that no landslides have been mapped within the proximity of the project area (USGS, 2020). As discussed above in Section 3.6.3 Environmental Setting, recent storms in 2017 have triggered numerous landslides upstream in Unit 4, but these are small scale events caused by the incised channel and instability from development along the creek. The project would include installation of grade control structures to stabilize the creek banks in Unit 4, which would reduce the risk of landslides in the area. The project would not increase the risk of landslides. No landslide-related impact would occur.

Mitigation: Implement Mitigation Measure 3.6-1.

Mitigation Measure 3.6-1: Geotechnical Investigation Report

The District shall have a professional geotechnical engineer conduct a geotechnical investigation to evaluate the potential for geotechnical hazards to occur on-site in accordance with the recommendations of the California Geological Survey. The Geotechnical Investigation Report shall provide site-specific recommendations for structures (e.g., floodwalls, fish pools, and stormwater pump station), work areas, and access routes where there is an elevated risk of geologic hazards. The Geotechnical Investigation Report shall be incorporated into the final project design of the retaining walls and floodwalls. The Geotechnical Investigation Report shall specify exact design coefficients that are needed by structural engineers to determine the type and sizing of structural materials. The Geotechnical Investigation Report shall be subject to performance criteria imposed by the California Building Code, as applicable. The Geotechnical Investigation Report shall be prepared by a registered civil engineer or certified engineering geologist and include appropriate measures to minimize seismic hazards and ensure structural safety of the proposed structures.

Significance after Mitigation: Mitigation Measure 3.6-1 would require the District to prepare a geotechnical investigation report and incorporate geotechnical recommendations in the final design. Implementation of Mitigation Measure 3.6-1 would reduce the impact from seismic shaking during operation to less than significant because the project would be designed to avoid damage from strong seismic events.

	Significance Determination
	Construction: Less than Significant
Impact 3.6-2: The project would not result in substantial soil erosion or the loss of topsoil.	**Operation and Maintenance: Less than Significant**

Construction

Project construction would include soil disturbing activities, including removal of the concrete channel within Frederick Allen Park and lower Unit 2, grading in Unit 4, tree removal, and excavation of larger fish pools. Without proper soil stabilization controls, construction activities including excavation and grading, and tree removal can increase the potential for exposed soils to be eroded by wind or stormwater runoff, resulting in long term soil loss. As discussed in Section 3.9 Hydrology and Water Quality, land disturbance associated with the project would be more than 1 acre and coverage under the Construction General Permit would be required. The proposed project would be required to develop and implement a SWPPP. Construction activities would be conducted consistent with Water Discharge Requirements prescribed for compliance with the state's Porter-Cologne Water Quality Control Act and BMPs outlined in the SWPPP. In conformance with the SWPPP and construction standards, erosion control methods would be implemented to prevent loss of soil at all work sites. The project design includes streambank stabilization measures to reduce the potential for soil loss, as described in Chapter 2, Project Description. In addition, Marin County has adopted the CBC Appendix J grading requirements, including preparing and maintaining the cut and fill slopes to control erosion. The streambank stabilization measures included in the project design and implementation of the sediment and erosion control BMPs included in the SWPPP would ensure that soil erosion and the loss of topsoil immediately following construction are less than significant.

Operation and Maintenance

The project will require removal of trees and vegetation within Frederick Allen Park and within Unit 2 to create natural habitat. The area of tree removal would be replaced with native vegetation including shrubs, grasses, and riparian trees. Revegetation would provide long-term stabilization to avoid substantial soil loss. The area of grading and excavation at the stormwater pump station and the floodwalls would be permanently stabilized by the project elements that would be installed in the area, including gravel and concrete. Long-term maintenance activities would include maintenance of landscaping and streambank stabilization control structures to ensure they function over the project life. Maintenance activities also include maintenance of vegetation and removal of sediment from the fish pools. The removal of sediment from the project fish pools would be similar sediment removal from the existing fish pools and the impact would be less than significant. Maintenance activities would ensure proper function of the project and long-term effectiveness of streambank stabilization features. The impacts from erosion and soil loss would be less than significant because the project design incorporates revegetation and streambank stabilization features to minimize soil loss.

Mitigation: None required.

Impact 3.6-3: The project would be located 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.	Significance Determination
	Construction: Less than Significant
	Operation and Maintenance: Less than Significant

Geologic and Soil Unit Stability

The project area consists of three geologic units, including the Franciscan Formation, Bay Mud, and valley fill/alluvium. The Franciscan Formation bedrock and valley fill/alluvium are comparatively strong and competent foundation materials. Bay Mud consists of silts and clays that are very soft and structurally weak. Bay Mud is found downstream of Stadium Way pedestrian bridge in Unit 2 beneath the artificial fill. Upstream from Stadium Way pedestrian bridge, Bay Mud is reportedly absent. As discussed in the Environmental Setting, the Franciscan Formation bedrock is approximately 35 to 40 feet below ground surface near the upstream end of the project and approximately 40 feet below ground surface near Kentfield and increases in depth towards the Bay. The project would require grading and excavation within Frederick Allen Park, Unit 4, and lower Unit 2. The grading and excavation would be greatest at Frederick Allen Park and would extend up to 10 feet below the current ground surface. The potential for the project to encounter bedrock is low because the maximum excavation would not extend to bedrock. The soil types underlying the project include Tocaloma-McMullin-Urban Land Complex and Xerorthents-Urban land complex (USDA, 2020). These urban land complex soils likely consist of artificial fill materials that have been compacted by roadways, the concrete channel, and urban activity.

Retaining Walls and Floodwalls

The project would include installation of 10-foot tall retaining walls in the approximate location of the existing flood control channel at the upstream end of Frederick Allen Park and connection to Unit 4 and at the downstream end of Frederick Allen Park, construction of larger fish pools within the concrete channel in Unit 3, installation of 2 to 4 foot tall floodwalls along the existing floodwall, removal of portions of the concrete channel to create natural habitats in Frederick Allen Park and at lower College of Marin, and installation of a stormwater pump station. The new structures including the retaining walls and floodwalls would be installed on soil units that primarily consist of urban fill in the urban environment. The Franciscan Formation and valley fill alluvium underlying the retaining walls and floodwalls are stable geologic and soil units and the soils would not become unstable as a result of the retaining wall or floodwall installation. The retaining walls and floodwalls would be similar to the existing concrete channel floodwalls and would not cause geologic or soil instability; therefore, the impact would be less than significant.

Frederick Allen Park and Fish Pools

The excavation of the floodplain at Frederick Allen Park and excavation of larger fish pools within the concrete channel would occur within the Franciscan formation and valley fill alluvium, which are stable soil and geologic units. The project would include installation of streambank stabilization measures including large rock, vegetated soil lifts, and landscaping within Frederick Allen Park and immediately upstream. The project also includes installation of concrete and rock within the fish pools. The project would not cause geologic or soil units to become unstable because the underlying geologic and soil units are stable, and the project has incorporated soil stabilization measures into the design. The impact form construction of the floodplain and habitat at Frederick Allen Park and the fish pools would be less than significant because the habitat and fish pools would be located on stable geologic and soil units and the project design includes soil stabilization features.

Lower College of Marin

The Bay Mud underlying the lower College of Marin concrete channel removal area is weak. The lower College of Marin concrete channel removal work involves removal of a portion of the existing concrete channel and riprap, creating a less steeply sloped habitat area and planting the area to establish saltwater marsh and transitional habitat. Riprap would be reinstalled as needed for stability. The reduced slope of the created habitat relative to existing conditions, and use of soil stabilization, including riprap reuse, would generally stabilize the underlying soils. In addition, Marin County Municipal Code requires the Department of Public works to review acceptable soils and geologic reports prior to construction activities located on Bay Mud. Per these regulatory requirements, the geotechnical investigation report for the lower College of Marin concrete channel removal, which is located on Bay Mud, will include detailed information related to soils matters such as stability, erosion; and settlement, and will include recommendations for remediating expansive soils, which may include, for example, removal of these soils and replacement with engineered fill. With adherence to the Marin County Municipal Code, the project would have a less than significant impact due to its location on unstable soil units.

Subsidence

Subsidence is commonly associated with severe, long-term withdrawal of groundwater in excess of recharge that eventually leads to overdraft of the aquifer. The project would include temporary groundwater dewatering in the location of excavation including the fish pools and lower Unit 2 construction. Groundwater dewatering would be localized and would only occur for a few weeks during construction in each area. No long-term groundwater withdrawal would occur. The short-term dewatering would not cause subsidence. No subsidence-related impacts would occur.

Liquefaction, Lateral Spreading and Landslides

Liquefaction, lateral spreading, and on- or off-site landslide impacts as analyzed above in Impact 3.6-1. The impact from liquefaction and lateral spreading would be less than significant, as discussed in Impact 3.6-1. The project would not result in a landslide on or off-site. No landslide impact would occur.

Mitigation: None required.

Impact 3.6-4: The project would not be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), and thus would not create substantial direct or indirect risks to life or property.	Significance Determination
	Construction: Less than Significant
	Operation and Maintenance: Less than Significant

The soil types underlying the project include Tocaloma-McMullin-Urban Land Complex and Xerorthents-Urban land complex. The Tocaloma-McMullin complex has low extensibility, or expansion potential. The extensibility rating for the Xerorthents-Urban land complex was not available from the NRCS web soil survey. However, the soil expansion potential is anticipated to be low because the soil complex is fill and heavily developed. The project does not involve construction of habitable structures or structures that could create a substantial risk to life or property in the case of soil expansion. The floodwalls will be located on top of existing floodwalls or setback from existing floodwalls and would not change the soil types or risk of expansive soils below the existing floodwalls. Marin County Municipal Code requires the Department of Public works to review acceptable soils and geologic reports prior to construction activities located on Bay Mud. Per these regulatory requirements, the geotechnical investigation report for the lower College of Marin concrete channel removal, which is located on Bay Mud, will include detailed information related to soils matters such as stability, erosion; and settlement, and will include recommendations for remediating expansive soils, which may include, for example, removal of these soils and replacement with engineered fill. With adherence to the Marin County Municipal Code, the project would have a less than significant impact with respect to expansive soils.

Mitigation: None required.

Impact 3.6-5: The project would not directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.	Significance Determination
	Construction: Less than Significant
	Operation and Maintenance: No Impact

Overview

Portions of the project area where ground disturbance will occur are underlain by Late Pleistocene and Holocene Bay Mud and valley fill/alluvium. Typical valley fill/alluvium in the project area consists of mixtures of alluvial soils and slope wash from the adjoining hills. Because it consists of recently deposited sediments, surficial exposures of alluvium are considered to have low potential for paleontological resources. Although numerous invertebrate fossils such as mollusk shells have been observed in the Young Bay Mud, due to its young age, the Holocene Young Bay Mud is considered to have low potential for significant fossils. The project is not located near or within a unique geologic feature. Therefore, the project would not affect a unique geologic feature.

Construction

Construction of the project would require ground-disturbing and excavation during removal of the fish ladder and grading of Unit 4, removal of the concrete channel and construction of a floodplain and realigned channel in Frederick Allen Park, excavation of larger fish pools, construction of the stormwater pump station, and removal of concrete at the lower College of Marin. There is a low potential to uncover previously undiscovered paleontological resources during ground-disturbing work because paleontological resources are not anticipated in sediments and rocks in the project area. The impact of construction on paleontological resources is less than significant.

Operation and Maintenance

Once constructed, the project would include maintenance activities, such as vegetation management, sediment and debris removal, and storm drain pump station and floodwall maintenance. These activities would not include ground-disturbing work. No impact on paleontological resources would occur.

Mitigation: None required.

3.6.7 References

Association of Bay Area Governments Resilience Program. (2020). *Modified Mercalli Intensity Scale (MMI)*. Retrieved August 19, 2020, from http://resilience.abag.ca.gov/shaking/mmi/

CDC. (2015). Retrieved August 7, 2020, from https://maps.conservation.ca.gov/cgs/informationwarehouse/index.html?map=tsunami

CGS. (2002, December). *California Geomorphic Provices Note 36.* Retrieved from https://www.contracosta.ca.gov/DocumentCenter/View/34134/CGS-2002-California-Geomorphic-ProvincesNote-36-PDF

CGS. (2018). A Guide for Government Agencies, Property Owners/Developers, and Geoscience Practitioners for Assessing Fault Rupture Hazards in California . *Earthquake Fault Zones* .

CGS. (2019). *Seismic Hazards Mapping Act*. Retrieved July 7, 2020, from California Department of Conservation California Geological Survey: https://www.conservation.ca.gov/cgs/shma

City and County of San Francisco . (2009, November). Candlestick Point-Hunters Point Shipyard Phase II Development Plan Project Draft Environmental Impact Report .

geomorphDESIGN. (2019, October 24). Self-Adjusted Channel Bed Elevation Geometry Files for Unit 4 Corte Madera Creek Flood Control Channel for Four Improvement Scenarios Administrative Draft Technical Memorandum.

GHD. (2019, June). Corte Madera Creek College of Marin to Kentfield Hospital Structural Assessment Draft Technical Memorandum.

Lawson, A. C. (1908). The California Earthquake of April 18, 1906, Report of the State Earthquake Investigation Commission.

Marin County . (2007, November 6). Marin Countywide Plan.

Marin County . (2019). Marin County Initial Study Checklist . Marin County Community Development Agency Planning Division.

Marin County . (2020). *Chapter 22.16 Discretionary Development Standards*. Retrieved from Marin County Municipal Code: https://library.municode.com/ca/marin_county/codes/municipal_code?nodeId=TIT22DECO_ARTIIZODIALLAUS_CH22.16DIDEST_22.16.030GEST

Marin County. (2005, November). Marin Countywide Plan: Geology, Mineral Resoruces and Hazardous Materials Technical Background Report .

NRCS. (2020, July 6). Custom Soil Resource Report for Marin County, California.

Regional Water Board. (2017, April 26). *2016 California List of Water Quality Limited Segments Beging Addressed by USEPA Approved TMDLs*. Retrieved August 20, 2020, from https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/2016_303d/category4a_report.shtml

Stetson Engineers Inc. (2000, December 31). Geomorphic Assessment of the Corte Madera Creek Watershed.

SVP. (2010). Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources . Society of Vertebrate Paleontology Impact Mitigaiton Guidelines Revision Committee.

Town of Ross. (2007, June). Town of Ross General Plan.

Town of Ross. (n.d., in USACE 2010). Lagunitas Road Bridge Repalcement Projet, Draft EIR Initial Sutdy Checklist.

UCMP. (2020, July 13). *UC Mesume of Paleontology Localities - Marin County*. Retrieved from https://ucmp.berkeley.edu/collections/databases/

URS Corporation. (2009, in USACE 2010, February). Lagunitas Road Bridge Replacement Project Foundation Report.

USACE. (1966, in USACE 2010). Design Memoradum No. 1, Corte Madera Creek Flood Control Project, Marin County, as in the December 2010 Corte Madera Creek Flood Control Study Final Baseline Report.

USACE. (1967, in USACE 2010). Design Memorandom No. 2, Corte Madera Creek Flood Control Project, Marin County, California, Units 2 and 3 ,as in the December 2010 Corte Madera Creek Flood Control Study Final Baseline Report.

USACE. (2010, December). Corte Madera Creek Flood Control Study Baseline Report .

USACE. (2018a, October). Appendix P Geotechnical Report for Draft Environmental Impact Statement (EIS)/Environmental Impact Report (EIR) of Corte Madera Creek Flood Risk Management Project.

USACE. (2018b, October). Corte Madera Creek Flood Risk Management Project Environmental Impact Statement/Environmental Impact Report.

USDA. (2020, July 6). Custom Soil Resource Report for Marin County, California.

USGS. (2002, December 10). San Andreas Fault Zone, Creeping Section (Class A) No. 1e. *Quaternary Fault and Fold Database of the United States*.

USGS. (2006). Liquefaction Susceptibility. *Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California Open-File Report 06-1037*.

USGS. (2011). Population and Business Exposure to Twenty Scenario Earthquakes in the State of Washington. *Open-File Report 2011-1016*.

USGS. (2015, March). UCERF3: A New Earthquake Forecast for California's Complex Fault System Fact Sheet 2015-3009.

USGS. (2020). *U.S. Landslide Inventory*. Retrieved August 6, 2020, from https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=ae120962f459434b8c904b456c82669d

WGCEP. (2008). The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2). *USGS Open File Report 2007-1437, CGS Special Report 203*.

This page is intentionally left blank.