Technical Memorandum: Ala Spit Restoration Feasibility, Island County, WA - Draft

Prepared for: Island County Public Health

Prepared by: Coastal Geologic Services Inc.
Preparers: Jim Johannessen, Licensed Engineering Geologist, MS
Stephanie Williams, Licensed Geologist, BS/BA

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Introduction and Purpose

The purpose of this technical memorandum is to document the site conditions and major project considerations of a potential rock groin and vertical bulkhead removal project at Ala Spit County Park. The area assessed encompasses high bluffs to the south that transition northward into a broad spit, Ala Spit, on the northeast portion of Whidbey Island within the waterbody of Skagit Bay, Island County, Washington (Figure 1). The site consists of bluff properties in private ownership and Ala Spit County Park which is owned by the Island County Parks Department. The park includes the area from the rock groin and bulkhead north to the end of Ala Spit. CGS staff visited the site on several occasions and conducted site assessments and a topographic survey on May 9, July 20, and July 25, 2013. This report will determine if full or partial removal of the rock groin and vertical bulkhead are feasible, and consider options for parking lot and Water Trails campsite relocation or reorientation. If full or partial removal of the structures is feasible, how and to what extent these actions would generally be accomplished will also be described below as restoration alternatives. Restoration alternatives for Ala Spit County Park are evaluated and a preliminary preferred alternative is presented at the end of this feasibility study. A conceptual design will be further developed upon receiving client comments.

Site Conditions

Park Context

Ala Spit County Park consists chiefly of an elongated, low-elevation spit composed of sand and gravel and extending from shore into deeper water. Spits are dynamic by nature, as they are created by deposition of unconsolidated sediment transported by littoral drift. Ala Spit is generally narrow at the neck, the portion of the spit that is attached to land, and broadens toward the end (Figure 2). At high tides, water currently flows over the low, narrow neck (also discussed in *Conclusions and Recommendations* section). Ala Spit extends north from a series of high-elevation feeder bluffs which supply the sand and gravel that created and maintains the spit. On the lee (west) side of the spit shallow, quiet waters offer protected salt marsh and pocket lagoon habitat.

North Geck Road is the main access to the park and it runs across the historical intertidal area immediately west of the base of the spit, possibly truncating the historical southern extent of the salt marsh and pocket lagoon habitat (Beamer et al. 2005). North Geck Road is paved and wide enough for cars to park along the edges and at the end of the road near the beach. A rock revetment near this portion of Ala Spit was removed in the fall of 2011 and replaced with interlocking large wood, subangular quarry spall fill, and “fish mix”(fine gravel-sand mix) beach nourishment (Herrera Environmental Consultants 2008 revetment removal design). A small patch of (possibly) remnant salt marsh habitat or wetland exists south of the access road (Beamer et al. 2005). Drainage from the uplands and from the remnant salt marsh or wetland flows into the pocket lagoon west of the spit. The topography starts to rise south of the spit and becomes forested. An approximately 3- to 4-ft-high (above grade) vertical concrete wall runs along the upper beach/backshore from the southeast corner of the road end. This bulkhead extends approximately 425 ft south to the rock groin (Photo Page 1, Figure 2). The rock groin consists of 2- to 5-ft stacked boulders and extends obliquely across the beach oriented northeast–southwest. A Water Trails campsite is located in the backshore behind the bulkhead and rock groin.

Approximately 11 wood piles were observed landward of the spit in the intertidal and subtidal. These appeared to be creosoted from a distance but were not checked closely.

Description of marine riparian vegetation, wetlands, large woody debris, and fish habitat use were presented in the feasibility report by Herrera Environmental Consultants (2008). The work and analysis included in this CGS feasibility report focuses on site conditions and analysis for the potential removal of the rock groin and bulkhead, along with geology, shore change, and coastal processes in support of these analyses.

Geology of Bluffs

Ala Spit is located in the northern portion of the Puget Lowland, a north–south trough between the Olympic Mountains and the Cascade Range. Several advances and retreats of glacial ice sheets into the Puget Lowland have filled this trough with various sediment deposits ranging from silt and clay to sand and boulders. Sediments deposited during glacial and interglacial periods can be seen in the high bluffs of Puget Sound while some has been eroded, reworked, and redeposited by subsequent glaciations. The most recent glaciation, the Vashon Stade (ice sheet advance), left behind largely silt and clay, sand, and gravel deposits, as well as glacial till, which is a diamicton, an unsorted mix of clay up to boulder-sized sediments.

CGS staff completed a field reconnaissance that focused on the high bank area south of the existing groin, and included assessment of the larger bluff area to the south and the spit, along with more limited reconnaissance of the development features in the park. Investigation was completed into geologic composition of bluff sediment and apparent slope stability. A beach and bluff profile was completed using a Lieca TCR-1105R Total Station. Survey shots were collected from the lower intertidal beach through the backshore and up the bluff face near the most waterward portion of the privately held house immediately adjacent to Ala Spit County Park.

The base of the bluff was covered with colluvium (slide debris) in this area. Colluvium consisted of silt and sand with lesser amounts of pebble. At approximately + 33 ft Mean Lower Low Water (MLLW) elevation, dense silt and fine sand beds were encountered. Above dense silt beds at approximately + 51 ft MLLW elevation deposits were interpreted as laminated glacial lake deposits. Minor seepage was observed at this elevation. Above this, an unknown thickness of sand and silty sand was encountered. Till was found towards the top of the bank with a definitive contact located approximately 12 ft below the bluff crest.

The geology of the bluffs in the vicinity of Ala Spit consists of layers of glacial and interglacial sediments or geologic units. Background research indicated the geologic units from youngest to oldest (higher elevation to beach level) as Vashon Till (Qgt), Vashon advance outwash (Qga), and Olympia nonglacial deposits (Qc(o)) (Dragovich et al. 2000). One mile south Vashon silt and clay deposits (Qgl) were mapped below Qga and above Qc(o) (Dragovich et al. 2000).

The geology observed in the field closely aligns with that mapped by Dragovich et al. (2000). The geologic units were characterized while ascending the bluff for topographic survey. A bluff cross section was generated from the topography data with approximate locations of the geologic units (Figure 3, Photo Page 2). The description of the units as observed in the field and correlated with the previously mapped units is as follows:

> Vashon Till (Qgt) – An unsorted mix of silt-, sand-, pebble-, and cobble-sized materials ranged from subangular to subrounded, and appeared to be matrix supported. Vashon Till is very recognizable and ubiquitous throughout Puget Sound.
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> Vashon Advance Outwash (Qga) - This unit was not observed at close range, but was believed to be of considerable thickness along the mid-bluff face and was more evident to the south. As observed in reference bluffs at beach level this unit was a dry buff- to orange-colored, sand-dominated unit, exhibiting arcuate-shaped exposures on the bluff face with colluvium deposits near the angle of repose (Photo Page 3). The silty, sandy, weathered unit below contact with Vashon Till, as observed on the adjacent bluff property and based on stratigraphic position, was thought to represent the Qga unit. Qga was described by Dragovich et al. (2000) as moderately to well sorted and stratified; composed of moderately to highly compacted medium to coarse sand, pebbly sand, and sandy gravel; and including minor amounts of silty sand or sandy silt and clay interbeds with scattered lenses and layers of pebble-cobble gravel.
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> Vashon Silt and Clay (Qgl) - A dense, silt-and–clay, cliff-forming unit that exhibits thick to thinly laminated layers, this unit was identified with greater certainty where the presence of very thin “rhythmite bedding” was apparent (Dragovich et al. 2000).
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> Olympia Nonglacial deposits (Qc(o)) - This medium to coarse sand and small pebble cross-bedded unit was observed at beach level to about 15 to 25 ft. Because it was described as being composed of “sand, gravelly sand, organic-rich sand, silty sand, silt, silty clay, and peat…may locally include outwash sand of the Possession Glaciation and nonglacial sediments of the older Whidbey Formation” (Dragovich et al. 2000) the location of the contact between this unit and the overlying Qgl is unknown.

The bluff in the area was well vegetated with primarily immature vegetation. Dominant species included red alder, bigleaf maple, Nootka rose, elderberry, thimbleberry, salmonberry, and trailing blackberry along with patches of English ivy (at the middle to upper portions of the bluff). Older trees appeared to be on the order of 20 to 25 years old. Most trees were near vertical; however, some appeared to be experiencing minor soil creep, leaning downslope and bowing somewhat.

There was no evidence of recent slope failures/landslides at the 2 private parcels just south of the groin. Bluff face topography seemed to be a product of past slides and slumps as the topography was slightly arcuate with minor hummocky areas near the bluff toe. Some amount of colluvium was present at the bank toe. Of importance was the broad float area landward of the beach, which was keeping waves quite a distance from the steeper bluff toe.

Slope Stability

Several mapping efforts that addressed slope stability have been conducted in the area. A relatively long section of bluff, both to the north and south of Ala Spit, is classified as "Unstable Slope" by the Ecology Coastal Zone (1978) (Figure 4). No recent landslides were mapped in the vicinity of Ala Spit in this mapping, although it took place prior to 1978. Slope stability of surficial materials was mapped by Miller et al. (1985), who classified slopes based on steepness, soil type, and instability type in the Port Townsend 30' x 60' quadrangle. Slopes south of Ala Spit were designated as Class 2, which includes coarse granular deposits and till, slopes that range from 15 to 30 percent (can be steeper locally), and slopes susceptible to failure due to toe erosion and surface erosion.

Coastal geomorphic (feeder bluff) mapping conducted by Coastal Geologic Services (Johannessen and Chase 2005) mapped the entire shoreline of Island County, and included landslides and toe erosion as ancillary data to supplement feeder bluff mapping. This mapping indicated a recent landslide (within 5 years prior to 2003 mapping) 600 ft south of the groin and intermittent landslides and toe erosion farther south.

Indicators of slope instability observed in the field in the approximately 900-foot-long area south of the groin include the general abundance of relatively young alder trees on the bluff face, few conifers on the bluff face, J-trunk and leaning trees, old landslide runout deposits at the bluff toe in several areas, and the presence of open scarps along the bluff face devoid of vegetation or exhibiting very little growth of vegetation (Photo Page 3). An estimation of slide frequency in the area based on historical aerial photographs will be reported in the *Historical Shore Change* section.

On the March 22, 2007, site visit, Herrera (2008) observed seven landslide events they believed to have taken place within the previous year: 3 slide events, 2 shallow slumps, and 2 surface erosion events.

Bluff Retreat

Bluff retreat is a form of mass wasting (downslope movement of earth materials), driven largely from wave-induced erosion at the toe of the bluff and subsequent slope instability. This is also referred to as marine erosion (Johannessen and MacLennan 2007). Erosion at the bluff toe leads to undercutting and oversteepening of the bluff and eventual collapse of the overlying materials as the slope returns to a more stable configuration (Cox et al. 1994). Bluffs in Puget Sound are especially prone to this type of erosion and retreat due to the presence of unconsolidated sediment. Wave-induced erosion, or toe erosion, is also controlled by the wave climate which will be further discussed in the *Coastal Processes* section.

Landslide Types and Mechanisms

Factors that control landslides in Puget Sound bluffs are dependent on the characteristics of the bluff – composition, resistance, permeability, slope structure, bluff weaknesses – and local topography including the slope's landslide history (Emery and Kuhn 1982). Drivers of coastal erosion include marine, subaerial, or human-induced (Johannessen and MacLennan 2007). Of these drivers, most landslides in Puget Sound occur as a result of subaerial erosion in response to heavy precipitation, initiating shallow failures, or elevated groundwater conditions (Shipman 2004). Precipitation frequently leads to destabilization of Puget Sound bluffs due to contrasting slope-forming processes of underlying strata (Tubbs 1974). An example of this is when permeable outwash sands overlie impermeable glacial lake clays, and at this contact between sand and clay the saturated lower sands weaken and lead to upslope failures (Tubbs 1974). Many Puget Sound bluffs have a mid-slope bench that occurs at this contact (Gerstel et al. 1997) as is the case with Reference Bluff 1 (Photo Page 3).

Several types of slope failure or landslide events were apparent in the bluffs south of Ala Spit. The most likely types of slope failure are listed below with evidence documented in Photo Page 3.

- Earth slumps – The slump block appearance of the bluff face, particularly the arcuate shape of the scarp, indicated that earth slumps can occur as a result of shallow downslope movement with a rotational component. The typical Puget Sound stratigraphy that includes till over sand over clay deposits is especially susceptible to this type of slope failure when surface- and groundwater permeate till and sand layers and slippage occurs along the clay and sand interface due to the impermeability of clay. The movement can develop into a complex landslide when broken material in the lower part advances as an earth flow (Miller et al.1985).
- Earth or debris flows – The slurry-like appearance of some of the landslide toe deposits found at the bluff toe indicated earth or debris flows, produced in wet to very wet conditions during times of heavy precipitation. Earth and debris flows include the mobilization of fine and coarse materials, respectively (Miller et al. 1985).
- Soil creep –J-trunked and leaning trees at benches on the bluff face indicated soil creep. The mechanism involves the uppermost soil and debris material moving very slowly downslope (Miller et al. 1985).

These types of slides can occur in conjunction with each other and it is not always clear what triggered the mass wasting or landslide event.

Reference Bluffs

Several bluffs south of Ala Spit were investigated during the May 25th site visit to serve as references against which to compare the stability of the adjacent private bluff property immediately south of the spit. LiDAR-generated cross sections were created along 4 profiles of reference bluffs and the adjacent private bluff (Figure 5a, b). The reference bluffs were roughly 400 ft apart. The cross section of the adjacent bluff property (Figure 5b) shows the close alignment of the LiDAR-generated and surveyed profiles, indicating the relative accuracy of the LiDAR cross section compared to current surveyed field conditions. It should be noted that while the reference bluffs may represent a coastal setting and stratigraphy similar to the adjacent bluff property, they differ dramatically in height and in the width of the area at the bluff toe (Figure 5a, b). The reference bluffs would likely be more susceptible to slope failure due to their greater height and resultant stronger gravitational forces.

Table 1. Bluff characteristics related to slope stability and listed from south to north.

Bluff	Landslide Indicators	Vegetation and Drainage	Toe Erosion
Reference Bluff 1	Open scarp face upper, slumped surface lower, colluvium at bluff toe	Young alders, J-trunk trees; no drainage apparent	Not present
Reference Bluff 2	Open scarp face upper, slumped and hummocky surface lower	Few conifers, young alders, J-trunk trees; no drainage observations	N/A – fill and armor
Reference Bluff 3	Open scarp face along most of the bluff, landslide deposits at bluff toe	Very little vegetation; no drainage apparent	Yes – into colluvium
Reference Bluff 4	J-trunk trees, colluvium at bluff toe	No conifers, young alders, surface drainage flow over bluff face	Yes – into sandy pebble unit
Adjacent Bluff	J-trunk trees, colluvium at bluff toe	No conifers & 10-20 yr old alders; fully functioning drainage system	Not present

Adjacent Bluff Property

Assessment of the slope and upland conditions of the residence at the adjacent bluff property occurred at the July 20, 2013, site visit. The house had been constructed between 1987 and 1988, according to the current owners who purchased the property in 1992. The previous owner had informed the current owners that when the house was constructed the bluff vegetation was clear-cut and landslides had ensued. Some “sagging” (possibly soil creep) was also indicated by the previous owner.

According to the current owners, a slide occurred just after they purchased the property to the effect that they could not get insurance for the house; this probably coincided with the major landslide events that occurred during the winter of 1996–1997 triggered by high saturation of soils from a rain-on-snow event and overall heavy precipitation. Shortly after this slide, the current owner installed a drainage system with a French drain and 2 tightlines draining surface water runoff to the north of the property to reduce the susceptibility of slope failure at this property. An earth slump on the south end of the property bluff face (just north of the large Douglas-fir at the bluff crest) had occurred about 10 years prior to the 2013 site visit.

The drainage system seemed to be fairly extensive for a residential property and appeared to be in good working order at the time of the visit. Very few instability issues had been encountered by the property owners since installation.

Beach

The beach at the Ala Spit site consists mainly of sand and pebble. Sand dominated much of the shore with varying amounts of pebble on top at mid-beach elevations. Beach sediment was considerably more coarse north of the parking lot in the eroded neck of the spit, where cobble and angular quarry spall rock was common on the high-tide beach. Pebble was also accumulated in thicker deposits over sand on the lee (north) side of the groin and over to the neck of the spit. Sediment generally transitioned to finer sediment at the upper beach. This trend was apparent on the south side of the groin where isolated boulder deposits possibly from landslide runout debris were also present (Photo Page 4). The general sediment trend of the spit included a gently sloping, sand-and-pebble high-tide beach above a broad low-tide terrace, also called a sand flat on the east shore. The leeward (west) side of the spit has a steeper sloping pebble beach, most easily observed at the neck of the spit (Photo Page 3). Also near the neck of the spit was angular quarry spall rock, which was likely a result of transport of fill material north from the parking lot area or the old rock revetment. Concentrations of pebble were high towards the central and northern portion of the spit at the mid-beach elevations and also at broad sand flats on the lower beach and into the low-tide terrace.

Coastal Processes

Coastal processes at this site are influenced by the characteristics of the specific drift cell and associated up-drift factors, including geology and stratigraphy, shore orientation, and subsequent exposure to wind-generated waves. The site is considerably exposed to the southeast over a 13-mile-fetch (distance over which wind-generated waves are formed) along Skagit Bay to the north side of the Stanwood area. This is a moderate to high fetch from the predominant and prevailing wind direction. From the north quadrant, the site experiences a low to moderate fetch of 3.5 miles from Similk Bay, generally during the summer months and during uncommon northeasterly winter storms.

Ala Spit is part of a larger coastal system that is defined by net shore-drift cells. Net shore-drift refers to the long-term effect of coastal processes in the form of discrete coastal sediment littoral transport systems as mapped by Schwartz et al. (1991) and Johannessen (1992). A net shore-drift cell extends from the beginning of a sediment source to a sediment sink or depositional area (Johannessen and MacLennan 2007). Across Puget Sound, river and stream sediment input is thought to be responsible for approximately 10% littoral or beach sediment in the region, with the majority (about 90%) originating from bluff erosion (Downing 1983, Keuler 1988). However, Skagit Bay is more of a contained system than most Puget Sound river estuaries due to the relative proximity of Whidbey Island to the mouth of the Skagit River, so river sediment likely contributes more than the approximate 10% of the littoral input (Downing 1983, Keuler 1988) for Ala Spit (especially under predevelopment and predredging/channelizing conditions).

Drift cell WHID-22 is approximately 1 mile long, originating at the headland north of Dugualla Bay and terminating at the north end of Ala Spit (Figure 1). The origin of this drift cell is only 3.0 miles from the mouth of the large Skagit River, which delivers large volumes of sand to the nearshore. Therefore, it is likely that some amount of river sand has been integrated into the WHID-22 drift cell, as suggested by Herrera (2008).

Disruption to sediment supply and sediment transport within a drift cell can have negative effects on the stability of depositional shores. Disruption to sediment transport processes can often degrade and deplete the quality and quantity of sediment being delivered to these depositional areas, such as Ala Spit (Johannessen and MacLennan 2007). Mapping by Johannessen and Chase (2005) showed that 28% of the drift cell was mapped as feeder bluff in current conditions, and that only 3% of the drift cell was modified. The Draft Island County Shoreline Master Program (SMP) includes an assessment of the geomorphic conditions of the Ala Spit reach (EW03) (Island County SMP, in preparation). The reach summary indicated that continued degradation of shoreline processes, particularly with expansion of armor (bulkheads), was a key management issue in this drift cell.

Rock Groin

The existing rock groin at Ala Spit County Park consists of large, angular 2- to 4-ft boulders, with some larger boulders. According to Herrera Environmental Consultants (2008), an interview with long-time resident Ed Koetje revealed that the groin (and bulkhead) had been installed in 1960 to encourage shoreline accretion on the southern end of the groin.

This groin was surveyed by CGS during the July 20th site visit. The quantity of rock in the groin based on the preliminary survey data and CADD work is approximately 210 cubic yards (CY), not accounting for the buried portion (Figure 2). This groin has a maximum elevation of +10.4 ft MLLW and a minimum elevation of +5.1 ft MLLW and is oriented across-shore obliquely toward down-drift or north. No subsurface investigations were conducted as part of these estimates, so the volumes above surface should be considered preliminary.

The groin has caused the beach south of it to accrete both sediment and large woody debris (LWD). It is likely that the rock groin abates toe erosion of the adjacent bluff property and reduces the susceptibility of this bluff to mass wasting processes and landslide events. This effect appears to extend approximately 125–175 ft south of the groin.

It is important to note that construction of the groin moved the shoreline on the order of 75 ft waterward, as evidenced by comparison of a 1956 aerial photo to current conditions. The groin also caused down-drift erosion north of the structure, as typically occurs (further discussed in the *Historical Shore Change* section below).

Vertical Bulkhead

The vertical concrete bulkhead is located north of the groin and extends to the south side of the parking area. This bulkhead was constructed in the 1960s along with the groin, and fill was added behind the structure for a level surface and the access road (Herrera 2008). The bulkhead measures approximately 425 linear feet (LF) and ranges between just over 2 ft to 4 ft above the beach surface. The original constructed height of the bulkhead was 7 ft according to Ed Koetje from personal communication with Herrera (2008). This height likely included the footing height below grade. It appears there has been accretion in this area since the time of installation.

Parking Area

Geck Road transitions into the parking area for Ala Spit where the grade of the road is reduced in the vicinity of the pocket lagoon. Cars park at the road end (most waterward extent of road) and along both sides of the road, which is clearly displayed in the 2013 aerial photo (Figure 2). This includes approximately 220 ft along the south side of the road, 175 ft along the north side of the road and enough room for approximately 4 cars at the road end in a space approximately 30 by 45 ft. It appears that this parking arrangement allows for a maximum of 11 cars along the south side, 9 cars along the north side, and 4 cars at the road end, for a maximum of 24 cars in this area of the park. However, because there are no designated parking areas and parking is irregular, the current maximum capacity is approximately 20 cars.

The low-elevation area south of the parking area at the end of the access road contains a marsh that had been identified by Eric Beamer et al. of Skagit River Systems Cooperative (2005) as a restorable marsh.

Kayak Camp

A small campsite for human-powered crafts such as kayaks is located landward of the rock groin and the south end of the concrete bulkhead. When observed on July 20, 2013, the campsite appeared as if it had not been used all spring and early summer. Very tall grass was growing which was not knocked down in any way. The fire area appeared as if it had not been used. This camp has a maximum footprint of 650 square ft as mapped in the field, but with encroachment of grasses, Nootka rose, and Himalayan blackberry, as well as drift logs thrown over the groin and bulkhead into the camping area, the footprint is smaller. Amenities at the campsite include a fire pit, sitting area, and room for one small tent. This campsite land is only dry and available due to the presence of the groin and bulkhead and the associated bad fill that was added to this area.

Historical Shore Change

Shore change work was completed by CGS using georeferenced aerial photos and early mapping. Data on shoreline position over time from Herrera (2008) was also used. Historical topographic mapping (T-sheet #2856) from 1908 shows the earliest reliable mapping of predevelopment conditions in the area. This image, along with vertical aerial photos and LiDAR (Table 2), was used to assess the changing morphology in the vicinity of Ala Spit.

Table 2. Available high-resolution vertical aerial photos used to assess site history and shore change.

Year	Source	Scale
1956	Skagit River Systems Cooperative	1:20,000
1969	Island County Public Works	1:24,000
1985	Island County Public Works	1:24,000
2007	Island County Planning Dept.	0.5 ft pixel

Bluff Change

Bluff crest recession was measured from historical aerial photos along reference bluff cross sections (Figure 2, 5a, and 5b) among the years 1956, 1969, 1985, and 2007. Analysis indicated the following observations and measurements (Table 3):

Reference Bluff 1: Very minimal recession in the bluff crest. A possible earth flow or debris flow had occurred prior to the 1985 aerial photo, as indicated by the trees in the debris pile at the bluff toe. The 1985 photo also indicated that the access road to the residence with the private bulkhead had recently been cleared.

Reference Bluff 2: Moderate recession between 1956 and 1969. The current bulkhead structure had not yet been built in 1956, but there appears to have been a wharf or pier structure along with the access road. The 1969 photo showed more build-out of the wharf or pier structures and a house at the bluff crest.

Reference Bluff 3: Steady moderate bluff crest recession between all years observed. A house had been constructed prior to 1956 at the bluff crest and a bare scarp was present immediately below the house on the upper bluff face. A possible debris flow, earth flow, or earth slump had occurred between 1956 and 1969 as shown by the appearance of a "chute" below the house devoid of vegetation and a bare scarp immediately below the house. The 1985 aerial photo indicated a period of relative stability, as both the vegetation and the upper bluff scarp appeared to have grown in. The house at the bluff crest appeared to have been moved back and/or reconstructed sometime between 1985 and 2007.

Reference Bluff 4: Steady moderate bluff crest recession between all years observed. A house had been constructed between 1956 and 1969 at the bluff crest. A debris flow or earth flow appeared to have occurred in close proximity to the bluff cross section between 1956 and 1969, possibly associated with the construction of the residence. The 2007 aerial photo showed a bare scarp in the upper bluff face in the same location as the previous slide.

Adjacent Bluff Property (immediately south of groin): Very minimal recession in the bluff crest between years. The groin, bulkhead, and associated backfill had been installed between 1956 and 1969 (construction in 1960). No evidence of slope instability was apparent on the basis of the photo record.

Erosion rates measured (Table 3) ranged from 0.12 to 0.93 ft/yr at the 4 reference bluff sites over the full 1956–2007 period. However, reference bluff 3 site was located a short distance down-drift of the major fill and shore armor area, which would have subjected it to accelerated erosion due to wave refraction and littoral sediment transport alteration, such that this is not a "natural" erosion rate. The sites with a location and bluff elevation which most resembled conditions at the bluff site adjacent to Ala Spit had an erosion rate of 0.12 ft yr (reference bluff 1) and 0.75 ft/yr (reference bluff 4) over the 1956–2007 period.

Table 3. Reference bluff crest recession distances (ft) and rates (ft/yr) among years.

Year	Ref Bluff 1	Ref Bluff 2	Ref Bluff 3	Ref Bluff 4	Adj Bluff
1956-1969	3.5	16.4	20.3	9.8	1.9
1969-1985	2.2	2.1	8.3	8.0	0.4
1985-2007	0.4	1.9	18.7	20.5	0.3
Total	**6.1**	**20.4**	**47.3**	**38.3**	**2.6**
Rate (ft/yr)	**0.12**	**0.40**	**0.93**	**0.75**	**0.05**

Note: Sources of error with this analysis include georeferencing, aerial photo distortion, and feature digitizing error. At a minimum the shore change analysis offers a relative sense of bluff crest recession over time and may have an error of approximately + or – 10 ft.

Ala Spit Shore Change

Herrera Environmental Consultants (2008) conducted a shore change assessment of Ala Spit (Figure 6) that showed a narrowing and elongating migration of Ala Spit over the course of nearly a century. The shorelines mapped include the 1908 T-sheet shoreline, and the Ordinary High Water (OHW) as indicated by riparian vegetation, wrack, and other indicators from 1956, 1971, 1981, and 2006 (Herrera 2008).

Comparison of the 1956 and current (2007) aerial photos with contrasting high water shorelines for the Ala Spit area reveal that the groin appears to have played a significant role in altering the morphology of the spit. The spit was much straighter in plan form in 1956 as compared to later years (Figure 7). The groin appeared to fill out into the intertidal and cause wave refraction and disruption of upper-beach sediment transport. This led to subsequent erosion of the area to the north, including the neck of the spit.

The spit's elongating and northwesterly translation or migration over the past 100 years can be explained by a few factors. One is that this occurs naturally: according to Downing (1983), spits tend to straighten the coastline with time. Spits often extend from the coastal where the shore orientation changes (Johannessen and MacLennan 2007) as is the case with Ala Spit. Spits can be near linear, recurved, or form as a complex of multiple spits (Zenkovich 1967) depending on shoreline morphology, localized and seasonal littoral drift regimes, and upland drainage or river delta inputs. In the case of Ala Spit it appears to be straightening and curving slightly towards the shoreline north of the spit. Views on spit growth and behavior are still debated, as this is dependent on several factors. However, one theory is that spits grow unidirectional followed by breaching (Robinson 1955). This would appear to be the case with Ala Spit currently, as it has elongated and narrowed (exhibiting growth to the north) and is breached at high tides.

Another potential factor is the effect of the groin on the plan form of the spit. Since installation in 1960 the groin has caused an offshore "shunting," i.e., sediment bypassing the upper beach at the spit neck to the lower beach or sand flat (see annotated "model" in Figure 8). This is a simple process evident in most aerial photos since the 1970s which show sand and gravel extending north from the tip of the groin, and not reattaching to the upper beach until 900–1,000 ft north of the groin (Figures 7 and 8). The sediment supply from up-drift feeder bluffs has only been slightly reduced due to development within this drift cell (Johannessen and Chase 2005), with the major impediments being the Ala Spit groin and the private bulkhead area approximately 1,500 ft south of the groin.

Conclusions and Recommendations

Overall conclusions of this feasibility study are presented here relative to the slope stability concern for the parcels adjacent to and south of the groin and bulkhead and the effects of the groin and bulkhead on the spit and associated habitats.

Groin and Bulkhead Removal Relative to Slope Stability

It was apparent during the 2013 site visits, in other work presented in the study, and in background research that the bluffs in the area south of Ala Spit are relatively unstable and that mass wasting (landslides) occurs intermittently in this area. This is indicated by vegetation patterns and open scarps along the bluff face devoid of vegetation or exhibiting very little growth of vegetation, as well as by the shore change assessment results.

The controls on slope stability in this area include surface and groundwater drainage, bluff stratigraphy, and wave-induced toe erosion. We have found that the rock groin has limited toe erosion of the bluff property immediately south of Ala Spit County Park. LWD accumulation and an overall greater height of sediment in the upper beach south of the groin are evidence of this. The rock groin has then essentially eliminated the wave-induced toe erosion in the approximately 150–200 ft south of the groin (as discussed in the *Rock Groin* section above), which is within the park property and the immediately adjacent private parcel.

Impacts of Groin and Bulkhead

Habitat Impacts

Schlenger et al. (2011) assessed degradation to nearshore ecosystem processes throughout the Puget Sound area. Sediment supply was ranked as moderately degraded within the Ala Spit drift cell. Sediment supply degradation was assessed by measuring the extent of armor along bluff-backed beaches in areas in which littoral drift occurs. Bluff erosion is known to be the predominant source of beach sediment throughout the region (Downing 1983, Johannessen and MacLennan 2007). Armor slows or precludes marine-induced erosion along bluffs, resulting in reduced sediment supply to the larger drift cell. As discussed above, some amount of sand is likely also contributed by the high-sediment-load Skagit River, although probably not to the extent suggested by Herrera (2008).

Critical marine and nearshore species that will benefit from restoration actions are documented at length by Herrera (2008). Most notable benefits will accrue to juvenile salmonid rearing habitat, surf smelt and Pacific sand lance spawning habitat, and eelgrass habitat. Most importantly, the stability of the spit will be enhanced by the greatest degree of groin and bulkhead removal feasibility, as this will restore littoral transport, the process which maintains the integrity of the spit itself (discussed immediately below). This includes the pocket lagoon, which may become further compromised if the partial spit breach continues to develop, as it has in the last few years.

Sediment Transport Alteration and Partial Breach

Analysis of geomorphic conditions indicates that the rock groin has caused sediment transport alteration at Ala Spit County Park, to the effect of thinning and lowering the neck of the spit. The location of the groin has diverted sediment to the lower intertidal, waterward of the upper elevation portions of the neck of the spit; sediment that would otherwise be transported along the upper beach for maintaining and replenishing the neck of the spit (Figures 7 and 8). The configuration of the rock groin has led to thinning of the neck and lowering, which along with removal of the revetment, has in turn led to considerable overwash. These processes have been notable in recent years since most of the old bulkhead was removed.

The recent site visits and photo accounts indicate that the Ala Spit neck is now partially breached at high tides. This negatively impacts pocket lagoon habitat and public access at the park. Starting at approximately 3:45 pm on July 20, 2013, water began overtopping the neck of the spit in the revetment removal area. Recorded tide was approximately +9.5 ft MLLW (NOAA tides and currents). At this time relatively rapid current was traveling from the southeast side to the protected northwest side of the spit. The cobble and small boulders appeared to be limiting further erosion of the neck of the spit. A significantly lowered elevation area was present near the neck of the spit in 2012 to 2013 (Figure 7). Cobble and large pebble were observed south of this overwash area on the upper beach (Photo Page 4). The overwash area was devoid of logs and other backshore features over a total length of approximately 300–375 ft. Photo Page 5 shows the neck breach and tidal currents flowing over the neck of the spit in recent years. The elevation of the low portion of the neck of the spit corresponded to approximate middle elevations of pickleweed (*Salicornia virginic*a), a type of salt marsh vegetation which typically grows just below MHHW.

An earlier phase of the Ala Spit Restoration Feasibility conducted by Herrera Environmental Consultants (2008) assessed several anthropogenic features as potentially responsible for a possible breach at the neck of Ala Spit, as per the Salmon Recovery Funding Board (SRFB) grant application. The goal of the project, taken directly from the mission statement of the SRFB was as follows:

> To maximize the recovery of salmon species, through the preservation and restoration of their habitat, while maintaining the current use of Ala Spit County Park by the public.

It was stated by Herrera (2008) in this report that they were going to test the following hypotheses based on language in the SRFB grant application:

- Ala Spit is close to being breached at the neck, thereby endangering an existing pocket estuary/lagoon associated with the spit.
- The small rock groin, immediately south of the spit, and the park bulkhead are inducing thinning of the neck of the spit (potentially resulting in a breach).

The major findings of the Herrera (2008) report in regard to the stated hypotheses above concluded the following:

- The neck of the spit is not about to be breached. However, the riprap revetment is being undermined as the pocket estuary/lagoon is slowly eroding due to the loss in sediment supply and the increase in wave energy. The loss of sediment supply has been caused by the elimination of overwash by the riprap revetment.
- The small rock groin and the park bulkhead are not responsible for the changes observed at the neck of Ala Spit. Instead, the riprap revetment has precluded sediment accretion on the spit by preventing overwash and splay formation.

The prior feasibility assessment placed a high importance on riprap revetment removal and this project, which involved revetment removal, placed LWD, and “fish mix” nourishment was completed in fall 2011.

Based on our analysis the neck of the spit was thinning and lowering prior to the 2011 revetment removal. However, it is our professional opinion that the 2011 riprap removal has greatly accelerated thinning and lowering of the neck of the spit. The placed LWD is no longer present in the neck of the spit and the large majority of fine gravel and sand “fish mix” is no longer on the upper elevation portions of the spit. This has occurred in the past 2 years without addressing the primary problem – the groin. The best course of action to remedy the problem presented at Ala Spit County Park is outlined below in the following section.

Preliminary Design Alternatives

Restoration alternatives were explored for the project area in an effort to maximize habitat restoration and public access of the park, while maintaining a balance with project constraints. The feasibility different potential restoration actions which could be carried out at Ala Spit County Park will be examined. This section will consider the following elements separately:

- full groin removal
- partial groin removal
- full bulkhead removal
- parking lot relocation

From these a *Preferred Alternative* is presented which will be further developed and refined upon receiving client comments. Alternatives for the Kayak Camp will also be considered under the listed restoration alternatives.

Full Rock Groin Removal

Full rock groin removal would initiate process-based restoration including the following:

- restoring sediment transport processes and beach morphology/spit configuration (100%)
- uncovering beach habitat (100%)

Under this action it is likely that upper beach erosion and deferred erosion at the adjacent private bluff property would lead to a degree of bluff toe erosion so this is not a feasible option at this time. On the basis of the bluff recession measured along the cross section for this property and recorded in Table 3, the adjacent bluff property has experienced very little bluff recession. This can largely be explained by the position of the rock groin "trapping" or accreting sediment and LWD at the toe of this bluff in the northern portion of the property and essentially eliminating wave-induced toe erosion at this location. In the future if the adjacent bluff property can be acquired into public ownership then the entire groin structure can be removed and processes can be fully restored.

It should be noted that actions involving the removal of the bulkhead would appear to have no impact on the stability of the adjacent bluff property, especially in regard to the back fill south of (behind) the bulkhead.

Care should be taken with the engraved memorial rock placed at the lower extent of the groin to reincorporate it into the infrastructure of the park.

Partial Rock Groin Removal

Partial rock groin removal includes a reduced and relocated groin structure. This adapted groin structure would offer protection to the toe of the slope at the adjacent bluff property but with a substantially reduced footprint that would allow for mostly restored sediment transport. Benefits that could be achieved while also not jeopardizing the stability of the bluff at this adjacent property include

- restoring sediment transport processes (up to 75%) and beach morphology/spit configuration;
- uncovering beach habitat (up to 75%);
- minimizing sediment transport alterations at the neck of the spit through placement of a reduced-area and reconfigured groin south of the present location.

It appears that the adjacent bluff property will require protection from wave-induced toe erosion to maintain its current level of stability. By placing a reduced area and shorter groin structure in a carefully selected location, elevation, and orientation at the bluff toe, this structure could offer protection to the bluff toe of the adjacent bluff property by holding accreted sediment and LWD while still allowing for a large percentage of sediment transport processes to be restored.

Bulkhead Removal

The 435-foot-long vertical concrete bulkhead could be completely removed as it is not needed to protect any primary structures, including the adjacent bluff property. The bulkhead does not play a role in the stability of the adjacent bluff property. Potential bulkhead removal includes full removal of the structure and gradual readjustment by wave action which would lead to some of the placed backfill from the original construction being redistributed. The potential bulkhead removal would result in

- reestablishment of upper beach habitat areas, which are now covered with fill and isolated from the beach system;
- reconnection of the backshore and adjacent marine riparian with the beach.

Parking Lot Relocation Alternatives

The very waterward end of Geck Road (used for parking for approximately 4 cars at maximum) would likely experience some gradual erosion with bulkhead and/or groin modification. Therefore, under these actions it is recommended that the road end be pulled back from its existing location.

Pulling the parking area landward while also including designated parking to accommodate more parking in less space is a feasible option. According to 2-ft contour lines generated from LiDAR there may also be limited space to expand the parking area slightly on portions of the south margins of Geck Road east of the drainage outfall. This would require full investigation by a wetlands specialist to delineate the extent of the remnant salt marsh area south of the existing location of Geck Road. In any event, installing designated parking spaces with paint would ensure maximum parking capacity for Ala Spit County Park.

Other Considerations

Kayak Camp Relocation Options

If there is full or partial removal of the rock groin and full removal of the concrete bulkhead then the Kayak Camp that has been built on fill landward of these structures will erode away and become unsuitable for a campsite. Based on 2-ft contours generated from 2001 LiDAR (Puget Sound LiDAR Consortium) there are two possibilities for camp relocation. Because this is a Kayak-in camp it is feasible to create a camping area on the north end of the spit in a relatively high elevation area and also approximately 120-150 ft south of the parking lot in the riparian zone just up from the beach.

Enlarged Culvert and Remnant Marsh Reconnection

Through our site analysis and that by Herrera (2008) it is clear that Geck Road, the access road to Ala Spit County Park, has cut off and filled what appears to have been a historical salt marsh. According to Aundrea McBride (2013, pers. comm.) of the Skagit River Systems Cooperative (SRSC), any opportunity to increase pocket estuary/pocket lagoon habitat is a benefit to Chinook salmon in Whidbey Basin. By enlarging the culvert under Geck Road, a much better connection would be made to this marsh area, as opposed to the small concrete culvert presently in place.

Beach Nourishment to Enhance Spit Stability

The addition of a considerable quantity of beach nourishment gravel now appears needed to reestablish the stability of the spit neck area. This would be placed starting south of the parking area through to the lowered neck of the spit.

Preferred Alternative

A combination of the restoration elements discussed above is recommended at this point. These options will be further detailed in the form of a conceptual restoration alternative which will be explained and illustrated in a brief technical memo to be delivered at the completion of this phase of the project, following review by the client. On the basis of the above recommendations, we anticipate the following components will be included in the preferred alternative:

- Groin modification, similar to partial groin removal. Specifically a portion of the groin rock would be relocated landward and to the south to provide protection of the bluff toe in the area waterward of the adjacent house.
- Full bulkhead removal.
- Relocation of the kayak campsite.
- Minor parking lot modifications, details to be determined.
- Beach nourishment, which will likely be beneficial for stability and habitats.

Our analysis and project constraints indicate that the preferred alternative will result in nearly full sediment transport processes restoration, immediate gain of upper beach habitat through direct removal of the entire rock groin, and reconnection of the upland with the beach due to the removal of the bulkhead. In the long term, much of the fill is expected to be eroded, returning the area that is now a closed freshwater wetland to its historical condition.

The preferred alternative would also result in enhanced recreation and improved conditions in terms of risk management, as park users will no longer be required to traverse the large rock groin and vertical bulkhead south of the parking area, and will also not be require to wade through moderate currents at the neck of the spit at times of higher tides.

No Action/ Existing Conditions

The no-action scenario would consist of leaving both the rock groin and the bulkhead in place and making no changes to existing conditions. Under no action there would be no increased habitat benefits to the beaches in the vicinity of the spit and the neck of the spit would likely continue to experience overwash and lowering. These changes would result in continuing degradation of habitat and also recreation at the park.

Limitations of This Report

This report was prepared for the specific conditions present at the subject property to meet the needs of the specific client. No one other than the client should apply this report for any purposes other than that originally contemplated without first conferring with the engineering geologists/geologist who prepared this report. The findings and recommendations presented in this report were reached on the basis of brief field visits and background information that included examination of surface features, bank exposures, soil characteristics, beach features, and coastal processes. In addition, conditions may change at the site due to human influences, floods, earthquakes, groundwater regime changes, or other factors. Thank you for engaging the professional services of Coastal Geologic Services, Inc. If we can be of any additional assistance please contact our office at (360) 647-1845.

References

Beamer, E.M., McBride, A., Henderson, R., and Wolf, K., 2005. Delta and Nearshore Restoration for the Recovery of Wild Skagit River Chinook Salmon: Linking Estuary Restoration to Wild Chinook Salmon Populations. Appendix to the Skagit Chinook Recovery Plan.

Cox, J., MacDonald, K., and Rigert, T., 1994. Engineering and Geotechnical Techniques for Shoreline Erosion Management in Puget Sound. Coastal Erosion Management Studies Volume 4. Shorelands and Environmental Assistance Program, Washington Department of Ecology, Olympia.

Downing, J., 1983. The Coast of Puget Sound: Its Processes and Development, University of Washington Press, Seattle, 126 p.

Dragovich, J. D., Troost, M. L., Norman, D. K., Anderson, G., Cass, J., Gilbertson, L. A., and McKay, D. T. Jr., 2000. Geologic Map and Interpreted Geologic History of the Anacortes South and La Conner 7.5-minute Quadrangles, Skagit County, Washington: Washington Division of Geology and Earth Resources Geologic Map, Open File Report 2000-6.

Gerstel, W.J., M.J. Brunengo, W.S. Lingley Jr., R.L. Logan, H.S. Shipman and T.J. Walsh, 1997. Puget Sound bluffs: the where, why, and when of landslides following the holiday 1996/1997 storms. Washington Geology. March 1997, 25(1):17-31.

Herrera Environmental Consultants, 2008. Feasibility Study for Restoration of Ala Spit. Prepared for Island County Planning and Community Development Department. 128 p.

Island County Shoreline Master Program – Update 2010 – 2013. http://www.islandcounty.net/planning/shorelines.htm

Johannessen, J.W., and MacLennan, A.J., 2007. Beaches and Bluffs of Puget Sound. Puget Sound Nearshore Ecosystem Restoration Project Report No. 2007-04. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Johannessen, J.W., and Chase, M.A., 2005. Island County Feeder Bluff and Accretion Shoreform Mapping. Prepared for Island County Marine Resource Committee.

Johannessen, J.W., 1992. Net Shore-drift in San Juan County and Parts of Jefferson, Island, and Snohomish Counties, Washington: Final Report. Western Washington University, for Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia. 58 pp., 25 maps.

Keuler, R.F., 1988. Map showing coastal erosion, sediment supply, and longshore transport in the Port Townsend 30- by 60-minute quadrangle, Puget Sound region, Washington: U.S. Geologic Survey Miscellaneous Investigations Map I-1198-E, scale 1:100,000.

McBride, A., 2013. Personal communication through email with Stephanie Williams of Coastal Geologic Services regarding pocket estuary/lagoon restoration as a benefit to Chinook salmon in Whidbey Basin. Research Ecologist at Skagit River Systems Cooperative. August 13, 2013.

Miller, R.D., Safioles, S.A., and Pessl, F., 1985. Map showing relative slope stability in the Port Townsend 30' x 60' Quadrangle, Puget Sound Region, Washington. Miscellaneous Investigations Series Published by the U.S. Geological Survey, 1:100,000 scale.

Robinson, A.H.W., 1955. The Harbour Entrances of Poole, Christchurch and Pagham. Geogr. Journ. p. 121, 33-50.

Schlenger, P., MacLennan, A., Iverson, E., Fresh, K., Tanner, C., Lyons, B., Todd, S., Carman, R., Myers, D., Campbell, S., and Wick, A., 2011. Strategic Needs Assessment: Analysis of Nearshore Ecosystem Process Degradation in Puget Sound. Prepared for the Puget Sound Nearshore Ecosystem Restoration Project. Technical Report 2011-02.

Schwartz, M.L., Harp, B.D., Taggart, B.E., and Crzastowski, M., 1991. Net shore-drift of Washington State, Washington Department of Ecology, Shorelands and Coastal Zone Management Program, Olympia, WA. Washington State Department of Ecology, 1979. Coastal Zone Atlas of Washington, v. 4, Island County: Dept. of Ecology, Olympia, Pub. No. DOE 77-21-4.

Shipman, H., 2004. Coastal bluffs and sea cliffs of Puget Sound, Washington. In M.A. Hampton and G.B. Griggs (eds.). Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends. 1693, U.S. Department of the Interior, U.S. Geological Survey, Denver, CO., 123p.

Tubbs, D.W., 1974. Landslides in Seattle, Washington. Division of Geology and Earth Resources Information Circular 52, 15 p., 1 plate.

Washington State Department of Ecology, 1979. Coastal Zone Atlas of Washington, v. 4, Island County: Dept of Ecology, Olympia, Pub. No. DOE 77-21-4.

Zenkovich, V.P. 1967. Processes of Coastal Development. Oliver and Boyd.

Coastal Geologic Services, Inc.

DRAFT

Jim Johannessen, Principal Geologist
Licensed Engineering Geologist, MS

Stephanie Williams
Associate Geologist, Licensed Geologist

ATTACHMENTS:

Figure 1. Ala Spit project area and net shore-drift map.
Figure 2. Ala Spit site features and conditions map.
Figure 3. Ala Spit adjacent bluff property geology cross section.
Figure 4. Ala Spit slope stability mapping in the project area (Ecology 1979).
Figure 5a,b. Ala Spit reference bluffs cross sections.
Figure 6. Shore change mapping of Ala Spit (Herrera Environmental Consultants 2008).
Figure 7. Historic 1956 and current (2013) air photo with contrasting shorelines for the Ala Spit area.
Figure 8. Ala Spit coastal geomorphic model.

Photo Page 1. Site features from May 9th, July 20th, and July 25th site visits.
Photo Page 2. Geologic units observed in the geologic cross section on the adjacent bluff property.
Photo Page 3. Reference bluffs for slope stability assessment.
Photo Page 4. Surface beach sediments of Ala Spit from south to north.
Photo Page 5. Ala Spit partial breach progression.

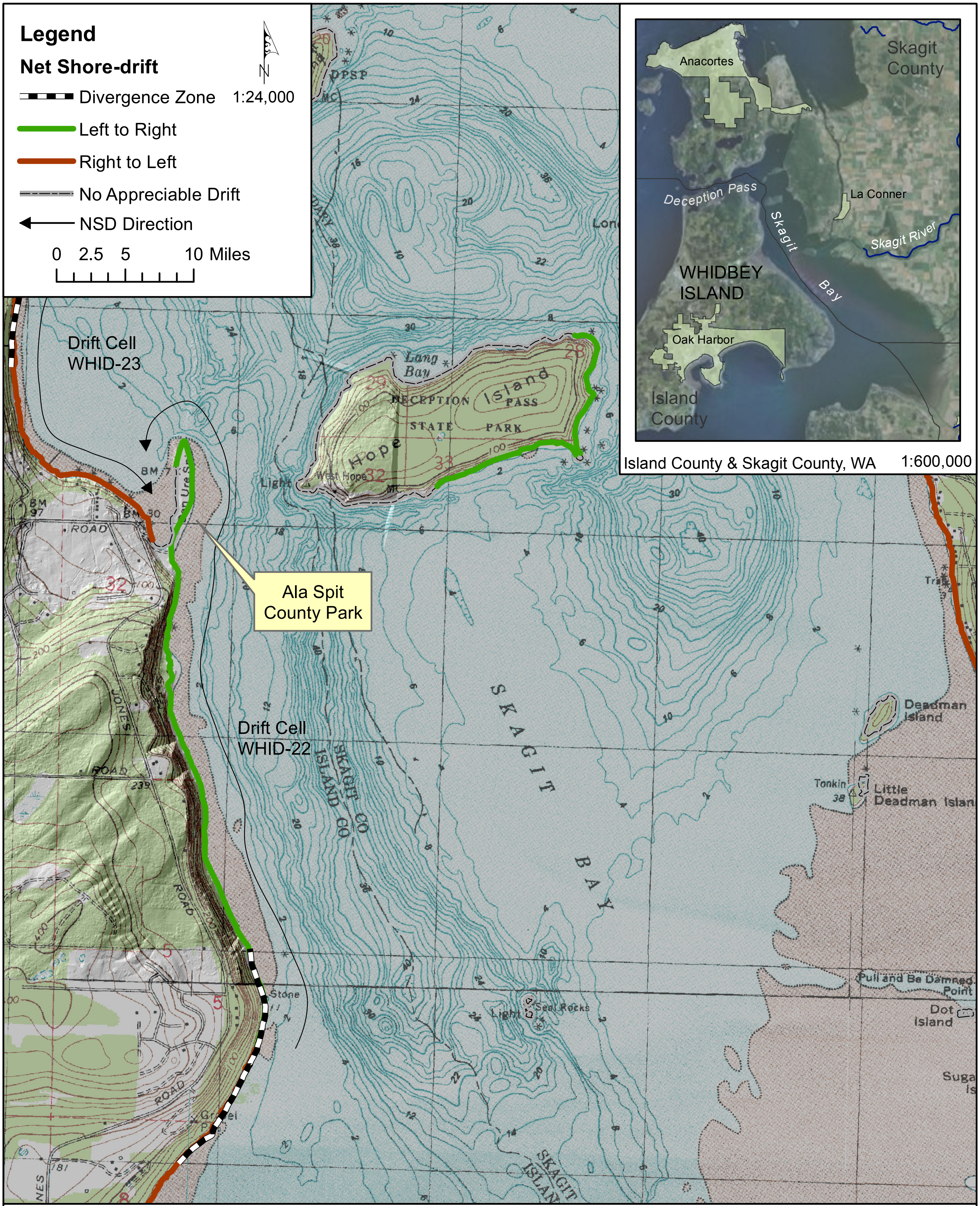

Figure 1. Ala Spit project area and net shore-drift map.

USGS Topographic Quadrangles, LiDAR Hillshade (clipped), and ESRI 2010 background imagery

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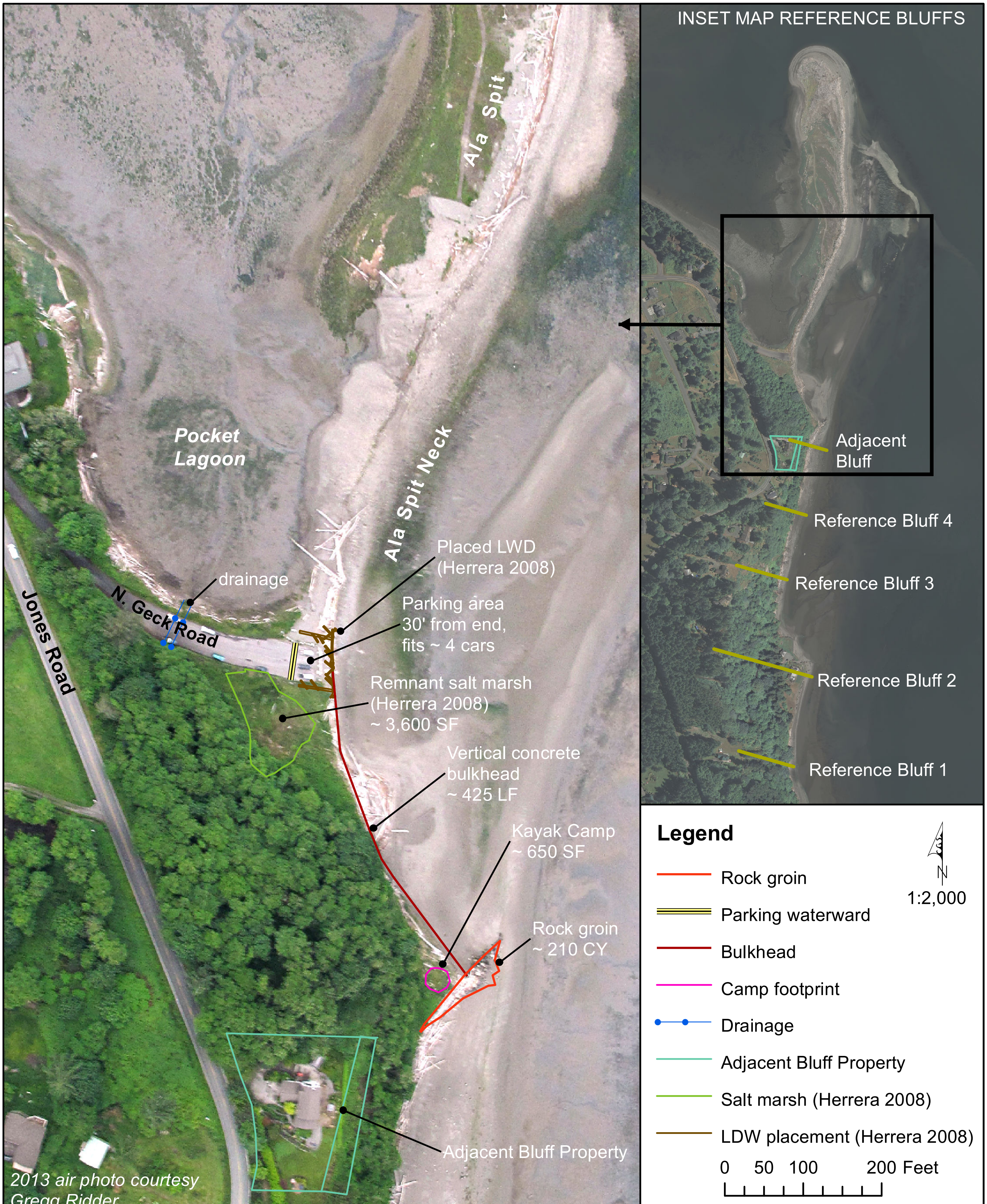

Figure 2. Ala Spit site features map and inset map of reference bluffs.

Island County (via Gregg Ridder) 2013 and Island County 2007 vertical air photos.

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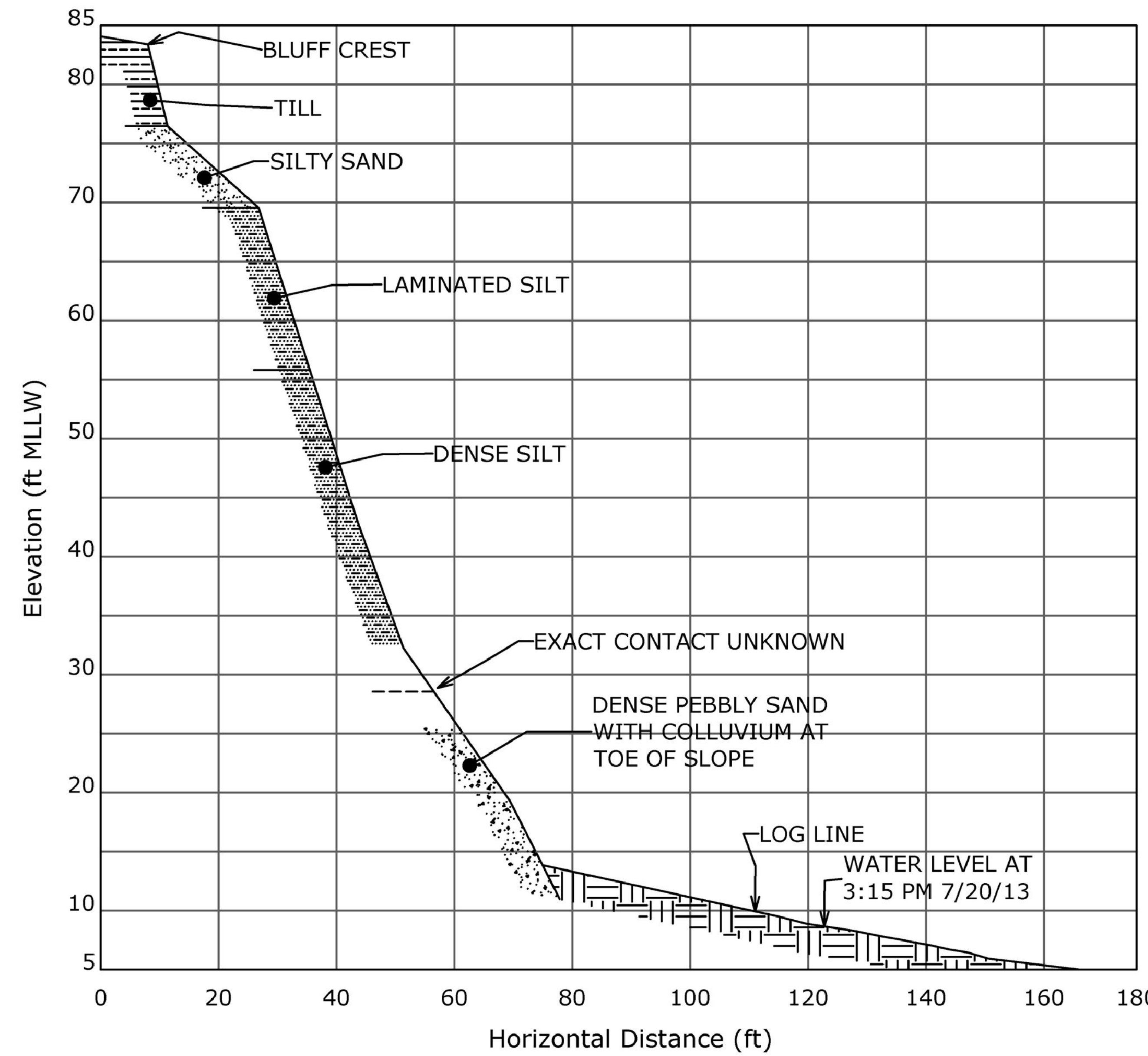

Geologic Cross Section

Figure 3. Ala Spit adjacent bluff property geologic cross section.

Island County 2007 air photo

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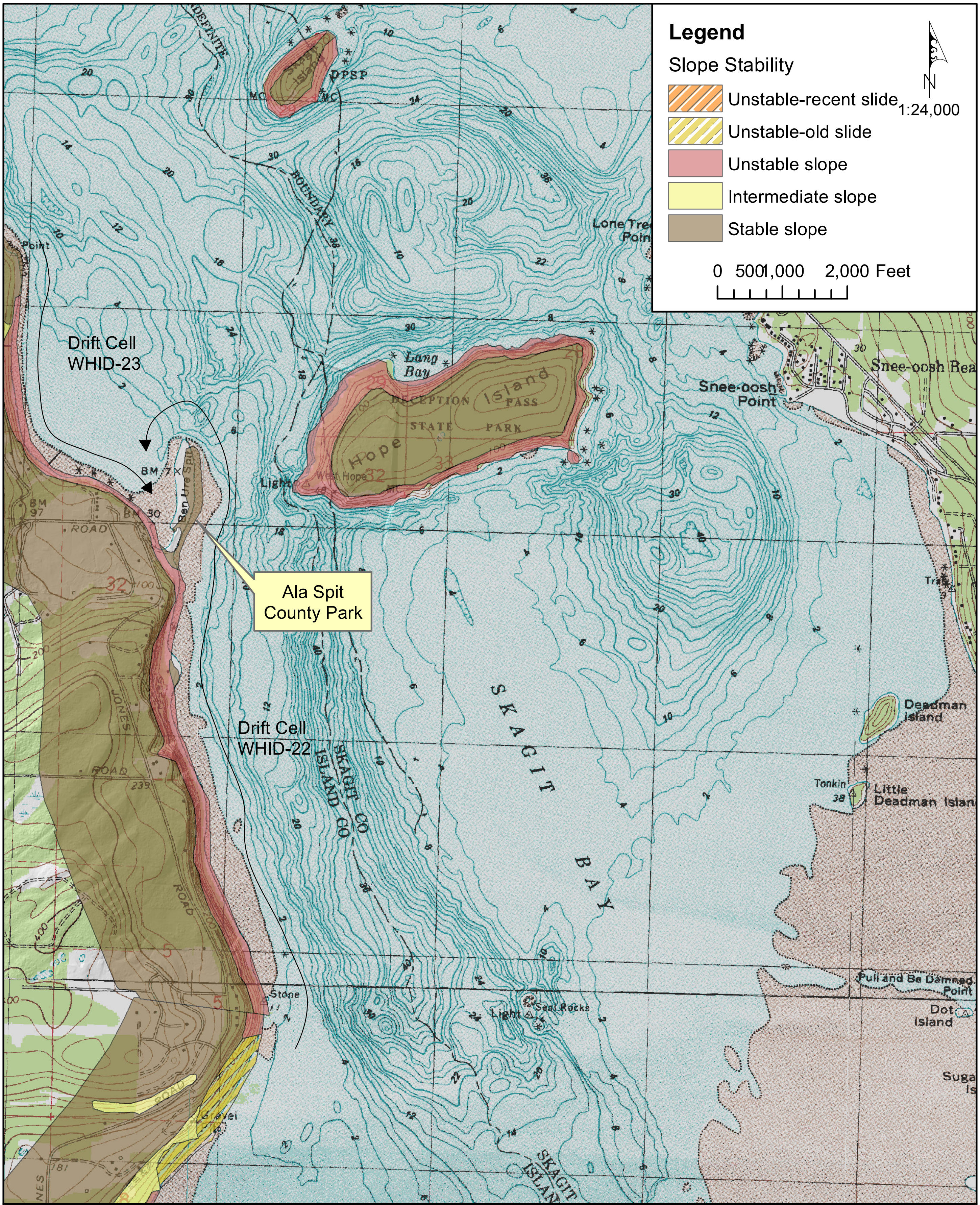
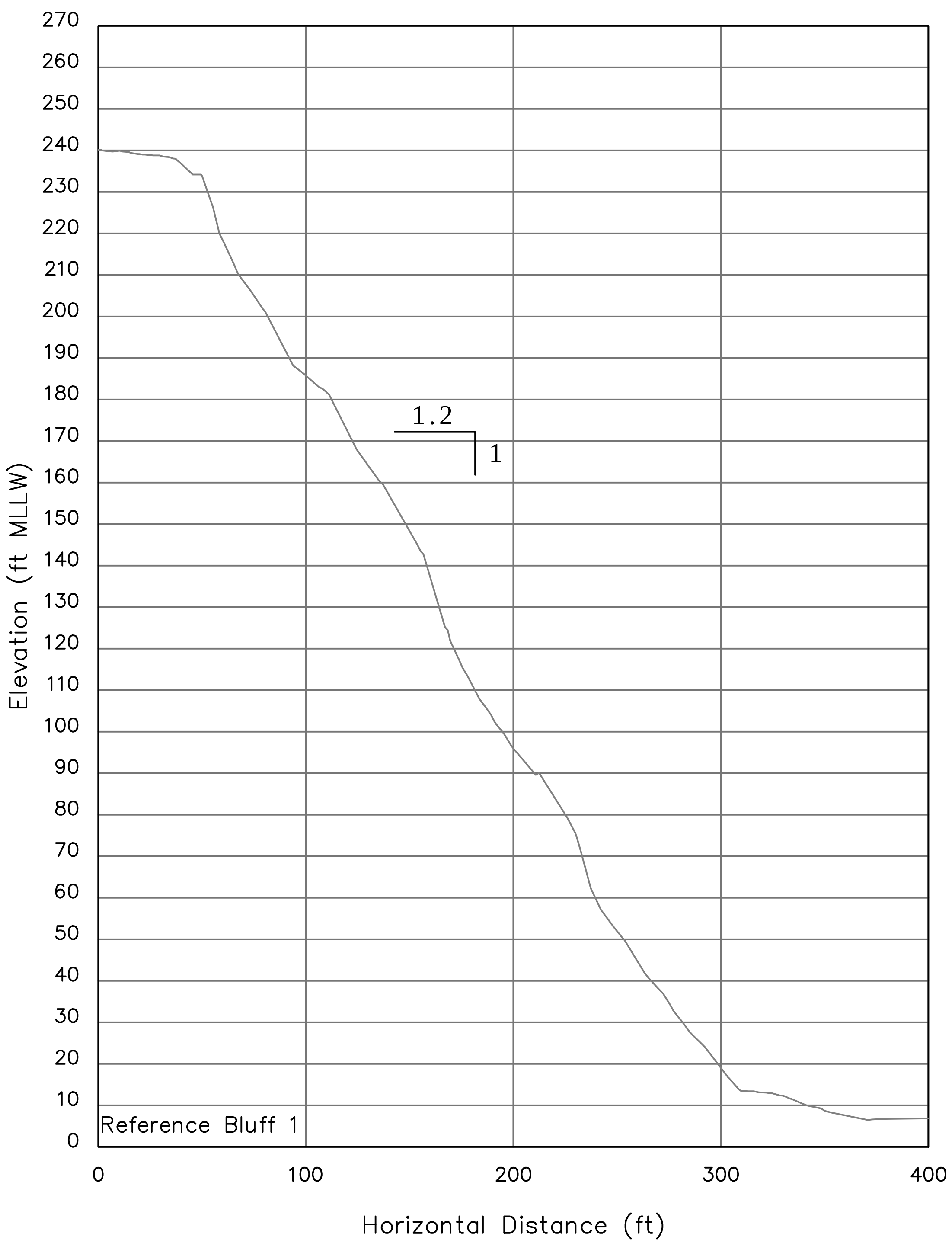
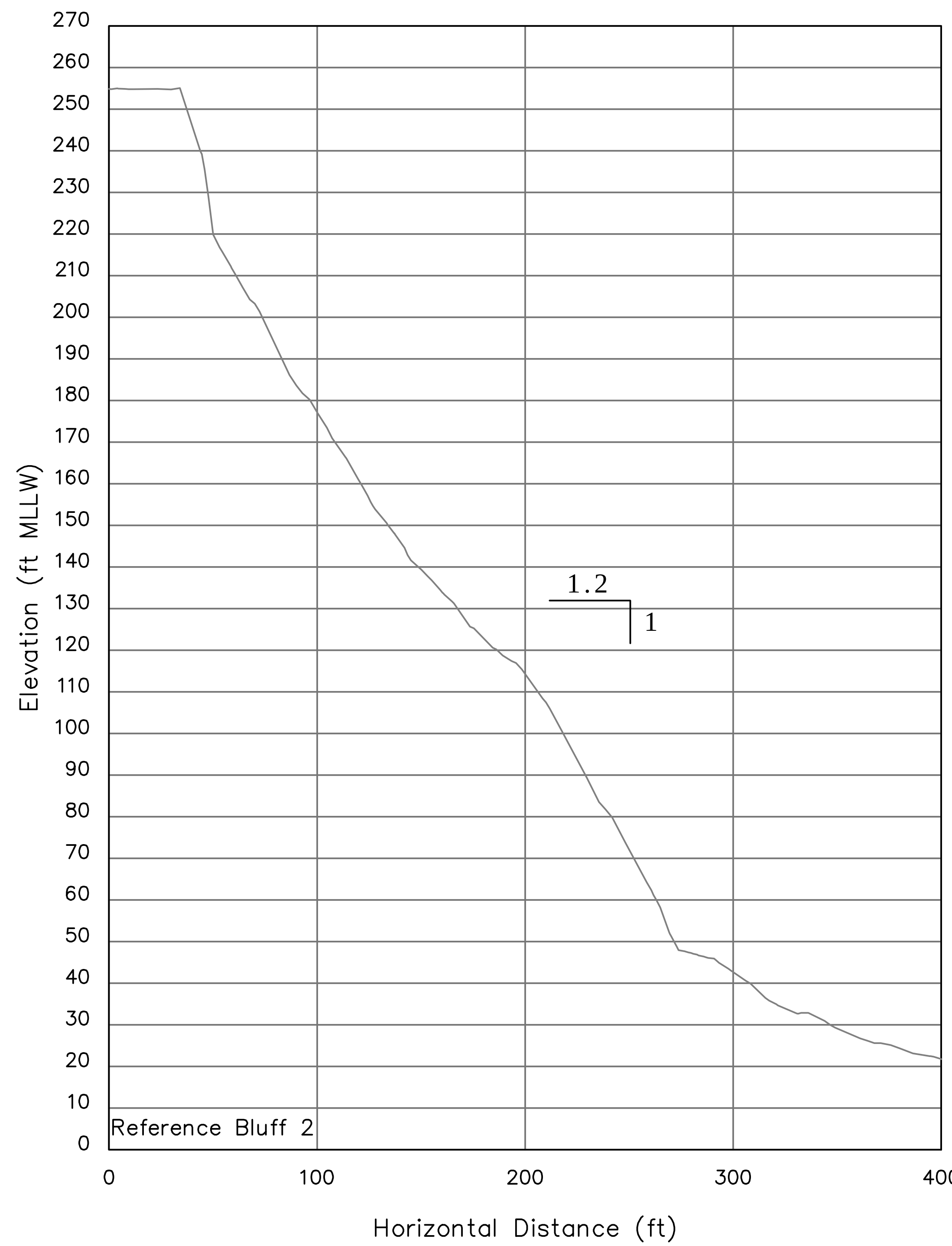


Figure 4. Ala Spit slope stability mapping (Ecology 1978).

USGS Topographic Quadrangles and LiDAR Hillshade (clipped).





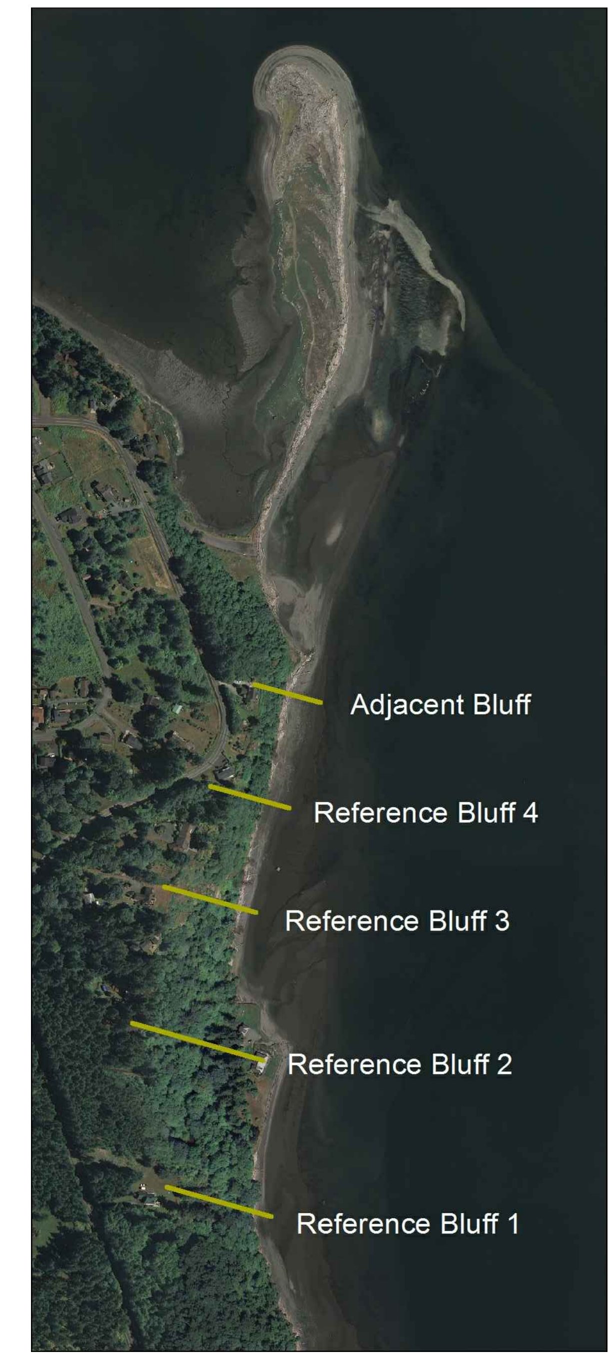


Figure 5a. Bluff cross sections (profiles) from LiDAR data south of Ala Spit. Sections shown at 2x vertical exaggeration. Slopes shown are average for entire bluff face.
LiDAR data acquired from Puget Sound LiDAR Consortium

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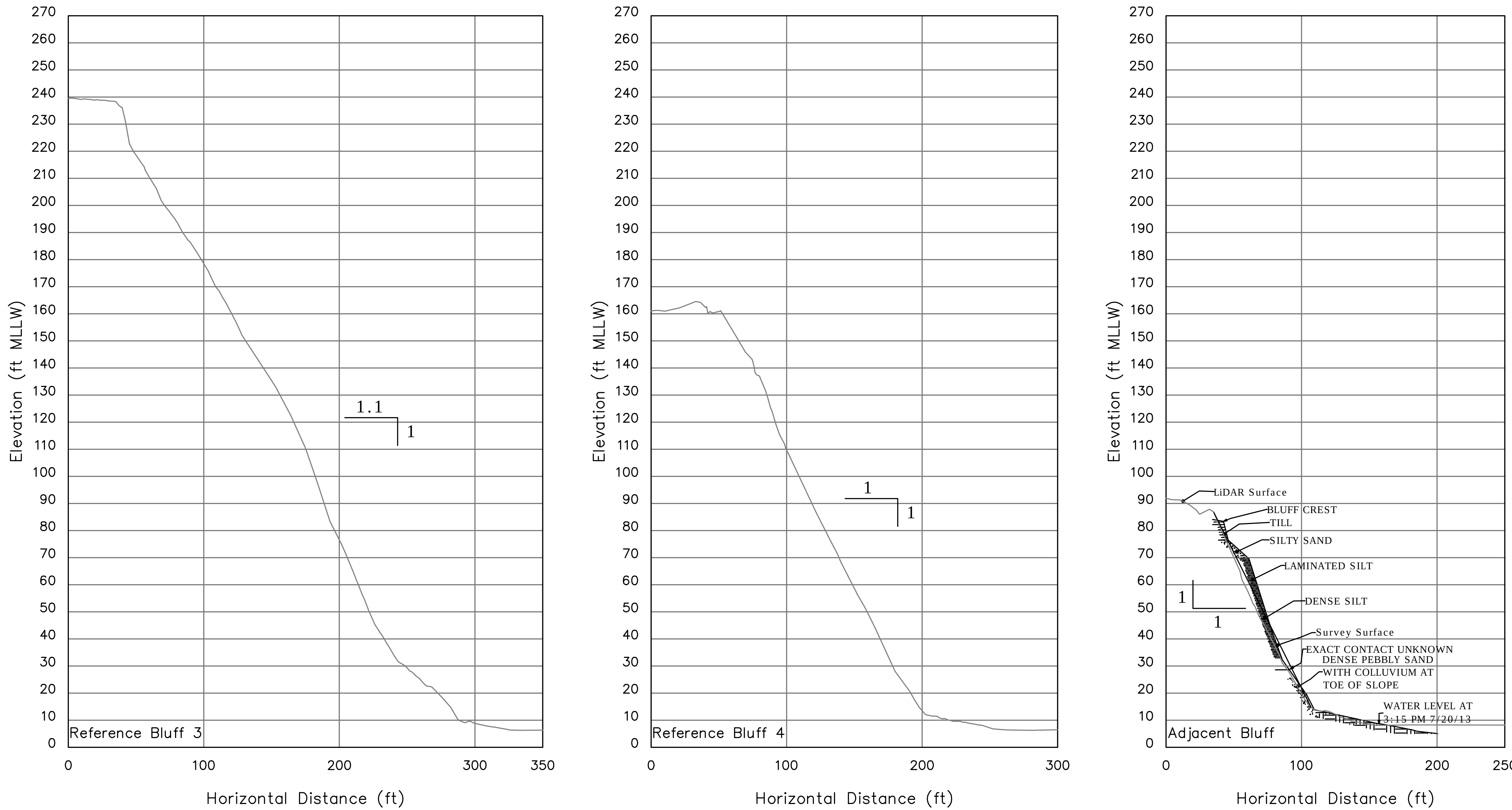

Figure 5b. Bluff cross sections (profiles) from LiDAR data south of Ala Spit. Sections shown at 2x vertical exaggeration. Slopes shown are average for entire bluff face. See Figure 5a for profile locations. Adjacent Bluff survey results shown for reference (Figure 3).
LiDAR data acquired from Puget Sound LiDAR Consortium

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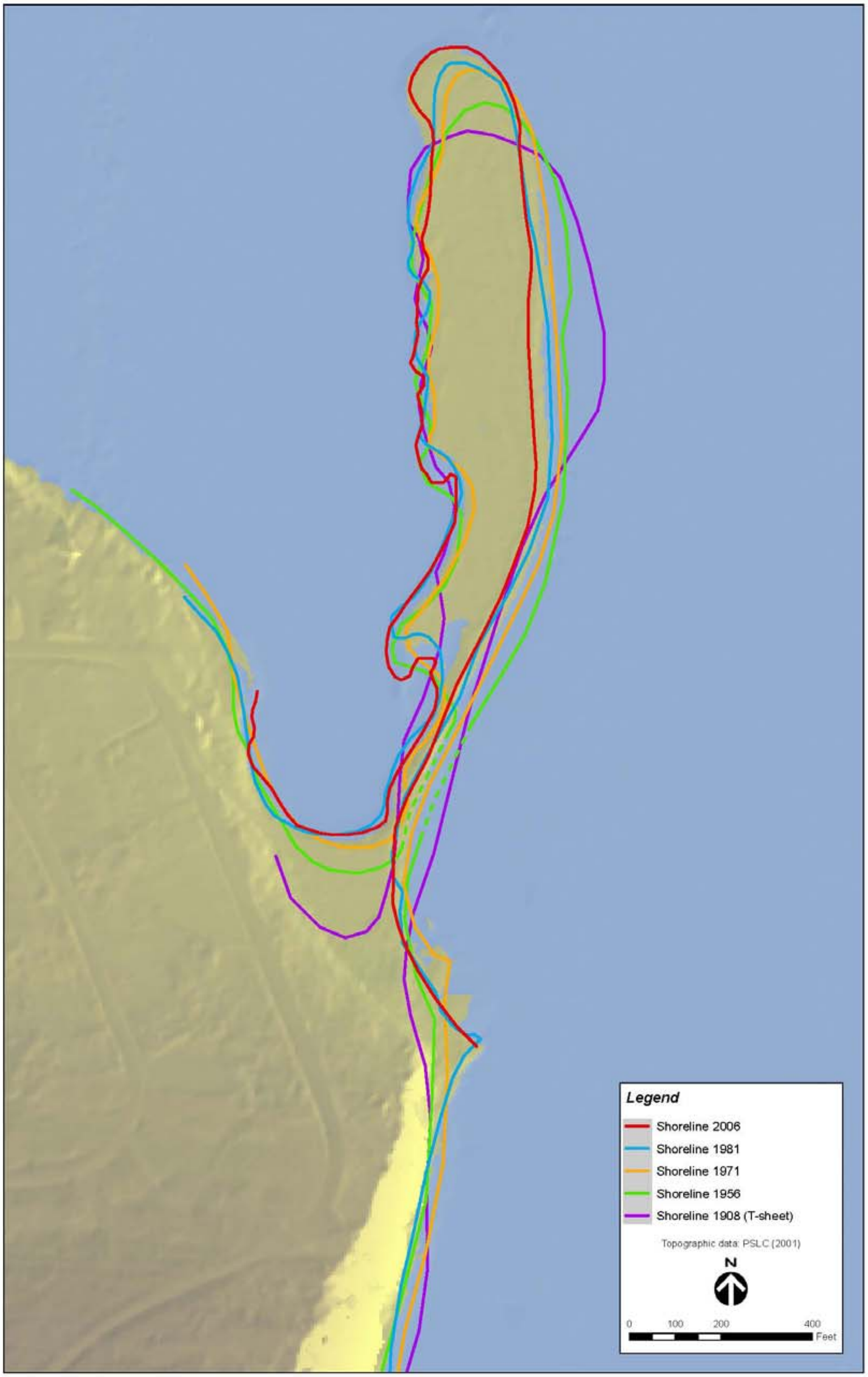

Figure 6. Shore change mapping of Ala Spit (Herrera 2008).

Figure 7. Historic 1956 and current (2013) air photo with contrasting shorelines.

Air Photos Courtesy of SRSC (1956) and Island County via Gregg Ridder (2013).

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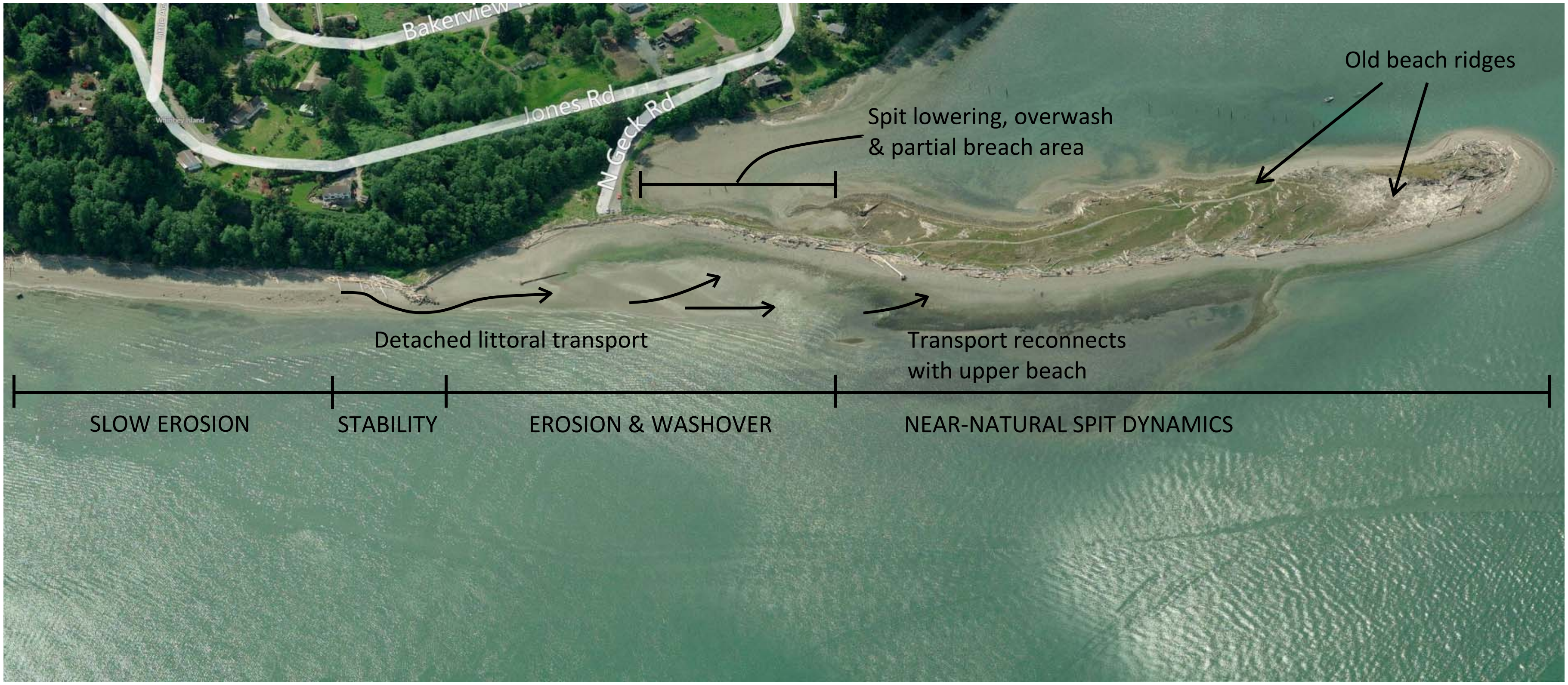

Figure 8. Ala Spit coastal geomorphic model annotated oblique aerial photograph (Bing aerials website accessed 2013).

	
Low tide from neck and parking area looking north (5-9-13)	Parking and large wood placement looking north (7-20-13)
	
Southwest edge of lagoon, road and parking to right (7-25-13)	Bulkhead from parking area south to rock groin (7-20-13)
	
Rock groin extending into lower intertidal (5-9-13)	Kayak camp in fill area between groin and bulkhead (5-9-13)

Photo Page 1. Ala Spit site features from May 9th, July 20th, and July 25th, 2013 site visits.

Fluvial sand and gravel (Qc(o) at beach level 50 ft to the south

Dense layer of silt and clay (Qgl) or transition area with (Qc(o))

Thinly laminated silt and clay deposit (Qgl)

Vashon till (Qgt)

Photo Page 2. Geologic units observed in the geologic cross section on the adjacent bluff property on July 20th and 25th site visit. Note: Vashon Advance Outwash (Qga) was not observed in the adjacent bluff property due to dense foliage and colluvium.

Southern most reference bluff (1), and likely Qga unit exposed	Reference bluffs (2-4) from private bulkhead north to Ala Spit

Reference bluff 3 – silty sandy colluvium with toe erosion	Reference bluff 4 – sand and pebble with minor toe erosion

Broad, accreted beach immediately south of the groin at the “Adjacent Bluff Property”

Photo Page 3. Reference bluffs for slope stability assessment of bluffs from the July 25th, 2013 site visit.

Sand and pebble south of groin with landslide runout boulder deposits background

Higher pebble concentrations over sand north of the groin with patches of *Salicornia*

East side of spit, gentle slopes at beach toe and sand flats

West side (lee) of spit with steeper gravelly slopes

Sub-angular quarry spall and pebble near the neck of the spit

Higher pebble concentrations in the central portion of the spit

Photo Page 4. Surface beach sediments of Ala Spit from south to north from May 9th and July 20th field visits.

	
10/11/2007, mid tide event and pre-revetment removal. (H. Shipman)	2010, low tide event and pre-revetment removal. (T. Smayda)
	
11/2011, mid tide event and post-revetment removal (H. Shipman)	2/22/12, mid tide event and post-revetment removal (CGS)
	
12/2012, extreme high tide event, post-removal (T. Zackey)	7/24/13, high tide event, post-removal (CGS)

Photo Page 5. Ala Spit neck partial breach progression. The log with rootwad in left background can be used for relative scale and water level.