Notes from Foundation Engineering, Inc Preliminary Geotechnical Investigation
Stamped report dated July 23rd, final draft received 8/2/2021

The boring extended to a depth of ±66.5 feet. Samples were retained at 2½-foot intervals to a depth of ±20 feet and typically at 5-foot intervals thereafter. Soil samples were obtained in conjunction with Standard Penetration Testing (SPT). The SPT provides an indication of the relative stiffness, or density, of the foundation soils. The number of blows required to drive the sampler the final 12 inches of an 18-inch long drive is recorded and represents the standard penetration resistance, or N-value, in blows per foot (bpf).

The subsurface conditions are relatively consistent to a depth of ±66.5 feet, the maximum depth of our exploration. The soils consist of predominantly light brown, fine sand with trace to some silt (Quaternary dune sand). This soil unit is consistent with the locally mapped geology, which suggests the area is underlain by sand to a depth of ±127 feet followed by sedimentary bedrock (Schlicker et al., 1972).

The recorded SPT N-values included on the appended log show a trend of increasing soil density with depth.

Mud-rotary drilling methods precluded an accurate groundwater measurement in BH-1 at the time of drilling. However, we noted the retained samples were damp to moist to a depth of 60 feet and moist to wet thereafter. This information suggests groundwater was likely present at a depth between ±51.5 and 60 feet at the time of our investigation.

Fault Rupture
We reviewed local geologic maps and the USGS Interactive Fault Map to identify potentially active crustal faults at and surrounding the project area. The available data indicates no known potentially active crustal faults or mapped faults extend beneath the project site (Schlicker et al., 1972; Niem and Niem, 1985; USGS, 2006). The nearest mapped potentially active crustal faults (Class A) are the Cascadia Fold and Fault Belt and unnamed offshore faults scattered within ±5 miles west of the site (USGS, 2006).

Liquefaction
Liquefaction is typically observed in saturated deposits of loose sand and non-plastic or low plasticity silt (i.e., a PI of less than 8) subjected to intense ground shaking. The soils underlying the site include loose sand to ±12.5 feet, followed by medium dense sand to ±50 feet, and dense to very dense sand at greater depths. The static groundwater is anticipated to be below a depth of ±50 feet. Therefore, the loose sandy soils are well above the anticipated groundwater level and these soils are not expected to become saturated enough to exhibit liquefaction.
We completed a preliminary liquefaction analysis based on the soil profile encountered in BH-1. We assumed a groundwater level at a depth of ±50 feet. The analysis suggests the dense to very dense sand encountered below ±50 feet is not susceptible to liquefaction.

Lateral Spread

Lateral spread is a liquefaction-induced hazard, which occurs when soil or blocks of soil are displaced down slope or toward a free face along a liquefied layer. The liquefaction hazard at the site is considered low. Therefore, the lateral spread hazard at the site should also be considered low.

Settlement of Unsaturated Soils

Settlement of unsaturated granular soils can occur under seismic loading due to soil densification. SPT N-values in the sand above the assumed static groundwater level (i.e., the upper ±50 feet of the soil profile) ranged from ±5 to 29 bpf indicating a loose to medium dense consistency. This material may be susceptible to settlement or densification under seismic loading. Additional drilling during the Phase 2 work will confirm the thickness and density of the sand above the groundwater level.

Landslides and Earthquake-Induced Landslides (Slope Stability)

The existing topography at the site is relatively flat with a gentle slope to the west and a steep slope to the east. No landslide or slope instability features were observed on site during our reconnaissance. DOGAMI's references, including LiDAR, also indicate no historic landslide inventory or mapped landslides at the site with a mostly low landslide susceptibility with isolated moderate susceptibility (DOGAMI, 2016, 2017, 2018).

We completed a preliminary evaluation of the slope stability of the east slope under static and seismic loads using limit equilibrium analysis with pseudo-static loading. The analysis was completed using the program SLIDE by Rocscience. Limits to the minimum Factor of Safety (FS) search were established to preclude the selection of shallow failure surfaces. The limits were set requiring the top of the failure surface to be set back from the crest of the slope and lower portion of the failure surface to pass through the toe of the slope.

The results suggest relatively high FS for static slope stability. However, a shallow slope failure in the loose sand stratum may occur under seismic loading. Additional explorations should be completed during the Phase 2 work to refine the thickness of the loose sand and evaluate the required slope setback distance for the proposed facilities.

Subsidence

Seismic-ground subsidence is a regional phenomenon resulting from a large magnitude earthquake generated from a subduction source, such as the CSZ. It occurs because the subduction of the oceanic crust beneath the continental crust compresses the continental crust and pushes it upward. Prior to the earthquake, the continental crust is held in this position by friction at the interface. The frictional bond breaks when the earthquake occurs, allowing the continental crust to drop.

The hazard map included in the Oregon Resilience Plan indicates ground subsidence in the project area could range from ±4 to 6 feet for a Mw 9 earthquake (OSSPAC, 2013). Ground subsidence cannot be mitigated. Therefore, it should be assumed the ground surface in the project area may drop up to 6 feet during a large CSZ interface earthquake.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Based on the preliminary geotechnical investigation described above, we have concluded the following:

1. Our preliminary investigation suggests there are several geologic or geotechnical hazards associated with building on the Oregon Coast, however, these hazards do not necessarily preclude building at the proposed site. Potential geologic hazards include ground motion amplification, settlement of non-liquefiable soil, slope stability, subsidence, and tsunami inundation. Full mitigation of these hazards is not practical. Therefore, risks from these hazards will need to be accepted for the construction of the proposed facilities. A more detailed analysis of the geologic and seismic hazards should be completed as part of a site-specific hazard study during the design-phase work, once the location, type and size of the facility is known. Additional explorations will be necessary to refine our preliminary analyses and provide detailed mitigation recommendations.

2. The site can be used for the planned development. However, densification of the upper loose sand is recommended to improve the bearing resistance of the soil and reduce potential settlement due to both static foundation loads and seismic ground shaking.
For planning and budgeting purposes, assume mitigation of loose sand will be required beneath building foundations and any settlement-sensitive hardscapes. The mitigation should be relatively straightforward and consist of excavating the sand to a depth of ±10 feet, moisture-conditioning the sand, and placing it back into the excavation and mechanically compacting it in lifts.

3. Conventional shallow foundations (i.e., spread footings and continuous wall footings) should be suitable to support the proposed facilities after the recompaction of the loose soil is completed.

4. Groundwater is not expected to be a critical geotechnical issue.

5. Additional exploratory drilling is recommended to evaluate the limits of overexcavation for the proposed facilities and provide detailed site grading and foundation design and construction recommendations.