4.5 Geology, Soils, and Seismicity

This section evaluates potential environmental impacts related to geology and soils during construction and operation of the project. Information in this section is based in part on the Geologic Hazard Evaluation and Soils Engineering Report, Samoa Peninsula Wastewater Project (SHN 2018). In addition to the analysis provided in this section, the following subjects are related to geology and soils, but are evaluated in other sections of this EIR:

- Potential impacts to water quality due to erosion, runoff, or alteration of drainage patterns are evaluated in Section 4.8 (Hydrology and Water Quality)
- Potential impacts related to tsunami inundation are also evaluated in Section 4.8 (Hydrology and Water Quality)

4.5.1 Setting

Regional and Local Geology

Northwestern California is located in a complex tectonic region dominated by northeast-southwest oriented compression associated with collision of the Gorda and North American tectonic plates. The Gorda plate is being actively subducted beneath North America north of Cape Mendocino, along the southern part of what is commonly referred to as the Cascadia Subduction Zone. This plate convergence has resulted in a broad fold and thrust belt along the western edge of the accretionary margin of the North American plate. In the Humboldt Bay region, this fold and thrust belt is manifested as a series of northwest-trending, southeast-dipping thrust faults, including the Little Salmon fault and faults that comprise the Mad River fault zone. These faults are active and are capable of generating large-magnitude earthquakes.

Basement rock in the Humboldt Bay region (that is, the regional Franciscan Formation) is unconformably overlain by a late Miocene to middle Pleistocene age sequence of marine and terrestrial deposits referred to as the Wildcat Group. The Wildcat Group, in turn, is truncated at its top by an unconformity of middle Pleistocene age, and is overlain by coastal plain and fluvial deposits of middle to late Pleistocene age. In the Eureka area, these middle and late Pleistocene age deposits are referred to as the Hookton Formation, and may be as much as 400 feet thick. Hookton Formation sediments are widely variable in texture and consistency, and are described as gravel, sand, silt, and clay.

Along the coast of northern California between Cape Mendocino to the south and Big Lagoon, about 60 miles to the north, a sequence of uplifted late Pleistocene age marine terraces is preserved. The City of Eureka, across Humboldt Bay from the Samoa Peninsula, occupies a series of northward-dipping terrace surfaces eroded into the Hookton Formation. Along the margins of Humboldt Bay, the Hookton Formation and marine terrace deposits are overlain by late Holocene age (younger than about 5-6,000 years old) bay muds and associated estuarine deposits, as well as local accumulations of dune deposits.

The project site is located along the Samoa Peninsula, the northern peninsula forming the oceanward side of Humboldt Bay. The location and morphology of Humboldt Bay is largely a result of tectonic processes. Humboldt Bay consists of two principal basins, Arcata Bay and South Bay. These shallow estuarine basins are connected across the bay mouth by the narrow "Eureka Channel." Each of the principal basins is associated with a tectonic syncline (that is, a crustal down-warp), and appears to represent a filled paleo-river valley. This is especially true in the northern basin, Arcata Bay, which appears to be an erosional feature associated with a former course of the Mad River. In that regard, much of the Samoa Peninsula is the remnant of the western divide of the Mad River drainage, and is underlain by the same earth materials that underlie the Eureka side of the bay. Toward the southern end of the Samoa Peninsula, the peninsula appears to transition into a true sand "spit," formed by the progradation of littoral sand transported in the longshore current. This is an important point, because the nature of the substrate underlying the Samoa Peninsula is a key consideration in the interpretation of geologic hazard.

The location of the inferred transition from an erosional "peninsula" with a core of older Pleistocene age sediment (Hookton Formation or equivalent), to a "spit" formed by prograding sand of late Holocene age, is not known. Based on geomorphic expression, the transition occurs near the southern end of the Samoa Peninsula. Two subsurface geologic transects have been developed across the bay, and help to constrain the location of the transition. One transect was developed by Caltrans (discussed in Geomatrix, 1994) at the location of the Samoa bridge just to the northeast of Samoa, the other was developed to the southwest at the location of a proposed wastewater treatment plant (Converse Davis Dixon Associates, 1976). Both of these geologic profiles suggest the central Samoa Peninsula is an erosional feature underlain by older sediments contiguous with those underlying the City of Eureka on the opposite side of the Eureka Channel/Humboldt Bay. Interpretation of the available geologic data suggests that the transition to a sand "spit" occurs south of the two profiles.

The entire Samoa Peninsula is covered with a variable thickness of dune sands. As discussed in Leroy (2000), the northern part of the Peninsula is covered with a thick sequence of dunes that can be subdivided into four distinct stratigraphic units. These dunes are typically forested, and reach as much as 60 to 70 feet above sea level. The town of Samoa occupies the southern end of these older, higher dunes. To the south, the Peninsula is covered with a relatively youthful accumulation of dunes that are generally less than 20 feet in elevation.

Groundwater is present at relatively shallow depth through the entire study area. Subsurface investigations have encountered groundwater typically within about 10 feet of sea level. Therefore, in low elevation areas south of Samoa, groundwater is expected to occur within the upper 5 to 10 feet of the ground surface. At the site of the Approved Samoa WWTF, which is at an elevation above 30 feet, the water table can be expected generally to occur below about 20 feet. Groundwater appears to occur most frequently within the loose dune sands in the upper 15 feet, and most boring logs note heaving sands at this stratigraphic interval (deeper drilling only occurs with drilling muds added to the borehole).

Seismicity and Faulting

The entire region is one of high seismicity; there are numerous active faults in close proximity to the site (see Table 4.5-1). The Samoa Peninsula occurs between the two primary onland fault zones within the fold-and-thrust belt described above–the Little Salmon fault zone and the Mad River fault zone. Although there are no known active faults crossing the Samoa Peninsula, an inferred fault, the North Spit fault has been identified near the southern end of the proposed project area. The North Spit fault has been identified in geophysical transects offshore of the Peninsula, but it has never been identified on land (either on the Peninsula or in Eureka); it is not considered active by the State.

Northwestern California is the most seismically active region in the continental United States. More than 60 earthquakes have produced discernable damage in the region since the mid-1800s. Historical seismicity and paleoseismic studies in the area suggest there are six distinct sources of damaging earthquakes in the northcoast region (Dengler et al. 1992):

Gorda plate earthquakes account for the majority of historical seismicity. These earthquakes occur primarily offshore along left-lateral faults, and are generated by the internal deformation within the plate as it moves toward the subduction zone. Significant historic Gorda Plate earthquakes have ranged in magnitude (M) from M5 to M7.5. The November 8, 1980, earthquake (M7.2) was generated on a left-lateral fault within the Gorda Plate.

The **Mendocino fault** is the second most frequent source of earthquakes in the region. The fault represents the plate boundary between the Gorda and Pacific plates, and typically generates right-lateral strike-slip displacement. Historic Mendocino fault events have ranged in magnitude from M5 to M7.5. The September 1, 1994, M7.2 event west of Petrolia was generated along the Mendocino fault. The Mendocino triple junction was identified as a separate seismic source only after the August 17, 1991 (M6.0) earthquake. Events associated with the triple junction are shallow onshore earthquakes that appear to range in magnitude from about M5 to M6. Raised Holocene terraces near Cape Mendocino suggest larger events are possible in this region.

Northern San Andreas fault events are rare but can be very large. The northern San Andreas fault is a right-lateral strike-slip fault that represents the plate boundary between the Pacific and North American plates. The fault extends through the Point Delgada region and terminates at the Mendocino triple junction. The 1906 San Francisco earthquake (M8.3) caused the most significant damage in the northcoast region, with the possible exception of the 1992 Petrolia earthquake.

Earthquakes within the **North American plate** can be anticipated from a number of intraplate sources, including the Mad River fault zone. There has been no large-magnitude earthquake associated with faults within the North American plate, although the December 21, 1954, M6.5 event may have occurred in the Mad River fault zone. Expected magnitudes for North American plate earthquakes are in the M6.5 to M8 range.

The **Cascadia Subduction Zone** represents the most significant potential seismic source in the northcoast region. A great subduction event may rupture along 200 km or more of the coast from Cape Mendocino to British Columbia, may be up to M9.5, and could be associated with extensive tsunami inundation in low-lying coastal areas. The April 25, 1992, Petrolia earthquake (M7.1) appears to be the only documented historical earthquake involving slip along the subduction zone, but this event was confined to the southernmost portion of the fault. Paleoseismic studies along the subduction zone suggest that great earthquakes are generated along the zone every 300 to 800 years. The last large subduction earthquake occurred in 1700. A great subduction earthquake would generate long duration, very strong ground shaking throughout the Pacific Northwest.

Table 4.5-1 Active Faults near the Project Area

Fault	Distance and Direction from the Project
Little Salmon	1.2 miles to the southwest
Fickle Hill	6.5 miles to the northeast
Mad River	8.8 miles to the northeast
Cascadia Subduction Zone	34.2 miles to the west
San Andreas	49.5 miles to the south

Surface Fault Rupture

Surface fault rupture describes displacement of the ground surface along a fault during an earthquake. Depending on the type of fault, this displacement may be horizontal, vertical, or both. Damage from fault rupture can be severe depending on the size of the displacement, but is limited to the relatively narrow area along the fault where it daylights at the ground surface. Surface fault rupture may occur as a discrete rupture trace or a broad zone of distributed shearing. Not all earthquakes result in fault rupture that reaches the ground surface; the larger the earthquake, the more likely it is to generate surface fault rupture.

Ground Shaking

Ground shaking is the primary cause of damage and injury during earthquakes. Ground-shaking impacts can lead to a variety of secondary seismic effects, including liquefaction, lateral spreading, and landslides. Ground shaking levels are typically a result of the size of the earthquake generating the shaking and the proximity to the fault source. Seismic shaking is influenced by the geology at a site; thick accumulations of saturated, unconsolidated sediments tend to amplify long wavelength seismic waves, while hard bedrock tends to amplify short wavelength seismic waves.

Earthquake size is measured in a variety of ways. These methods tend to focus on direct measurement of the amount of seismic energy released during the earthquake or on the characterization of human-felt effects. The most common and widely accepted method of measuring earthquake magnitude is the moment magnitude scale. The moment magnitude scale is based on the total moment (energy) release of the earthquake. This scale accounts for a variety of earthquake sizes, including large earthquakes. It is derived from modeling recordings of the earthquake at multiple stations.

The Modified Mercalli Intensity Scale for Earthquakes, shown in Table 4.5-2, describes ground-shaking intensity in terms of human perception and damage to the built environment, and takes into account localized earthquake effects.

Table 4.5-2 Modified Mercalli Intensity Level

Scale	Earthquake Effects
I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI.	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII.	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Liquefaction

Liquefaction is described as the sudden loss of soil shear strength due to a rapid increase of soil pore water pressures caused by cyclic loading from a seismic event. In simple terms, it means that a liquefied soil acts more like a fluid than a solid when shaken during an earthquake. In order for liquefaction to occur, the following are needed:

- granular soils (sand, silty sand, sandy silt, and some gravels),
- a high groundwater table, and
- a low density of the granular soils (typically associated with young geologic age).

The adverse effects of liquefaction include local and regional ground settlement, ground cracking and expulsion of water and sand, the partial or complete loss of bearing and confining forces used to support loads, amplification of seismic shaking, and lateral spreading. During liquefaction events, pipelines tend to become buoyant due to the loss of confining pressure and “float” toward the ground surface.

Lateral spreading is defined as lateral earth movement of liquefied soils, or competent strata riding on a liquefied soil layer, downslope toward an unsupported slope face, such as a creek bank, or in this case toward the bay. In general, lateral spreading is typically observed on low to moderate gradient slopes but has been noted on slopes inclined as flat as one degree.

Seismically induced ground failures have been documented on two occasions in the project vicinity following historical moderate to large magnitude earthquakes. Specific accounts of historical ground failures include the following account from the 1906 earthquake:

> *At Samoa…where the Vance Company has its mill and warehouses. At one warehouse, the ground sunk beneath it several feet. The floor of the planing mill sank several inches on the east side and some are of the opinion that the factories settled also at one wall* (Youd and Hoose, 1978).

Historical photographs indicate that the Vance Company mill complex was located along the bayfront, and likely was founded on unengineered, “reclaimed” bay soils. It is, therefore, not surprising that ground deformation occurred during the 1906 earthquake, as similar events were documented in reclaimed soils along the bayfront elsewhere.

In 1954, the following account is recorded:

> *Hammond Lumber Company brought its operations to a sudden halt when several breaks occurred in the underground main of the company’s fire protection system. A.O. LeFors, spokesperson for Hammond, stated that the mill will not operate in Samoa or at its Eureka plants until repairs have been made* (Youd and Hoose, 1978).

Humboldt County GIS Hazard maps identify the area as being potentially susceptible to liquefaction hazards (Humboldt County 2018). Subsurface investigations on the Samoa Peninsula have encountered young and unconsolidated clean sands and loose- to medium-dense sands extending to depths of about 15 feet (SHN 2018). The lower part of this section of loose Holocene age sand is typically below the water table, which may rise seasonally to within a few feet of the ground surface. When saturated, such soils are predisposed to liquefaction and other related soil behavior. Heaving sand conditions were encountered at shallow depths when hand augurs were advanced during geotechnical studies for this project (SHN 2018). Quantitative liquefaction assessment conducted at the Town of Samoa identified limited intervals of liquefiable sediments below the water table, as below about 15 feet the material becomes too dense to liquefy (SHN 2018). Estimated total settlement values for the upper sediments were on the order of a few inches or less. Liquefaction can result in flotation of buried pipelines.

Landslides

Landslides occur when soils on a hillside become unstable and slide down a slope. Landslides can occur in soil or rock, and they are typically caused by excessive atmospheric moisture or by seismic shaking. Where the failed material is granular or rocky, landslides tend to occur quickly and catastrophically; where cohesive soils are present, landslides will form as slow-moving flows. Landslide risk depends on the types of earth materials of the hillside and the steepness of the slope. As the Samoa Peninsula within the project area is a low-relief area absent of significant sloping ground, there are no known landslide hazards shown on available published geologic hazard maps.

4.5.2 Regulatory Framework

Federal

There are no federal plans, policies, regulations, or laws related to geology and soils applicable to this project.

State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this act, the State Geologist established regulatory zones, called "earthquake fault zones," around the surface traces of active faults and published maps showing these zones. Within these zones, buildings for human occupancy cannot be constructed across the surface trace of active faults. Because many active faults are complex and consist of more than one branch, each earthquake fault zone extends approximately 200 to 500 feet on either side of the mapped fault trace.

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. There are no Alquist-Priolo Earthquake Fault Zones within the project area (CDC 2018). Therefore, the provisions of the 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. 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, where the state is charged with identifying and mapping areas at risk of strong groundshaking, liquefaction, landslides, and other corollary hazards, with cities and counties required to regulate development within mapped Seismic Hazard Zones.

Under the California Seismic Hazards Mapping Act, permit review is the primary mechanism for local regulation of development. Specifically, 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 and measures to reduce potential damage have been incorporated into the development plans. The California Geological Survey has not yet evaluated the project site or surrounding area under the Seismic Hazards Mapping Act.

Regional and Local

Humboldt Bay Area Plan of the Local Coastal Program

For the project site, the relevant local hazard mitigation plan relative to geohazards appears in the Humboldt Bay Area Plan (HBAP) of the Humboldt County Local Coastal Program (Humboldt County 2014). As stated within the HBAP, sections marked *** contain relevant Coastal Act policies that have also been enacted as County policy. The pertinent section follows:

Section 3.17 (Hazards) states in part:

*** 30253. New Development shall:

1. Minimize risks to life and property in areas of high geologic, flood and fire hazard.
2. Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding areas or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

A. PLANNED USES

The hazard policies apply to all new development within the planning area. For the most part these policies have been extracted from Humboldt County's adopted Seismic Safety Element.

The only area with any significant instability problem planned for more intense development is on Humboldt Hill, east of Highway 101, which is classified as an area of "moderate instability," according to County seismic safety maps. Another significant hazard to development within most of the agricultural lands and along both the North and South Spits is liquefaction. Much of this same area is also within the limit of the 100-year floodplain, and is in an area of potential tsunami runup. Maps of slope stability hazards are included in Appendix D, and are referenced in policies from the Seismic Safety element of the General Plan which are reiterated below. The numerical index on these maps indicate relative slope stability and are to be used with the risk rating matrix in Appendix C. This information indicates where a site investigation would be required prior to the issuance of a development permit (see policy section 2 below).

B. DEVELOPMENT POLICIES

1. New development shall be consistent with the adopted Humboldt County Safety and Seismic Safety element of the General Plan. Of particular interest, when siting new development, the Natural Hazards/Land Use Risk Rating Matrix on Figure 3-5, Section 3300 of Vol. 1 should be used in conjunction with Plate III. Plate III is a map delineating seismic zones relating to earthquake shaking as well as land stability and other natural hazard conformation.
2. The County shall amend Chapter 70, Section 7006, of the Uniform Building Code to require soil engineering and geological engineering investigations, prepared by a registered geologist or by a professional civil engineer with experience in soil mechanics or foundation engineering, or by a certified engineering geologist, for classes of development and hazard areas as shown in Table 1 and Plate III and DNOD maps as attached (See Appendices C, D & E).

a. The report should consider, describe and analyze the following.

(1) Cliff geometry and site topography, extending the surveying work beyond the site as needed to depict unusual geomorphic conditions that might affect the site;

(2) Historic, current and foreseeable cliff erosion, including investigation of recorded land surveys and tax assessment records in addition to the use of

historic maps and photographs where available and possible changes in shore configuration and sand transport;

(3) Geologic conditions, including soil, sediment and rock types and characteristics in addition to structural features, such as bedding, joint and faults;

(4) Evidence of past or potential landslide conditions, the implications of such conditions for the proposed development, and the potential effects of the development on landslide activity;

(5) Impact of construction activity on the stability of the site and adjacent area;

(6) Ground and surface water conditions and variations, including hydrologic changes caused by the development (i.e. introduction of sewage effluent and irrigation water to the ground water system; alterations in surface drainage);

(7) Potential erodibility of site and mitigating measures to be used to ensure minimized erosion problems during and after construction (i.e. landscaping and drainage design);

(8) Effects of marine erosion on seacliffs;

(9) Potential effects of seismic forces resulting from a maximum credible earthquake;

(10) Any other factors that might affect slope stability.

b. The report should evaluate the off-site impacts of development (e.g. development contributing to geological instability on access roads) and the additional impacts that might occur due to the proposed development (e.g. increased soil moisture from a septic system). The report should also detail mitigation measures for any potential impacts and should outline alternative solutions. The report should express a professional opinion as to whether the project can be designed so that it will neither be subject to nor contribute to significant geologic instability throughout the lifespan of the project. The report should use a currently acceptable engineering stability analysis method and should also describe the degree of uncertainty of analytical results due to assumptions and unknowns. The degree of analysis required should be appropriate to the degree of potential risk presented by the site and the proposed project.

c. The developments permitted in the hazard areas shall be sited and designed to assure stability and structural integrity for their expected economic life spans while minimizing alteration of natural landforms. Bluff and cliff developments (including related storm runoff, foot traffic, site preparation, construction activity, irrigation, waste water disposal and other activities and facilities accompanying such development) shall not create or contribute significantly to problems of erosion or geologic instability on the site or on surrounding geologically hazardous areas.

d. Alteration of cliffs and bluff tops, faces, or bases by excavation or other means shall be minimized. Cliff retaining walls shall be allowed only to stabilize slopes.

3. Tsunamis–New development below the level of the 100 year tsunami run-up elevation described in Tsunami Predictions for the West Coast of the Continental United States (Technical Report H-78-26 by the Corps of Engineers) shall be limited to public access, boating, public recreation facilities, agriculture, wildlife management, habitat restoration, and ocean intakes, outfalls, and pipelines, and dredge spoils disposal. New subdivisions or development projects which could result in one or more additional dwelling units within a potential tsunami run-up area shall require submission of a tsunami vulnerability report which provides a site-specific prediction of tsunami run-up elevation resultant from a local Cascadia subduction zone major earthquake.

4.5.3 Evaluation Criteria and Thresholds of Significance

For the purpose of this EIR, the evaluation criteria and significance thresholds summarized below are used to determine if the project would have a significant effect related to geology and soils. The following questions are from CEQA Guidelines' Appendix G Environmental Checklist Section VI. Would the project:

a. Expose people or structures to potential substantial adverse effects, including the risk of 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 substantial evidence of a known fault?
   - Location of project crossing a mapped Alquist-Priolo Fault Zone or other known fault.

   ii. strong seismic ground shaking?
   - Construction not in conformance with requirements of applicable building code(s) and geotechnical design practice.

   iii. seismic-related ground failure, including liquefaction?
   - Non-compliance with recommendations of project-specific geotechnical report.

   iv. Landslides?
   - Location of project coincides with known landslide hazards shown on available published geologic hazard maps.

b. Result in substantial soil erosion or the loss of topsoil?

   - Non-compliance with SWRCB's NPDES stormwater permit for general construction activity (Order 2009-0009-DWQ).

c. Be located on a geologic unit or soil that is unstable, or that would become unstable and potentially result in on or offsite landslides, lateral spreading, subsidence, liquefaction or collapse?

d. Non-compliance with SWRCB's NPDES stormwater permit for general construction activity (Order 2009-0009-DWQ)?

   - Non-compliance with requirements of applicable building code(s).
   - Non-compliance with recommendations of project-specific geotechnical report.

e. 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?

- Non-compliance with recommendations of project-specific geotechnical report.
- Non-compliance with requirements of applicable building code(s).
- Non-compliance with recommendations of project-specific geotechnical report.

f. 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?

- Installation of septic systems or wastewater disposal systems in unsuitable soils.

4.5.4 Methodology

Geotechnical reports for this project and other projects on the Samoa Peninsula, as well as published geologic maps and reports, were reviewed to develop the conclusions presented herein. Evaluation of the potential impacts are based on information obtained from available literature, state policies regarding geologic hazards (surface fault rupture), State and local maps showing tsunami inundation potential, Humboldt County policies and codes, and field visits.

In accordance with CEQA, the effects of a project are evaluated to determine if they would result in a significant adverse impact on the environment. Geology and soil impacts are analyzed below according to topic. Mitigation measures directly correspond with an identified impact. As there are no perceived differences between potential geologic impacts relative to the "short-term" and "long-term" phases, they are discussed together in the following section.

4.5.5 Impact Analysis

Impact GEO-1: **Would the project expose people or structures to potential substantial adverse effects 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?**

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.a.i) identified in Section 4.5.3.

The project site is not within an Alquist-Priolo Earthquake Fault Zone. Therefore, there would be **no impact** from exposure to rupture of a known earthquake fault delineated on the Alquist-Priolo Earthquake Fault Zoning Map.

Significance *No Impact*

Mitigation **None Required**

Impact GEO-2: **Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death, involving strong seismic ground shaking?**

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.a.ii) identified in Section 4.5.3.

Strong seismic shaking may have an impact on project improvements, as the project area is located in a seismically active area with several faults, capable of producing moderate to large earthquakes, within 10 miles of the project site. Strong seismic ground shaking is more likely to impact above-grade facilities associated with the project improvements to the Approved Samoa WWTF. The project's buried PVC pipelines are less likely to be impacted by strong ground shaking, although pipeline joints may be stressed under strong, long-duration shaking conditions. Therefore, the project's impact from exposure to strong seismic ground shaking would be **significant**.

Significance *Significant*

Mitigation **GEO-2: Reduce Geologic Hazards through Design and Construction Measures**

The PCSD shall design and construct the project in conformance with the specific recommendations contained in the geotechnical report prepared for the project. Specifically, the design and construction shall be consistent with the geotechnical recommendations for seismic design and liquefiable soils, which may include flexible joints for underground utilities, preventing flotation of pipelines, earthwork, and excavation. Professional inspection of the pipe installation and any foundations shall be performed during construction to ensure compliance with the recommendations.

After Mitigation *Less than Significant with Mitigation*

Implementation of Mitigation Measure GEO-2, Reduce Geologic Hazards through Design and Construction Measures, would reduce significant impacts from strong seismic ground shaking to a less-than-significant level by implementing design and construction measures identified in the site-specific geotechnical study.

Impact GEO-3: **Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death, involving seismic-related ground failure, including liquefaction?**

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.a.iii) identified in Section 4.5.3.

The Humboldt County GIS Hazard maps identify the project area as being potentially susceptible to liquefaction hazards. The project area is underlain by geologically youthful and unconsolidated clean sands and loose- to medium-dense sands extending to depths of about 15 feet. The lower part of this section of loose Holocene age sand is typically below the water table, which may rise seasonally to within a few feet of the ground surface. When saturated, such soils are predisposed to liquefaction and other related soil behavior. There are historic accounts of liquefaction-related effects on the Samoa Peninsula during previous earthquakes. For the subject project, liquefaction may affect the bearing capacity of subgrade soils beneath above-ground facilities (WWTF and individual pump stations). Project facilities would be subject to liquefaction during an earthquake. The impact from exposure to liquefaction would be **significant**.

Significance *Significant*

Mitigation **GEO-2: Reduce Geologic Hazards through Design and Construction Measures**

Refer to Impact GEO-2 above for the full text of Mitigation Measure GEO-2: Reduce Geologic Hazards through Design and Construction Measures.

After Mitigation *Less than Significant with Mitigation*

Implementation of Mitigation Measure GEO-2, Reduce Geologic Hazards through Design and Construction Measures, would reduce significant impacts from seismic-related ground failure to a less-than-significant level by implementing design and construction measures identified in the site-specific geotechnical study.

Impact GEO-4: Would the project expose people or structures to potential substantial adverse effects involving landslides?

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.a.iv) identified in Section 4.5.3.

The Samoa Peninsula is a sand-covered Peninsula associated with minimal topographic relief. The project area is not associated with significant slopes that are subject to landslides. Therefore, there would be **no impact**.

Significance *No Impact*

Mitigation **None Required**

Impact GEO-5: Would the project result in substantial soil erosion or the loss of topsoil?

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.b) identified in Section 4.5.3.

The project area is underlain by loose dune sand with a high erosion potential. However, the project area is relatively flat, so the potential for the project improvements to generate erosion, even in loose dune sands, is relatively low. In addition, the improvements to the Approved Samoa WWTF would be isolated to an already developed site that would retain stormwater, and any potential sediment or flows that could cause erosion, on site. The pipeline improvements would be installed beneath flat paved roadways. These underground facilities would not cause erosion. Therefore, the project's impact on soil erosion would be **less than significant**.

Significance *Less than Significant*

Mitigation **None Required**

Impact GEO-6: 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?

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.c) identified in Section 4.5.3.

As discussed above, the project site is located on a low gradient, sand-covered coastal peninsula. Although liquefaction is a potential hazard during strong seismic shaking (see discussion in Impact GEO-3, above), the area is not subject to "unstable" soils that would be impacted by the project. Nor would the project alter soil conditions such that previously "stable" soils become "unstable." Neither construction nor operation include strong vibration activities, such as pile driving, which would result in liquefaction or subsidence. As noted under Impact GEO-4, the site is flat and not subject to landslides.

The impact associated with the project relative to unstable soils in the project area would be **less than significant**.

Significance *Less Than Significant*

Mitigation **None Required**

Impact GEO-7: Would the project 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?

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.d) identified in Section 4.5.3.

The project site is underlain by sandy soils that are not associated with the potential for soil expansion. Geotechnical testing of soils from the Samoa Peninsula have not identified soils subject to potential expansivity. Therefore, there would be **no impact**.

Significance *No Impact*

Mitigation **None Required**

Impact GEO-8: Would the project 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?

This impact analysis addresses CEQA Guidelines Appendix G checklist item VI.e) identified in Section 4.5.3.

The project does not involve the use of septic tanks. The project would develop a wastewater collection and treatment system so that existing septic systems, that are currently located in soils incapable of adequately supporting the septic tanks, on the Samoa Peninsula can be removed. The existing onsite sewage disposal systems are problematic on the peninsula, due to the highly permeable nature of the surficial dune sands and the high levels of tidally-influenced groundwater. The project would be beneficial to the soils and water quality at the location of the existing septic systems, and therefore the project would have **no impact** from the addition of new septic tanks as the project does not include the installation of new septic tanks.

Significance *No Impact*

Mitigation **None Required**

4.5.6 Cumulative Impacts

Impact C-GEO-1: Would the project result in a cumulatively considerable contribution to a significant cumulative impact related to geology and soils?

The nature of geologic hazards is site-specific, and, therefore, geologic hazards do not accumulate as impacts on resources do, as indicated in other sections of this EIR. Construction would be consistent with current standards for seismic and geologic hazards. No cumulatively considerable impact would occur.

Significance *No Impact*

Mitigation **None Required**

4.5.7 References

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