3.6 Geology and Soils

This section evaluates the potential impacts to geology and soils during construction, invasive plant management, and maintenance of the proposed Project. Construction activities include the earthwork involved in the estuarine restoration and infrastructure improvement portions of the Project. Invasive plant management activities include the removal of dense-flowered cordgrass (*Spartina densiflora*), European beachgrass (*Ammophila arenaria*), and dwarf eelgrass (*Zostera japonica)* using any one or a combination of the methods described in Section 2.5 (Proposed Invasive Plant Management). Maintenance activities include periodic repairs and improvements to the non-motorized boat put-in, trails, parking lots and road within the Project Area, and also include monitoring activities. For the purpose of this section, the study area includes the Project Area and areas adjacent to the Project Area that may be or become geologically unstable and that could impact resources in the Project Area.

3.6.1 Setting

The study area includes a sliver of coastline that comprises approximately 1,070 acres. It extends for nearly four miles between the Eel River mouth and Table Bluff. North Bay and McNulty Slough represent the south and east boundary of the study area and the Pacific Ocean forms the west boundary. Immediately east and parallel to the beach is a dune field that forms a low ridgeline. Collectively, the beach and dune field represent a barrier beach/spit that separates the Eel River valley and delta from the ocean. Between the barrier beach and McNulty Slough is a lowland saltmarsh that was diked and drained to accommodate livestock grazing during the late 1800s. Associated with that grazing was the construction of a network of levees that border both sides of McNulty Slough and diminish tidal exchange into and across the saltmarsh.

Geologic Setting

Regional Geology

Published geologic maps (Ogle 1953; Evenson, 1959; McLaughlin et al. 2000) show the study area located within the lower Eel River valley, which is underlain with unconsolidated Holocene to Pleistocene fluvial and floodplain deposits consisting of sand, silt, and gravel deposited in near-shore, estuarine, and fluvial environments (Figure 3.6-1 – Regional Geologic Setting). Evenson (1959) documents that groundwater levels (i.e., the groundwater table) within the lower Eel River valley generally lies within 20 feet of the ground surface. The valley is a broad northwest-southeast trending syncline (fold) formed by active compression tectonics (Carver 1987; Clarke 1992; Kelsey 2001). The valley's average rate of subsidence over the last 2,000 years is reported to be 1 – 3 millimeters (mm) per year; however, that subsidence has occurred abruptly during sudden events that are hypothesized to be related to major earthquakes within the southern Cascadia subduction zone (Li and Carver 1992; Kelsey 2001). The valley is bounded along the south by the Ferndale fault (McLaughlin et al. 2000) and the steeply inclined sedimentary rocks that form the Ferndale Hills (Ogle 1953). To the north, the valley is bounded by a broad arching fold named the Table Bluff anticline, which creates the uplands area of the same name. That anticline is considered genetically related to the Little Salmon thrust fault system (Ogle 1953; McLaughlin et al. 2000; Kelsey 2001) but not the specific trace of that fault, which is formally designated by the State of California as a Holocene active fault (Davis 1991; CGS 2018).

Seismic Setting

The lower Eel River valley is controlled by numerous folds and faults generated in response to active compression tectonics. More specifically, the valley lies about 30 miles north of the Mendocino Triple Junction (MTJ) where three vast tectonic plates meet. South of the MTJ, the Pacific plate is juxtaposed against the North American Plate (NAP) along the strike-slip San Andreas fault zone. North of the MTJ, including the area just offshore from the study area, the Gorda plate converges with and subducts beneath the NAP at the southern end of the Cascadia subduction zone (CSZ). The MTJ has been migrating northward for approximately 30 million years and that migration has generated the tectonic compression that created the folds and faults which control the physiography of the Eel River valley. Additionally, the complex interactions between the three plates at the MTJ make this region one of the more tectonically active areas of the world (Furlong and Schwartz 2004). That tectonic activity generates multitudes of earthquakes and associated ground-shaking that is felt throughout the region. Because the lower Eel River is underlain by generally saturated alluvial sediments (Ogle 1953; Evenson 1959), earthquake shaking in the area is likely to be stronger because seismic waves move more slowly through these softer sedimentary earth materials.

Dengler et al. (1992) identify five sources of seismicity on the North Coast of California which include: the Gorda plate, the Mendocino fault that marks the boundary between the Gorda and Pacific plates, the San Andreas fault, the NAP, and the CSZ. Dengler et al. (1992; see Figure 5) also document that communities located along the stretch of coastline between Petrolia and Eureka, which includes the study area, had been subjected to at least 15 earthquakes with strong ground shaking since the year 1900. Some of those communities had experienced 23 such events. Of those events, one occurred along the CSZ on April 25, 1992 and was a 7.1 moment magnitude (M) earthquake that generated severe shaking in the towns of Petrolia, Ferndale, Rio Dell, and Scotia. That earthquake was felt in southern Oregon, as far south as San Francisco, and in Reno, Nevada (USGS 2020). In the lower Eel River valley, very strong ground-shaking occurred in response to a 5.3 M earthquake that occurred near Ferndale on June 7, 1975. Additional information on the seismicity of northern California is available from the California Geological Survey (CGS). For example, Special Publication 115 (Toppozada et al. 1995) is a planning scenario for a "*great*" 8.4 M moment magnitude earthquake along the CSZ in Humboldt and Del Norte counties. Map Sheet 48 (Branum et al. 2016) shows the relative intensity of ground shaking from anticipated future earthquakes throughout the state. Furthermore, a joint effort by the U.S. Geological Survey (USGS) and CGS (Petersen et al. 1996) presents a probabilistic seismic hazard assessment for the state.

Soils

Soil units mapped within the study area by the National Resource Conservation Service (NRCS, 2020) include many soil "series" that in most locations are so intricately distributed amongst each other that they are described together as "complexes". Soil series present along the Tablebluff uplands at the north end of the study area include the Hookton, Tablebluff, Cannonball, Candymountain, and Leopoli. Hookton soil is a very deep loam that is somewhat poorly drained and derived from mixed alluvium. Tablebluff soil is a very deep silt loam that is moderately well drained and derived from eolian deposits over mixed alluvium. Cannonball soil is a very deep sandy loam that is well drained and derived from mixed marine sediments. Candymountain soil is a very deep silt loam that is moderately well drained and derived from mixed marine sediments. Leopoli soil is a very deep loam that is well drained and derived from eolian deposits over mixed alluvium.

Soil series associated with the barrier beach and dune field along the west side of the study area include the Oxyaquic Udipsamments, Samoa, and Clambeach. Oxyaquic Udipsamments soil is associated with beaches, is very deep fine sand that is moderately well drained and derived from beach sand and gravel. Samoa soil is associated with dunes, is very deep sand that is somewhat excessively drained and derived from eolian and marine sand deposits. Clambeach soil is very deep sand that is very poorly drained and also derived from eolian and marine sand deposits.

Soils series present within the lowland saltmarsh portions of the study area include the Weott, Occidental, and Wigi. Weott soil is very deep silt loam that is very poorly drained. It is associated with backswamps and floodplains and is derived from mixed alluvium. Occidental and Wigi soils are very poorly drained, deep silty clay loam. They are both associated with saltmarsh habitat and are derived from mixed alluvium. Wigi soil is also very deep silty clay loam that is very poorly drained. It is associated with saltmarsh habitat and is derived from mixed alluvium. Levees bordering McNulty Slough were constructed from borrow ditches excavated in these same soils. LACO (2014) describes the earth materials comprising the levees as dark-gray to very-dark-gray, soft to medium-stiffness, silt and silt with fine sand. As per specific soil testing and the Unified Soil Classification System nomenclature, LACO (2014) classifies the earth material within the levees as being mostly silt with some clay. Additional discussion of soil types within the Project Area is provided in Section 3.2 (Agriculture and Forestry Resources). Soils mapped in the Project Area are illustrated on Figure 3.2-1, NRCS Mapped Soil Units.

Expansive Soils

Expansive soils are capable of causing considerable distress to roads and building foundations as they "*rise-and-fall*" in accordance with the cycles of soil wetting (swelling) and drying (shrinking). Soils with high percentages of silicate clays are those that have the potential for shrinking and swelling. The clay content of a soil can be estimated in terms of its "*plasticity*" which means it can be molded and rolled into a thin thread provided the water content is appropriate (Brady and Weil 1996). Mapping by the NRCS (2020) shows the lower elevation areas of the study area to have the highest percentage of clay content ranging between 30 percent and 40 percent with Plasticity Index values of between 8 and 16. Thus, those soils in the lower elevation areas of the study are defined as silty clay loam and are considered to have a low to medium potential for expansion.

Soil Erosion

Soil erosion is a process whereby soil materials are worn away and transported to another area, either by wind or water. Areas susceptible to erosion occur where surface soils possess low-density and/or low-strength properties. Slope angle is another factor in soil erosion – the greater the angle and longer the slope, the greater the erosion hazard, especially if the soil is bare of vegetation. With the exception of the existing channels, levees, dune side slopes, and Table Bluff, slope gradients in the study area are generally flat (less than five percent). See Section 3.9 (Hydrology and Water Quality) for a discussion of geomorphic processes, including accretion and erosion of slough channels due to tidal processes.

Specific to the levees along McNulty Slough, a qualitative analysis of levee erosion potential was undertaken in the study area by LACO (2014). Criteria including bank slope, soil type, width of marsh flat, presence of revetment, vegetation cover and location within the slough with respect to tidal exchange were combined and assigned values of relative erosion potential. Segments of the eastern and western McNulty Slough levees were then ranked according to the erosion potential valuation results which ranged from moderate to very high. The western McNulty Slough levee ranked as mostly high (66 percent), followed by moderate (20 percent), with a small portion of the levee ranked as having very high erosion potential (2 percent). Approximately 12 percent of the western levee was not assigned a value of relative erosion potential because an old failed levee was blocking the current levee which was not visible by boat, located in central Area B and identified as segment 7W (LACO 2014). The eastern McNulty Slough levee also ranked mostly high (80 percent) with some segments in the very high (20 percent) category. The erosive processes at work are those normally associated with tidal exchange flows during ebb and flow tides. For an analysis of the Project's potential impacts on water quality from removal of dense-flowered cordgrass, the McNulty Slough levees, and scouring potential refer to Section 3.9 (Hydrology and Water Quality).

Seismic Hazards

As described above, the study area lies within a seismically active region subject to frequent moderate to large earthquakes. Seismic hazards are those that could reasonably be expected to occur in the study area during a major earthquake on any of the nearby faults. Some hazards can be more severe than others depending on the location, underlying materials, and level of ground shaking. The State of California formally recognizes surface ground rupture, liquefaction, earthquake-induced landslides, tsunamis, and amplified ground shaking as the primary seismic hazards of concern. Zoning of fault rupture hazard is codified in the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (Public Resources Code [PRC], Division 2, Chapter 7.5, Section 2621-2630), while zoning of the other hazards is formalized in the Seismic Hazards Mapping Act of 1990 (PRC, Chapter 7.8, Section 2690-2699.6). The California Department of Conservation is responsible for implementing these acts and the work is conducted by CGS. Numerous publications have been prepared over the years as this work has progressed. Chief among those publications are numerous 1:24,000 scale maps delineating active fault traces as well as various guidelines, such as Special Publication 42 titled: Earthquake Fault Zones; A Guide for Government Agencies, Property Owners / Developers, and

Geoscience Practitioners for Assessing Fault Rupture Hazards in California (CGS 2018). Other reports include Special Publication 117A titled: Guidelines for Evaluating and Mitigating Seismic Hazards in California (CGS 2008), and Special Publication 118 titled: Recommended Criteria for Delineating Seismic Hazard Zones in California (CGS 2004).

Surface Fault Rupture

"Surface fault rupture is the result of fault movement that breaks to the surface of the earth either suddenly during earthquakes, or slowly due to a process known as fault creep, and is the result of tectonic movement that originates deep in the Earth" (CGS 2018). The magnitude and nature of fault rupture can vary for different faults or even along different strands of the same fault. Surface rupture can damage or collapse buildings, cause severe damage to roads and pavement structures, and cause failure of overhead as well as underground utilities. The study area does not lie within an Alquist-Priolo "Fault Rupture Hazard Zone." However, it does lie less than five miles southwest from the Little Salmon fault that is zoned as Holocene-active. Additionally, the study area lies approximately 32 miles from both the MTJ located to the south and the CSZ offshore to the west.

Ground Shaking

Earthquakes have the capacity to produce a range of ground shaking intensities in the study area, but the area has not yet been mapped in terms of delineating a "Seismic Hazard Zone" by the State of California. Key factors in a particular site's susceptibility to ground shaking include the magnitude of the earthquake, the distance between the site and the earthquake focus, and the local geological conditions at the site. Ground shaking is amplified in softer rocks and sedimentary basins like that of the lower Eel River valley. Ground motion during an earthquake includes parameters such as horizontal and vertical acceleration, seismic wave velocity, and duration of shaking. A common measure of ground motion is the peak ground acceleration (PGA). PGA is measured using strong motion accelographs that are similar to seismographs that record earthquake waves; typically, horizontal (i.e., side-to-side) acceleration is greater during an earthquake than the vertical (up-and-down) acceleration. PGA is typically expressed as a percentage of gravitational acceleration (g). A scale (see Table 3.6-1) combining PGA ranges, instrumental intensity, and qualitative descriptions of earthquakes similar to that used in the Modified Mercalli Intensity scale has been prepared for California by USGS as a recent refinement of the ShakeMap system (Wald et al. 2005).

PGA is a parameter used in the design of buildings in areas of high seismicity. A common standard is that buildings be designed to withstand the ground shaking at a site that has only a 10% chance of being exceeded in 50-years. This also means there is a 90% chance that such ground motions will not be exceeded in 50 years at the site. Using the CGS online Ground Motion Interpolator (CGS 2020) and a Vs30 value of 180 meters per second (m/s) for the Project Area, a PGA value of 0.49g is returned. In other words, the model indicates that over the next 50 years, the study area has only a 10% chance of experiencing a PGA of 0.49g (49% g). Such shaking would be associated with a severe earthquake. For perspective, the strong to very strong ground shaking experienced in the lower Eel River valley associated with earthquakes that occurred in 1975 and 1992 (see above) has been estimated by the USGS (ShakeMaps) to have been in the range of 0.1g to 0.2g respectively.

Liquefaction, Lateral Spreading and Subsidence

Liquefaction is a phenomenon whereby unconsolidated and/or near-saturated soils lose cohesion and are converted to a fluid state as a result of strong ground shaking. Typical consequences of liquefaction include sand boils (liquefied soil ejected to the ground surface), ground cracking associated with blocks of cohesive soils "floating" on the underlying liquefied soil, lateral spreading of soils down-gradient toward unsupported slopes, and/or dynamic settlement (Bolt 1993; Yeats 1998; Pipkin et al. 2005). Liquefaction is particularly common in clean loose sand or gravelly sand deposits that are saturated with water and buried less than 30 feet below the earth's surface (Yeats 1998).

As introduced above, Evenson (1959) documents a very shallow groundwater table in the lower Eel River valley as well as deposits of unconsolidated deposits of sand and gravel underlying the valley floor. Thus, the potential exists for liquefaction to occur within the study area. Kilbourne et al. (1980) document a potential for liquefaction in the lower Eel River valley and include notes from Lawson et al. (1908) regarding widespread instances of liquefaction in the lower Eel River valley generated in response to the 1906 San Francisco earthquake. Additionally, the Division of Mines and Geology (DMG 1992) reports widespread liquefaction in the Eel River valley associated with the April 1992 Petrolia earthquake. Moreover, map S-1 and S-3 of Special Publication 115 (Toppozada et al. 1995) shows the lower Eel River valley and the study area to have a high potential for liquefaction associated with a *"great"* earthquake along the CSZ. Collectively the discussion above supports the conclusion that the potential for liquefaction to occur within the study area in response to strong ground shaking is high.

Slope Failure and Landslides

Slope failures, commonly referred to as landslides, include many phenomena that involve the downslope movement of earth material, either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. Various factors involved with landsliding include: slope inclination, lithology, bedding orientation, surface drainage patterns, groundwater levels, and past patterns and instances of mass wasting. Additionally, landslides are characterized and classified on the basis of specific criteria such as depth of debris and earth material composition (CGS 2013). NRCS (2020) employs the term "soil slippage potential" to describe a hazard in which a mass of soil will slip when vegetation is removed, soil water is at or near saturation, or when other normal practices are applied.

Table 3.6-1. Qualitative ShakeMap Instrumental Intensity Scale

Inputs	Intensity								
Perceived shaking	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
Potential damage	None	None	None	Very light	Light	Moderate	Moderate to heavy	Heavy	Very heavy
Peak Acceleration (%g)	< 0.17	0.17 – 1.4	1.4 – 3.9	3.9 – 9.2	9.2 –18	18 – 34	34 – 65	65 – 124	> 124
Peak Velocity (cm/s)	< 0.1	0.1 – 1.1	1.1 – 3.4	3.4 – 8.1	8.1 – 16	16 – 31	31 – 60	60 – 116	> 116
Instrumental Intensity	**I**	**II–III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X+**

Source: Wald et al. 2005

The study area is characterized by low-relief tidally inundated saltmarsh, dunes that form a low ridgeline along the west boundary, aging levees located along both banks of McNulty Slough and within the interior of Project Area, and the Table Bluff uplands, with a small amount of freshwater and brackish wetlands near its base. The nearest slopes having a gradient of 25 percent or greater occur along the flanks of Table Bluff. NRCS (2020) describes the soil slippage potential of Table Bluff to be low. Similarly, published geologic maps (Ogle 1953; Evenson 1959; McLaughlin et al. 2000) do not show landslides in the study area. Therefore, the potential for slope failure and landslide hazards are considered to be low within the study area.

Tsunami

A tsunami is a wave, or series of waves, generated by an earthquake, landslide, volcanic eruption, or even large meteor hitting the ocean (CGS 2012). As outlined in Toppozada et. al. (1995, Map S-1), the study area is vulnerable to tsunami runup (i.e., inundation) associated with a great earthquake along the CSZ.

Dune Development

The west boundary of the study area is a barrier beach/spit composed of a shoreline beach and a dune field immediately east of the backshore. Barrier beaches are formed through a complex interaction between sea level changes, longshore transport of sand, wave action, and wind (McCubbin 1982; Easterbrook 1993; USACE 2002). Longshore transport is the term used to describe the movement of water and sediment parallel to the coastline. These are the currents that move sediment discharged from river mouths up or down the coastline. Wave action continually extracts sediment from the longshore currents and distributes it along the adjacent beach. Storm waves deposit even more sand on the beach and transport it to the backshore area. Once on the beach, the sand is then picked up and blown by winds inland and beyond the beach forming a sand dune field. Primary dunes are composed of sand blown directly from the beach face. Secondary dunes form in response to the subsequent modification of the primary dune by continued wind (eolian) processes and are generally located further inland (Sloss et al. 2012).

Foredunes are primary dunes that rise-up from the backshore of the beach and includes two types: incipient foredune and established foredune. Incipient dunes are low relief primary dunes that accumulate in the backshore portion of the beach above the high tide mark. These dunes are generally small, parallel to the beach, and are the result of wind-blown sand being trapped by a roughness element such as large wood or vegetation (Sloss et al. 2012). Established foredunes develop from the incipient dune and have greater height, width, age, and morphological complexity. Additionally, they commonly coalesce to form a prominent ridgeline parallel to the beach. As the dunes get larger and older, vegetation cover increases, and they become more stable. However, they remain susceptible to modification via wind erosion and a field of secondary dunes generated by that modification forms immediately inland of the foredune. Secondary dunes develop in response to wind erosion of the primary dunes and are of a variety of different forms: parabolic, barchan, transverse, longitudinal, and blowouts (USACE 2002; Sloss et al.2012). Periodically, storm waves locally breach the foredune ridge as “overwash” that erodes a shallow channel through the foredune and into the secondary dune field. Sand and flotsam entrained with the overwash settles out as a “washover” fan within the secondary dune field (McCubbin 1982; Easterbrook 1993). Relict foredunes are old foredunes that now lie inland from the contemporary foredune and are incorporated (partially buried) within the field of secondary dunes. Their presence is indicative of a shoreline that is advancing seaward (i.e., progradation). Collectively, Smith (1954) describes the morphology of a coastal dune field as a "complex maze of ridges, mounds, and hollows with seemingly extreme degrees of disorder".

In the study area, the Eel River is a major supplier of sand to the longshore current within the Eureka Littoral cell. Littoral cells are segments of the coast with distinct sediment sources, defined longshore transport pathways, and sinks where the sediment is removed from the littoral system (Patsch and Griggs 2006). The Eureka littoral cell stretches between Trinidad Head located approximately 30 miles north of the study area to the rocky outcroppings of False Cape located approximately 10 miles south of the study area (Patsch and Griggs 2007). Although the prevailing wind direction is from the north and northwest, a predominant longshore current direction is not considered to exist within the Eureka littoral cell, and the available evidence suggests that currents of the Eureka littoral cell moves in both directions especially along the south end of the cell (Patsch and Griggs 2007). However, longshore transport within the Eureka littoral cell is resulting in seasonal accretion (or progradation) of the shoreline within the study area located north of the Eel River mouth, and seasonal erosion of the shoreline located south of the mouth of the Eel River (KHE 2015; Hapke et al.2006; Patsch and Griggs 2007). Moreover, the volume of large wood distributed along the beach north of the Eel River mouth is vastly greater than that distributed to the south. Thus, while a predominant longshore current is not considered to exist in the south portion of the Eureka littoral cell (Patsch and Griggs 2007), it appears obvious that longshore transport is generally to the north during the winter when large volumes of water, sediment, and wood are discharged from the Eel River. See Photo 3.6-1 for a visual representation of north trending littoral transport at the mouth of the Eel River and Figure 3.6-2 (Shoreline Accretion and Erosion Trends Eel River Segments).

Photo 3.6-1 Longshore sediment transport at the Eel River mouth within the Eureka littoral cell. North is to the left, and the sediment plume is being carried north by the longshore current. Photograph by B. Finney, January 18, 2016.

As part of a larger investigation of the Eel River estuary and associated dune fields south of the Eel River mouth, Kamman Hydrology & Engineering, Inc., (KHE) also analyzed a segment of the beach and dunes within the study area. Based on a detailed analysis of geomorphic changes documented in aerial photographs and a comparison of topographic profiles, KHE (2015) found that up until about 1993, a fairly stable dune field existed in the study area with a single set of foredunes up to 20 feet in elevation. Between 1993 and 2005 however, a period of dune construction occurred in which a second and completely independent foredune ridge formed approximately 260 feet west of the original foredune (Photo 3.6-2). The seaward advance of the dune field is referred to as dune progradation, and the previous foredune system becomes relict (Sloss et al. 2012). An independent review of aerial photographs taken in 1948 confirms KHE's conclusion regarding the presence of a fairly stable dune field prior to 1993. More specifically, the foredune ridge line visible in the 1948 photographs is generally coincident with that of 1993. Additionally, a striking difference visible in the 1948 photographs is a general lack of vegetation cover across the entire dune field.

Photo 3.6-2: "Relict" (pre 1993) foredune ridge on the right (east) and contemporary foredune ridge to the left (west). View looking north through the trough between the two ridgelines. Note the dense proliferation of European beachgrass. Photograph by M. Smelser, April 10, 2020.

The contemporary dune field is largely covered by the invasive non-native European beachgrass. European beachgrass develops vigorous roots and rhizome systems, and active sand burial stimulates the production of new shoots that extend several feet below the surface (Pickart and Sawyer 1998). The plant grows fast and spreads both as a steady advance into the foredunes and as dispersed in-fillings within the secondary dune field (Photo 3.6-3). Pickart and Sawyer (1998) also report that it is the vertical rhizome system which is responsible for the plant's superior dune-building (i.e., anchoring) capabilities.

Planting of European beachgrass on west coast dunes was common in the first half of the twentieth century. First introduced at Golden Gate Park, San Francisco in the late 1800s (Lamson-Scribner 1895] in Pickart 1998), the species was heralded as a desirable sand stabilizer and was eventually embraced by U.S. Soil Conservation Service and other agencies (Pickart 1997). Since then it has spread and invaded large areas of Humboldt County's coastal dunes, including most of the dune field within the study area. Preliminary vegetation mapping by CDFW indicates that the study area includes approximately 345 acres of sand dunes. At least 40 percent, and perhaps as much as 60 percent of that dune area is covered by European beachgrass. Oblique aerial photographs taken in 1979 and 2013 of the study area (Photos 3.6-4a and b) show the dramatic increase of European beachgrass over time, the new foredune ridgeline, and the overall stabilization of the entire dune field.

Photo 3.6-3: European beachgrass on left advancing on patchy dune-mat vegetation, and into a sculpted hollow of the secondary dune field. Because dense of European beachgrass largely prevent mobilization of the underlying sand, dunes so vegetated are considered “stabilized.” In contrast, those dunes with patchy vegetation and many bare spots capable of being eroded are considered “semi-stable.” View is looking north toward the Table Bluff uplands. Photograph by M. Smelser, April 10, 2020.

1979 **2013**

Photos 3.6-4a and b Oblique aerial photographs of the Project Area which showing the seaward advance of both the dune field and the dense infestation of European beachgrass between 1979 and 2013. Note the hairpin turn of McNulty Slough in the background and the Sand Road visible in the middle of each photograph stretching from left to right. Photographs sourced from the CA Coastal Records Project, taken by Kenneth and Gabrielle Adelman.

The sand-trapping ability of European beachgrass has resulted in geomorphologic as well as ecological impacts to dunes along the west coast which is discussed in Section 3.4 (Biological Resources). Within the study area, the steep, continuous foredune ridge built and structurally reinforced by European beachgrass has had repercussions for both plants and animals. Specifically, foredunes are no longer reworked to the extent they once were, and the flow of sand into the secondary dune field behind the foredune has been largely cut-off thereby reducing active dune processes and the associated disturbance of the substrate. Additionally, the thick proliferation of European beachgrass across the secondary dune field has generally arrested normal dune processes and dynamism throughout that area as well. Such dynamism or disturbance is considered an essential ecosystem driver in dune systems that keeps the environment patchy and promotes high species diversity (Pickart 2008). For this discussion, dunes completely covered in European beachgrass that prevents mobilization and reworking of the underlying sand substrate are considered "*stabilized.*" In contrast, dunes covered in patchy native vegetation and with much exposed substrate are defined as "*semi-stable.*" Historic aerial photographs from 1948 and 1965 (i.e., prior to European beachgrass invasion) indicate that in general, the semi-stable secondary dune field extended about 600 feet east of the foredune. Locally however, the east limit of the dune field stretches approximately 800 feet beyond the foredune

3.6.2 Regulatory Framework

Federal

There are no federal policies or regulations relevant to the Project for geology and soils.

State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code, Division 2, Chapter 7.5) was passed in 1972 to mitigate the hazard of surface faulting (i.e., ground rupture) to structures designed for human occupancy (CGS, 2018). Title 14 of the California Code of Regulations (CCR), Section 3601(e), defines buildings intended for human occupancy as those that would be inhabited for more than 2,000 hours per year. In accordance with the Alquist-Priolo Act, the State Geologist is responsible for delineating regulatory zones, called "earthquake fault zones," around the surface traces of faults that exhibit evidence of ground rupture during the Holocene Epoch (i.e., the last ~11,700 years). These zones are depicted on USGS 7.5-minute topographic quadrangle maps and published by the CGS. Because many active faults are complex and consist of more than one branch, earthquake fault zones can extend several hundred feet on either side of the mapped fault trace. Within these zones, buildings for human occupancy cannot be constructed unless the building site has been formally investigated by a Professional Geologist who has prepared a geologic report demonstrating that the proposed structure would not lie astride the trace of an active fault.

While the study area lies approximately 3.5 miles southwest of the Little Salmon fault zone which is an Alquist-Priolo Earthquake Fault Zone (CGS 2019), no portion of the study area lies within such a fault zone. The Project also would not include construction or ongoing use of buildings that meet the criterion for human occupancy. Therefore, the regulatory provisions of the Alquist-Priolo Act do not apply to the Project.

Seismic Hazards Mapping Act

Like the Alquist-Priolo Act, the Seismic Hazards Mapping Act of 1990 (Public Resources Code [PRC] Sections 2690 to 2699.6) is intended to reduce damage resulting from earthquakes. More specifically, the act sets forth a statewide minimum public safety standard such that buildings for human occupancy do not collapse in response to an earthquake (CGS, 2008). While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including strong ground shaking, liquefaction, and seismically induced landslides. Its provisions are similar in concept to those of the Alquist-Priolo Act in that the State Geologist is charged with identifying and delineating areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards. Counties and cities are then tasked regulating development within the mapped Seismic Hazard Zones. In particular, cities and counties are prohibited from issuing development permits for sites within Seismic Hazard Zones until appropriate site-specific geologic and/or geotechnical investigations have been conducted by a state-licensed engineering geologist or civil engineer, and measures to reduce potential damage have been incorporated into the development plans.

Official Seismic Hazard Zone Maps have not yet been prepared for all parts of the State, and the lower Eel River valley (i.e., the study area) is one region that has not been mapped for seismic hazards such as liquefaction and landsliding. Humboldt County's Web GIS contains generalized geologic hazard (e.g., liquefaction and landslides) zoning delineations and uses that information as part of the decision-making process in the issuance of County building permits.

California Building Code

The State of California provides minimum standards for building design through the California Building Code (CBC 2019). The CBC applies to building design and construction in the state and is based on the 2018 International Building Code (IBC) that is in use or has been adopted in the 50 U.S. states. In other words, the CBC represents a modification of the IBC unique to the needs and conditions of California. Seismic safety and structural design requirements are set forth in CBC Chapter 16. Chapter 18 provides criteria for geotechnical and structural considerations related to the investigation of soils as well as the design and construction of foundations and retaining walls. Appendix J regulates earthwork grading activities including drainage and erosion control, and construction on unstable soils such as those subject to liquefaction.

California Public Resources Code

As part of the determination made pursuant to PRC Section 21080.1, the lead agency must determine whether a project would have a significant effect on paleontological resources.

Several sections of the PRC protect cultural resources and PRC Section 5097.5 protects vertebrate paleontological sites located on public land. Under Section

5097.5, no person shall knowingly and willfully excavate upon, or remove, destroy, injure, or deface any prehistoric ruins, vertebrate paleontological site (including fossilized footprints), or any other paleontological, or historical feature situated on public lands, except with the express permission of the public agency that has jurisdiction over the lands. Section 30244 of the PRC requires reasonable mitigation for impacts on paleontological and archaeological resources that occur as a result of development on public lands.

California Coastal Act

The Project Area is within the Coastal Zone. The California Coastal Act contains policies relevant to paleontological resources. The following Coastal Act sections are relevant to this analysis:

> *Public Resources Code Section 30244 Archaeological or paleontological resources*
>
> *Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.*

Regional and Local

Lands within the Project Area are owned by the California Department of Fish and Wildlife (CDFW) or are under the jurisdiction of the State Lands Commission, and therefore will not require local permits (i.e., Conditional Use Permit) from Humboldt County nor adherence to the Humboldt County General Plan or the Local Coastal Program Eel River Area Plan. Per hydraulic modelling and the Basis of Design Report, construction, invasive plant management and maintenance activities are not anticipated to affect geology and soils outside of the Project Area, except for potential impacts to the eastern McNulty Slough levee which is discussed in Section 3.9 (Hydrology and Water Quality). Therefore, local and regional regulatory policies are not included in the analysis of this section.

3.6.3 Evaluation Criteria and Significance Thresholds

The Project would cause a significant impact related to geology and soils, as defined by the CEQA Guidelines (Appendix G), if it would:

- Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42;
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil.

- 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.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.
- Directly or indirectly destroy a unique paleontological resource or site or unique geological feature.

Area of No Project Impact

The following significance criteria are not discussed further in the impact analysis, for the following reasons:

- **Would the Project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?** There are no structures within the Project Area, and no habitable structures are proposed under the Project. Additionally, the Project is not located within an active or potentially active fault zone, and is not located within a special studies zone or an Alquist-Priolo Fault Rupture Hazard Zone. Therefore, this significance criterion is not applicable to the Project and is not discussed further.
- **Would the Project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving landslides?** The Project Area is characterized by flat terrain, dunes, levees and Table Bluff to the north. According to the NRCS Web Soil Survey, the soil slippage potential of Table Bluff is low (NRCS 2020). Similarly, landslides are not common in the study area. Therefore, landslide hazards are considered to be low. As a result of the flat terrain, and lack of landslides in the vicinity, the Project is not anticipated to result in on- or off-site landslides, and no impact would occur. Therefore, this significance criterion is not applicable to the Project and is not discussed further.
- **Would the Project 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?** The Project would not include the use or construction of septic tanks or alternative wastewater disposal systems. Therefore, this significance criterion is not applicable to the Project and is not discussed further.

3.6.4 Methodology

The study area is defined as the Project Area and areas adjacent to the Project Area that may be, or may become, geologically unstable and which could impact resources in the Project Area. Project activities are evaluated in terms of their potential significance to impact (i.e., increase risks associated with) the identified geologic hazards. Mitigation measures are then described for those impacts determined to be significant.

3.6.5 Impacts and Mitigation Measures

Impact GEO-1: Would the Project directly or indirectly cause potential substantial adverse effects including the risk of loss, injury, or death involving strong seismic ground shaking or seismic-related ground failure, including liquefaction?

As described in Section 3.6.1, the study area is located within a seismically active region which is subject to frequent moderate to large earthquakes. Additionally, liquefaction has been documented in the lower Eel River valley as a function of larger earthquakes, and potential for liquefaction during a large future earthquake is considered high.

The Project includes the installation of a bridge spanning approximately 50 feet over the BI-3 breach, as well as a box culvert crossing at BI-4, which would be at risk of collapse from ground shaking and liquefaction. Recreational amenities including the parking lot, kiosk and non-motorized boat put-in as well as the access road and existing levees would similarly be susceptible to damage during strong seismic ground shaking.

Increased tidal exchange within McNulty Slough and the interior saltmarsh is not expected to materially change liquefaction potential of the underlying soils because increased tidal exchange would not substantially alter either the distribution of subsurface sediments or the degree to which those sediments are saturated. On the other hand, liquefaction within the Project Area has the potential to generate localized ground failures that could adversely impact portions of the existing levees as well as the bridge, culvert and non-motorized boat put-in. The parking lot and kiosk would be constructed on higher ground and are therefore less likely to be affected by liquefaction as compared to the low-lying portions of the study area. To minimize the risk that structures would collapse during seismic ground shaking, all Project structures would be designed by a licensed engineer and would conform to the CBC (2019) and current seismic design standards. Upon incorporating such design standards into the Project, Impact GEO-1 is less-than-significant.

Mitigation Measures: No mitigation is necessary.

Level of Significance: Less than significant.

Impact GEO-2: Would the Project result in substantial soil erosion or loss of topsoil?

Grading, earthwork, construction access, and long-term maintenance activities that temporarily disturb soils and sand in the Project Area could result in increased potential for erosion or loss of topsoil and sand on- and off-site, which could be a potentially significant impact. To minimize this impact, construction equipment would access individual work sites from the top of existing levees and berms, where possible, and along the sand road, where necessary. Additionally, implementation of Mitigation Measure WQ-6 (Designate Ingress/Egress Routes) would reduce the potential for soil disturbance and subsequent erosion by minimizing the area used for ingress/egress, staging, stockpiling and storage, which will reduce soil disturbance, and subsequent potential erosion. The temporary access routes along the levees and berms, bridge spanning BI-3, non-motorized boat put-in, box culvert and dunes would be constructed with adequate best management practices (BMP) to ensure immediate protection from erosion and would include design components as needed to ensure long-term stability. Therefore, with implementation of Mitigation Measure WQ-6, the impact would be less than significant.

Low ground-pressure equipment, and/or equipment staged from barges, would be used in discrete restoration areas that are not accessible from existing levees or berms. All areas disturbed by temporary staging and access would be de-compacted and naturalized, as needed, prior to Project completion. In addition, all soil areas where excavation or ground disturbance (including construction and invasive plant management activities) would occur or could deliver sediment to an adjacent surface water would be treated with erosion control BMPs (see Mitigation Measure HWQ-1 [Implement Best Management Practices to Protect Water Quality], and HWQ-2 [Erosion and Water Quality Control Measures During Channel Excavation and Ground Disturbance] below).

The physical disruption associated with European beachgrass removal in dune ecosystems can reset vegetation succession and increase the abundance of early successional species, including the endangered beach layia (*Layia carnosa*) (Pickart and Sawyer 1998). In the Primary and Secondary Treatment Areas, native dune vegetation would both be planted in some areas, and is anticipated to revegetate passively in others. Potential dune destabilization from removal of European beach-grass is anticipated to be temporary while native dune mat communities re-establish, and would also be minimized by the spatial and temporal phasing of vegetation treatments under the Project. Additional discussion of the potential impacts on dune stability resulting from removal of European beachgrass is provided under Impact GEO-3.

Changes in the hydrology of the site, including an increase in the tidal exchange resulting from implementation of the Project, could impact erosion rates within existing tidal channels, newly constructed channels, and/or adjacent waterbodies, such as McNulty Slough. See Section 3.9 (Hydrology and Water Quality) for further analysis of potential erosion resulting from hydrodynamic changes associated with implementation of the Project.

Mitigation Measures: Implement Mitigation Measures WQ-6, HWQ-1, and HWQ-2.

The Project would implement Mitigation Measure WQ-6, as defined from the Programmatic Final EIR for the Humboldt Bay Regional Spartina Eradication Plan (H.T. Harvey and GHD 2013), hereafter referred to as the 2013 Spartina PEIR, to reduce potential impacts from erosion and loss of topsoil. The 2013 Spartina PEIR measures have been slightly adapted to reflect that their implementation would also apply to invasive plant management of European beachgrass, and to other Project activities that would result in comparable potential impacts to soils (e.g., use of equipment to implement the tidal restoration component of the project).

Mitigation Measure WQ-6: Designate Ingress/Egress Routes

Temporary ground disturbance associated with site ingress/egress, staging, stockpiling, and equipment storage areas could occur in areas outside and adjoining work areas. Where areas adjacent to staging and stockpile areas are erosion prone, the extent of staging and stockpile shall be minimized by flagging their boundaries. An erosion/sediment control plan shall be developed for erosion prone areas outside the work area where greater than 0.25 acre (0.1 hectare) of ground disturbance may occur as a result of ingress/egress, access roads, staging and stockpile areas. The erosion/sediment control plan shall be developed by a qualified professional and identify BMPs for controlling soil erosion and discharge for Project-related contaminants. The erosion/sediment control plan shall be prepared prior to any ground disturbing activities, and implemented during construction (H.T. Harvey & Associates and GHD 2013, page 128).

Mitigation Measure HWQ-1: Implement Best Management Practices to Protect Water Quality

The following representative BMPs will be implemented to protect water quality during construction:

- Contractors will be responsible for minimizing erosion and preventing the transport of sediment to sensitive habitats/wetlands. Accordingly, all contractors that would be performing demolition, construction, grading, operations or other work that could cause increased water pollution conditions at the site (e.g., dispersal of soils) shall receive training regarding the environmental sensitivity of the site and need to minimize impacts. Contractors also shall be trained in implementation of stormwater BMPs for protection of water quality.
- The following BMPs from the current California Stormwater Quality Association's California Stormwater BMP Handbook for Construction will be implemented by the Contractor:
  - EC-1: Scheduling
  - EC-2: Preservation of Existing Vegetation
  - NS-2: Dewatering Operations
  - NS-9: Vehicle Equipment and Fueling
  - NS-10: Vehicle and Equipment Maintenance
  - WM-2: Material Use; and
  - WM-4: Spill Prevention and Control
- Sufficient erosion control supplies will be maintained on site at all times, available for prompt use in areas susceptible to erosion during rain events;
- Disturbance of existing vegetation will be minimized to only that necessary to complete the work;

- The contractor will make adequate preparations, including training and providing equipment, to contain oil and/or other hazardous materials spills;
- Dewatering operations will be conducted where needed, with water disposed of appropriately (e.g., allowed to settle in an isolated area, or discharged to an upland location where it won't discharge back to surface waters);
- Vehicle and equipment maintenance should be performed off-site whenever practical;
- The contractor shall ensure that the site is prepared with BMPs prior to the onset of any storm predicted to receive 0.5 inch (1.27 centimeter) or more of rain over 24 hours; and
- All erosion and sediment control measures shall be maintained until disturbed areas are stabilized.

Mitigation Measure HWQ-2: Erosion and Water Quality Control Measures During Channel Excavation and Ground Disturbance

Erosion and turbidity control measures shall be implemented in areas where excavation or ground disturbance would occur and could deliver sediment to an adjacent surface water (e.g., construction of Project tidal channels, installation of ditch blocks and large wood, levee lowering and removal, and installation of public access components). Depending on site conditions, these measures could include installation and maintenance of in-stream turbidity curtains, cofferdams and/or silt-fence along channel banks, as specified in Project designs, specifications and erosion control plans. Whenever feasible, construction will be scheduled to coincide with low tides to avoid increases in turbidity or potential impacts to aquatic habitats. Where possible, channel excavation or dredging will be isolated and hydrologically disconnected from surface waters.

Level of Significance: Less than significant with mitigation.

Impact GEO-3: **Would the Project 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?**

As described above, the Project is located in a unique and dynamic geologic environment in which tectonic plate motion generates strong earthquake shaking along with potential broad crustal uplift and/or subsidence. Liquefaction has occurred in the lower Eel River valley in the past in response to strong earthquake shaking and is expected to occur again during larger earthquakes. This affect is most likely to occur within the saturated low-elevation saltmarsh area, along the beach, and possibly the secondary dunes field within the Project Area. Liquefaction is not expected to occur within the Table Bluff uplands adjacent to the Project Area, primarily because the sediments underlying that area are better consolidated and not saturated.

Lateral spreading is related to the liquefaction phenomena but requires the earth materials involved to be topographically inclined to facilitate gravitational sliding and displacement. Given the generally flat topography of the beach and saltmarsh, lateral spreading is considered unlikely to occur in those areas. However, it is highly likely that the levees constructed atop the liquefiable salt-marsh sediments would undergo localized deformation and displacements (breaks). Such breaks in the levee would not create adverse environmental impacts such as undesired or unanticipated flooding because the levee system is already breached in several locations and, by design, the Project includes additional levee breaches. The dune field could similarly be subject to lateral spread, but not the Table Bluff uplands because the sediments are better consolidated and not saturated.

Landsliding is considered unlikely in the dune field because the sediment is not consolidated. Landsliding is also unlikely in the low-lying salt-marsh area because there is little topographic relief. However, shallow slumps and debris slides out of the steep levee slopes have occurred in the past and should be expected to occur in the future. In terms of topographic relief, the Table Bluff uplands has the greatest potential for landsliding within the study area. However, obvious indicators (e.g., hummocky topography) of past landslide activity along the slope are not present, so the potential for future landsliding is considered low.

To restore dune morphological processes and ecological function, the Project proposes to eradicate invasive plant species, primarily European beachgrass, to allow native dune mat vegetation communities to re-colonize in the Project Area. As described in Section 2.5.5 (European Beachgrass Management), approximately 279 acres of European beachgrass would be removed from the Primary and Secondary Treatment Areas. The Primary Treatment Area is comprised of the northern 2.6 miles of shoreline and generally corresponds to 207 acres having the highest European beachgrass cover (61 percent to 100 percent) of the dune restoration area. The Secondary Treatment Area includes the southerly one mile of shoreline and generally corresponds to 73 acres having less European beachgrass cover (less than 61 percent cover). See Figure 2-6 for a map of the Primary and Secondary Treatment Areas.

Removal of European beachgrass within the dune restoration area would be phased temporally and spatially to retain stability along the edges of the treatment area and to provide native vegetation time to re-establish. Removal of European beachgrass from the Primary Treatment Area would occur in two phases over a six-year period. Phase 1 would treat five, approximately 1,300 feet long plots, each spatially separated by approximately 1,300 feet, beginning at the northern boundary of the restoration area. Phase 2 would treat an additional five plots of the same size in areas not treated during Phase 1. Similar to the Primary Treatment Area, removal of European beachgrass from the Secondary Treatment Area would also occur over several years, take advantage of natural breaks in the plant communities, and likely reflect a “spot treatment” approach, rather than removal of European beachgrass from contiguous plots. It is assumed that ongoing invasive plant management activities would occur for up to ten years or as long as needed to achieve control and/or eradication.

The predominant means of European beachgrass removal would include prescribed burning and/or herbicide application, followed by manual and/or mechanical approaches as the secondary means of removal. The sequencing of prescribed burning and herbicide application has the advantage over mechanical removal because it preserves the remnant European beachgrass stubble and roots as anchoring to retain the semi-stability of the dune system (Pickart 1997). Mechanical removal of European beachgrass could damage the habitat structure and complexity provided by the abundant large wood found on or buried in the dunes; may destabilize the dunes and mobilize sand more quickly than other methods; and potentially result in burial of native dune mat community in the short term. Manual removal of European beachgrass (via hand pulling) is not anticipated to impact dune stability because such removal would target sparse areas of European beachgrass and would be utilized as a means of maintenance following other treatments. Because of the potential for dune destabilization associated with mechanical removal of European beachgrass, burning and herbicide application is the preferred European beachgrass removal method because it retains its rhizomes and roots aiding dune stability while native vegetation establishes in the study area.

In summary, implementation of the Project would not increase the potential for, or magnitude of, liquefaction or collapse, lateral spreading, subsidence, or landslide within the study area. In this regard, Project impacts are considered less than significant. Implementation of the Project would, by design, reduce the stability of sand dunes through removal of European beachgrass. However, the temporal and spatial phasing of the proposed treatments would generally minimize areas of instability and any initial post-treatment instabilities would be temporary. The applied treatments in conjunction with natural dune formation processes are expected to create and maintain a semi-stable dune system similar to that which was present prior to the proliferation of European beachgrass. Native vegetation including dune mat is expected to re-establish quickly (both passively from nearby sources and through augmented plantings), as has been demonstrated by other small- and large-scale projects (Pickart 2008). Therefore, removal of European beachgrass using prescribed burning and herbicide treatments would not create unstable soils, and instead would restore a more mobile dune dynamic that would support a more natural ecosystem similar to what was present prior to the invasion of European beachgrass. Therefore, these Project impacts are considered less-than-significant.

Because of the flat saltmarsh topography and dense-flowered cordgrass removal resulting in generally shallow soil disturbance, such disturbance would not increase the potential for, or magnitude of, soil liquefaction or collapse, lateral spreading, subsidence, or land sliding within the study area. Construction in the tidal marsh portion of the Project would take place from either levees or barges and would not increase soil instability due to the implementation of Mitigation Measures HWQ-1 (Implement Best Management Practices to Protect Water Quality), HWQ-2 (Erosion and Water Quality Control Measures During Channel Excavation and Ground Disturbance), and WQ-6 (Designate Ingress/Egress Routes). Since all Project structures and trails would be designed by a licensed engineer in accordance with seismic design parameters outlined in the CBC (2019), the risk that structures would collapse during a seismic event would be minimized. Maintenance activities, such as monitoring and trail maintenance, would have no impact on the geologic stability of the Project Area. Therefore, Project construction, invasive plant removal, and normal maintenance activities would not increase the potential for landslide, lateral spreading, subsidence, liquefaction or collapse.

Mitigation Measures: Implement Mitigation Measures HWQ-1, HWQ-2 and WQ-6.

Level of Significance: Less than significant with mitigation.

Impact GEO-4: Would the Project 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?

Soils in the lower elevation parts of the study area are silty clay loam with a low to medium potential for expansion. Therefore, the potential exists that roadways could be damaged in response to heaving and settlement associated with the shrinking and swelling of the soil. To minimize the risk that structures would fail due to expansive soils, all Project structures, including but not limited to the bridge, box culvert, and non-motorized boat put-in, would be designed by a licensed engineer in accordance with the 2019 CBC.

The Project would enhance recreational opportunities through the construction of trails, and it is anticipated that there would be an increase in use of the Project Area following Project construction. Although the Project Area contains expansive soils, the trails would be located atop existing levees and would be designed in accordance with the CBC (2019). Potential impacts from Project activities in expansive soils are considered less-than-significant because proposed infrastructure would be designed and constructed in conformance with applicable standards to reduce the direct and indirect risk to life or property due to construction on expansive soils.

Mitigation Measure: No mitigation is necessary**.**

Level of Significance: Less than significant.

Impact GEO-5: Would the Project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

There are no known unique paleontological resources or geologic features within the Project Area. Because the sand dunes are relatively new geologically, and river flooding over the decades has resulted in silt deposits in the tidal and flood prone portions of the Project Area, the likelihood of the Project affecting paleontological resources is low. However, the possibility of encountering a paleontological resource during construction cannot be completely discounted; therefore, the impact related to the disturbance or damage of previously undiscovered paleontological resources, if present, is considered potentially significant.

Mitigation Measures: Implement Mitigation Measure GEO-1.

Mitigation Measure GEO-1: Protect Paleontological Resources during Construction Activities

If fossils are encountered during construction (i.e., bones, teeth, or unusually abundant and well-preserved invertebrates or plants), construction activities within 50 feet (15 meters) of the find shall be stopped. CDFW shall be immediately notified, and a professional paleontologist shall be retained to evaluate the potential resource, assess the nature and importance of the find, and document the discovery as needed. Based on the scientific value or uniqueness of the find, CDFW may allow work to continue after the paleontologist has recorded the find, or may recommend salvage and recovery of the material if it is determined that the find should, but cannot, be avoided. The paleontologist shall make recommendations for any necessary treatment that is consistent with currently accepted scientific practices. CDFW will work with a qualified palaeontologist to determine the appropriate final disposition for any fossils found onsite. The final disposition of any paleontological resources recovered on state lands under the jurisdiction of the State Lands Commission must be approved by the State Lands Commission.

Level of Significance: Less than significant with mitigation.

Implementation of Mitigation Measure GEO-1 would reduce potentially significant impacts on undiscovered paleontological resources to a less-than-significant level by: 1) providing a process for evaluation of any resources encountered during construction, and 2) either avoidance or recovery of resources consistent with appropriate laws and requirements.

3.6.6 Cumulative Impacts

Impact GEO-C-1: Would the Project contribute to a cumulatively significant impact to geology and soils?

The nature of geologic impacts is largely site-specific. Therefore, geologic hazards do not accumulate as impacts as other resources do. The Project would comply with state regulations and policies; and design standards would be implemented to reduce the direct and indirect risk to life or property from potential geologic hazards. Mitigation Measures HWQ-1, HWQ-2 and WQ-6 would be implemented to reduce potentially significant impacts from Project-related soil erosion or soil instability to a less-than-significant level, and Mitigation Measure GEO-1 would be implemented to reduce potentially significant impacts on undiscovered paleontological resources to a less-than-significant level. With implementation of these mitigation measures, the Projects contribution to cumulative impacts would not be considerable, and therefore cumulative impacts on geology and soils would be less than significant.

Mitigation Measures: No additional mitigation is necessary.

Level of Significance: Less than significant.

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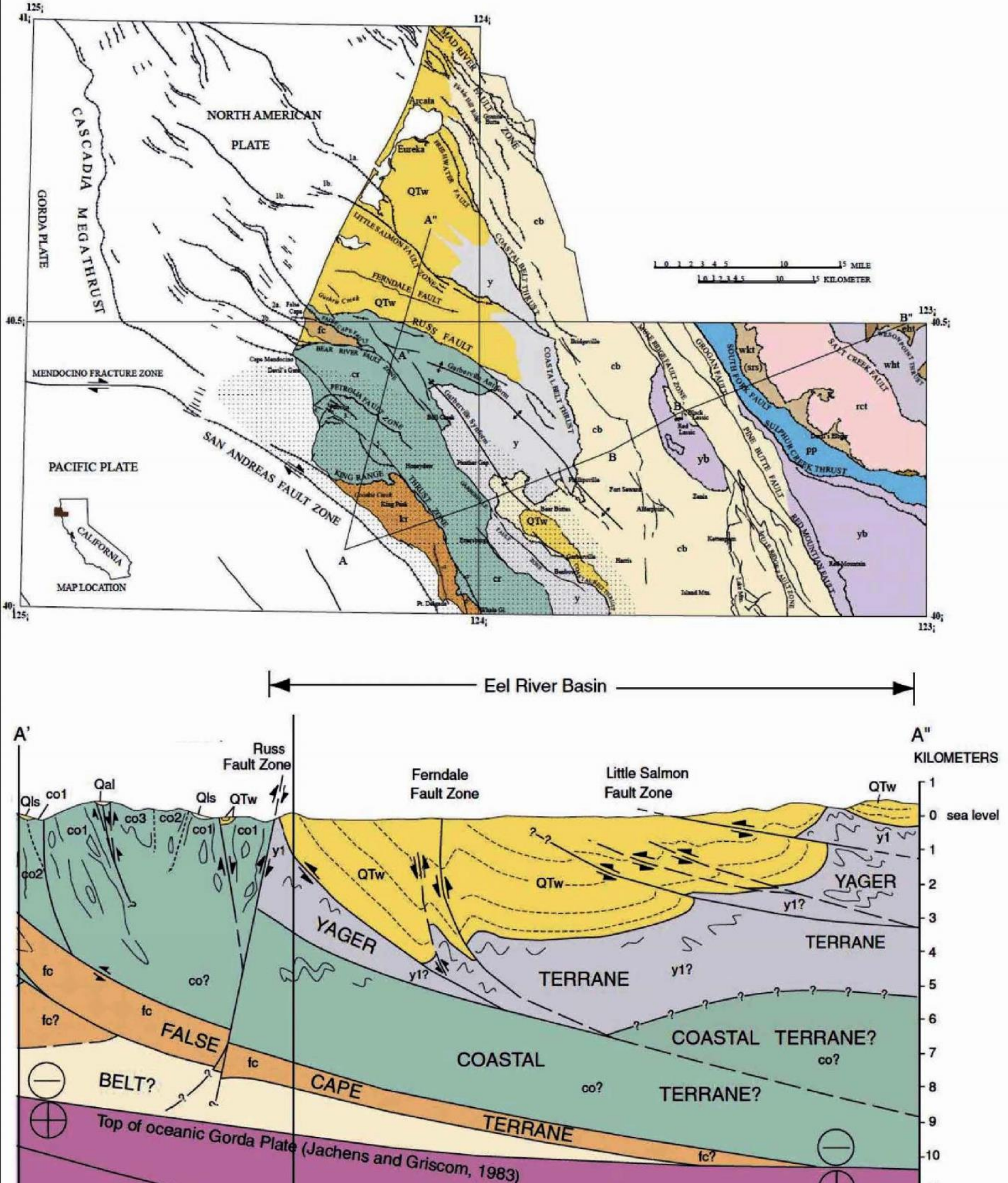

Regional Geology of Eel River coastal plain. Alignment of cross-sectional profile A'-A" (lower graphic) is indicated in upper graphic. Formation abbreviations: QTw – marine and non-marine siltsone, sandstone, and mudstone; y1 - sheared and highly folded mudstone of the Yager terrane; co – highly folded and sheared sandstone, mudtone (mélange) of the Coastal terrane; and fc – thin-bedded sandstone and limestone of the False Cape terrane. Data and Figure Modified from McLaughlin et al., 2000, and cited from KHE 2015.

California Department of Fish and Wildlife
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Regional Geologic Setting

FIGURE 3.6-1

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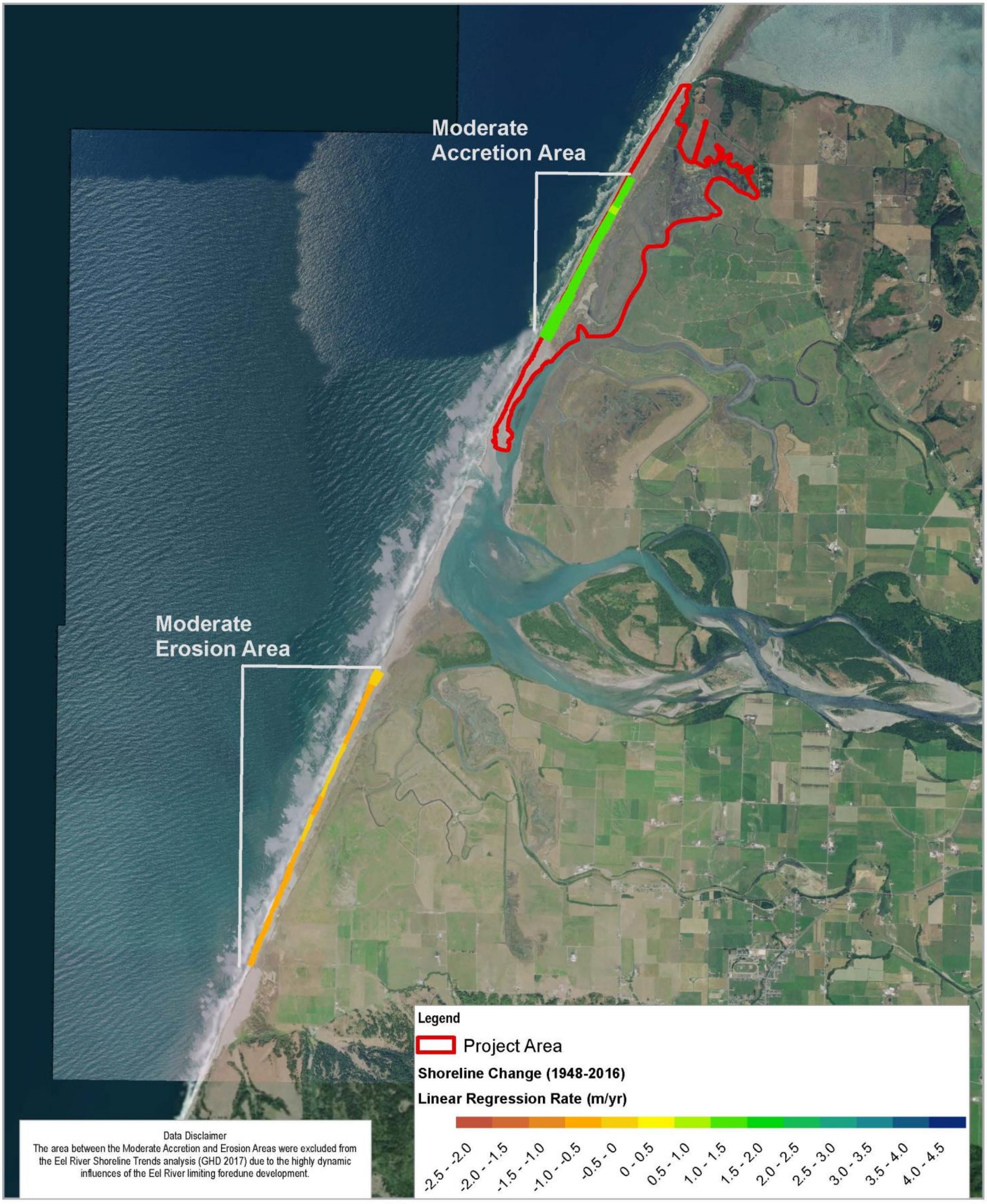

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Revision No. -
Date 6/22/2020

Shoreline Accretion and Erosion Trends
Eel River Segments

FIGURE 3.6-2

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Data source: Project Boundary, GHD, 10/17/2018; Shoreline change analysis, GHD, 2017; Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: jclark2