Soft Shore Protection As An Alternative To Bulkheads - Projects And Monitoring

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Introduction

Beach erosion and improper development along the shore have been the norm in Puget Sound and the Northwest Straits. Traditional "hard" bulkheading (seawalls) has been the usual response to this situation until very recently, when "soft shore protection" alternatives have been encouraged by regulators and well-informed citizens. Soft shore protection (SSP) projects rebuild the high-tide beach to provide protection of property and homes and increase coastal sediment supply, the foundation of our sediment-starved coastal systems. Soft shore protection in the Puget Sound region has typically entailed the use of indigenous materials such as gravel, sand, logs, and root masses to absorb wave energy (Johannessen, 2000a). Wolf Bauer designed many SSP projects since the 1970s, with many Seattle Park projects and numerous constructed beaches in Puget Sound and British Columbia. These projects usually consisted of large gravel beach nourishment projects that were not monitored and remain very poorly documented.

A key factor that defines soft shore protection is flexibility, in order to mimic natural processes. For example, an enhanced gravel berm provides protection against storm waves due to its ability to reshape itself in a way to dissipate wave energy. Incoming wave water is absorbed into the gravel berm and then percolates out gradually. This is in direct contrast to a solid bulkhead. Although quantitative research on the impacts of "hard structures" on beaches is scarce, bulkheads have been shown to reflect waves without dissipating wave energy, causing beach scour and focusing wave energy onto adjacent beach and backshore areas (Macdonald et al., 1994). Bulkheads also cause a number of cumulative negative impacts to coastal systems (Pilkey, 1988) including: sediment "starvation", loss of beach area, sediment size increase, and loss of bluff and backshore vegetation. These physical changes to beach systems often result in increased erosion rates, increased incidence of coastal flooding, and the perpetuation of bulkheading as the all too common "domino effect" occurs along our shores. Recent studies have documented extensive shoreline modifications along local shores

Coastal Geological Services has designed approximately 14 soft shore protection projects in the Puget Sound region, two of which are: Driftwood Beach, Blakely Island, and West North Beach, Samish Island (Figure 1.) Each of these two sites will be discussed separately.

Driftwood Beach, Blakely Island

Project Area

Driftwood Beach is the largest beach on Blakely Island (Figure 1). The beach is exposed to a direct wave attack during NE windstorms. The fetch from the NE is 10 miles. Sustained winds in excess of 35 knots occur during winter nor'easters that originate in the Fraser River Valley of British Columbia, Canada. Wave refraction causes wind waves from the SE and south (predominant and prevailing) from Rosario Strait to break on the beach. The long-term sediment transport (net shore-drift) is from SE to NW along Driftwood Beach (Johannessen, 1992). Net shore-drift sediment in this drift cell is limited to a minimal amount of sediment that originates from isolated outcrops of glacial drift atop bedrock along the northeast portion of the Blakely Island (Johannessen, 1992).

Ecological resources were identified prior to project design in order to avoid impacts to these resources. No spawning areas for surf smelt or sand lance (forage fish for salmon) had been mapped or identified along Driftwood Beach. Upper intertidal beach sediment was too coarse within the project area for forage fish spawn. Macro algae and eelgrass were observed intermittently below MLLW (mean lower low water) on the lower-most beachface in late March and July of 1998. A low to moderate density of green algae occurred below –0.5 ft MLLW and moderate to high density of brown and green algae occurred below –

2.0 ft MLLW (Johannessen, 1998b). Small patches of eelgrass occurred below elevation –2.0 ft MLLW with larger patches at lower elevations (Johannessen, 1998b).

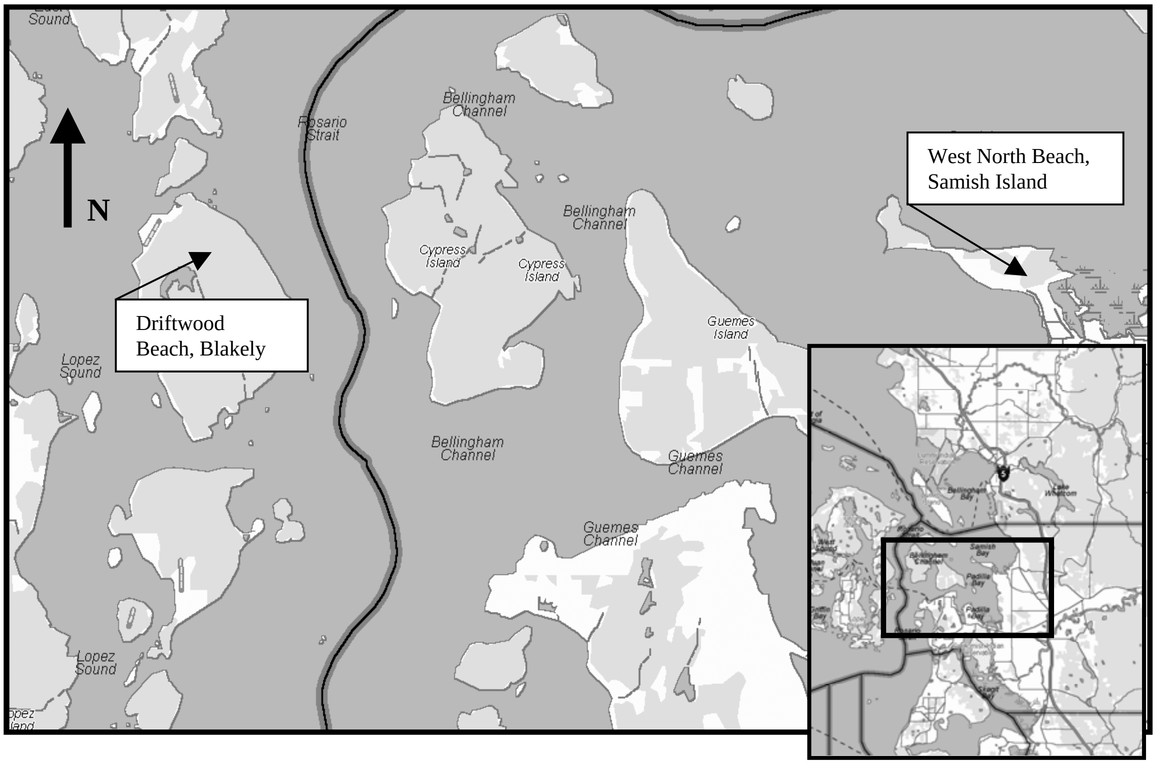

Figure 1. Location of Driftwood Beach, Blakely Island and West North Beach, Samish Island soft shore protection projects.

Project Description

The Driftwood Beach project was designed and constructed for the Blakely Island Maintenance Commission, which is the community group composed of the majority of Blakely Island property owners. The project was constructed in February and early March of 1999, which involved creating a 600 ft long protective gravel berm waterward of narrow upland access area. The project consisted of removing non-native materials and importing beach gravel and sand. Soil fill and debris were first removed from the upper berm and backshore area. A barge was used to import gravel from an approved upland gravel pit in Whatcom County. The barge was equipped with a high capacity conveyor system for direct offloading directly to the upper beach. The conveyor was adjustable and had sufficient length to allow for offloading (at high tide) without grounding the barge. The imported gravel consisted of 1,600 cy (cubic yards) of washed, rounded gravel. The berm gravel was a custom product with a size range of ¾ to 4 inch. Gravel was spread to a uniform slope on the beach face that extended up to a berm crest at +12.0 ft MLLW.

Goals

1. Protect the small community owned upland area from further erosion caused by previous gravel mining.
2. Restore the beachface and backshore to a natural condition including removing fill and debris, and planting a native plant community in the backshore area.
3. Avoid waterward migration of coarse gravel and impacts to nearshore habitats including macro algae and eelgrass beds.

To these ends, the design included pulling the artificial upland boundary landward by removing fill and debris, moving the road/path landward, establishing realistic beach slopes, and the use of coarse gravel (3/4 to 4 inch) for the protective berm. Clean coarse sand was brought into the backshore area and that area was planted extensively using locally collected native plants and seeds.

Objectives

1. Assess gravel stability and volume adjustments.
2. Determine if nourishment gravel is moving waterward to cover macro algae or eelgrass.

Beach Profiling

Profiles were surveyed with a Leica TCR-1105 total station using existing survey monuments for survey control, along previously established profile lines running approximately perpendicular to the shoreline across the beach. Data reduction and volume calculations were performed in AutoCAD Land Development Desktop 2000. Profiles extended from the backshore planting area down to elevations -2 to -4 ft MLLW.

The beach exhibited little change between the summer of 1999 and the summer of 2000. Starting at the updrift end of the nourish project, approximately 30 ft from the SE end of the nourishment gravel, the upper beachface lowered between elevation +9 and +12 ft MLLW. The original placement of gravel at this end was not feathered into the beach smoothly (Johannessen, 2000b and Shipman et. al, 2000); instead a “ridge” of gravel was located at the upper beach that ended fairly abruptly 30 ft alongshore to the SE. This ridge was leveled out by wave action in the winter of 1999-2000 with some of the material moving to the SE to the unnourished beach, resulting in the profile lowering displayed.

The second profile from the southern end, profile F, changed little from 1999 to 2000 (Figure 3). The high berm (created storm berm) remained approximately 10 ft waterward of the erosional scarp of the degraded 1998 beach. The beach below +5.5 ft MLLW was in the same position as in January 1998, after experiencing erosion in the severe winter of 1998-1999 and then nourishment in March 1999. The beach through the central and NW portions of the project remained almost unchanged since 1999, having lowered generally 0.2 to 0.3 ft (vertically) between 0 and +6 ft MLLW. Most of this area was below the nourishment footprint. Berm gravel feathered into the preexisting lower beach (at +3.5 to +4.0 ft MLLW) but the point where this occurred could no longer be discerned in the field.

Figure 2. Driftwood Beach, Blakely Island, looking NW on 4/2/01.

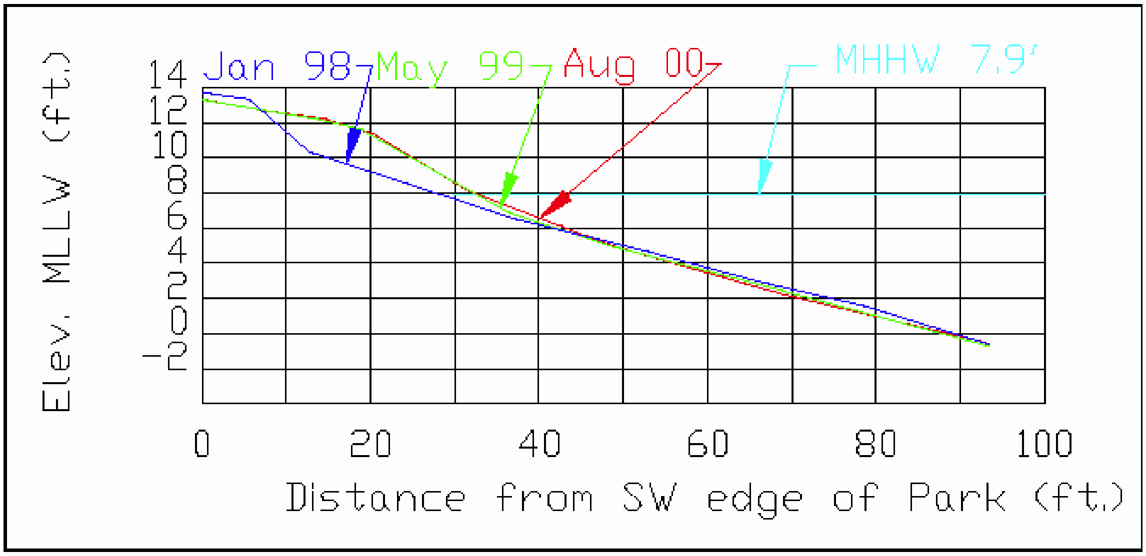

Figure 3. Profile F, Driftwood Beach, Blakely Island.

The upper beachface through the central and NW portion of the project area, including profile C at the northern end, changed slightly since 1999 (generally less than 0.2 ft vertically) with approximately the same volume of material present (Figure 4). A small berm was located at approximately +10.5 ft MLLW. Minor additions of backshore sand and/or topsoil, along with vigorous vegetation growth, has raised the near-level backshore area very slightly since 1999.

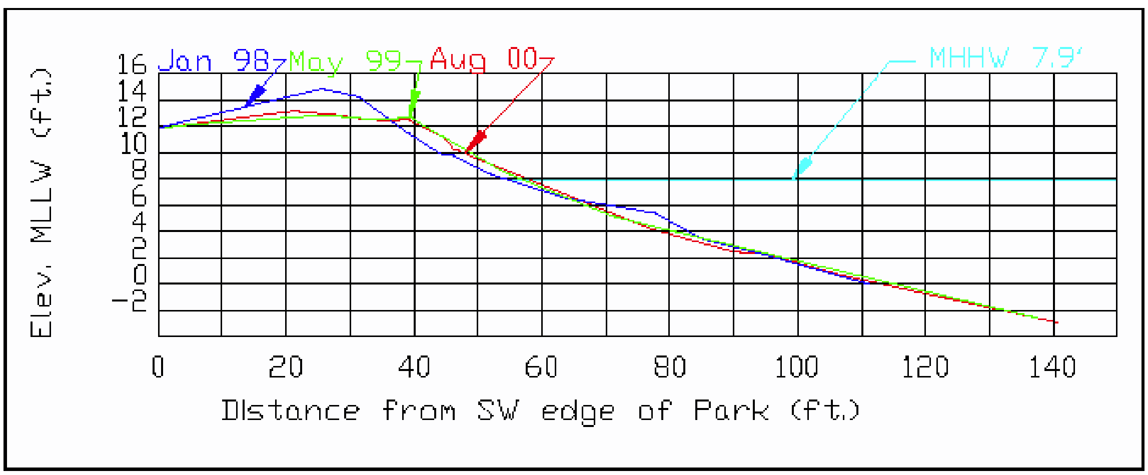

Figure 4. Profile C, Driftwood Beach, Blakely Island.

The beach NW of the nourishment area was almost identical to the 1999 beach. The middle beachface was lowered by approximately 0.2 ft from +2 to +5 ft MLLW. Minor accretion occurred near the NW end of the natural gravel beach. Very minor accretion occurred on the lower and middle beachface and approximately 0.3 to 0.8 ft of vertical accretion occurred above +8.5 ft MLLW. A small berm was located at elevation +11 ft MLLW. The backshore area was unchanged at profile A.

Beach Nourishment Volume Change

The total volume of the beach within the nourishment area was calculated for 1999 and 2000 monitoring periods using consistent methods year to year. The area between slightly SE of profile F and NW of profile C was calculated from 4 ft MLLW up to the interface between storm berm gravel and backshore sand (as present in August 2000). The total volume in 2000 was 90 cubic yards (cy) less than in 1999. This is equivalent to 5.6 % of the initial 1998 nourishment volume of 1,600 cy.

There are likely two reasons for this minor reduction in volume since 1999. Compaction of the newly placed coarse sediment is thought to account for a portion of the volume change. Beach nourishment gravel was placed at the end of the winter of 1998-1999 and storm waves in the winter of 1999-2000 may have packed the gravel, reducing void spaces. Secondly, since both ends of the nourishment placement were not feathered into the beach well, a small volume of the nourishment gravel appears to have moved beyond both ends of the volume calculation area.

Sediment Characterization

The sediment composition was examined along 3 of the profiles in August 2000. However, sediment samples were not collected due to a lack of change and logistical problems. Instead, visual examination was conducted and photos were taken of the upper 0.75 ft of beach substrate. This method was similar to sediment characterization in 1999 (Johannessen, 2000b), and was utilized because the sediment within the nourishment area was still basically nourishment sediment only.

Beach sediment at elevation +8 ft MLLW at the southern end consisted of the ¾ to 4 inch nourishment gravel down to at least 1 ft, with no finer material. Sediment at +5 ft MLLW consisted of nourishment gravel only in the upper 0.25 ft and a mixture of course sand to cobble below 0.25 ft. The composition of the lower substrate was roughly equally distributed between coarse sand/granule, pebble, and cobble. This area was near the lower extent of nourishment and the lower portion of the washed nourishment gravel appears to be infilling with finer sediment (through wave action delivering sediment) from the bottom up.

The sediment characterization at +8 ft MLLW at the northern end was pebble in the upper 0.5 ft and coarse sand to pebble below that. Sediment at +5 ft MLLW was pebble and cobble in the upper 0.2 ft MLLW and coarse sand to cobble below that This area contained finer sediment even in the baseline sampling period (Johannessen 1998a) since it is the terminus of the net-shore drift cell (Johannessen, 1992).

Backshore Restoration

Restoration of backshore area was beyond the scope of CGS design work and monitoring, but brief comments are made here to address this important element of the project. Lynne Athmann and Lance Douglas of Blakely Island have been the primary people that have planned and implemented the backshore restoration effort. Some consultation was provided by Dr. Michael Williams part way through planting. Many local landowners have volunteered their time for planting and weeding the area, and that effort should continue.

As of summer 2000, the vast majority of the backshore area was vegetated with appropriate native plants (Figure 2). Watering was required in summer months and weeding has been done repeatedly. Native dunegrass (*Elymus mollis*) was doing exceptionally well, as is shore pine, ocean spray, and a host of native herbaceous plants. Vegetation extended from the community property line on the SW waterward to the +12.5 to +13 ft MLLW elevation. This area also contained a “nature path” in the place of the wide pre-project gravel road (to nowhere).

Summary and Conclusions

Summer 2000 beach profile data from Driftwood Beach Blakely Island revealed that the beach within the nourishment area has been stable since installation. Beach profile changes were generally restricted to 0.3 ft of vertical change, usually in the form of mid-elevation beachface lowering. This can be attributed to very minor onshore transport of gravel and volume reduction through compaction following the first full winter of the project. The winter of 1999-2000 was generally fairly mild in terms of high wind events but did contain several early and late winter windstorms.

Beach volume change between summer 1999 and summer 2000 was a decrease of approximately 90 cy. This minor volume reduction is attributed to compaction of the newly placed coarse gravel and the movement of a portion of the nourishment gravel beyond the ends of the project/ volume calculation area.

Beach sediment consisted of nourishment gravel within the project area, remaining essentially the same since the project was completed. Finer gravel was present north of the nourishment project area, as was documented during baseline conditions (Johannessen, 1998a).

The protective berm-beach performed very well through the summer of 2000. The project has so far achieved the first goal of protecting the small community owned beach area very well. Similarly, the stability and volume adjustments were documented, thereby achieving the first objective of the monitoring plan. The second goal of the project included restoring the backshore to a natural condition including removing fill and debris, and planting a native plant community in the backshore area. This has also been successfully accomplished in a relatively short time period. No waterward movement of nourish gravel has occurred, achieving the third project goal and the second objective of the monitoring plan.

Samish Island

Project Description

The protective berm project fronts 13 houses/cabins and is located on the western part of North Beach on the north shore of Samish Island, in Skagit County. The project was designed by Wolf Bauer and Jim Johannessen and was constructed in the fall of 1998 and winter of 1998-99. The project was designed to greatly slow chronic beach erosion and property damage that had been occurring at an accelerated rate since about 1980 (Johannessen, 1998c and Shipman, 1998). The project involved creating a protective gravel berm waterward of existing vertical bulkheads. The project as originally proposed would have included the participation of an additional two properties at the west end of the built project. The owners of these two properties dropped plans to participate in the construction of the protective berm prior to construction. Additionally, approximately 90 feet of the beach west of the western-most participant was used as an updrift gravel stockpile area. This area had a continuation of the berm with a gradually tapered west end.

The project involved importing gravel by barge from approved upland gravel pits in Whatcom County. Berm gravel consisted of 5,230 cy (cubic yards) of washed, rounded gravel. The berm gravel sizes were 80% 1-2 inch gravel and 20% 2-8 inch gravel, the latter component is known as cobble. The fish gravel consisted of 1,040 cy of ¼ to ¾ inch, washed, rounded gravel.

Goals

1. Protect houses and property through continued presence of gravel berm stability and volume adjustments annually
2. Reestablish surf smelt spawn habitat (presently degraded) on the upper intertidal beach face that will be buried by construction of the protective berm.

Objectives

1. Protect houses and property:
    - ♦ Maintain a supra tidal protective berm top (at elevation +10.5 ft MLLW) in front of houses and 10-20 ft wide; beach face will slope waterward beyond berm top
    - ♦ Beach stability will be greater than pre-project, following the first 2 years when adjustments will occur (comparison can only be qualitative due to lack of historic data)
    - ♦ Annual gravel volume loss will be less than 7.5 % of initial placement volume
2. Reestablish (degraded) surf smelt spawn habitat:
    - ♦ Sediment sizes within band encompassing +7.0 to +8.5 ft MLLW will include pea gravel suitable for surf smelt spawn within 3 years of project completion
    - ♦ If habitat is not created as above, carry out contingency plan

Monitoring Results

Coastal Geologic Services, Inc. initially monitored baseline beach conditions in the project area in July 1997, and 1998 (Table 1). Monitoring of 10 profiles, numbered 2-11 from west to east, was performed three times in 2000. Surveying occurred in March and August 2000, and again following a NE windstorm in September 2000 (Table 1).

Table 1. Beach profile and sediment sample data summary.

ACTIVITY	SCHEDULE	NUMBER OF PROFILES SURVEYED
Baseline Beach Profiles	Summer 1997	11
	Fall 1998	5
1999 Beach Profiles	Spring 1999 (as-built)	10
	Summer 1999	9
2000 Beach Profiles	Spring 2000	10
	Summer 2000	10
	Fall 2000 (post storm)	10
Sediment Samples*	Spring	4
	Summer	4
Annual Data Report	Summer	1

Profiles were surveyed with a Leica TCR-1105 total station using existing survey monuments for survey control, along previously established profile lines running approximately perpendicular to the shoreline across the beach. Data reduction and volume calculations were performed in AutoCAD Land Development Desktop 2000. Minimum profiling was to consist of 8 profiles: profiles 1, 2, 3, 5, 7, 9, 10 (atop drift sill) and 11. Profile 2 is west of the gravel placement area. Profiles 3 through 9 are within the area of gravel placement. Profile 10 was intended to monitor changes in beach height (and rock stability) along the length of the drift sill. Profile 11 monitored the beach approximately 110 ft east of the eastern property of the project area.

Beach Photos - August 2000

The photos below show the appearance of the beach at the end of the summer of 2000 (Figures 5 and 7). The berm crest is visible in the left-center of each photo. Backshore vegetation is visible (volunteer plants- *Rumex salicifolius*). The profile location is at the white tape and sediment sample bags are along the tape at the upper beachface. Note the berm gravel on the outer half of the berm top and the mixed sand and gravel beachface.

2000 Performance Standard Assessment

1. Protect houses and property:

- Maintain a supra tidal protective berm top (at elevation +10.5 ft MLLW) in front of houses that is 10-20 ft wide; beachface will slope waterward beyond berm top.

The berm top width throughout the 13-property project area was between 16.5 ft (Profile 3) and 24 ft (Profile 7) during September 2000. Similar widths were measured in August and March 2000. This can be compared to the 20 ft wide design berm top. The berm width decreased the most at Profile 3, where the initial width was 26 ft because of the placement of excess fish gravel to “get ahead” of net-shore drift, and the September 2000 width was 16.5 ft. The berm crest at profiles 4 through 7 moved landward due to storm events in the winter of 1999-2000 that had wave run up in excess of the 1999 berm top elevations. The berm crest was between 20 and 24 ft waterward of the seawall at profiles 4-7. The berm crest elevation increased to between +10.6 and +10.8 ft MLLW by the high water storms. This was slightly above the original design elevation of +10.5 ft MLLW. A second reason for the landward translation of the berm crest was some amount of eastward transport of nourishment sediment. Sediment was transported away from the rounded beachface area at the western extent of the project (Profile 3) where excess fine gravel was originally placed. The western area was always expected to slowly erode. Most of the fish gravel has been transported away from the western 100 ft or so of the project area.

Figure 5. Profile 3, near west end (up-drift end) of Samish Island protective berm, looking west on 8/24/00.

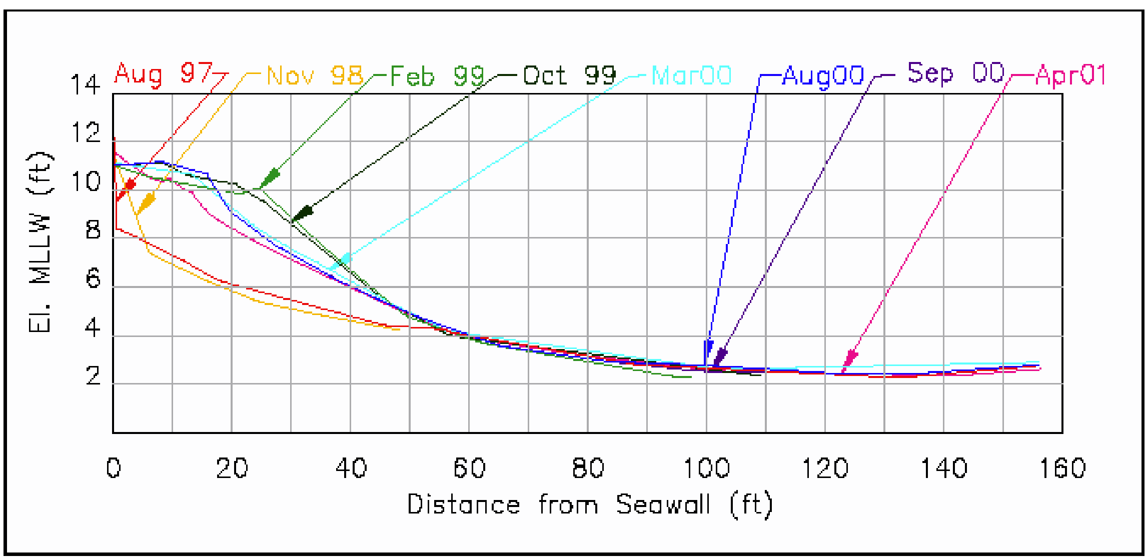

Figure 6. Profile 3, near west end (up-drift end) of Samish Island protective berm, looking west.

Figure 7. Profile 9, near west end (down-drift end) of Samish Island protective berm, looking west on 8/24/00.

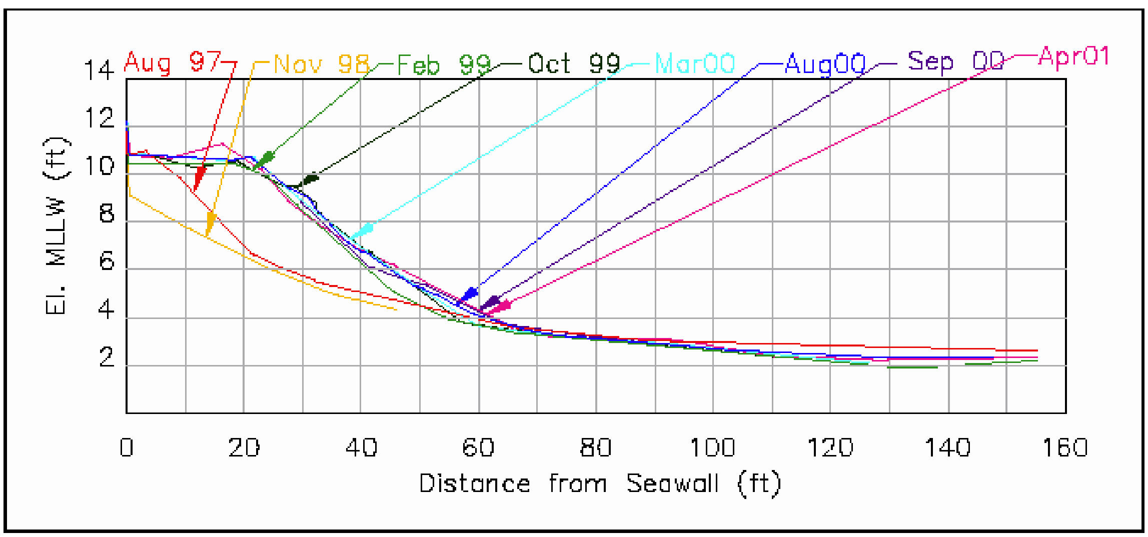

Figure 8. Profile 9, near west end (down-drift end) of Samish Island protective berm, looking west.

- Beach stability will be greater than pre-project, following the first 2 years when adjustments will occur (comparison can only be qualitative due to lack of historic data)

Some erosion of the upper beachface was discussed in the above section. Partially offsetting this in the second year was beach shape adjustment and redistribution of gravel that caused accretion along the lower beachface. Accretion occurred below elevation +6 ft MLLW at Profiles 4 through 9. The drift sill (profile 10) has been fairly stable since construction. The discrepancies evident in the beach profiles are mostly due to different measurement points along the somewhat irregular sill surface. The area near the bulkhead had a sand mound placed atop the sill that was worn down by foot traffic. The beach surface from 65 to 90 ft waterward of the bulkhead lowered approximately 0.75 ft between 1999 and 2000, probably due to the presence of the sill. Waterward of 90 ft from the bulkhead, there was no evidence of erosion. Profile 11, located down-drift of the project, has undergone several small adjustments since the nourishment. The beach at profile 11 remained higher than pre-project above elevation +7 ft MLLW, with a high point in March 2000. The beach between +4 and +7 ft MLLW was slightly lower than pre-nourishment, and the beach waterward of the +4 ft MLLW has remained fairly stable.

Backshore vegetation was planted in some locations alongshore. This consisted of small amounts of native dunegrass (*Elymus mollis*) and a few other herbaceous plants in the area within approximately 10 ft of the bulkhead. The most common backshore vegetation by far now is a “volunteer” species, the willow dock (*Rumex salicifolius*). This is a close relative of the rhubarb. This is a common native backshore area plant that also grows in disturbed sites inland. All of these plants will help in a small way to maintain stability of the berm in the event of a very large high tide combined with a windstorm from the north.

Beach stability has been as expected for the first 2 years, meeting the beach stability goal.

- Annual gravel volume loss will be less than 7.5 % of initial placement volume.

The volume of nourishment sediment within the project area was evaluated for volume changes between profiling times. The volume calculation area extended laterally from profile 2 to profile 10 and extended waterward from the seawall approximately 65 ft to the +4.0 ft MLLW elevation. This lower elevation generally coincided with the waterward extent of the nourishment area.

From October 1999 to March 2000, the beach volume above +4 ft MLLW increased 5 cy (Table 2). From March 2000 to August 2000 there was a net gain of 154 cy above +4 ft MLLW. This accretion is most noticeable along the lower beach at profile 5, where the lower beachface was raised approximately 1.5 ft From August 2000 to September 2000, there was a net gain of +46 cy, bringing the annual change from 1999 to 2000 to 103 cy of erosion. The annual loss is equivalent to 1.6 percent of the total project nourishment, well below the amount of annual change that the beach project was designed to stay within (7.5 percent), meeting this goal.

Table 2. Beach volume change 1999-2000.

Time Period	Volume Change	Percentage Change
Oct. 1999 – March 2000	+5 cy	0 %
March 2000 – Aug. 2000	-154 cy	-2.5 %
Aug. 2000 – Sep. 2000	+46 cy	+0.7 %
Annual Change 1999 – 2000	-103 cy	-1.6 %

2. Reestablish (degraded) surf smelt spawn habitat:

- Sediment sizes within band encompassing +7.0 to +8.5 ft MLLW will include pea gravel suitable for surf smelt spawn within 3 years of project completion.

Surf smelt utilize 1-7 mm sediment for spawning (Pentilla, 1978). Comparison of surf smelt spawning substrate has been performed at Lummi Shore Road in Bellingham since 1996. Results of biological and physical monitoring at Lummi Shore Road revealed that samples containing eggs generally had greater than 40% (by weight) 1-8 mm size sediment (Johannessen, 2000c). Prior to project construction on Samish Beach, the beachface habitat was degraded and patchy. Pre-project beach sediment consisted of pebble, cobble and medium sand, and did not contain much 1-7 mm sediment. This was due to the cumulative impacts of bulkheading and groins on North Samish Island, which decrease bluff sediment input into the north Samish Island beach system and impair littoral drift.

A moderate amount of suitable surf smelt spawning area was reestablished by 2000 within the project area. Sand was deposited within the berm on the mid and upper intertidal beachface, although the occurrence of suitable sediment varied and was not continuous alongshore (Figures 5 and 7).

Sediment samples have been collected from the upper intertidal zone (from elevation +7.0, +7.5, and +8.0 ft MLLW). These samples were all processed for grain size and results are summarized in Figure 2. Data reveal that the best potential spawning area was found at Profile 9. Three locations had fine gravel and sand approaching or exceeding 40 percent, indicating suitable surf smelt spawning habitat (Johannessen, 2000c).

- If habitat is not created as above, carry out contingency plan.

The amount of fine gravel and sand that has accumulated in the project area has met pre-project expectations. The percentage of 1-8 mm sediment on the upper intertidal beachface has increased overall since October 1999. There is no need for implementing the contingency plan based on these findings. Additionally, the amount of 1-8 mm sediment on the beachface will likely increase in coming summers.

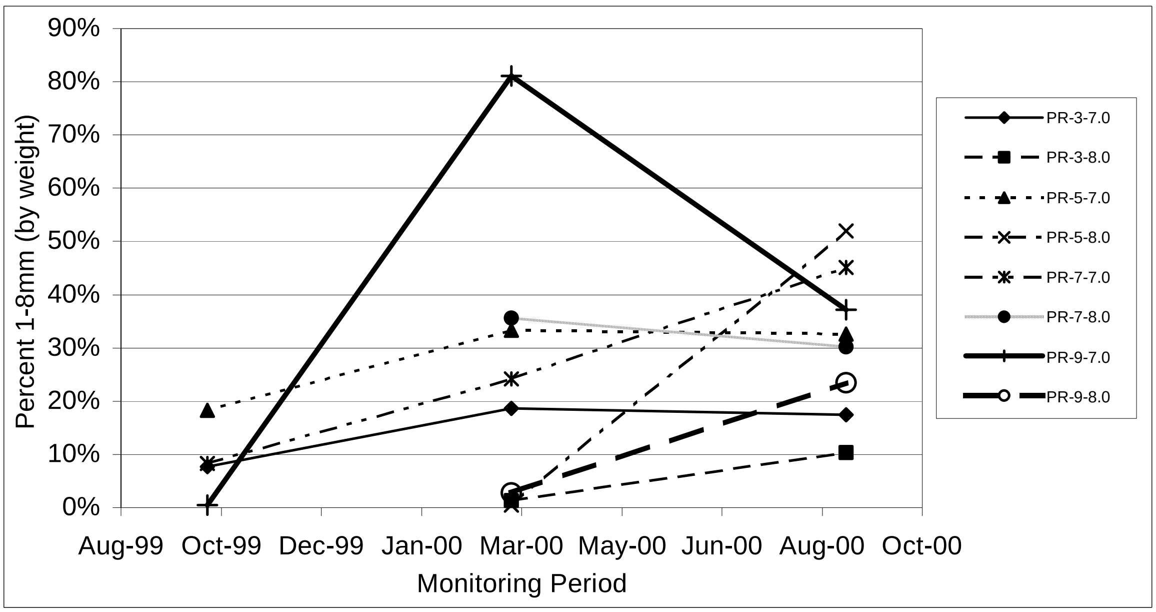

Figure 9. Beachface sediment characterization.

Summary and Conclusions

The project has been relatively stable since it was built. The backshore was planted at some properties, consisting of small amounts of native dunegrass (*Elymus mollis*) and a few other herbaceous plants in the area within approximately 10 ft of the bulkhead. The berm adjusted slightly, moving landward and increasing in elevation due to the wave energy reshaping it. There has been only a 1.6% loss of sediment from 1999 to 2000 due to sediment compaction and littoral drift. The sediment size suitable for surf smelt spawning from +7.0 to +8.5 ft MLLW increased from 1999 to 2000, along most of the profiles. The air spaces in the coarse gravel is filling in with sand, as the waves deliver sand (littoral drift) when they drain through the cobble berm. Natural revegetation is slowly occurring although many areas consist of willow dock (Rumex salicifolius) a common native backshore area plant that also grows in disturbed sites inland. All of these plants will help in a small way to maintain stability of the berm in the event of a very large high tide combined with a windstorm from the north. This project provides a rare example of a large cooperative beach rehabilitation project undertaken by a group of individual property owners (Zelo, 2000).

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