Geologic Hazards and
Geotechnical Investigation
For Retaining Wall
Tax Lot 2801, Map 07-11-22CD
2808 SW Anchor Court
Lincoln City, Lincoln County, Oregon

Prepared for:
Mr. Charles Herman
[redacted]

Project #Y234666

February 10, 2023

H.G. Schlicker & Associates, Inc.

H.G. Schlicker & Associates, Inc.
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Project #Y234666 February 10, 2023

To: **Mr. Charles Herman**
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Subject: **Geologic Hazards and**
Geotechnical Investigation For Retaining Wall
Tax Lot 2801, Map 07-11-22CD
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Lincoln City, Lincoln County, Oregon

Dear Mr. Herman:

The accompanying report presents the results of our geologic hazards and geotechnical investigation for a retaining wall at the above subject site.

After you have reviewed our report, we would be pleased to discuss it and to answer any questions you might have.

This opportunity to be of service is sincerely appreciated. If we can be of any further assistance, please contact us.

H.G. SCHLICKER & ASSOCIATES, INC.

Adam M. Large, MSc, RG, CEG,
President/Principal Engineering Geologist

AML:mgb

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H.G. Schlicker & Associates, Inc.
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Dear Mr. Herman:

1.0 Introduction and General Information

At your request and authorization, a representative of H.G. Schlicker and Associates, Inc. (HGSA) visited the subject site on January 17, 2023, to complete a geologic hazards and geotechnical investigation of Tax Lot 2801, Map 07-11-22CD, located a 2808 SW Anchor Court in Lincoln City, Oregon (Figures 1 and 2; Appendix A). We previously visited the site in 2009. It is our understanding that you are replacing a free-standing retaining wall along your driveway in the southwest portion of the site.

This report addresses the engineering geology and geologic hazards at the site with respect to constructing a retaining wall. The scope of our work consisted of a site visit, site observations and measurements, hand augered borings, slope profiles, limited review of the geologic literature, interpretation of topographic maps, lidar, and aerial photographs, and preparation of this report which provides our findings, conclusions, and recommendations.

2.0 Site Description

The subject site is located in the Nelscott area of Lincoln City, Oregon (Figure 1). The ocean view site consists of an irregularly shaped tax lot which is approximately 170 feet deep, east to west, and 100 feet wide, north to south (Figure 2). An existing 2 to 3-story house is present on the site, with its lower floor consisting of daylight basements that are daylighted to the east (Appendix A). The site is bounded to its east by S.W. Anchor Avenue, to its west by S.W. Anchor Court, and to its north and south by adjacent lots. Access to the site is by way of an approximately 70-foot long driveway that enters from S.W. Anchor Court. A daylight basement garage is also present to its northeast that provides access from S.W. Anchor Avenue.

The westernmost edge of the site is located approximately 50 feet east of an approximately 70-foot high ocean bluff that slopes down to the west from approximately 40 to 70 degrees (Appendix A). The lower two-thirds of the bluff is sparsely vegetated with beach grass and salal, and the upper third of the bluff is not vegetated.

2.1 Proposed Development

Based on the information provided, you plan to construct a new 7-foot high by 48 feet long retaining wall along the driveway. We have provided geotechnical recommendations for design of the proposed free-standing retaining wall in Sections 8.1 through 8.12 below. HGSA should be contacted to review development plans for the site.

2.2 History of The Site and Surrounding Areas

According to Lincoln County records, the existing house was constructed in 1930, with the garage added in 1996. In the proposed construction area, we previously observed an approximately 6.5-foot-high stacked block and mortar retaining wall along the south side of the main driveway that supports a north-facing cut. This wall was tilting 2 to 3 degrees outward and had numerous cracks, indicating that the wall was failing.

At the time of our recent site visit, the block retaining wall had been demolished and generally removed; however, what appeared to be the concrete footing of the old retaining wall remained in the excavation. We observed marine terrace sand exposed in the approximately 4 to 7 feet tall near vertical cut slope. Forms for the footing of the new wall were present at the base of the slope. A large stockpile of sand soil spoils was present in the driveway (Appendix A).

The subject property is not oceanfront; the area west of the site does not have an oceanfront protective structure, and lies in an area of high bluffs that generally lack oceanfront protective structures. According to the Oregon Coastal Atlas Ocean Shores Data Viewer (http://www.coastalatlas.net/oceanshores, accessed January 2023), the lots west of S.W. Anchor Court are eligible for beachfront protective structures on the Goal 18 Eligibility Inventory. However, the potential to receive a permit for oceanfront protection is dependent upon meeting certain regulatory requirements in addition to the Goal 18 eligibility requirement.

2.3 Site Topography, Elevations and Slopes

The western portion of the subject site along SW Anchor Court is approximately 50 feet east of the top of a west-facing bluff, and the eastern portion of the site is located on an approximately 15 to 20 feet high east-facing hill slope along SW Anchor Avenue (Figures 2, 3 and 4). Lidar derived elevations at the site range from approximately 80 feet at the base of the eastern hillslope to approximately 104 feet at the upper portion of the site (NAVD 88) (Figure 3).

The area of the proposed retaining wall, along the driveway in the southwestern portion of the site, is generally flat to slightly sloping to the west (Figures 3 and 4).

2.4 Vegetation Cover

The excavated area, proposed for the construction of the retaining wall is devoid of vegetation; however, the top of the cut slope is vegetated with grass, salal and ornamental plants (Appendix A).

2.5 Subsurface Materials

Detailed descriptions and analyses of geology and subsurface materials at the site are provided in Section 3.0 below.

2.6 Site Oceanfront Conditions

The site is not identified as an oceanfront property, according to Lincoln County records.

2.7 Drift Logs or Flotsam

At the time of our site visit, we observed a few drift logs on the beach area west of the site. Satellite imagery indicates that the accumulation of driftwood and flotsam in the vicinity is generally light throughout the year.

2.8 Streams or Drainage and Influence on Beach Elevations

We did not observe streams in the vicinity of the site. The nearest major stream is the Siletz River, approximately 1.3 miles south of the site. Canyon Creek discharges onto the beach approximately 0.9 miles north of the site. The beach elevations near the site can be slightly influenced by the mouth of the bay; however, beach elevations west of the site are predominantly influenced by ocean waves and currents.

2.9 Headland Proximity and Influence on Beach Sediment Transport and Elevations

Generally, headlands are not present in this local section of the Oregon Coast and the Lincoln City oceanfront. The site lies within the Lincoln littoral cell. Smaller rock outcrops and reefs near the shoreline appear to have influenced the seasonal/periodic formation of rip currents and rip current embayments along this section of the coast, limiting the ability of rip currents to scour a deep channel to the back beach area. The sands within the Lincoln littoral cell are believed to have little or no transport beyond Cascade Head to the north and Cape Foulweather to the south.

2.10 Shore Protection Structures

The site is not identified as an oceanfront property, according to Lincoln County records. Oceanfront protection is not present on the lots west of S.W. Anchor Court.

2.11 Beach Access Pathways

There is no direct access to the beach from the subject site. The nearest public beach access is present approximately 450 feet north of the site off S.W. Anchor Avenue.

2.12 Human Impacts and Influence on Site Resistance to Ocean Wave Attack

The site is not identified as an oceanfront property, according to Lincoln County records. Based on our observations, direct human impacts are not contributing to the alteration of the resistance of the bluff west of the site from wave attack.

3.0 Geologic Mapping, Investigation and Descriptions

3.1 Geology

The site lies in an area which has been mapped as Quaternary marine terrace deposits consisting of semi-consolidated, fine- to medium-grained, uplifted beach sand overlain locally by fine-grained stabilized dune deposits (Schlicker et al. 1973; Snavely et al., 1976). The uplifted marine terrace sediments are typically high-energy near-shore marine deposits capped by beach and dune sand (Kelsey et al., 1996).

The marine terrace deposits mantle wave-cut benches on tilted strata of upper Eocene Nestucca Formation. The Nestucca Formation consists of thin-bedded, tuffaceous marine siltstone and sandstone with interbeds of tuff and glauconitic sandstone. Locally the Nestucca Formation dips to the west at approximately 20 degrees and is below beach level.

The bluff slope west of the site exposes tan, dense, friable, fine- to medium-grained terrace sand along the lower two-thirds of the bluff, overlain by fine-grained, friable, cross-bedded dune sand with some dark brown to black, stiff, organic, sandy, silty paleosol interbeds with wood fragments.

The cut slope in the area of the proposed retaining wall exposes fine-grained, friable sand overlain by organic-rich silt (Appendix A).

3.1.1 Subsurface Investigation

At the time of HGSA's site investigation, we advanced three hand augered borings to depths of up to approximately 1 foot below ground surface (bgs). Approximate locations of the borings are shown on Figures 3 and 4. Soils encountered in the borings were visually classified by an engineering geologist from our office according to the Unified Soil Classification System (USCS) as follows:

B-1	**Depth (ft.)**	**USCS**	**Description**
	0 – 0.66	SM FILL	Silty SAND FILL; brown, wet, loose to medium dense. With numerous gravel fragments.
	0.66 – 1.0	SP	SAND; light brown, wet, loose to medium dense. Boring terminated in medium dense sand.

B-2	**Depth (ft.)**	**USCS**	**Description**
	0 – 0.66	SM FILL	Silty SAND FILL; brown, wet, loose to medium dense. With numerous gravel fragments.
	0.66 – 1.0	SP	SAND; light brown, wet, loose to medium dense. Boring terminated in medium dense sand.

B-3	**Depth (ft.)**	**USCS**	**Description**
	0 – 0.5	SM FILL	Silty SAND FILL; brown, wet, loose to medium dense. With numerous gravel fragments.
	0.5 – 1.0	SP	SAND; light brown, wet, loose to medium dense. Boring terminated in medium dense sand.

In general, materials encountered at shallow depths in the area of the proposed retaining wall were loose to medium-dense sand overlain with approximately 6 to 8 inches of loose fill soil. We also observed that concrete remained in the excavated area, which appeared to be remnants of the previous retaining wall footing.

3.2 Description of the Fronting Beach

3.2.1 Summer and Winter Average Beach Widths

The beach at the site has a width of approximately 100 feet to more than 300 feet in this area during the winter and summer, respectively, depending upon sand transport in any given year. The beach here is very dynamic and frequently changes, primarily due to rip current formation and El Niño and La Niña ocean conditions. Typically, the beach is broad and dissipative in summer, becoming narrower and steeper in winter, particularly during prolonged storm cycles.

3.2.2 Beach Sediment Median Grain Size

Based on our knowledge of the area, beach sediment west of the site is typically comprised of primarily fine-grained to lesser medium-grained sand. At the time of our site visit, much of the sand had been stripped from the beach, and numerous pebbles and cobbles were present in the wave swash zone (Appendix A).

3.2.3 Summer and Winter Beach Elevations and Average Slopes

The beach generally slopes west at approximately 7 degrees in the winter and a few degrees in the summer. Based on our review of beach morphology monitoring data available for this section of Oregon's coast from 1997 to 2002, beach elevations varied by several feet from minimum to maximum, with minor changes at the beach-bluff junction and dune (Allan and Hart, 2005). The beach elevation can change substantially associated with El Niño and La Niña events. Elevations for the site derived from the 2016 lidar provided by NOAA show the elevation above mean sea level of the beach-bluff junction west of the subject property as approximately 20 feet (NAVD 88), which generally agrees with data from Allan and Hart (2005).

3.2.4 Rip Currents or Embayments

Rip currents and rip current embayments have formed frequently along this stretch of beach within the last decade, as evidenced by our review of historical satellite imagery.

3.2.5 Offshore Rock Outcrops and Sea Stacks

Offshore rock outcrops or sea stacks are not present in the immediate vicinity of the site. Mapping by Priest and Allan (2004) shows Tertiary Intrusive Basalt outcrops approximately 0.2 miles north of the site and 0.6 miles south of the site (Appendix A).

3.2.6 Depth of Beach Sand to Bedrock

During our site visit, we did not observe any exposed bedrock on the beach immediately west of the subject site. However, the presence of pebbles and cobbles on the beach indicates that the wave cut platform was likely only a few feet below the beach surface at the time of our site visit. Beach sand depths here can reach about 8 feet or more in some years and be scoured to bedrock in other years.

3.3 Geologic Structures

Structural deformation and faulting along the Oregon Coast are dominated by the Cascadia Subduction zone (CSZ), which is a convergent plate boundary extending for approximately 680 miles from northern Vancouver Island to northern California. This convergent plate boundary is defined by the subduction of the Juan de Fuca plate beneath the North America Plate and forms an offshore north-south trench approximately 60 miles west of the Oregon coast shoreline. A resulting deformation front consisting of north-south oriented reverse faults is present along the western edge of an accretionary wedge east of the trench, and a zone of margin-oblique folding and faulting extends from the trench to the Oregon Coast (Geomatrix, 1995).

The nearest mapped faults to the site are approximately ¼ mile north and ¾ mile south of the site (Schlicker et al., 1973; Snavely et al., 1976). These faults are northeast-trending normal faults which have been upthrown to their northwest. They cut Tertiary units with no indication of recent movement.

The nearest mapped potentially active faults are the Yaquina Head Fault located approximately 18.7 miles south of the site, and the Yaquina Bay Fault located approximately 21.7 miles south of the site. The Yaquina Head Fault is an east-trending oblique fault with left-lateral strike-slip and either contractional or extensional dip-slip offset components (Personius et al., 2003). It offsets the 80,000-year-old Newport marine terrace by approximately 5 feet, indicating a relatively low rate of slip, if still active (Schlicker et al., 1973; Personius et al., 2003). The Yaquina Bay Fault is a generally east-northeast trending oblique fault that also has left-lateral strike-slip and either contractional or extensional dip-slip offset components (Personius et al., 2003). This fault is believed to extend offshore for approximately 7 to 8 miles and may be a structurally controlling feature for the mouth of Yaquina Bay (Goldfinger et al., 1996; Geomatrix, 1995). At Yaquina Bay, a 125,000-year-old platform has been displaced approximately 223 feet up-on-the-north by the Yaquina Bay Fault. This fault has the largest component of vertical slip (as much as 2 feet per 1,000 years) of any active fault in coastal Oregon or Washington (Geomatrix, 1995). Although the age for the last movement of the Yaquina Bay Fault is not known, the fault also offsets 80,000-year-old marine terrace sediments.

4.0 Erosion and Slope Stability

We observed indications of minor wind and rain erosion along the exposed north-facing cut slope in the area of the proposed retaining wall along the southern boundary of the site.

As discussed above, the site is located approximately 50 feet east of a steep oceanfront bluff slope that consists primarily of friable sand deposits; the proposed retaining wall is approximately 70 feet east of the bluff. The bluff is undergoing recession as the result of wind and rain erosion, ocean wave erosion, and related landsliding that appears to fail back 5 to 10 feet at a time. The site is also mapped in an area of moderate to high landslide susceptibility based on the DOGAMI methodology (Burns, Mickelson, and Madin, 2016).

The site lies in an area mapped as undergoing critical erosion of marine terraces and sediments (Schlicker et al., 1973). Priest and others (1994) have determined the average annual erosion rate for the bluff as 0.27 ± 0.34 feet per year. This erosion rate was calculated by measuring the distance between existing structures to the bluff and compared to distances measured on a 1939 or 1967 vertical aerial photograph (Priest et al., 1994). During our site visit, we observed evidence of recent and ongoing recession of the bluff (Appendix A).

Based on mapping completed by Priest and Allan (2004), the bluff and beach lie within the Active Erosion Hazard Zone, with Anchor Court lying within the High-Risk Coastal Erosion Hazard Zone. The western part of the site, including the proposed construction area, lies within the Moderate-Risk and Low-Risk Coastal Erosion Hazard Zones. The house and garage at the site appear to be mapped outside of the coastal erosion hazard zones. The methodology provided by Priest and Allan (2004) defines four coastal erosion hazard zones for bluffs of Lincoln County, Oregon as follows:

"*The basic techniques used here are modified from Gless and others (1998), Komar and others (1999), and Allan and Priest (2001). The zones are as follows:*

> *1) Active hazard zone: The zone of currently active mass movement, slope wash, and wave erosion.*
>
> *2) The other three zones define high-, moderate-, and low-risk scenarios for expansion of the active hazard zone by bluff top retreat. Similar to the dune-backed shorelines, the three hazard zones depict decreasing levels of risk that they will become active in the future. These hazard zone boundaries are mapped as follows:*
>
> *a. High-risk hazard zone: The boundary of the high-risk hazard zone will represent a best case for erosion. It will be assumed that erosion proceeds gradually at a mean erosion rate for 60 years, maintaining a slope at the angle of repose for talus of the bluff materials.*
>
> *b. Moderate-risk hazard zone: The boundary of the moderate-risk hazard zone will be drawn at the mean distance between the high- and low-risk hazard zone boundaries.*

c. Low-risk hazard zone: *The low-risk hazard zone boundary represents a "worst case" for bluff erosion. The worst case is for a bluff to erode gradually at a maximum erosion rate for 100 years, maintaining its slope at the angle of repose for talus of the bluff materials. The bluff will then be assumed to suffer a maximum slope failure (slough or landslide). For bluffs composed of poorly consolidated or unconsolidated sand, another worst case scenario will be mapped that assumes that the bluff face will reach a 2:1 slope as rain washes over it and sand creeps downward under the forces of gravity. For these sand bluffs, whichever method produces the most retreat will be adopted*" (Priest and Allan, 2004).

It should be noted that mapping done for the 2004 study was intended for regional planning use, not for site specific hazard identification.

The subject property appears to be at a relatively low risk of being impacted by bluff recession during the anticipated life of the structure (50 to 60 years). However, future erosion and landsliding along the bluff can encroach into the area of Anchor Court, causing damage to the road and limiting access to the western part of the site. The upper edge of the bluff is currently approximately 10 to 25 feet west of the roadway of Anchor Court in the area of the site.

4.1 Analyses of Erosion and Flooding Potential

4.1.1 DOGAMI Beach Monitoring Data

Discussed in Section 3.2.3 above, beach monitoring data for this section of Oregon's coast shows that beach elevations varied by several feet from minimum to maximum over the monitored period of 1997 to 2002 (Allan and Hart, 2005).

4.1.2 Human Activities Affecting Shoreline Erosion

Human activity has not significantly altered wave attack resistance of the bluff west of the site.

4.1.3 Mass Wasting

Weathering, landsliding, recession rates and other erosional processes at this oceanfront site are discussed in Section 4.0 above and Section 4.2 below. Priest (1994) has determined the average annual erosion rate for the oceanfront bluff segments in the site area as 0.27 ± 0.34 feet per year.

4.1.4 Erosion Potential From Wave Runup Beyond Mean Water Elevation

Coastal erosion rates and hazard zones (as referenced in Priest and Allan, 2004) are presented in Section 4.0 above. In the bluff-backed shoreline recession methodology applicable to the area west of the subject site, wave erosion at the bluff toe and associated parameters such as rock composition, vegetative/protective cover, ballistics of debris, bluff slope angle of repose etc., are more critical to erosion zone and rate estimates than calculating of wave run-up elevation which changes with many variables such as changing beach elevations, presence of transient dunes, etc. It is the chronic nature of the wave attack hazard that can undercut the toe of the bluff, creating bluff instability and over an extended period of time has the potential to over-steepen and undermine the bluff.

4.1.5 Frequency of Erosion-Inducing Processes

As discussed in Section 4.0, the average annual erosion rate for the site is 0.27 ± 0.34 feet per year and is currently estimated at 0.60 feet per year, resulting in 36 feet of setback over a 60-year period for erosion plus a regulatory required 5-foot setback for a total of 41 feet of setback from the upper bluff edge based on erosion. Ocean wave, wind and rain erosion are continuous and ongoing processes which impact bluff recession. Future landsliding at the subject site would cause additional recession of the upper bluff. We anticipate that future landslides could fail back 5 to 10 feet at a time if not mitigated; however, these would be very infrequent and impossible to predict when they will occur.

4.1.6 Dune-Backed Shoreline Erosion Potential

As discussed in Section 4.0 above, the area west of the site has a bluff-backed shoreline.

4.1.7 Sea Level Rise

Information from NOAA's Garibaldi and Newport/South Beach monitoring stations provides an average sea level rise of approximately 2.11 ± 0.67 mm/year between 1967 and 2021 (NOAA Tides & Currents Sea Level Trends http://tidesandcurrents.noaa.gov/ sltrends/sltrends.html). Global climate change can also influence rates of sea level rise (refer to Section 7.0).

4.1.8 Estimated Annual Erosion Rate

Detailed discussion of recession and estimated erosion rates is in Section 4.0 above; Priest (1994) has determined the average annual erosion rate for the bluff at the site as 0.27 ± 0.34 feet per year.

4.2 Assessment of Potential Reactions to Erosion Episodes

4.2.1 Legal Restrictions of Shoreline Protective Structures

According to Lincoln County records, the site is not identified as an oceanfront property and therefore is not eligible for a shoreline protective structure. According to the Ocean Shores Viewer (http://www.coastalatlas.net /oceanshores/, accessed February 2023), the tax lots west of the site appear to be Goal 18 eligible for beachfront protective structures; however, the potential to receive a permit for oceanfront protection is dependent upon meeting certain regulatory requirements in addition to the Goal 18 eligibility requirement.

4.2.2 Potential Reactions to Erosion Events and Future Erosion Control Measures

Site geologic hazards conclusions and development recommendations are presented in Section 8.0 below, which includes recommended oceanfront setbacks for foundations along with discussion of inherent risks to the development of sites with engineering geologic characteristics such as those at the site, as presented and analyzed in Section 4.0 above. Deep foundations, retaining walls, underpinning of foundations, vegetation management, relocation of structures and bioengineering can all be potential reactions and control measures to erosion events.

4.2.3 Annual Erosion Rate for the Property

Priest (1994) has determined the average annual erosion rate for the oceanfront bluff segments in the site area as 0.27 ± 0.34 feet per year. For further information please refer to Sections 4.0 and 4.1.8 above and Section 8.2 below.

5.0 Regional Seismic Hazards

Abundant evidence indicates that a series of geologically recent large earthquakes related to the Cascadia Subduction Zone have occurred along the coastline of the Pacific Northwest. Evidence suggests that more than 40 great earthquakes of magnitude 8 and larger have struck western Oregon during the last 10,000 years. The calculated odds that a Cascadia earthquake will occur in the next 50 years range from 7–15 percent for a great earthquake affecting the entire Pacific Northwest, to about a 37 percent chance that the southern end of the Cascadia

Subduction Zone will produce a major earthquake in the next 50 years (OSSPAC, 2013; OSU News and Research Communications, 2010; Goldfinger et al., 2012). Evidence suggests the last major earthquake occurred on January 26, 1700 and may have been of magnitude 8.9 to 9.0 (Clague et al., 2000; DOGAMI, 2013).

There is now increasing recognition that great earthquakes do not necessarily result in a complete rupture along the full 1,200 km fault length of the Cascadia subduction zone. Evidence in the paleorecords indicates that partial ruptures of the plate boundary have occurred due to smaller earthquakes with moment magnitudes (Mw) < 9 (Witter et al., 2003; Kelsey et al., 2005). These partial segment ruptures appear to occur more frequently on the southern Oregon coast, as determined from paleotsunami studies. Furthermore, the records have documented that local tsunamis from Cascadia earthquakes recur in clusters (~250–400 years) followed by gaps of 700–1,300 years, with the highest tsunamis associated with earthquakes occurring at the beginning and end of a cluster (Allan et al., 2015).

These major earthquake events were accompanied by widespread subsidence of a few centimeters to 1–2 meters (Leonard et al., 2004). Tsunamis appear to have been associated with many of these earthquakes. In addition, settlement, liquefaction and landsliding of some earth materials are believed to have been commonly associated with these seismic events.

Other earthquakes related to shallow crustal movements or earthquakes related to the Juan de Fuca plate have the potential to generate magnitude 6.0 to 7.5 earthquakes. The recurrence interval for these types of earthquakes is difficult to determine from present data, but estimates of 100 to 200 years have been given in the literature (Rogers et al., 1996).

Based on the 1999 Relative Earthquake Hazard Map of the Lincoln City area (Madin and Wang, 1999), the subject site lies in an area designated as Zones C and D. Zones C and D represent areas which show low to the least hazards associated with earthquakes. The degree of relative hazard was based on the factors of ground motion amplification, liquefaction, and slope instability.

The subject site is mapped in an area of very strong expected earthquake shaking during an earthquake in a 500-year period (DOGAMI Oregon HazVu website, accessed February 2023). “Very Strong” is the third-highest level of a six-level gradation from “Light” to “Violent” in this mapping system.

DOGAMI’s HazVu website (https://gis.dogami.oregon.gov/maps/hazvu/) has mapped the area of the site as having a low susceptibility to liquefaction.

6.0 Flooding Hazards

Based on the 2019 Flood Insurance Rate Map (FIRM, Panel #41041C0109E), the site lies in an area rated as Zone X (outside of the 0.2% annual chance floodplain).

Based on the Oregon Department of Geology and Mineral Industries mapping (DOGAMI, 2013), the subject site lies outside the tsunami inundation zone resulting from an approximately 9.1 and lesser magnitude Cascadia Subduction Zone (CSZ) earthquake. The 2013 DOGAMI mapping is based upon 5 computer-modeled scenarios for shoreline tsunami inundation caused by potential CSZ earthquake events ranging in magnitude from approximately 8.7 to 9.1. The January 1700 earthquake event (discussed in Section 5.0 above) has been rated as an approximate 8.9 magnitude in DOGAMI's methodology. More distant earthquake source zones can also generate tsunamis.

7.0 Climate Change

According to most of the recent scientific studies, the Earth's climate is changing as the result of human activities which are altering the chemical composition of the atmosphere through the buildup of greenhouse gases, primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (EPA, 1998). Although there are uncertainties about exactly how the Earth's climate will respond to enhanced concentrations of greenhouse gases, scientific observations indicate that detectable changes are under way (EPA, 1998; Church and White, 2006). Global sea level rise, caused by melting polar ice caps and ocean thermal expansion, could lead to flooding of low-lying coastal property, loss of coastal wetlands, erosion of beaches and bluffs, and saltwater contamination of fresh groundwater. Global climate change and the resultant sea level rise will likely impact the subject site through accelerated coastal erosion and bluff retreat. It can also lead to increased rainfall which can result in an increase in landslide occurrence.

8.0 Conclusions and Recommendations

The main engineering geologic concerns at the site are:

1. Uncontrolled fill and concrete debris were encountered in the wall footing area during site observations and subsurface exploration and will need to be removed.

2. The existing temporary cut slope along the driveway appears steeper than 1H:1V and may require temporary shoring during the construction of the new wall.

3. The bluff slope west of the site is undergoing continuous erosion, sloughing and shallow landsliding, which can fail back 5 to 10 feet or greater at a time. These

hazards are common to coastal properties in this area. However, the proposed construction area is approximately 70 feet from the top edge of the bluff slope.

4. There is an inherent regional risk of earthquakes along the Oregon Coast which could cause harm and damage structures. Ground shaking associated with earthquakes can cause reactivation of existing landslides and also generate new landslides. The site lies outside of the mapped tsunami inundation hazard zone. However, a tsunami impacting the Lincoln City area could cause harm, loss of life and damage to structures. These risks must be accepted by the owner, future owners, developers and residents of the site.

The following recommendations should be adhered to during design and construction:

8.1 General Recommendations

1. HGSA will need to review a complete plan set for the proposed construction of the retaining wall on the lot. The plans will need to incorporate the recommendations included herein. Please note that these recommendations are intended for the construction of a retaining wall along the driveway in the southwestern portion of the site

2. Lincoln City may require a topographic survey performed by a licensed land surveyor to identify the bluff edge and determine the bluff setback's location. However, the location of the proposed wall appears to be well east of our recommended setback, discussed below.

Provided that all recommendations herein are adhered to, no adverse effects are anticipated on adjacent properties.

8.2 Site Preparation and Setbacks

It is anticipated that excavations at the site can be completed using conventional earth-moving equipment. Unsuitable fill, debris, and soft soils should be completely removed from all footing areas (see Section 8.3 below).

If wet weather grading is unavoidable due to construction schedules, or if wet soil conditions are encountered, stabilization of the subgrade soils with aggregate may become necessary. The use of clean, well-graded inch 1 inch minus crushed rock fill (containing less than 5 percent material passing the No. 200 sieve) is recommended. Thickness of the applied granular fill should be sufficient to stabilize the subgrade soils.

Per the City of Lincoln City's requirements, we have determined a 41 feet oceanfront setback based on an average annual erosion rate of 0.60 ft/yr for 60 years and have added Lincoln City’s required additional 5 feet.

To help mitigate future recession of the bluff caused by erosion and landsliding, we recommend that new shallow foundations for the retaining wall be set back a minimum of 41 feet east of the upper bluff edge, as shown on Figures 3 and 4. The proposed construction lies well east of this oceanfront bluff setback area.

Please note the Oregon Coast is a dynamic and energetic environment. Most of the coastline is currently eroding and will continue to erode in the future. Most structures built near ocean bluffs will eventually be undermined by erosion and landsliding. The setback recommendations presented in this report are based on past average erosion rates as determined from aerial photography, and past and current geologic conditions and processes. These setbacks are intended to protect the proposed wall from bluff recession for 60 years. Geologic conditions and the rates of geologic processes can change in the future. Setbacks greater than our recommended minimum setbacks would provide the proposed structure with greater anticipated life and lower risk from some geologic hazards.

8.3 Soil Bearing Capacities

All footing areas should be stripped of all organic and loose/soft soils and existing fills.

Footings bearing in undisturbed, native, non-organic, firm soils or properly compacted structural fill placed on these soils may be designed for the following:

ALLOWABLE SOIL BEARING CAPACITIES	
Allowable Dead Plus Live Load Bearing Capacity [a]	1,500 psf
Passive Resistance	200 psf/ft embedment depth
Lateral Sliding Coefficient	0.30
[a] Allowable bearing capacity may be increased by one-third for short-term wind or seismic loads.	

8.4 Retaining Walls

For static conditions, free-standing retaining walls should be designed for a lateral static active earth pressure expressed as an equivalent fluid weight (EFW) of 35 pounds per cubic foot, assuming level backfill. An EFW of 45 pounds per cubic foot should be used assuming sloping backfill of 2H:1V. At-rest retaining walls should be designed for a lateral pressure expressed as an equivalent fluid weight of 60 pounds per cubic foot, assuming level backfill behind the wall equal to a distance of at least half of the height of the wall. Walls need to be fully drained to prevent the build-up of hydrostatic pressure.

The EFWs provided herein assume static conditions and no surcharge loads from vehicles or structures. If surcharge loads will be applied to the retaining walls, forces on the walls resulting from these loads will need to be added to the pressures given herein.

For seismic loading, a unit pseudostatic force equal to 13.5 pcf $(H)^2$, where H is the height of the wall in feet, should be added to the static lateral earth pressures. The location of the pseudostatic force can be assumed to act at a distance of 0.6H above the base of the wall.

RETAINING WALL EARTH PRESSURE PARAMETERS	
Static Case, Active Wall (level backfill/grades)	35 pcf [a]
Static Case, Active Wall (2H:1V backfill/grades)	45 pcf [a]
Static Case, At-Rest Wall (level backfill/grades)	60 pcf [a]
Seismic Loading (level backfill/grades)	13.5 pcf $(H)^2$ [b]

[a] Earth pressure expressed as an equivalent fluid weight (EFW).

[b] Seismic loading expressed as a pseudostatic force, where H is the height of the wall in feet. The location of the pseudostatic force can be assumed to act at a distance of 0.6H above the base of the wall.

Imported free-draining granular backfill for walls should be placed in 8-inch horizontal lifts and machine compacted to 95 percent of the maximum dry density as determined by ASTM D1557. Compaction within 2 feet of the wall should be accomplished with lightweight hand-operated compaction equipment to avoid applying additional lateral pressure on the walls. Drainage of the retaining wall should consist of slotted drains placed at the base of the wall on the backfilled side and backfilled with free-draining crushed rock (less than 5% passing the 200 mesh sieve using a washed sieve method) protected by non-woven filter fabric (Mirafi® 140N, or equivalent) placed between the native soil and the backfill. Filter fabric protected free-draining crushed rock should extend to within 2 feet of the ground surface behind the wall, and the filter fabric should be overlapped at the top per the manufacturer's recommendations. All walls should be fully drained to prevent the build-up of hydrostatic pressures. All retaining walls should have a minimum of 2 feet of embedment at the toe or be designed without passive resistance. The EFWs provided above assume that free-draining material will be used for the retaining wall backfill.

8.5 Seismic Requirements

The structure and all structural elements should be designed to meet current Oregon Residential Specialty Code (ORSC) seismic requirements. Based on our knowledge of subsurface conditions at the site, and our analysis using the guidelines recommended in the ORSC, the structure should be designed to meet the following seismic parameters:

SEISMIC DESIGN PARAMETERS	
Site Class	D
Seismic Design Category	D_2
Mapped Spectral Response Acceleration for Short Periods	S_S = 1.347 g
Site Coefficients	F_a = 1.200 F_v = 1.700
Design Spectral Response Acceleration at Short Periods	S_{DS} = 1.077 g

8.6 Structural Fills

Structural fills should consist of imported, crushed granular material, free of organics and deleterious materials, and contain no particles greater than 1 inch in diameter so that nuclear methods (ASTM D2922 & ASTM D3017) can be easily used for field density and moisture testing. Structural fill should be placed in 8-inch lifts maximum and compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D1557. All areas to receive fill should be stripped of all soft soils, organic soils, organic debris, existing fill, and disturbed soils.

STRUCTURAL FILL	
Compaction Requirements	95% ASTM D1557, compacted in 8-inch lifts maximum, at or near the optimum moisture content

Proper test frequency and earthwork documentation usually requires daily observation during stripping, rough grading, and placement of structural fill. Field density testing should generally conform to ASTM D2922 and D3017, or D1556. To minimize the number of field and laboratory tests, fill materials should be from a single source and of a consistent character. Structural fill should be approved and periodically observed by HGSA and tested by a qualified testing firm. Test results will need to be reviewed and approved by HGSA. We recommend that at least three density tests be performed for every 18 inches or every 200 cubic yards of fill placed, whichever requires more testing. Because testing is performed on an on-call basis, we recommend that the earthwork contractor schedule the testing. Relatively more testing is typically necessary on smaller projects.

8.7 Cut and Fill Slopes

Temporary unsupported cut and fill slopes less than 9 feet in height should be sloped no steeper than 1 horizontal to 1 vertical (1H:1V). If temporary slopes greater than 9 feet high are desired, or if water seepage is encountered in cuts, HGSA should be contacted to provide additional recommendations. Temporary cuts in excess of 5 feet high and steeper than 1H:1V will likely require appropriate shoring to provide for worker safety, per OSHA regulations. Temporary cuts should be protected from inclement weather by covering them with plastic sheeting to help prevent erosion.

TEMPORARY AND PERMANENT CUTS	
Temporary Cuts	1H:1V (maximum) [a]
Permanent Cuts	2H:1V (maximum) [a]
[a] All cuts greater than 9 feet high, or cuts where water seepage is encountered, should be approved by a representative of H.G. Schlicker & Associates, Inc.	

If the cut slope recommendations provided herein cannot be achieved due to construction and/or property line constraints, temporary or permanent retention of cut slopes may be required, as determined by a representative of HGSA.

Permanent unsupported cut and fill slopes should be constructed no steeper than 2 horizontal to 1 vertical (2H:1V). Fill slopes steeper than 2H:1V should be mechanically reinforced using geogrids, or other suitable products as approved by HGSA.

8.8 Plan Review and Site Observations

We should review all site and foundation plans prior to construction to ensure that these plans conform with the intent of our recommendations. There will be additional charges for these services.

We should observe footing excavations prior to forming and/or pouring of concrete, and placing fill to assure that suitable bearing soils have been reached. At the time of our observations, we may recommend additional excavation if suitable bearing soils have not been reached. There will be additional charges for these services.

Our recommended site observations and plan reviews are detailed in Appendix B of this report.

Please provide us with at least five (5) days' notice prior to any needed site observations. There will be additional costs for these services.

8.9 Worker Safety

All construction activities should be completed in accordance with OSHA standards and all State and local laws, rules, regulations and codes.

9.0 Limitations

The Oregon Coast is a dynamic environment with inherent unavoidable risks to development. Landsliding, erosion, tsunamis, storms, earthquakes and other natural events can cause severe impacts to structures built within this environment and can be detrimental to the health and welfare of those who choose to place themselves within this environment. The client is warned that, although this report is intended to identify the geologic hazards causing these risks, the scientific and engineering communities knowledge and understanding of geologic hazards processes is not complete. This report pertains to the subject site only, and is not applicable to adjacent sites nor is it valid for types of development other than that to which it refers. Geologic conditions including materials, processes and rates can change with time and therefore a review of the site and/or this report may be necessary as time passes to assure its accuracy and adequacy.

The augered borings and related information depict generalized subsurface conditions only at these specific locations and at the particular time the subsurface exploration was completed. Soil and groundwater conditions at other locations may differ from the conditions at these locations.

Our investigation was based on engineering geological reconnaissance and a limited review of published information. The information presented in this report is believed to be representative of the site. The conclusions herein are professional opinions derived in accordance with current standards of professional practice, budget and time constraints. No warranty is expressed or implied. The performance of this site during a seismic event has not been evaluated. If you would like us to do so, please contact us. This report may only be copied in its entirety.

10.0 Disclosure

H.G. Schlicker & Associates, Inc. and the undersigned Certified Engineering Geologist have no financial interest in the subject site, the project or the Client's organization.

11.0 References

Allan, J. C. and Hart, R., 2005, A geographical information system (GIS) data set of beach morphodynamics derived from 1997, 1998, and 2002 LIDAR data for the central to northern Oregon coast: Technical Report to the Oregon Department of Land Conservation and Development: Oregon Department of Geology and Mineral Industries, Open-File Report O-05-09, 16 pages.

Allan, J. C., Ruggiero, P., Cohn, N., Garcia, G., O'Brien, F. E., Serafin, K., Stimely, L. L. and Roberts, J. T., 2015, Coastal Flood Hazard Study, Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-15-06, 351 p.

Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016, Landslide susceptibility overview map of Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-16-02, 48 p., 1 plate.

Church, J. A., and White, N. J., 2006, A 20th century acceleration in global sea-level rise: Geophysical Research Letters, v. 22, LO1601, 4 p.

Clague, J. J., Atwater, B. F., Wang, K., Wang, Y., and Wong, I., 2000, Penrose Conference 2000 - Great Cascadia Earthquake Tricentennial, Programs Summary and Abstracts: Oregon Department of Geology and Mineral Industries, Special Paper 33, 156 p.

DOGAMI, 2013, Tsunami inundation maps for Lincoln City, South, Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries, TIM-Linc-02, maps.

EPA, 1998, Climate Change and Oregon; Environmental Protection Agency, EPA 236-98-007u, 4 p.

Geomatrix Consultants, 1995, Seismic design mapping, State of Oregon, final report: Prepared for the Oregon Department of Transportation, Project No. 2442.

Goldfinger, C., Kulm, L. D., Yeats, R. S., Applegate, B., MacKay, M. E., and Cochrane, G. R., 1996, Active strike-slip faulting and folding of the Cascadia Subduction-Zone plate boundary and forearc in central and northern Oregon: U.S. Geological Survey Professional paper 1560, p. 223-256.

Goldfinger, C., Nelson, C. H., Morey, A. E., Johnson, J. E., Patton, J. R., Karabanov, E., Gutiérrez-Pastor, J., Eriksson, A. T., Gràcia, E., Dunhill, G., Enkin, R. J., Dallimore, A., and Vallier, T., 2012, Turbidite event history—Methods and implications for Holocene paleoseismicity of the Cascadia subduction zone: U.S. Geological Survey Professional Paper 1661–F, 170 p.

Kelsey, H. M., Nelson, A. R., Hemphill-Haley, E., and Witter, R. C., 2005, Tsunami history of an Oregon coastal lake reveals a 4600-yr. record of great earthquakes on the Cascadia subduction zone: Geological Society of America Bulletin, v. 117, no. 7/8, p. 1009-1032.

Kelsey, H. M., Ticknor, R. L., Bockheim, J. G., and Mitchell, C. E., 1996, Quaternary upper plate deformation in coastal Oregon: Geological Society of America Bulletin, v. 108, no. 7, p. 843-860.

Leonard, L. J., Hyndman, R. D., and Mazzotti, S., 2004, Coseismic subsidence in the 1700 great Cascadia earthquake: Coastal estimates versus elastic dislocation models: Geological Society of America Bulletin, May/June 2004, v. 116, no. 5/6, pp. 655–670.

Madin, I. P., and Wang, Z., 1999, Relative earthquake hazard maps for selected urban areas in western Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map Series IMS-10.

Oregon Seismic Safety Policy Advisory Commission (OSSPAC), February 2013, The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the next Cascadia Earthquake and Tsunami Report to the 77th Legislative Assembly: State of Oregon Office of Emergency Management, 341 p.

OSU News and Research Communications, May 24, 2010, Odds are 1-in-3 that a huge quake will hit Northwest in next 50 years: Oregon State University, Corvallis http://oregonstate.edu/ ua/ncs/archives/2010/may/odds-huge-quake-Northwest-next-50-years

Personius, S. F., Dart, R. L., Bradley, L-A, Haller, K. M., 2003, Map and data for Quaternary faults and folds in Oregon: U.S. Geological Survey, Open-File Report 03-095, 556 p., map.

Priest, G. R., Myers, E., Baptista, A. M., Fleuck, P., Wang, K., Kamphaus, R. A., and Peterson, C. D., 1997, Cascadia Subduction Zone tsunamis: Hazard mapping at Yaquina Bay, Oregon, final technical report to the National Earthquake Hazard Reduction Program: Oregon Department of Geology and Mineral Industries, Open-File Report O-97-34.

Priest, G. R., Saul, I., and Diebenow, J., 1994, Explanation of chronic geologic hazard maps and erosion rate database, coastal Lincoln County, Oregon: Salmon River to Seal Rock: Oregon Department of Geology and Mineral Industries, Open-File Report 0-94-11, 45 p.

Priest, G. R. and Allan, J. C., 2004, Evaluation of Coastal Erosion Hazard Zones Along Dune and Bluff Backed Shorelines in Lincoln County, Oregon: Cascade Head to Seal Rock, Technical Report to Lincoln County: Oregon Department of Geology and Mineral Industries, Open-File Report O-04-09, 202 pages.

Rogers, A. M., Walsh, T. J., Kockelman, J., and Priest, G. R., 1996, Earthquake hazards in the Pacific Northwest - an overview: U.S. Geological Survey, Professional Paper 1560, p. 1- 54.

Schlicker, H. G., Deacon, R. J., Olcott, G. W., and Beaulieu, J. D., 1973, Engineering geology of Lincoln County, Oregon: Oregon Department of Geology and Mineral Industries, Bulletin 81.

Witter, R. C., Kelsey, H. M., and Hemphill-Haley, E., 2003, Great Cascadia earthquakes and tsunamis of the past 6700 years, Coquille River estuary, southern coastal Oregon: Geological Society of America Bulletin, v. 115, p. 1289-1306.

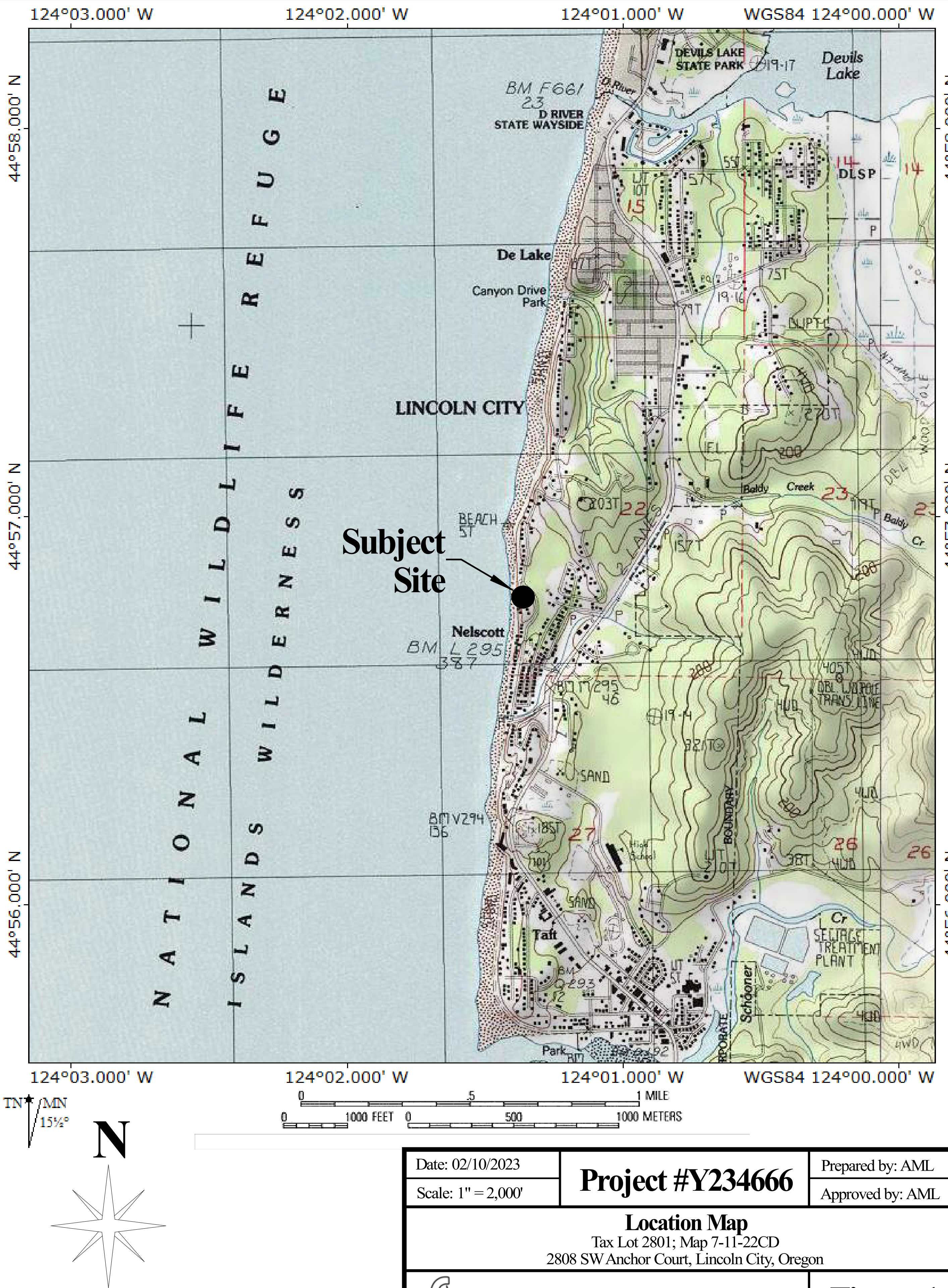
It has been our pleasure to serve you. If you have any questions concerning this report, or the site, please contact us.

Respectfully submitted,

H.G. SCHLICKER AND ASSOCIATES, INC.

EXPIRES: 12/31/2023

Adam M. Large, MSc, RG, CEG
President/Principal Engineering Geologist
AML:mgb



Date: 02/10/2023	**Project #Y234666**	Prepared by: AML
Scale: 1" = 2,000'		Approved by: AML

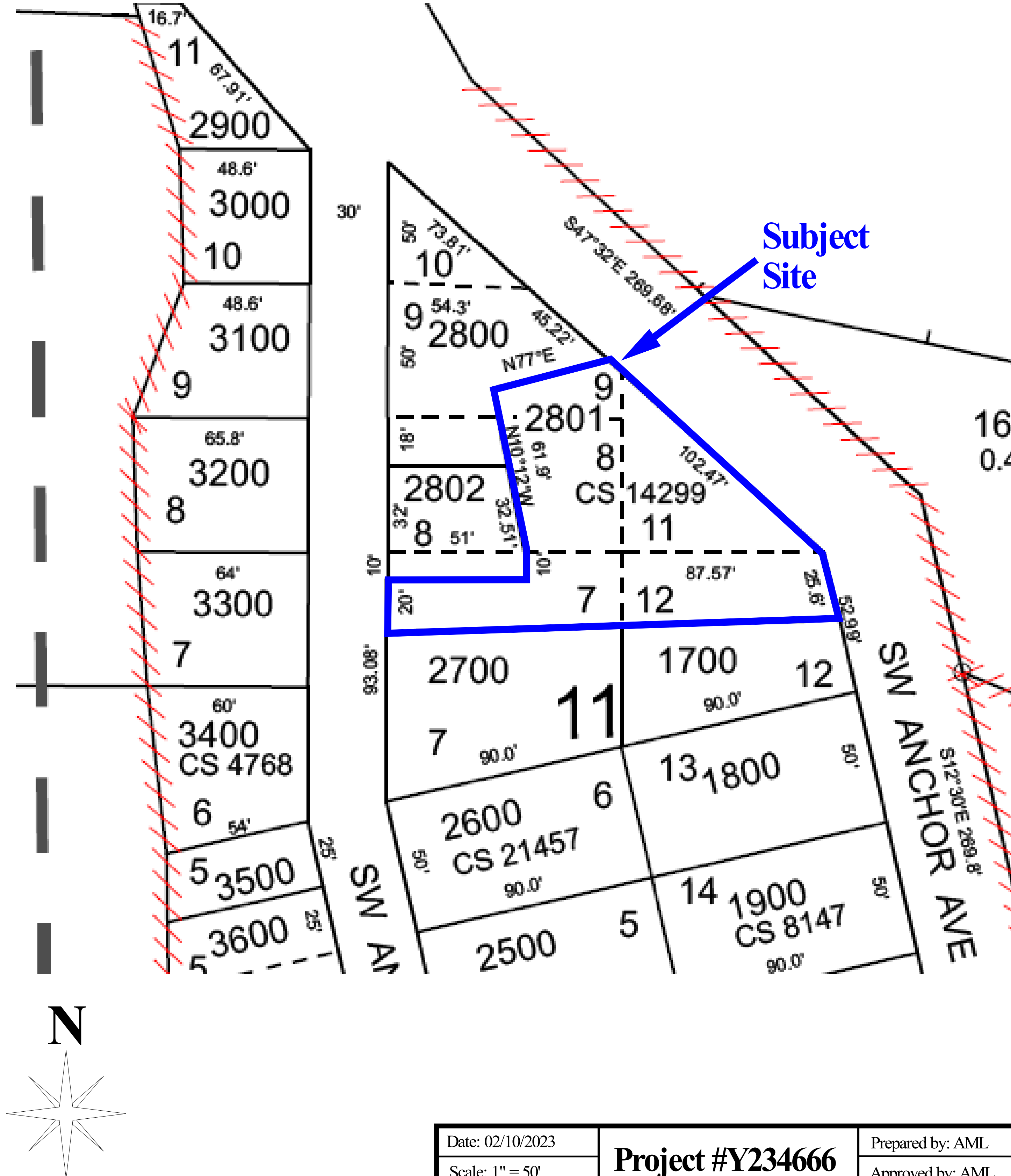
Location Map

Tax Lot 2801; Map 7-11-22CD

2808 SW Anchor Court, Lincoln City, Oregon

H.G. Schlicker & Associates, Inc.

Figure 1

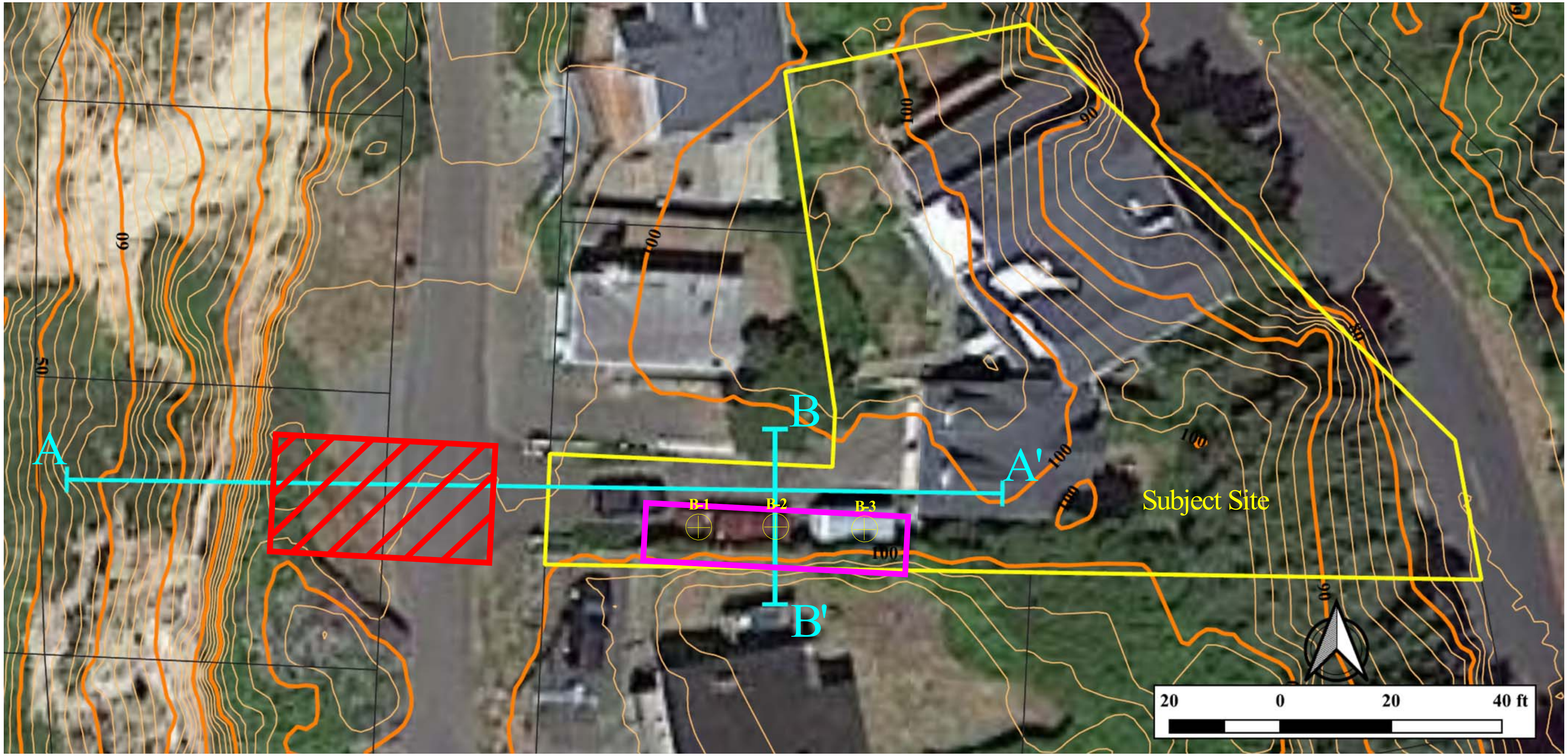


Modified from the Lincoln County assessor's plat
T7S, R11W, Sec. 22.
All locations and dimensions are approximate.

Date: 02/10/2023 Scale: 1" = 50'	**Project #Y234666**	Prepared by: AML Approved by: AML

Plat Map
Tax Lot 2801; Map 7-11-22CD
2808 SW Anchor Court, Lincoln City, Oregon

H.G. Schlicker & Associates, Inc. | **Figure 2**



= Approximate Area of Proposed Construction

= Geologic Hazard Setback Area

B-1 = Approximate location of boring

A A' = Approximate trend of profile line

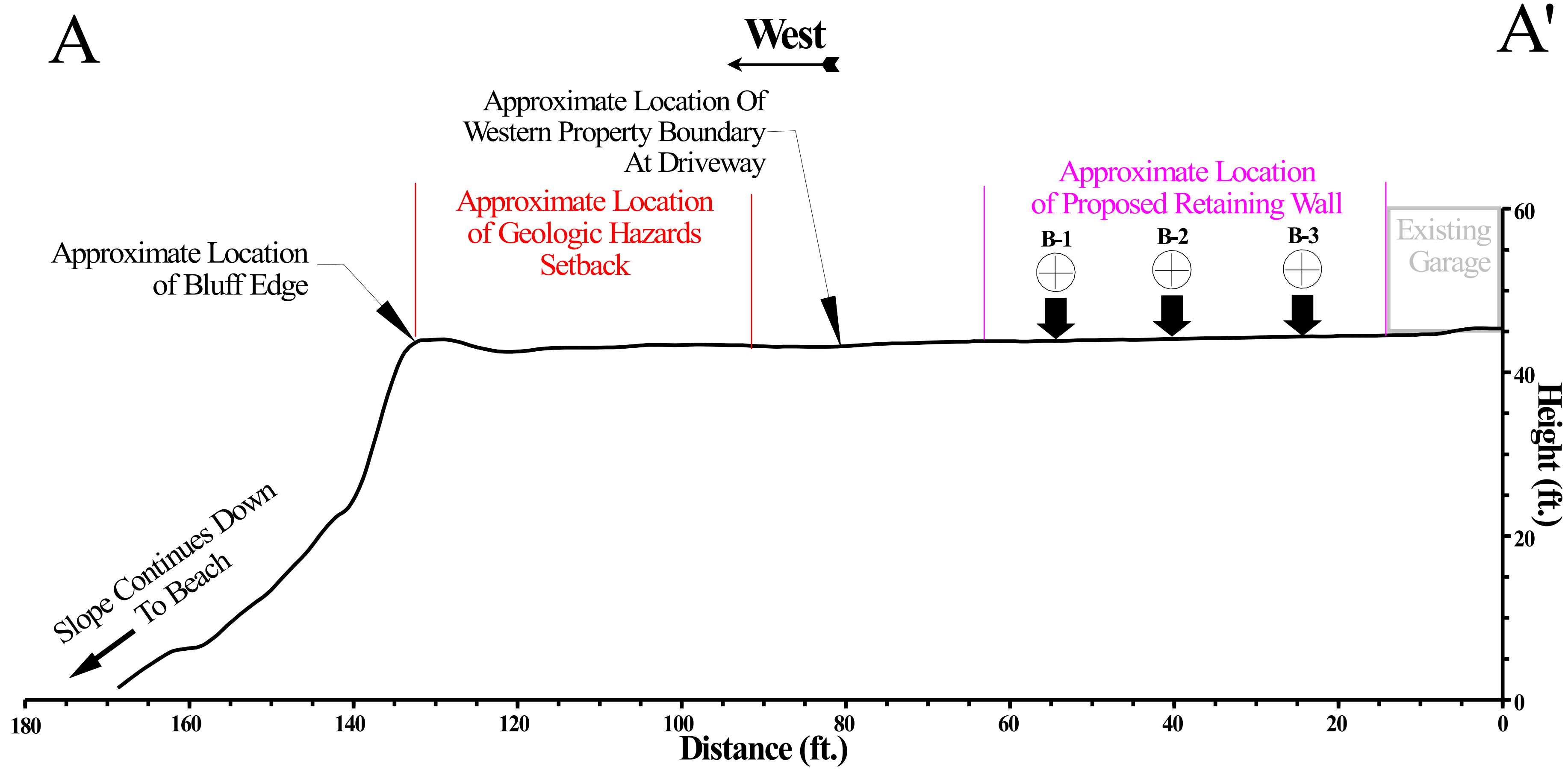
Imagery provided by Google. Topographic data derived from West Coast el nino 2016 DEM provided by NOAA.
All locations and dimensions are approximate.

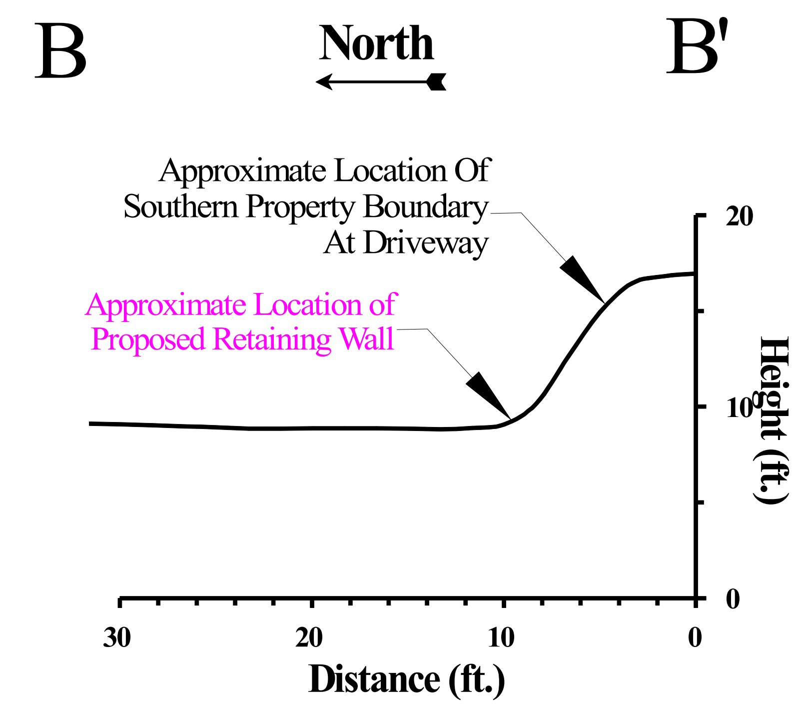
Date: 02/10/2023	Project #Y234666	Prepared by: MGB
Scale: 1" = 20'		Approved by: AML

Site Topographic Map
Tax Lot 2801; Map 7-11-22CD
2808 SW Anchor Court, Lincoln City, Oregon

H.G. Schlicker & Associates, Inc.

Figure 3





B-1 = Approximate location of boring

Topographic data derived from West Coast el nino 2016 DEM provided by NOAA.
All locations and dimensions are approximate.

Date: 02/10/2023	**Project #Y234666**	Prepared by: MGB
Scale: As Shown		Approved by: AML

Slope Profiles, A-A' and B-B'
Tax Lot 2801, Map 07-11-27CD
2808 S.W. Anchor Court, Lincoln City, Lincoln County, Oregon

H.G. Schlicker & Associates, Inc.

Figure 4

Appendix A
- Site Photographs -

Photo 1 – Easterly view of the site from the driveway near SW Anchor Court.

Photo 2 – View of the cut slope and area proposed for the retaining wall.

Photo 3 – View of soils encountered in boring B-1.

Photo 4 – View of the soils encountered in boring B-3.

Photo 5 – Northerly view of the bluff slope, beach, and ocean, west of the site, from near the bluff edge.

Photo 6 – Southerly view of the bluff slope, beach and ocean, west of the site, from near the bluff edge.


Photo 7 – Downslope view of the bluff slope and beach from near the bluff edge.

Appendix B

- Checklist of Recommended Plan Reviews and Site Observations -

Project #Y234666

APPENDIX B
Checklist of Recommended Plan Reviews and Site Observations
To Be Completed by a Representative of H.G. Schlicker & Associates, Inc.

Item No.	Date Done	Procedure	Timing
1*		Review site development, foundation, drainage, grading and erosion control plans.	Prior to permitting and construction.
2*		Observe foundation excavations.	Following excavation of foundations, and prior to placing fill, forming and pouring. **
3*		Review Proctor (ASTM D1557) and field density test results for all fills placed at the site.	During construction.

* There will be additional charges for these services.
** Please provide us with at least 5 days' notice prior to all site observations.