

# **Geotechnical Report**

# Geotechnical Overview

## Revised Update

### Port Gamble Redevelopment

Town Site, Mill Site, & Agrarian Area  
Port Gamble, Washington

February 2, 2018

Terracon Project No. 81135034

**Prepared for:**

Olympic Property Group  
Poulsbo, Washington

EA Engineering, Science and Technology  
Seattle, Washington

**Prepared by:**

Terracon Consultants, Inc.  
Mountlake Terrace, Washington

Offices Nationwide  
Employee-Owned

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The Terracon logo features the word "Terracon" in a bold, white, sans-serif font. The letter "T" is significantly larger and more stylized than the other letters, with a thick vertical stem and a horizontal top bar that extends to the right. The logo is set against a dark red background.

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

February 2, 2018

Olympic Property Group  
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Attention: Ms. Sue Allison

EA Engineering, Science and Technology  
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Seattle, WA 98121  
Attention: Mr. Rich Schipanski & Ms. Kristy Hollinger

RE: **GEOTECHNICAL OVERVIEW**  
**Port Gamble Redevelopment**  
***Town Site, Mill Site, & Agrarian Area***  
Port Gamble, Washington  
Terracon Project No. 81135034

Dear Sue, Rich, and Kristy:

Terracon Consultants, Inc. (Terracon) provided a written overview of geotechnical site conditions at the Port Gamble Town Site, Mill Site, and agrarian area in order to satisfy specific requirements for the project Environmental Impact Statement (EIS); this overview was presented in a report dated August 15, 2013. Our services at that time were performed in general accordance with our proposal letter (Terracon No. P81130136) dated May 7, 2013. The findings of geotechnical overview subsequently became part EIS prepared by EA Engineering, Science, and Technology, Inc.

Following preparation of the EIS in 2013, we understand that recent minor adjustments have been made to Alternative 1 and Alternative 2 proposed development. Due to these adjustments, Olympic Property Group (OPG) has asked Terracon to revisit the Geotechnical Overview findings presented in 2013, and to adjust those findings where necessary. Those adjustments will be reflected in EA's revised final EIS for the Port Gamble Redevelopment project.

We also understand that a recreational trail user parking area has been added as a part of Alternative 1 and Alternative 2 development. The trail parking area would be south of town along the east side of SR 104, in a location outside of the previous EIS study area. Development of this parking area will be reflected in the revised final EIS.



We appreciate the opportunity to be of continued service to you on this project. If you have any questions concerning our report, or if we may be of further service, please don't hesitate to contact us.

Sincerely,  
**Terracon Consultants, Inc.**



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Geotechnical Department Manager

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Project Engineer

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## GEOTECHNICAL OVERVIEW

### PORT GAMBLE REDEVELOPMENT TOWN SITE, MILL SITE, & AGRARIAN AREA PORT GAMBLE, WASHINGTON

Terracon Project No. 81135034  
February 2, 2018

#### 1.0 INTRODUCTION

This report presents an overview of geotechnical conditions at Port Gamble, Washington, with respect to the proposed redevelopment plans. The project site covered by this geotechnical overview comprises three significant areas within the boundaries of Port Gamble. These areas can be described as the **Town Site**, which includes an existing mixture of commercial and residential buildings; the **Mill Site**, which lies on a large fill pad adjacent to town; and an **agrarian area**, which lies closely southwest of town. Together, these three areas encompass 318.7 acres. A fourth, minor area is located south of the town site and is the proposed location for multi-use **Trail Parking**, which would facilitate user access to an existing network of multi-use trails to the south and west of Port Gamble.

The proposal would redevelop the Port Gamble site with a mix of residential, commercial, agricultural, and open space uses intended to complement the historic character of the site and create an economically sustainable community. This proposed redevelopment could ultimately contain between 225 and 265 new residential units, a hotel, 35,000 to 156,000 square feet of commercial space, and 236 to 251 acres of open space. The new buildings will typically have one to three stories above grade, with no basements. Associated utilities, roadways, and parking areas will be included, and all existing structures will be preserved. Final build-out of the proposed redevelopment is anticipated to occur over an approximately 10-year timeframe, ending around 2023, although actual build-out would depend on market conditions.

The current proposal includes three alternatives and several scenarios. These can be summarized as follows.

- **Alternative 1: Proposed Action (“Full Build-out”)** — Involves infill development on the Town Site and Mill Site, including approximately 265 residential units and numerous commercial buildings. The Mill Site in particular would be developed with commercial and residential buildings (including a 100-room hotel) ranging up to 35 feet high. Mill



Site grades would be raised by 5 to 8 feet (requiring approximately 175,000 cubic yards of fill) to extend above the floodplain, and approximately 10,000 cubic yards of cut might be required to remove unsuitable debris. Scenario A involves a shoreline setback variance (reduce the shoreline setback to 35 feet with a 15-foot building setback, for a total of 50 feet), whereas Scenario B does not involve a shoreline setback variance (retain the current 50-foot shoreline setback with a 7.5-foot building setback, for a total of 57.5 feet). Re-grading in the Town Site and adjacent areas would involve areal cuts and fills as deep as about 10 or 12 feet. Re-grading for roadway improvements would require alignment cuts ranging up to about 15 feet and fills ranging up to about 18 feet. In addition, new underground utilities would require trenching to depths on the order of 5 to 10 feet. Grading around the Trail Parking facility would involve cuts and fills of less than two feet, plus pavement and drainage to capture and discharge stormwater away from nearby steep slopes.

- **Alternative 2: Redevelopment Alternative (“Lesser Included Alternative”)** — Involves infill development on the Town Site and Mill Site, including 225 residential and numerous commercial buildings. The Mill Site in particular would be developed with commercial and residential buildings (including a 100-room hotel) ranging up to 30 or 35 feet high, except that an undeveloped restoration area would be created. Redeveloped parts of the Mill Site would be raised by 5 to 8 feet to extend above the floodplain. Total quantities of cut and fill on the Mill Site would be somewhat smaller than those estimated for Alternative 1. Re-grading in the Town Site and adjacent areas would involve areal cuts and fills as deep as about 10 or 12 feet. Re-grading for roadway improvements would require alignment cuts ranging up to about 15 feet and fills ranging up to about 18 feet. In addition, new underground utilities would require trenching to depths on the order of 5 to 10 feet. Grading around the Trail Parking facility would involve cuts and fills of less than two feet, plus pavement and drainage to capture and discharge stormwater away from nearby steep slopes.
- **Alternative 3: No Action Alternative** — Includes three scenarios. Under Scenario A, no redevelopment would occur at the site, and existing conditions would continue indefinitely. Scenario B would involve redevelopment under existing zoning, but this would be completed by others (not OPG) over time. Scenario C would similarly involve redevelopment under existing zoning by others, but the Mill Site would be restored (also by others) to a natural condition, and no re-grading or new development would occur in this area. New Trail Parking at the southeastern corner of the EIS study area would not occur under this alternative

## 2.0 PREVIOUS WORK

During previous phases of geotechnical work at the project site, Terracon (formerly Zipper Zeman Associates) performed several studies, as described in the following documents:

- **Geotechnical Feasibility Report: Baseline Site Conditions Study**; Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238; dated December 15, 2005.
- **Geotechnical Pre-Design Report: Townsite & Millsite Study**; Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238-03; dated May 2, 2006.
- **Geotechnical Pre-Design Report: Forested Upland Study**; Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238-05; dated January 29, 2007.
- **Geotechnical Setback Review: Port Gamble Townsite Development**; Kitsap County, Washington; Terracon project 81125064; dated December 31, 2012.
- **Geotechnical Overview: Port Gamble Redevelopment**; Kitsap County, Washington; Terracon project 81135034; dated August 15, 2013

As part of the aforementioned studies, we completed a variety of exploration and research tasks. These tasks included the following items, which also form the basis for our geotechnical overview described herein:

- Reviewed topographic maps, lidar maps, geologic maps, regional hazard maps, aerial photographs, surface photographs, and boring logs regarding the site vicinity.
- Performed a surface reconnaissance of the site and immediate vicinity. To support conclusions associated with development of the multi-use Trail Parking area, we performed an additional site reconnaissance on September 18, 2017.
- Advanced eighteen exploratory borings and ten exploratory test pits at strategic locations across the site, to depths ranging up to about 70 feet below existing grades.
- Performed limited geotechnical laboratory testing on representative samples of the near-surface soils.

## **3.0 EXISTING SITE CONDITIONS**

The following subsections describe the existing site conditions (the affected environment), based on the information sources listed in Section 2.0. This section includes topography, geology, near-surface soils, groundwater, and geologic hazards.

### **3.1 Topographic Conditions**

Port Gamble occupies part of an upland peninsula that is rimmed by marine bluffs on three sides. These bluffs extend up to approximately 100 feet high, with inclinations ranging from about 2H:1V (horizontal:vertical) to near-vertical. Teekalet Bluff spans the northern end of the peninsula over a distance of about 1¼ miles. Hood Canal and Gamble Bay lie to the west and east of the peninsula, respectively. Specific topographic conditions for various site areas are described below.

### **3.1.1 Town Site and Agrarian Area Topography**

Surface grades throughout the Town Site are fairly level to gently rolling overall. One notable feature is a broad, shallow, grass-covered depression located near the center of town. The depression is reportedly a natural lakebed that was drained and gradually infilled over the past century or more. The Town Site is bordered on both the north and east by natural marine bluffs. In the agrarian area south and west of town, surface grades slope upward at a gentle angle.

### **3.1.2 Northern Bluff Topography**

The northern town bluff begins near the northeastern corner of town and extends about 500 yards westward past the community park, the community cemetery, and a small residential area, terminating at the outlet of a stream (locally called Machias Creek or Gamble Creek). This bluff ranges from about 20 feet high at each end to about 85 feet high near the middle, at a point directly below the existing cemetery. Surface inclinations along the bluff generally range from about 1H:1V to ¼H:1V, with angles generally steepening in an upward direction; as such, most of the bluff has a slightly concave shape, which we infer to result from on-going erosion at the top and associated deposition at the bottom. In many locations, the uppermost 10 to 15 feet of bluff is nearly vertical and sometimes has a slightly overhanging brow of root-laden soils.

### **3.1.3 Eastern Bluff Topography**

The eastern town bluff begins near the northeastern corner of town and extends southward along the western side of Gamble Bay for more than 500 yards, past the community water tanks and adjacent residential area. Bluff heights along the entire segment range from about 20 to 50 feet, and inclinations range from about 1H:1V to ¼H:1V. Between the Town Site and the Mill Site, we did not observe evidence of recent landsliding along this bluff. The presence of the Mill Site fill pad appears to substantially reduce the occurrence of erosion at the bluff toe, which would otherwise cause slope instability. South of the Mill Site fill pad, however, the erosive effects of wave action are present at high tide and have created numerous areas of oversteepened slopes, fresh outcrops of glacial till soil, toppled trees, and non-vegetated colluvium blocks; all of these features indicate that fairly active coastal bluff retreat processes are occurring here.

### **3.1.4 Mill Site Topography**

The Mill Site consists of an expansive flat and level area that begins at the base of the northern and eastern town bluffs and extends into the mouth of Gamble Bay. This flat area consists of a fill pad that was created in the mid to late 1800s to accommodate a sawmill. The fill pad surface lies at an elevation approximately 15 feet above sea level.

## **3.2 Subsurface Soil Conditions**

### **3.2.1 General Geology**

According to published geological maps, including WSDNR (2005), the site is dominated by Quaternary-age glacially deposited soils. The three main soil deposits are briefly described below. Refer to our *Geotechnical Feasibility Report* (2005) for more information, if desired.

- **Glacial Till:** The most prevalent soil type is *glacial till*, which the maps describe as a “non-sorted, non-stratified mixture of silt, sand, and gravel up to boulder size” ranging anywhere from about 3 to 80 feet thick. Glacial till typically possesses a very high density, very high shear strength, and very low permeability. This deposit mantles most of the upland area within and surrounding the Port Gamble Town Site, forming a *till cap* over the older soils beneath it.
- **Advance Outwash:** The glacial till deposit is underlain by a laterally extensive deposit of *advance outwash*, which is described as “moderately to well-sorted, well-stratified...gravel and sand and...silt and clay.” Thicknesses can range from 10 feet to several hundred feet. Advance outwash soils typically possess a high density, high shear strength, and low to moderate permeability, but the finer-grained varieties (clays and silts) can develop stress fractures that reduce their effective shear strength. Advance outwash exposures have been mapped along the east-facing upland hillslope located southwest of the Town Site, but not within the actual Town Site.
- **Pre-Glacial Deposits:** Several small-scale exposures of older *pre-glacial deposits* have been mapped in the Town Site vicinity. We observed an exposure of such soils in a cut bank along a pedestrian access trail that extends down the northern town bluff. Typically, the pre-glacial deposits comprise stratified mixtures of clay, silt, sand, and/or gravel. Because these deposits pre-date the local glaciation, they underlie both the glacial till and advance outwash deposits, and they extend several hundreds of feet below the ground surface.

### **3.2.2 Mill Site Soils**

Based on our previous exploratory test pits and borings advanced at the site, and on our review of other available subsurface information, we present the following summary of near-surface soil

conditions at the Mill Site. Refer to our *Geotechnical Pre-Design Report (2006)* for detailed information and exploration logs, if desired.

The Mill Site is underlain by layered dredge sands containing wood particles and other debris associated with the sawmill operations. These non-native soils are quite variable both vertically and horizontally. Beginning with the uppermost layer, the near-surface Mill Site soils can be described as follows.

- **Layer 1: Surficial Granular Fill Soil** — Consists of sands, silty sands, and gravels with relatively small quantities of extraneous materials, such as wood, concrete, brick, and seashell fragments. Densities range from very loose to dense but are primarily in the loose to medium dense category. The thickness ranges from about 5 to 20 feet. This layer is most prevalent near the center of the Mill Site pad (where extensive overexcavation has reportedly been performed in association with a former power plant) and at the southern end of the pad.
- **Layer 2: Wood-Laden Fill Soil** — Consists of silty sands containing a relatively large amount of wood material ranging from sawdust-size particles to 4-inch wood chips. Densities range from loose to medium dense. The thickness ranges from about 5 to 15 feet. This layer appears to be most prevalent on the northern and eastern margins of the Mill Site pad.
- **Layer 3: Upper Marine Sediment** — Consists of sands, silty sands, and sandy silts, with varying amounts of gravels and seashells. Thicknesses range up to about 33 feet. Densities range from loose to medium dense or stiff. This layer appears to comprise native marine sediments, but might include some dredged sediments that were used as fill material.

### **3.2.3 Town Site Soils**

Based on our previous exploratory test pits and borings advanced at the site, and on our review of other available subsurface information, we present the following summary of near-surface soil conditions at the Town Site. Refer to our *Geotechnical Pre-Design Report (2006)* for detailed information and exploration logs, if desired.

Within the large, circular depression near the middle of the Town Site, our exploration revealed a sequence that appears to be lacustrine (lakebed) sediments transitioning into pre-glacial soils. Elsewhere across the Town Site, the lacustrine sediments are not present, so that the uppermost soil unit consists of pre-glacial soils. These areas are described below.

- **Central Depression Soils** — The central depression is underlain by loose, silty, gravelly sands (with brick fragments) overlying about 4 feet of very soft to medium stiff, clayey silt with variable amounts of sand and organic matter. Interpreted to be fill

material and/or disturbed native soils. Underlain by medium stiff to stiff, sandy or clayey lacustrine silts interbedded with 1- to 2-inch-thick layers of silty sand.

- **General Area Soils** — Most areas of the Town Site are underlain by very stiff to hard clays and silts with variable amounts of sand and gravel extending to depths of approximately 20 to 40 feet below existing grades. These cohesive soils are interpreted to be pre-glacial soils.

### **3.3 Groundwater Conditions**

Available hydrological documents indicate that several aquifers underlie the site at various depths. These can be broadly classified as *shallow aquifers* and *deep aquifers*, per the following summary. Refer to our *Geotechnical Feasibility Report (2005)* for detailed information.

#### **3.3.1 Shallow Aquifers**

The shallowest aquifer lies within the advance outwash deposit that was previously observed in the upland southwest of town. It is laterally very extensive (probably spanning nearly the entire upland area) but has a saturated thickness of only about 15 feet or less. Although this aquifer generally exists in an unconfined state, we infer that it creates numerous springs where it daylight along hillslopes or bluffs. It is reportedly not a significant source of drinking water for developments within and near the subject site because its upland position puts it above the elevation of most developed properties.

#### **3.3.2 Deep Aquifers**

Deeper aquifers have been found to occupy scattered lenses of saturated sands and gravels contained within a large deposit of silty and clayey soils. Elevations of the various saturated zones range from nearly at sea level to more than 500 feet below sea level. Due to the confined nature of the saturated lenses, artesian pressures can be fairly high; the piezometric heads typically rise several hundred feet above the actual lenses. Nearly all drinking water wells within and near Port Gamble reportedly extend into one of these deeper aquifers.

#### **3.3.3 CARA Mapping**

According to the 2006 Critical Aquifer Recharge Areas (CARA) map of Kitsap County, parts of the subject site are considered to be CARAs. Specifically, most of the Mill Site is mapped as a Category I CARA, indicating that it has a high potential for certain land use activities to adversely affect groundwater. On the Town Site, there are several localized zones that are mapped as Category II CARAs, indicating a vulnerability of current or potential water sources. These localized zones coincide with the eastern and northern Town Site bluffs, as well as Machias Creek, which flows through the Town Site. However, none of these Mill Site and Town Site CARAs appears to

be hydraulically connected to a current or potential drinking-water aquifer; most likely, any usable aquifers are much deeper and are overlain by one or more layers of low-permeability soils.

### **3.4 Geologic Hazards**

Appendix A of this report presents an excerpt from Title 19 of the Kitsap County Code related to geological hazard areas. Based on this code description, on the Kitsap County *Geologically Hazardous Areas* map (2007), on the conditions described above, and on our local geotechnical engineering knowledge, we infer that certain parts of the site are subjected to geologic hazards. These can be classified as erosion hazards, landslide hazards, liquefaction hazards, and settlement hazards. Our assessments of each hazard are discussed below. Refer to our *Geotechnical Feasibility Report* (2005) and our *Geotechnical Pre-Design Report* (2006) for more information, if desired.

#### **3.4.1 Erosion Hazards**

The steep marine bluffs extending along the northern and eastern sides of the Town Site are inherently prone to surficial erosion. According to the WSDOE *Coastal Atlas Map* (2013), the eastern bluff has an *intermediate* erosion classification and the northern bluff has an *unstable* erosion classification, as shown on the enclosed Erosion Hazard Areas map (Figure 1). The eastern and northern bluffs meet Kitsap County's criteria for *Areas of Moderate Geologic Hazard* and *Areas of High Geologic Hazard*, respectively. Based on published soil mapping and on our previous observations of exposed soils, we infer that the northern and eastern bluffs possess a significant risk of erosion. The likely mechanisms for this erosion include surficial raveling, sloughing, and creep.

#### **3.4.2 Landslide Hazards**

The presence of steep marine bluffs extending along the northern and eastern sides of the Town Site inherently creates a landsliding concern. According to the WSDOE *Coastal Atlas Map* (2013), the eastern bluff has an *intermediate* landslide stability classification and the northern bluff has an *unstable* landslide classification, as shown on the enclosed Landslide Hazard Areas map (Figure 2). The eastern and northern bluffs meet Kitsap County's criteria for *Areas of Moderate Geologic Hazard* and *Areas of High Geologic Hazard*, respectively.

Based on published soil mapping and on our previous observations of exposed soils, we infer that the landslide risk on the northern and eastern bluffs is commensurate with the time frame being considered. In a short-term scenario—over a duration on the order of several years—the landslide risk can be regarded as relatively low; we generally do not perceive an imminent risk of landsliding. In a medium-term scenario—over a period of several decades—the landslide risk can be regarded as moderate. In a long-term scenario—over a period of several centuries—the landslide risk is significantly greater.

The localized portion of northern bluff adjacent to Buena Vista Cemetery represents a notable exception to the aforementioned risk scenarios. The bluff reaches its greatest height (about 85 feet) here, and the ground behind the bluff face has dropped by as much as 4 feet relative to the surrounding ground surface. Based on our previous observations, this down-set block feature appears to be an active *earth slump* failure of the upper bluff. We infer that this portion of bluff has a moderate to high risk of landsliding in a short- or medium-term scenario.

### **3.4.3 Liquefaction Hazards**

The term *liquefaction* refers to a sudden loss of shear strength due to earthquake motions. This condition can result in ground subsidence, heaving, and/or lateral spreading, along with damage to building, slabs, pavements, and other surface elements.

Our 2006 geotechnical analysis of subsurface conditions indicated that a crescent-shaped area forming the eastern margin of the Mill Site is highly susceptible to liquefaction during a moderate or severe earthquake. The ground surface within this area, which is shown on the enclosed Liquefaction Hazard Areas map (Figure 3), could potentially experience settlements on the order of 3 to 12 inches, depending on the earthquake severity. Given this liquefaction hazard, the crescent-shaped zone meets Kitsap County's criteria for *Areas of Moderate Geologic Hazard*.

Subsurface conditions throughout other areas of the Port Gamble project site are characterized by dense granular soils or stiff to hard cohesive soils. Such soils are generally not associated with liquefaction. Consequently, we infer these areas have a low or negligible potential for liquefaction during a moderate or severe earthquake.

## **4.0 IMPACTS OF THE ALTERNATIVES**

Our assessment of various impacts to the existing site conditions are discussed below for each of the three project alternatives.

### **4.1 Alternative 1 (Proposed Action)**

The following subsections address geotechnical impacts associated with Alternative 1, which involves a variety of infill development on the Town Site and Mill Site. Except where specifically noted, these impacts apply equally to both Scenario A (shoreline setback variance) and Scenario B (no shoreline setback variance).

#### **4.1.1 Topographic Impacts**

**Mill Site Re-Grading:** Topographic impacts are most significant at the Mill Site, where surface grades would be raised by 5 feet overall, with some localized areas being raised up to about 8 feet. The purpose of this filling is to raise grades above the floodplain level.

**Town Site Re-Grading:** The Town Site and adjacent land would be raised as much as 18 feet in some areas and be lowered as much as 15 feet in other areas. These grade changes would generally occur as balanced or near-balanced cut-and-fill operations over the lateral extent of new building pads and improved roadway sections. Fill will be placed in thin wedges on gently inclined subgrades and as thicker wedges on moderate slopes. Generally, these fills are very localized and do not cover large areas.

#### **4.1.2 Subsurface Soil Impacts**

**Mill Site Excavations:** Impacts to subsurface soils across the Mill Site will be extremely minor, because excavations will occur largely within the new fill material being used to raise surface grades. Only excavations for deep foundations or deep utilities (if any) would extend into existing Mill Site soils.

**Town Site Excavations:** Impacts to subsurface soils across the Town Site and adjacent land will include excavations for new building pads, new underground utilities, and improved roadways. Excavation depths ranging up to about 15 feet are planned. These soils will primarily comprise variable deposits of silts, sandy silts, clayey silts, sands, and silty sands. Nearly all such soils are highly moisture-sensitive and would not be suitable for reuse as structural fill during the wet season of the year or during any extended periods of wet weather.

**Vibrations:** Construction activities associated with the development will generate a moderate level of vibrations. The greatest sources of vibrations will likely be oscillating-drum compactors, dump trucks, trackhoes, and bulldozers. Given the soil types underlying the Town Site and most of the Mill Site, we infer that ground vibrations from such sources will be attenuated over relatively short distances. We therefore expect that the adverse effects of these construction vibrations will be negligible except when equipment is being used within several feet of an existing structure. It should be noted that the soils underlying the outer margin of the Mill Site are more sensitive to vibrations, due to their liquefaction potential. However, we anticipate that there will be little or no construction occurring in this area.

**Static Settlement:** The greatest risk of static settlements appears to exist within the depression near the center of the Town Site. New structures located within the depression near the center of the Town Site of settlements would be susceptible to long-term static settlement due to compression of the underlying soft sediments. We estimate that static compression of the soft, cohesive sediments in this depression could lead to structural settlements in the range of several inches to 1 foot.

### **4.1.3 Groundwater Impacts**

**Shallow Aquifers:** Shallow aquifers likely underlie the site in the form of saturated granular zones contained within silty or clayey soils. It is likely that many of these shallow zones vary seasonally, and none is reported to be a source of drinking water. As such, we do not infer an adverse impact.

**Deep Aquifers:** Deep aquifers have been identified below the site and reportedly provide a source for drinking water wells. These aquifers generally occupy scattered lenses of saturated sands and gravels contained within a large deposit of silty and clayey soils at elevations ranging from nearly sea level to more than 500 feet below sea level. Due to depth and the confined nature of the saturated lenses, combined with the relatively shallow depth of planned excavations and permanent development features, it does not appear that the development will adversely impact the deep aquifers.

**Mill Site CARAs:** Most of the Mill Site is mapped as a Category I CARA, probably as a result of its low surface elevation. We anticipate that total quantities of surface water infiltrating through the Mill Site surface will be reduced due to new impervious surfaces associated with the development. If untreated runoff water from pavements is allowed to infiltrate into the Mill Site soils, there could potentially be adverse contaminant impacts to the underlying groundwater. It should be emphasized, however, that the groundwater aquifer immediately underlying the Mill Site does not appear to be a potential source for drinking water, given its proximity to seawater.

**Town Site CARAs:** The eastern and northern Town Site bluffs, as well as the channel of Machias Creek, are mapped as Category II CARAs. In our opinion, adverse impacts to the bluffs are unlikely because groundwater tends to seep out of the bluff face rather than into the face. The creek channel, however, could potentially be adversely affected if untreated runoff water from pavements is allowed to flow into the creek.

### **4.1.4 Geologic Hazard Impacts**

**Erosion:** The steep northern and eastern marine bluffs are inherently prone to surficial erosion. Although no development is planned for either of these bluffs, any stormwater runoff that flows over the bluffs would increase the magnitude of erosion.

**Landslide:** The steep northern and eastern marine bluffs possess a landslide risk that ranges from low to high, depending on the time frame being considered. Because no development is planned for these bluffs, we do not infer a risk of increased landsliding unless stormwater runoff is allowed to flow over the bluffs. The localized portion of northern bluff adjacent to Buena Vista Cemetery represents a much greater and more imminent risk of landsliding, considering that this location exhibits an active landslide slump set.

**Liquefaction:** A liquefaction hazard exists within a crescent-shaped area forming the eastern margin of the Mill Site. During a moderate or severe earthquake, any new structures within this zone could potentially experience dynamic settlements on the order of 3 to 12 inches, depending on the earthquake severity. Impacts could be slightly greater for Scenario A than Scenario B, because the former would allow buildings to sit as much as 7.5 feet farther into the hazard area than the latter.

## **4.2 Alternative 2 (Redevelopment)**

The following subsections address geotechnical impacts associated with Alternative 2, which involves a variety of infill development on the Town Site and Mill Site. Due to the similarities between Alternative 1 and Alternative 2, the impacts are also similar.

### **4.2.1 Topographic Impacts**

**Mill Site Re-Grading:** Topographic impacts are most significant at the Mill Site, where surface grades would be raised by 5 feet overall, with some localized areas being raised up to about 8 feet. The purpose of this filling is to raise grades above the floodplain level.

**Town Site Re-Grading:** The Town Site and adjacent land would be raised as much as 18 feet in some areas and be lowered as much as 15 feet in other areas. These grade changes would generally occur as balanced or near-balanced cut-and-fill operations over the lateral extent of new building pads and improved roadway sections. Fill will be placed in thin wedges on gently inclined subgrades and as thicker wedges on moderate slopes. Generally, these fills are very localized and do not cover large areas.

### **4.2.2 Subsurface Soil Impacts**

**Mill Site Excavations:** Impacts to subsurface soils across the Mill Site will be extremely minor, because excavations will occur largely within the new fill material being used to raise surface grades. Only excavations for deep foundations or deep utilities (if any) would extend into existing Mill Site soils.

**Town Site Excavations:** Impacts to subsurface soils across the Town Site and adjacent land will include excavations for new building pads, new underground utilities, and improved roadways. Excavation depths ranging up to about 15 feet are planned. These soils will primarily comprise variable deposits of silts, sandy silts, clayey silts, sands, and silty sands. Nearly all such soils are highly moisture-sensitive and would not be suitable for reuse as structural fill during the wet season of the year or during any extended periods of wet weather.

**Vibrations:** Construction activities associated with the development will generate a moderate level of vibrations. The greatest sources of vibrations will likely be oscillating-drum compactors,

dump trucks, trackhoes, and bulldozers. Given the soil types underlying the Town Site and most of the Mill Site, we infer that ground vibrations from such sources will be attenuated over relatively short distances. We therefore expect that the adverse effects of these construction vibrations will be negligible except when equipment is being used within several feet of an existing structure. It should be noted that the soils underlying the outer margin of the Mill Site are more sensitive to vibrations, due to their liquefaction potential. However, we anticipate that there will be little or no construction occurring in this area.

***Static Settlement:*** The greatest risk of static settlements appears to exist within the depression near the center of the Town Site. New structures located within the depression near the center of the Town Site of settlements would be susceptible to long-term static settlement due to compression of the underlying soft sediments. We estimate that static compression of the soft, cohesive sediments in this depression could lead to structural settlements in the range of several inches to 1 foot.

### **4.2.3 Groundwater Impacts**

**Shallow Aquifers:** Shallow aquifers likely underlie the site in the form of saturated granular zones contained within silty or clayey soils. It is likely that many of these shallow zones vary seasonally, and none is reported to be a source of drinking water. As such, we do not infer an adverse impact.

**Deep Aquifers:** Deep aquifers have been identified below the site and reportedly provide a source for drinking water wells. These aquifers generally occupy scattered lenses of saturated sands and gravels contained within a large deposit of silty and clayey soils at elevations ranging from nearly sea level to more than 500 feet below sea level. Due to depth and the confined nature of the saturated lenses, combined with the relatively shallow depth of planned excavations and permanent development features, it does not appear that the development will adversely impact the deep aquifers.

**Mill Site CARAs:** Most of the Mill Site is mapped as a Category I CARA, probably as a result of its low surface elevation. We anticipate that total quantities of surface water infiltrating through the Mill Site surface will be reduced due to new impervious surfaces associated with the development. If untreated runoff water from pavements is allowed to infiltrate into the Mill Site soils, there could potentially be adverse contaminant impacts to the underlying groundwater. It should be emphasized, however, that the groundwater aquifer immediately underlying the Mill Site does not appear to be a potential source for drinking water, given its proximity to seawater.

**Town Site CARAs:** The eastern and northern Town Site bluffs, as well as the channel of Machias Creek, are mapped as Category II CARAs. In our opinion, adverse impacts to the bluffs are unlikely because groundwater tends to seep out of the bluff face rather than into the face. The creek channel, however, could potentially be adversely affected if untreated runoff water from pavements is allowed to flow into the creek.

### **4.2.4 Geologic Hazard Impacts**

**Erosion:** The steep northern and eastern marine bluffs are inherently prone to surficial erosion. Although no development is planned for either of these bluffs, any stormwater runoff that flows over the bluffs would increase the magnitude of erosion.

**Landslide:** The steep northern and eastern marine bluffs possess a landslide risk that ranges from low to high, depending on the time frame being considered. Because no development is planned for these bluffs, we do not infer a risk of increased landsliding unless stormwater runoff is allowed to flow over the bluffs. The localized portion of northern bluff adjacent to Buena Vista Cemetery represents a much greater and more imminent risk of landsliding, considering that this location exhibits and active landslide slump set.

**Liquefaction:** A liquefaction hazard exists within a crescent-shaped area forming the eastern margin of the Mill Site. During a moderate or severe earthquake, any new structures within this zone could potentially experience dynamic settlements on the order of 3 to 12 inches, depending on the earthquake severity.

### **4.3 Alternative 3 (No Action)**

The following subsections address geotechnical impacts associated with Alternative 3, which comprises three different scenarios. Scenario A involves no redevelopment; Scenario B involves redevelopment under existing zoning; and Scenario C involves Town Site redevelopment under existing zoning, along with Mill Site restoration. Because all work in Scenarios B and C is currently unplanned and would be performed entirely by others (not OPG), the associated impacts cannot be evaluated with any degree of certainty.

#### **4.3.1 Topographic Impacts**

Scenario A would have no topographic impacts. For Scenarios B and C, topographic impacts would be commensurate with the amount of re-grading involved, but this factor is currently unknown. In general, any development-gearred scenarios that involve re-grading within the Mill Site and Town Site might have impacts comparable overall to those previously described for Alternatives 1 and 2. However, because it is assumed that Scenario C would not involve any fill placement or other re-grading on the Mill Site, there would be no topographic impacts on the Mill Site under this scenario.

#### **4.3.2 Subsurface Soil Impacts**

Scenario A would have no excavation, vibration, and static settlement impacts. For Scenarios B and C, subsurface soil impacts would be commensurate with the amount of subsurface construction (re-grading, foundations, utilities, etc.) involved, but this factor is currently unknown. In general, any development-gearred scenarios that involve subsurface construction within the Mill Site and Town Site might have impacts comparable overall to those previously described for Alternatives 1 and 2. However, because it is assumed that Scenario C would not involve any foundation construction, utility excavation, or other development activity on the Mill Site, there would be no subsurface soil impacts on the Mill Site under this scenario.

#### **4.3.3 Groundwater Impacts**

Scenario A would have no deep aquifer impacts. For Scenarios B and C, we do not anticipate any aquifer impacts unless a deep subsurface structure or foundation element is planned for the redevelopment. However, this does not seem likely, given the character of the site.

#### **4.3.4 Geologic Hazard Impacts**

Scenario A would have no impacts to the current erosion, landslide, and liquefaction hazards. For Scenarios B and C, these geologic hazard impacts would be commensurate with the amount of construction occurring within or near the respective areas, but this factor is currently unknown. In general, any development-gearred scenarios that involve construction within the Mill Site and Town Site might have impacts comparable overall to those previously described for Alternatives 1 and 2. However, because it is assumed that Scenario C would not involve any building or hardscape construction on the Mill Site, there would be no liquefaction impacts on the Mill Site under this scenario.

## **5.0 MITIGATION MEASURES**

Mitigation measures will be similar or even identical for the three different development alternatives. Consequently, the following text sections apply equally to all three alternatives.

### **5.1 Topographic Impact Mitigation**

- No overall re-grading of the Town Site is planned. Re-grading will be limited to only those areas slated for building construction or roadway improvements.
- Overall re-grading of the Mill Site is planned to raise surface grades above the flood plain, which provides a considerable benefit to the site. An associated benefit of the grade increase is that future excavations for footings, utilities, and other development-related features will occur primarily within the new fill soils; this will minimize excavations into existing Mill Site soils.

### **5.2 Subsurface Soil Impact Mitigation**

- All utility excavations will be immediately backfilled with suitable fill soils, and all fill soils will be compacted to achieve a dense condition.
- At the Mill Site, future excavations for footings, utilities, and other development-related features will occur primarily within the new fill soils, rather than extending into existing Mill Site soils.
- Wherever possible, soils excavated from the site will be reused as on-site structural fill.
- Additional fill soils could potentially be obtained from the large, forested upland area located southwest of the Town Site. If development of this upland coincides with the subject development, then soil generated by excavations for the off-site roadways, houses, and utilities might become available for reuse at the Town Site or Mill Site. Our numerous subsurface explorations performed throughout the forested upland in 2007

revealed a sequence of glacial till (silty, gravelly sands) over advance outwash (gravelly sands and sandy gravels). These soils are generally suitable for reuse as structural fill.

- If construction work must be performed immediately adjacent to an existing structure, the risk could be greatly mitigated by using conventional smaller equipment.
- The risk of long-term static settlements within the depression near the center of the Town Site could be effectively mitigated by conventional methods such as overexcavation and replacement with granular structural fill, or through the use of intermediate-depth foundations. This approach would also apply to any other localized zones of compressible soils that might be discovered during the course of earthwork.
- If pile-driving or other heavy construction must be performed here (such as for a new boardwalk or wharf), it would be prudent to complete the work before building any settlement-sensitive structures nearby.
- Pile-driving vibrations could be significantly reduced by using low-displacement pile types (such as H piles) instead of high-displacement piles (such as pipe piles), and by using oscillating hammers rather than impact hammers.

### **5.3 Groundwater Impact Mitigation**

- Adverse impacts to the Town Site and Mill Site CARAs can be mitigated by proper treatment of stormwater runoff from parking lots and other possible contaminant sources.
- Groundwater recharge across the Mill Site can be maintained closer to current levels by using granular fill soils to raise Mill Site surface grades, and by using pervious hardscapes where practical.
- The risk of shallow groundwater impacts will be largely mitigated because the planned development does not involve any stormwater infiltration systems.
- The risk of deep aquifer impacts will be mitigated or eliminated by the lack of deep subsurface excavations or structures.
- The risk of shallow or deep aquifer impacts is inherently mitigated by the presence of glacial till and other low-permeability soils mantling the entire Town Site.

### **5.4 Geologic Hazard Mitigation**

Mitigation factors related to erosion, landsliding, liquefaction, and settlement hazards are summarized below.

#### **5.4.1 Erosion Hazard Mitigation**

A Temporary Erosion and Sedimentation Control Plan (TESCP) would be prepared and implemented per the Kitsap County Stormwater Design Manual. This plan would include any or all of the following measures.

- Schedule earthwork for the drier summer months, whenever possible, especially in the case of construction sites on sloping terrain.
- Minimize disturbance of existing trees and undergrowth on sloping terrain.
- Apply best-management practices, such as silt fences, bioswales, check dams, stockpile covers, and grate filters, on all construction sites.
- Replant trees and groundcover vegetation as soon as feasible in areas that are necessarily disturbed by earthwork activities.
- Provide temporary erosion-control blankets or permanent rock armoring on steep terrain vegetation is slow to get established.
- Install temporary or permanent tightline pipes, where practical, to convey stormwater from steep sites to appropriate downslope facilities on flatter terrain.
- Install permanent stormwater runoff diversion systems, such as swales, curbs, berms, or pipes, to prevent flow directly over steep slopes.

#### **5.4.2 Landslide Hazard Mitigation**

As a prescriptive mitigation measure to reduce landslide hazards, development will generally adhere to Kitsap County requirements for generic buffers and setbacks. Actual setbacks and buffers will comply with the following criteria, per our geotechnical recommendations. In all cases, these setbacks and buffers are measured from the *brink*, which refers to the intersection of the slope face and the upland surface.

- **Northern Bluff:** To provide a buffer zone, the slope itself and a 25-foot-wide strip of ground immediately behind the brink must be protected from disturbance of any native vegetation and must be free from construction of any impervious surfaces. For the prescriptive top-of-slope setback (S), all buildings must be positioned a minimum horizontal distance equal to 1.3 times the vertical height (H) of the slope or equal to the vertical slope height plus 25 feet, whichever is greater. Considering that the bluff heights in the western segment range up to about 45 feet, the setbacks in this segment should follow the  $S=H+25$  formula. In the eastern segment, however, where the bluff height tapers down to zero, the setbacks can be reduced linearly by applying the  $S=1.3H$  formula.

- **Eastern Bluff:** To provide a buffer zone, the slope itself and a 25-foot-wide strip of ground immediately behind the brink must be protected from disturbance of any native vegetation and must be free from construction of any impervious surfaces. For the prescriptive top-of-slope setback, all buildings must be positioned a minimum horizontal distance of 40 feet from the brink. This setback appears to be geotechnically appropriate, given the relatively uniform bluff height.

### **5.4.3 Liquefaction Hazard Mitigation**

The liquefaction hazard appears to be present only along the peripheral margin of the Mill Site. In our opinion, this hazard can be effectively mitigated through the use of conventional geotechnical foundation designs such as drilled or driven piles, mat foundations, and aggregate bearing pads. We recommend not locating settlement-sensitive hardscapes within the zone; instead, the use of softscapes, flexible pavements, and settlement-tolerant hardscapes should be emphasized for this zone. The most suitable mitigation measure will depend on several variables, including the specific structure location, the structure type, and the risk-tolerance.

## **6.0 UNAVOIDABLE ADVERSE IMPACTS**

Given the site impacts discussed in Section 4.0 and the mitigation measures described in Section 5.0, we do not foresee any significant unmitigated impacts related to topography, near-surface soils, groundwater, or geologic hazards. In our opinion, significant mitigations can be applied to all impacts by means of proper design implementation and construction practices

## **7.0 REFERENCES**

- **Geotechnical Feasibility Report: Baseline Site Conditions Study**, Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238; dated December 15, 2005.
- **Geotechnical Pre-Design Report: Townsite & Millsite Study**, Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238-03; dated May 2, 2006.
- **Geotechnical Pre-Design Report: Forested Upland Study**, Port Gamble Multi-Use Development; Port Gamble (Kitsap County), Washington; ZZA project J-2238-05; dated January 29, 2007.
- **Geotechnical Setback Review: Port Gamble Townsite Development**, Kitsap County, Washington; Terracon project 81125064; dated December 31, 2012.

- **Washington State Coastal Atlas Map:** <https://fortress.wa.gov/ecy/coastalAtlas/default.aspx>; Washington State Department of Ecology (WSDOE); updated 2013
- **Quaternary Geology and Stratigraphy of Kitsap County:** <http://www.kitsapgov.com/gis/metadata/metadata.asp?xml=enviro/stability.shp.xml>; Jerald Deeter, 1979 thesis (WWU); website date March 2004.
- **Geology Map:** *Kitsap County, Washington, Geologic Map Units*; Washington State Department of Natural Resources; OFR 2005-3; dated December 2005.
- **Geological Hazard Map:** *Kitsap County, Washington, Geologically Hazardous Areas*; Kitsap County Department of Community Development; dated June 2007.
- **CARA Map:** *Kitsap County, Washington, Critical Aquifer Recharge Areas; Category I and II*; Kitsap County Department of Community Development; dated December 2006.

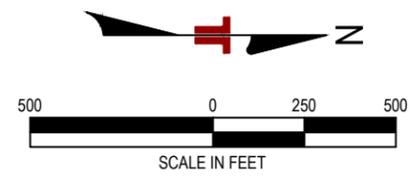
## 8.0 GENERAL COMMENTS

This report has been prepared for the exclusive use of our clients, for specific application to the currently proposed project, and in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.



**LEGEND:**

-  MODERATE GEOLOGICAL HAZARD AREA WITH "INTERMEDIATE" EROSION STABILITY CLASSIFICATION
-  HIGH GEOLOGICAL HAZARD AREA WITH "UNSTABLE" EROSION STABILITY CLASSIFICATION



Basemap DWG file provided by Triad and modified by Terracon.

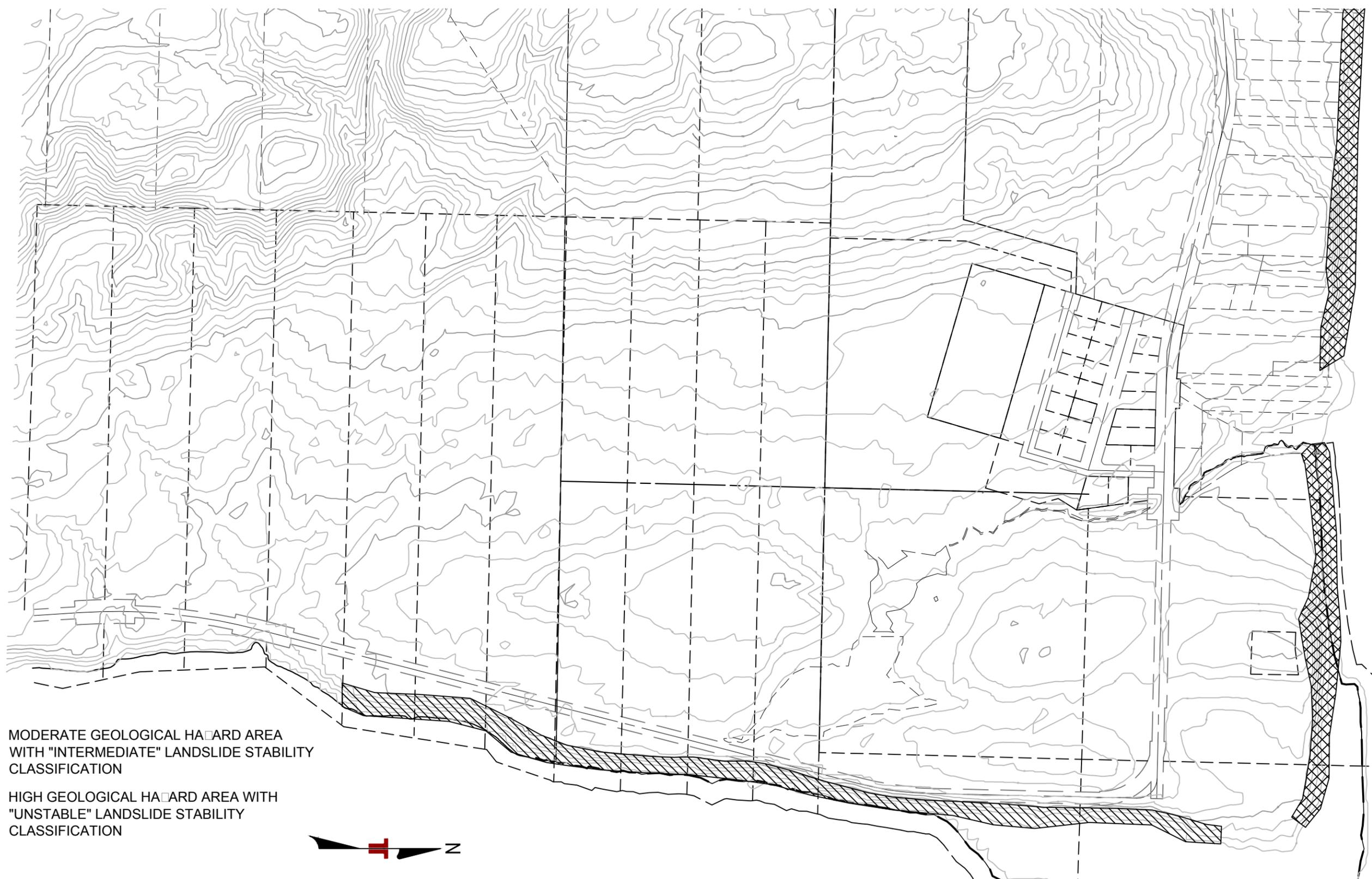
SOURCE: KITSAP COUNTY DEPT. OF COMMUNITY DEVELOPMENT (2013) AND WASHINGTON STATE DEPT. OF ECOLOGY COASTAL ATLAS (2013)

Project Mgr:	JMB	Project No.	81135034
Drawn By:	RMS	Scale:	AS SHOWN
Checked By:	JMB	File No.	TerraFigs.dwg
Approved By:	JMB	Date:	August 2013

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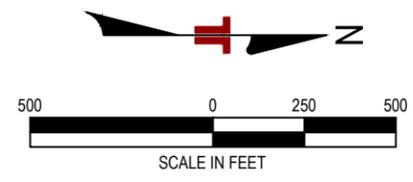
**EROSION HAZARD AREAS**  
 Port Gamble Redevelopment  
 Port Gamble, Washington  
 Prepared for: Olympic Property Group

FIG. No.  
**1**



**LEGEND:**

-  MODERATE GEOLOGICAL HAZARD AREA WITH "INTERMEDIATE" LANDSLIDE STABILITY CLASSIFICATION
-  HIGH GEOLOGICAL HAZARD AREA WITH "UNSTABLE" LANDSLIDE STABILITY CLASSIFICATION



Basemap DWG file provided by Triad and modified by Terracon.

SOURCE: KITSAP COUNTY DEPT. OF COMMUNITY DEVELOPMENT (2013) AND WASHINGTON STATE DEPT. OF ECOLOGY COASTAL ATLAS (2013)

Project Mgr:	JMB	Project No.	81135034
Drawn By:	RMS	Scale:	AS SHOWN
Checked By:	JMB	File No.	TerraFigs.dwg
Approved By:	JMB	Date:	August 2013

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**LANDSLIDE HAZARD AREAS**  
Port Gamble Redevelopment  
Port Gamble, Washington  
Prepared for: Olympic Property Group

FIG. No.  
**2**



**LEGEND:**



MODERATE GEOLOGICAL HAZARD AREA  
SUSCEPTIBLE TO LIQUEFACTION DURING  
STRONG EARTHQUAKE

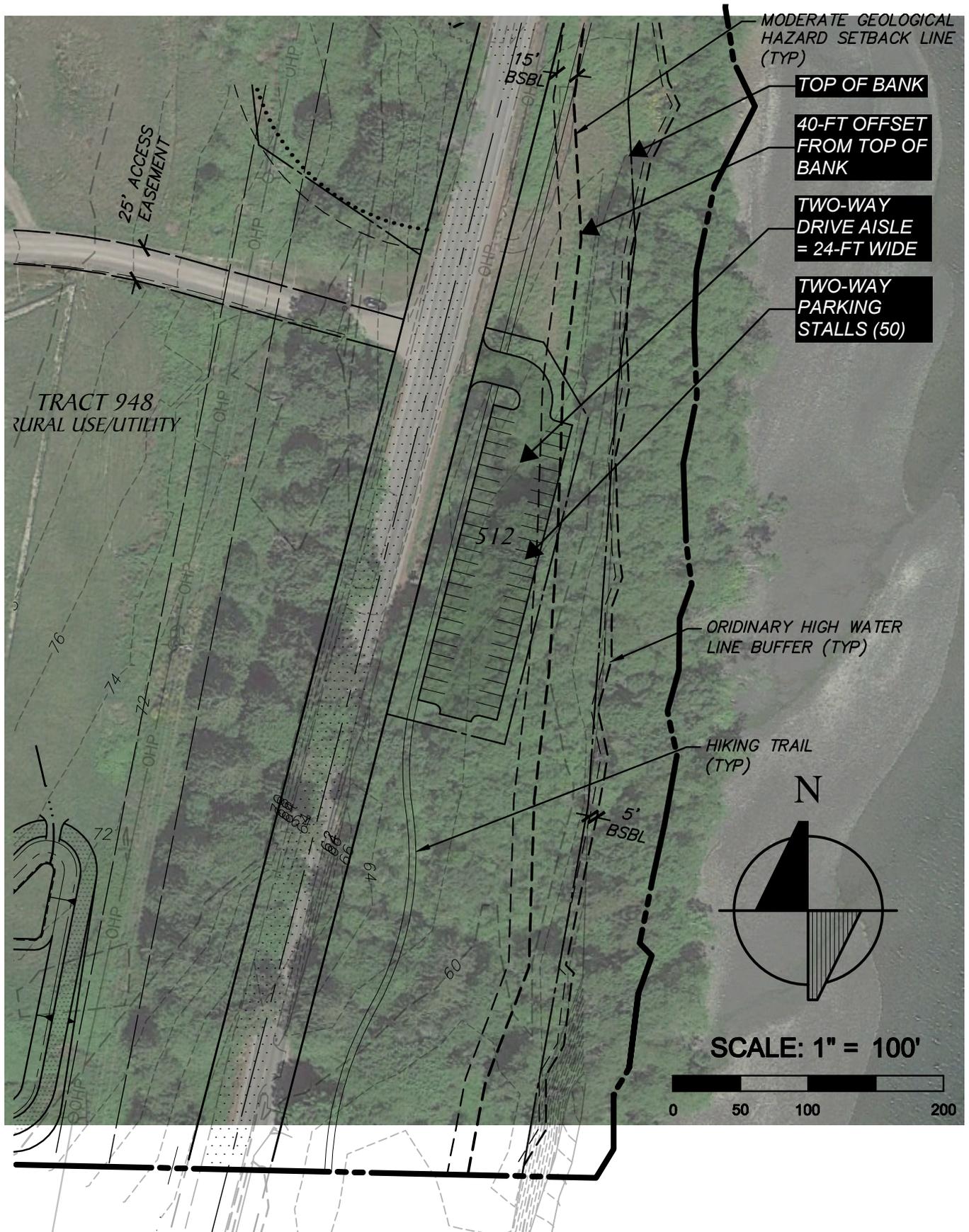


SCALE IN FEET

SOURCE: □□/TERRACON GEOTECHNICAL ANALYSIS (2006) AND KITSAP COUNTY DEPT. OF COMMUNITY DEVELOPMENT (2013)

Basemap DWG file provided by Triad and modified by Terracon.

Project Mngr: JMB	Project No. 81135034	<b>Terracon</b> Consulting Engineers and Scientists <small>21905 64th Avenue W, Ste 100 Mountlake Terrace, WA 98043 PH. (425) 771-3304 FAX. (425) 771-3549</small>	<b>LIQUEFACTION HAZARD AREAS</b> Port Gamble Redevelopment Port Gamble, Washington Prepared for: Olympic Property Group	FIG. No.
Drawn By: RMS	Scale: AS SHOWN			<b>3</b>
Checked By: JMB	File No. TerraFigs.dwg			
Approved By: JMB	Date: August 2013			



Project Mngnr:	CTM	Project No.	81135034
Drawn By:	AMP	Scale:	AS SHOWN
Checked By:	CTM	File No.	Exhibit 4
Approved By:	CTM	Date:	September 2017

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**MULTI-USE TRAIL PARKING AREA**

Port Gamble Redevelopment  
Port Gamble, Washington  
Prepared for: Olympic Property Group

Exhibit  
**4**

## **APPENDIX A**

### **Kitsap County Code – Title 19.400.410**

#### **A. Classification. The following categories shall be used in classifying geologically hazardous areas.**

##### **1. Areas of High Geologic Hazard.**

- a. Areas with slopes greater than or equal to 30 percent and mapped by the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County as “Unstable” (U), “Unstable Old Land Slides” (UOS) or “Unstable Recent Slides” (URS).
- b. Areas with slopes greater than or equal to 30 percent in grade and deemed by a qualified geologist or geotechnical engineer to meet the criteria of U, UOS, or URS.

##### **2. Areas of Moderate Geologic Hazard.**

- a. Areas designated U, UOS, or URS in the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County, with slopes less than 30 percent; or areas found by a qualified geologist to meet the criteria for U, URS, and UOS with slopes less than 30 percent; or
- b. Slopes identified as “Intermediate” (I) in the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County, or areas found by qualified geologist to meet the criteria of I; or
- c. Slopes 15 percent or greater, not classified as I, U, UOS, or URS, with soils classified by the U.S. Department of Agriculture Natural Resources Conservation Service as “highly erodible” or “potentially highly erodible”; or
- d. Slopes of 15 percent or greater with springs or groundwater seepage not identified in subsections (a), (b) or (c) above; or
- e. Seismic Areas subject to liquefaction from earthquakes (Seismic Hazard Areas) such as hydric soils as identified by the Natural Resources Conservation Service, and areas that have been filled to make a site more suitable. Seismic areas may include former wetlands which have been covered with fill.