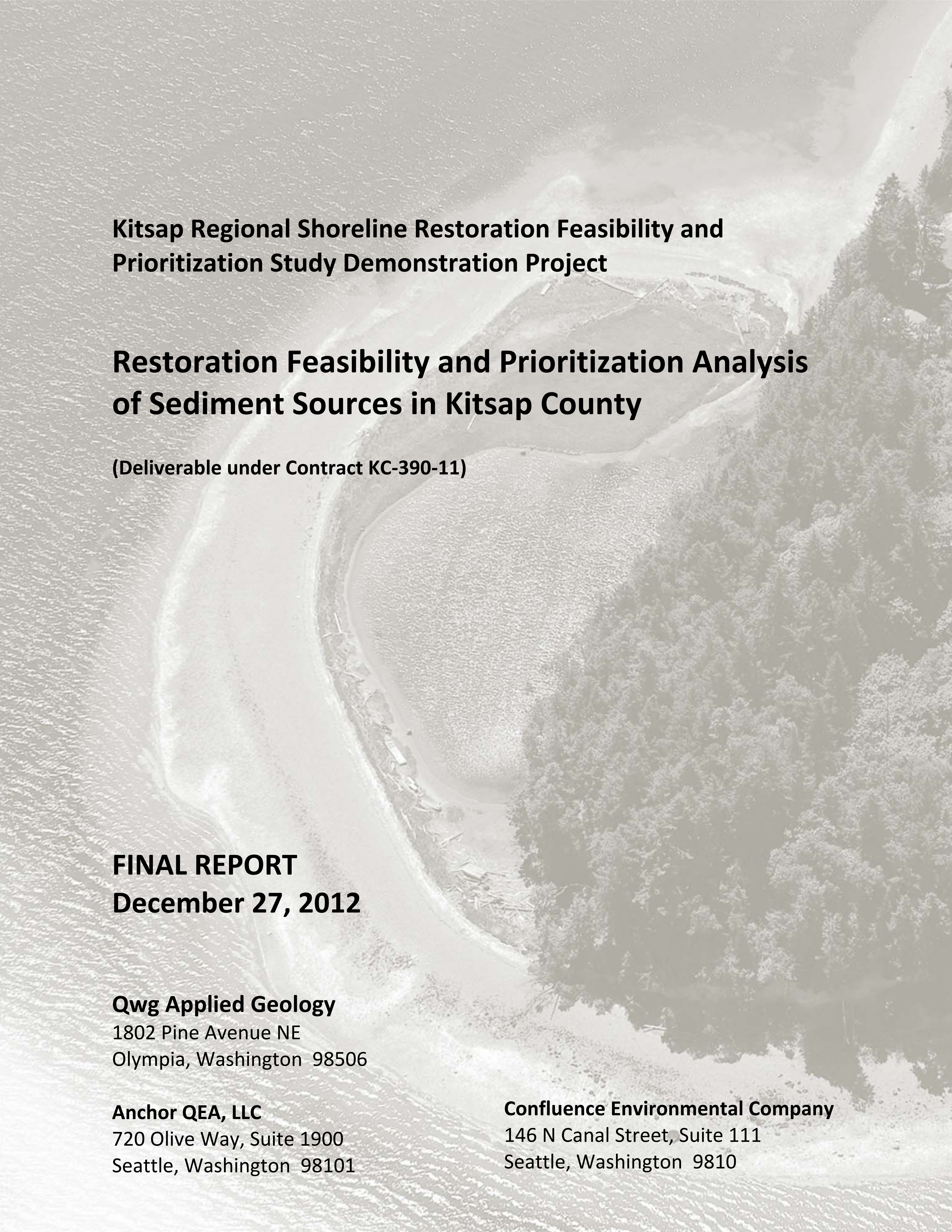

Kitsap Regional Shoreline Restoration Feasibility and Prioritization Study Demonstration Project

Restoration Feasibility and Prioritization Analysis of Sediment Sources in Kitsap County

(Deliverable under Contract KC-390-11)

FINAL REPORT
December 27, 2012

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Acronyms and Abbreviations

County	Kitsap County
EPA	U.S. Environmental Protection Agency
GIS	geographic information system
LiDAR	Light Detection and Ranging
MHHW	mean higher high water
OHW	ordinary high water
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington State Department of Ecology
USGS	U.S. Geological Survey

1. INTRODUCTION

This report describes the methods and findings of sediment input source mapping and shoreline restoration/protection prioritization along the shorelines of Kitsap County (County), excluding the City of Bainbridge Island[1]. The project was conducted as part of the Kitsap Regional Shoreline Restoration Project grant that the County received from the U.S. Environmental Protection Agency (EPA). The objectives of the EPA-funded effort are to support local initiatives to identify, prioritize, garner support for, and restore shoreline processes. The impetus for the project stems from concerns about the extensive shoreline armoring that has occurred along the County's marine shorelines, and the effects this has on nearshore ecosystems (Shipman 2010). The specific concern being addressed by this project is the interruption of natural sediment input, transport, and deposition processes that has been caused by the shoreline armoring.

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) report titled *Management Measures for Protecting and Restoring the Puget Sound Nearshore* (Clancy et al. 2009) identifies the contribution of natural sediment input to the shoreline as a fundamental ecological process contributing to the appearance and function of Puget Sound shorelines. In addition, sediment input is one of the most important processes that will allow for a natural response to sea level rise. Successful shoreline restoration entails re-connecting sediment supplies that have been interrupted or disconnected from the shoreline. Erosion control structures, such as bulkheads, are identified as one of the major culprits in the disruption of sediment supply, and are an emphasis for possible removal in restoration efforts. According to County data, 82% of all Kitsap County shoreline parcels are developed, and shoreline armoring is present along approximately 38% of the County's shoreline (30% when Bainbridge Island is excluded[1]). Bulkheads or other types of armoring are typically installed because of real or perceived erosion concerns. In fact, shoreline armoring structures have been constructed in locations ranging from exposed shorelines with relatively high erosion risks to protected coves with relatively low erosion risks. It is important to note that while this study focuses on the sediment sources and the impacts of shoreline armoring structures to sediment inputs, the shoreline armoring structures have many other impacts on the habitat and ecological processes, including in areas where the armoring is not located along a mapped sediment source.

An initial effort in identifying restoration opportunities was the mapping and identification of sediment sources of high ecosystem value, as well the identification of obstructions that impede those sources from contributing to the shoreline environment. The first step in these efforts was to characterize all potential sediment sources through a compilation of available datasets on historical shoreline conditions and current shoreline armoring. Other remote observation and mapping tools were also applied. No field work was conducted for this project.

The term "sediment source" is intentionally used rather than the more familiar term "feeder bluff." "Feeder bluff" generally conjures an image of a large, steep coastal slope of exposed sediment. However, such features are only one type of sediment input source among several that make important

[1] In the remainder of this document, references to Kitsap County shorelines refer only to the project area (i.e., excluding Bainbridge Island).

sediment contributions to Puget Sound. In order to provide a more comprehensive interpretation of potential sediment sources, the mapping work completed in this study included the identification of various landslide types, currently stable coastal slopes with a potential for delivery under past or predicted future conditions, and tributary streams. In this way, the mapping approach supported additional distinction between the various coastal slope processes and morphology, and the potential for sediment input from streams discharging into the shore environment. Regarding currently stable coastal slopes, the term *bluff* is applied, defining it by an earlier and more specific use of the term (see Section 2.3) in which the sediment contributions tend to be small and variable.

The prioritization work conducted in this study is intended to provide a science-based assessment of the highest priority areas recommended for restoration or protection. Protection would focus on those areas currently providing substantial unimpeded sediment inputs to the shore environment. Restoration would focus on those areas where sediment sources, identified as potentially contributing substantial sediment inputs to a drift cell, are currently disconnected from the shore environment. In this assessment, sediment sources were quantified by their length along the shoreline, and assigned relative rates and volumes of sediment input based on professional interpretations of geologic processes and mechanics of sediment input. From this analysis, additional objective criteria were applied to identify specific areas with the potential for restoration and/or protection. These areas were prioritized based on the improvements, in the case of restoration, or continuing contribution, in the case of protection, they could offer to the connectivity of sediment supply to the shoreline. In addition, the prioritization incorporated a social feasibility component in which risk to infrastructure and landowner interest was determined to create a better understanding of where scientific and social opportunities coexist. Discussions were initiated to identify potential restoration and protection sites with willing landowners. The County's ultimate goal is to carry out on-the-ground restoration projects over the next several years. In this way, the study provides a systematic prioritization that can inform opportunities to restore sediment supply in areas where restoration projects are considered more feasible today, as well as longer-term project development if project feasibility improves elsewhere.

This report is organized to provide in Section 2 the methods and results of the sediment source mapping, including sediment source locations and selected factors affecting sediment input. Section 3 presents a sediment source rating system developed to characterize the relative potential for contributing sediment at the drift cell and reach (i.e., sub-drift cell) scales. Section 4 presents the shoreline prioritization approach for drift cells and reaches, including a preliminary risk analysis. Section 5 describes the approach to identifying project sites, including ongoing work to identify potentially willing landowners and site-scale analysis considerations. Section 6 presents stewardship recommendations to assist the County and other restoration practitioners in evaluating appropriate restoration or protection actions based on site conditions.

This report is delivered in an electronic format, which allows readers to view multiple combinations of data layers on the figure maps by interactively turning selected map layers on and off. The format used is a layered PDF, readable with Adobe Acrobat. A tool bar on the left hand side includes a layers symbol ( ), which can be clicked on to access the layers menu for turning layers on and off. A more detailed explanation of how to use the layered PDF features on the map figures is presented in Appendix A.

2. SEDIMENT SOURCE MAPPING

Sediment source mapping for this study relied entirely on previously collected data from a variety of data sources, in combination with interpretation of remote sensing data (i.e., Light Detection and Ranging [LiDAR], oblique shoreline photographs, and ortho-rectified images), and geologic mapping. No field observations were made for this study. The datasets listed below were used in identifying and classifying potential sediment sources, as well as characterizing existing shoreline modifications. Additional reference information for these data sources is provided in Appendix B. The six datasets most useful for mapping sediment sources are indicated by an asterisk (*).

- Kitsap County Boundary
- Kitsap County Hydrology (2007) Lines
- Kitsap County Hydrology (2007) Polygons
- Kitsap County Hydrology (2007) Drift Cells
- Kitsap County Nearshore Inventory - Armoring
- Kitsap County Parcels
- Kitsap County Roads
- Kitsap County Structures
- East Kitsap County Nearshore Habitat Assessment (Battelle 2009)
- West Kitsap County Nearshore Habitat Assessment Addendum (Battelle 2010)
- PSNERP Current Shoreforms (v3.0, 2010)
- PSNERP Historic Shoreforms (v3.0, 2010)
- PSNERP Shoreline and Watershed Modifications (v3.0, 2010)
- * U.S. Geological Survey (USGS) Landslides Mapped from LiDAR (2008) Scarps
- * USGS Landslides Mapped from LiDAR (2008) Deposits
- Washington State Department of Ecology (WDOE) Net Shore Drift Mapping
- * WDOE 2005 Aerial Oblique Photographs
- * WDOE Coastal Zone Atlas Slope Stability
- Washington Department of Natural Resources (WDNR) ShoreZone Inventory
- * WDNR Geology (1:100,000)
- * WDNR Landslides

The geologic cross-section information from Deeter (1979) was also digitized and available during the analysis. The cross-sections are provided in Appendix C.

2.1. Methods for Identifying Potential Sediment Sources

The identification of potential sediment sources was initially carried out strictly as a geographic information system (GIS) exercise, using existing datasets listed above. The WDNR ShoreZone Inventory data layer of ordinary high water (OHW) was used to locate the shoreline. Any mapped or delineated likely sediment-producing feature or process (e.g., landslides, and stream mouths) was graphically “forced” to the shoreline, so that they appear parallel to the shoreline no matter what their actual location or orientation on the land. There, reaches were designated as either YES or NO for having a likely sediment source. This effort resulted in a linear (polyline) dataset that represented potential sediment input sources from the uplands or upstream.

Following this GIS-generated mapping, the entire length of County shoreline was reviewed using WDOE oblique shoreline photographs, LiDAR imagery, drift cell data, and geologic mapping. This review allowed for refinement of the initial GIS-generated designations. The primary objectives of this fly-over review were to: 1) confirm and refine the designated extents of potential sediment input sources; and 2) add classification information to describe each potential sediment source. Categories of sediment input were delineated on the basis of previous landslide mapping (e.g., the USGS study and WDNR), topography (including LiDAR imagery), and "fly-over" observations. Although historical sediment input sources were not identified per se, historical information from existing datasets (Battelle 2009, 2010; Johannessen and MacLennan 2007a) was used to cross check current and potential sediment input conditions. In evaluating the potential for sediment input, conditions of no shoreline armoring were assumed, which, in turn, provides a best estimate of historical conditions.

2.2. Sediment Source Categories

Sediment source categories were developed based on a characterization of sediment input process, and in consideration of classification schemes used in other similar shorelines studies (Battelle 2009, 2010; Johannessen and MacLennan 2007a). However, the categories were modified into a three-tiered classification system, with slightly different terminology than previous studies, based on specific characteristics typical of the County shoreline. The revisions make the categories more useful and descriptive for the purposes of this restoration feasibility study. Each reach of the shoreline identified as a potential sediment source was given a *Feature* type. Individual Features were further described with *Attributes*, which were influenced by *natural and manmade Modifiers*.

Features are used to describe types of landforms that have or could contribute sediment and include the following:

- Predominantly shallow landslides
- Predominantly deep-seated landslides
- Mixed shallow and deep-seated landslides
- Bluffs
- Tributaries

Attributes are used to describe additional characteristics of specific Feature types. Attributes offer the best indication of relative sediment volume inputs by a potential sediment source and include the following:

- Bank height – for landslides and bluffs
- Basin and delta characteristics – for tributaries
- Geology – (applied at the site-scale analysis)

Basin and delta characteristics of tributaries were based on a qualitative remote assessment of the following:

- Likelihood of sediment delivery to mouth (presence of landslides in basin; sediment sinks such as ponds, wetlands, and lakes)
- Relative delta size
- Delta type (wave- versus stream-dominated)

Modifiers describe either a process or an interruption of a process. There are three dominant Modifiers active in the County; two natural and one manmade. Modifiers directly affect the likelihood that a Feature with a specific set of Attributes will contribute sediment to the shoreline environment. For instance, two bluffs of similar height may not have an equal chance of contributing sediment to the shoreline environment if one is on a shoreline that is exposed to large, frequent wind waves and the other is in a protected embayment. The Modifiers used in this analysis are listed below and were chosen based on their importance and ubiquity in the County:

- Net shore drift (natural)
- Relative wave exposure (natural)
- Armoring (manmade)

Each of the categories (Features, Attributes, and Modifiers) is described in more detail in the following sections.

2.3. Sediment Source Feature Classes

Five sediment source Features were defined as described above. Within the landslide category are three sub-categories: shallow landslides, deep-seated landslides, and a mix of the two, as discussed in the following sections.

2.3.1. Predominantly Shallow Landslides

Shallow landslides include mapped or photo-identified debris flows, debris slides, debris avalanches, and block falls and topples. Such mass-wasting processes generally occur within a narrow zone of the upland immediately adjacent to the shoreline. Recently active predominantly shallow landslides are typically apparent as exposed sediment (no vegetation) and fallen trees at or near the shoreline.

Depending on the many factors discussed in various publications on the shoreline processes of Puget Sound (Shipman 2008; Johannessen and MacLennan 2007a), these landslides generally contribute sediment every few years and in volumes on the order of a few cubic yards to tens of cubic yards in any single event. In this mapping framework, "feeder bluffs" are a subset of the predominantly shallow landslide category.

2.3.2. Predominantly Deep-seated Landslides

Deep-seated landslides generally involve a much broader zone of the upland and can extend inland 0.5 miles or more. They can contribute large amounts of sediment on the order of tens to hundreds of cubic yards, with a recurrence interval on the order of decades. Shallow landsliding generally has a shorter recurrence interval at a given location, but may be superimposed on deep-seated landslide Features.

2.3.3. Mixed Shallow and Deep-seated Landslides

This composite of landslide types was mapped where a combination of landslide processes is evident; either where shallow landslides are superimposed on the scarps and toes of deep-seated landslides, or where shoreline reach segments would be too short to break out each landslide type at a practical mapping scale.

2.3.4. Bluffs

The definition of bluff from Bird (2005) was used to distinguish steep slopes mapped with landslides (and readily available sediment), from those not likely to make significant sediment contributions unless coastal conditions change significantly. Bird defines bluffs as, "bold, steep sometimes rounded coastal slopes on which soil and vegetation conceal, or largely conceal the underlying rock formations…." The bluff designation suggests that there was little to no evidence for historical landsliding, but that wave erosion may ultimately contribute sediment in areas where relative wave vulnerability is a significant factor. In some instances, steep slopes that are stabilized to some extent by shore armoring may end up designated as bluffs.

2.3.5. Tributary

Tributary streams have the potential to contribute significant sediment to the shoreline. This contribution is related to the transport and deposition of suspended sediment and bedload moved downstream through fluvial processes. The sediment is transported from the stream into the shoreline environment, where it becomes subject to shoreline drift processes. Tributary delta characteristics can be used to qualitatively evaluate a tributary's effectiveness in contributing sediment to the shoreline environment.

2.4. Sediment Source Attributes

The sediment source Features described above are the key indicator of relative potential sediment contribution, but for any given Feature there are Attributes that have important bearing on the potential rate and volume of contribution. The term slopes, as used below, refers to mapped sediment sources that are either bluffs or one of the three types of landslide features. A different set of Attributes applies to slopes than to tributaries, as described below.

2.4.1. Attributes of Slopes

Slope Features include Predominantly Shallow Landslides, Predominantly Deep-seated Landslides, Mixed Shallow and Deep-seated Landslides, and Bluffs. The following Attributes are used to refine the potential sediment contribution of each slope Feature.

Bank Height

In mapping bank height (also commonly referred to in the literature as bluff height), it was intended to assign each section of shoreline to one of three general classes based on relative perceived hazards associated with certain height ranges: low (less than 10 feet high), medium (approximately 10 to 30 feet high), and high (greater than 30 feet high). However, the County shoreline has a remarkable amount of variability in bank heights even over relatively short distances. Consideration of calculating bank height from LiDAR data highlights the complexity of identifying exactly where the top of the bank is located relative to its distance from the shoreline. Many slopes are stepped, or benched, and in the case of deep-seated landslides, the top of bank can be 0.5-mile or more inland. Involved calculations of this sort, while very valuable, were beyond the scope of this study. To provide a qualitative detailed interpretation of the bank height Attribute, five classes were designated in the GIS layer based on qualitative visual interpretation of the WDOE oblique shoreline aerial imagery, as follows:

1. No to low (less than 10 feet)
2. Medium (approximately 10 to 15 feet)
3. Medium to high (15 to 30 feet)
4. High (greater than 30 feet)
5. Variable (0 to greater than 30 feet).

The breaks between height classes are based on previous studies (e.g., Gerstel and Brown [2006]), which incorporate public perceptions of threats associated with different height ranges.

2.4.2. Attributes of Tributaries

The Attributes useful for describing relative sediment input potential of tributaries combine the evaluation of basin-scale characteristics with those of the sediment discharge zone, or delta. The characteristics of the basin influence its sediment budget and transport mechanisms. This was the initial basis for identifying those tributaries that could effectively transport sediment to their mouth. A second-tier analysis used delta morphology to give an indication of the likelihood that the sediment discharged at the mouth of those tributaries remains in the shoreline environment, rather than being transported offshore. A qualitative rating for potential sediment input of High, Medium, or Low was given to each tributary identified as a possible sediment source based on the following Attributes.

Likelihood of Sediment Delivery to Mouth

This Attribute is based on several key morphologic features of the watershed. Sediment sinks such as lakes or wetlands effectively block sediment from reaching the mouth. Tributaries with sediment sinks were not considered as potential sediment input sources. Similarly, extremely low gradient reaches of stream are likely to inhibit the downstream transport of coarse material, as do obstructions in the lower reaches of the tributary or near the tributary mouth.

Delta Size

Based on remote observations, deltas were assigned to one of three relative size classes of large, medium, or small. Although size is not necessarily an effective indicator of relative sediment contribution to the shoreline environment, it provides one more descriptor in combination with those listed here.

Delta Type

Tributaries identified as possible sediment input sources were ultimately categorized by the morphologic characteristics of their delta. Using a simplified shore typology of wave- versus stream-dominated deltas, all tributaries were assigned one or the other Attribute based on morphologic cues visible in aerial images. This assessment assumes that wave-dominated deltas allow tributary sediment to be redistributed along the shoreline, whereas stream-dominated deltas are more likely to result in sediment deposition into deeper water and, therefore, not available to the shoreline environment.

2.5. Sediment Source Modifiers

Three Modifiers to sediment sources were identified that affect potential rates (and, therefore, volumes) of sediment input from the Features described in Section 2.3. The effect of the Modifiers, two natural and one man-made, is due to their influence on the likelihood of sediment input and redistribution to the shoreline environment. As the name suggests, Natural Modifiers are natural conditions that affect the likelihood of sediment being input and redistributed in the shoreline environment. Man-made Modifiers are alterations along the shoreline that serve to interrupt the natural sediment input and redistribution processes.

2.5.1. Natural Modifiers

Net Shore Drift

The term net shore drift refers to the “net” direction along the shoreline that sediment is likely to be transported from a source area. While the direction of drift may vary seasonally, net shore drift describes the overall direction of sediment movement. The direction of net shore drift is generally assigned to “drift cells,” which are discrete sections of shoreline where sediment supply, transport, and deposition occurs in a closed system from other shoreline sections. Sediment-input sources can be limited to one end or another of a drift cell, or scattered throughout. Generally, sediment is transported from input sources longshore from the updrift end to the downdrift end of the drift cell. The “downdrift” end of a drift cell is often characterized by shoreforms that are formed by the long-term supply and accretion of sediment, such as a barrier spit. Between sediment-input sources are transport zones.

Where a sediment source falls within a drift cell will affect its relative importance to that cell. A sediment source at the updrift end of the drift cell will provide a greater benefit to the drift cell than one at the downdrift end. This is because sediments input near the updrift end can be transported along a larger portion of the drift cell than sediments input near the downdrift end of the drift cell. In many drift cells in Puget Sound, the updrift end of two adjacent drift cells occurs in the same area, termed a divergence zone, where the direction of longshore drift is indistinct such that sediment likely moves from the site alternately into one or the other drift cell; therefore, in one of two different directions. In this way, divergence zones are considered to contribute sediment inputs to two drift cells.

Maps identifying net shore drift also identify areas of “no appreciable drift,” where sediment is only minimally transported, if at all. WDOE prepared maps of net shore drift for the marine shorelines of Washington in the early 1990s (Schwartz et al. 1991). For the eastern shorelines of Kitsap County, the net shore drift mapping was updated and refined by Johannessen and MacLennan (2007b).

Relative Wave Exposure

Wave processes experienced by a shoreline provide one of the controlling processes for shoreline shape (morphology), as well as sediment input and redistribution (Howes et al. 1995). In addition to climatic and seasonal controls of winds generating waves, the wave energy environment of shorelines depends upon the distance of water over which wind can blow to generate waves (known as fetch), and the shoreline orientation to predominant wind directions. Generally in Puget Sound, the prevailing wind direction is south (i.e., from south to north) or southwest during the winter and west or northwest in the summer (Finlayson 2005). Stronger winds tend to occur in the winter than summer, and the strongest winds are southerlies experienced during winter storms. Due to their orientation to prevailing and predominant winds, south-facing shorelines tend to endure higher wave energy conditions.

To characterize the relative wave exposure of shorelines, an analysis was conducted based on techniques developed in a shoreline inventory in British Columbia (Howes et al. 1999). Relative wave exposure was assessed based on the relationship between the modified effective fetch (i.e., composite fetch calculated based on fetch distance measured at three angles to shoreline) and maximum fetch (i.e., longest fetch distance for given location on shoreline). Shoreline reaches were assigned to one of the five following relative wave exposures categories:

1. Very protected
2. Protected
3. Semi-protected
4. Semi-exposed
5. Exposed

Table 1 presents the relative wave exposure category assignments based on modified effective fetch and maximum fetch. This Natural Modifier provides an indicator of relative erosion rates, as well as subsequent availability of sediment for transport once it has been entered the shoreline environment. See Appendix D for more information on the analysis methods and results.

Table 1. Relative Wave Exposure Categories Assigned to Kitsap County Shorelines

Maximum Fetch	Modified Effective Fetch			
	<1 km	**1-5 km**	**5-10 km**	**10-50 km**
<1 km	Very Protected	--	--	--
1-5 km	Protected	Protected	--	--
5-10 km	Semi-Protected	Semi-Protected	Semi-Protected	--
10-50 km	Semi-Protected	Semi-Exposed	Semi-Exposed	Exposed
>50 km	--	Semi-Exposed	Exposed	Exposed

2.5.2. Manmade Modifier

Shoreline Armoring

Shoreline armoring was the one manmade Modifier used in the analysis. Shoreline armoring affects rates (and, therefore, volumes) of sediment input from the Features described in Section 2.3 by impeding its connectivity with the shoreline. This Modifier was applied as an overprint of where shoreline armoring has been mapped for East Kitsap County Nearshore Habitat Assessments (Battelle 2009), and West Kitsap County Nearshore Habitat Assessments (Battelle 2010). It represents where sediment is prevented or inhibited from moving from sources to the shoreline.

2.6. Summary of Sediment Source Distributions

The results of the sediment source mapping are shown in Figure 1. Figure 1 includes separate layers for each Feature, Attribute, and Modifier. Instructions for turning layers on and off are included as Appendix A. These sediment distributions are the basis of subsequent quantitative and hypothesis-based analyses described in detail in Sections 3 and 4.

Table 2 summarizes the extent of sediment sources from shoreline slopes (i.e., not including tributaries) and the extent of armoring. Sediment sources were identified along 90.5 miles of shoreline, which is 35% of the total shoreline. Areas of predominantly shallow landslides were the most extensive type of sediment source feature in the county, extending along 33.8 miles of the shoreline. Bluffs were the least extensive type of sediment source feature (17.7 miles).

Table 2. Summary of the Extent of Slope Sediment Sources and Shoreline Armoring

Sediment Source Feature	Miles	Miles Armored	Miles Unarmored	Percent Armored
Predominantly Shallow Landslide	33.8	6.8	27.0	20%
Predominantly Deep-Seated Landslide	20.1	5.0	15.1	25%
Mix of Shallow and Deep-Seated Landslides	19.0	3.2	15.7	17%
Bluff	17.7	8.5	9.2	48%
Not A Sediment Source[1]	115.0	38.7	76.4	34%
Total[2]	205.7	62.2	143.4	30%

Table Notes: 1) This includes all shoreline mapped as tributary.
2) Some totals reflect inconsistencies due to rounding.

Shoreline armoring occurs along 62.2 miles, which is 30% of the total shoreline. Among sediment source feature types, shoreline armoring was most extensive along bluffs as 48% of the length was armored. The presence of a high percentage of armoring along bluffs is consistent with the bluff definition which includes steep slopes that are stabilized by armoring. As indicated in the bluff definition (Section 2.3.4), some instances of landslide categories may have been designated as bluffs because the armoring has stabilized the slope and concealed indications of a landslide feature. Armoring along the landslide shorelines was 21% by length overall, and ranged between 17% by length of mixed landslides and 25% by length of deep-seated landslides. The overlap between sediment source locations and shoreline armoring is one key aspect of the prioritization approach described in Section 4.

In the County, 120 tributary mouths were mapped (see Figure 1). Of these, 83 were identified as potential sediment sources.

Generally, longer reaches of high-bank sediment input sources are present along Kitsap County's eastern shoreline than along the western shoreline; however, bank height attributes are quite variable among the range of slope sediment source features mapped – shallow landslides, deep-seated landslides, and mix of shallow and deep. This generalization is based on *potential* input and does not consider *existing* connectivity of those sediment sources to the shore environment. Areas mapped as bluffs tend to fall into the lower two thirds of bank height attribute classes. We interpret these areas as having been stable or armored long enough that mature vegetation cover now obscures the visual cues otherwise used to identify landslides.

High bank areas tend to occur where shoreline orientation aligns with the north-south trend of glacial fluting, paralleling thicker sequences of sediment. Areas of highly variable bank height coincide with deep-seated landslides or mixed shallow and deep-seated. The relative thickness and stratigraphic position of different types of sedimentary deposits controls groundwater movement and are factors in the type slope process observed. Preliminary interpretation of the stratigraphy exposed along Kitsap County's shoreline (Deeter, 1979, and Appendix C) suggests that the consolidated, pre-Vashon non-glacial sediments of the Whidbey Formation may comprise a greater proportion of the sediments underlying the slopes along the County's western shoreline than those along the east side of the County. Numerous first and second order drainages dominate the slopes along Hood Canal, reflecting the control on surface run-off of these dense, fine-grained sediments. Overlying younger, coarser glacial sediments appear to slightly dominate slope stratigraphy on the east side of the County. Here, surface drainages are generally less developed, likely owing to the more permeable nature of these coarser upper sediments.

The geologic mapping by Deeter (1979) (Appendix C), highlights the variability throughout the county of the stratigraphy and relative sediment thickness. These data were reviewed for the example shoreline segments presented in Section 5, and are included as an appendix for use in future project evaluation and site selection.

The variability in sediment input processes (as identified by the different Features mapped), sediment type, and bank heights associated with features at different locations, speaks to the importance of evaluating reach- and site-specific conditions and characteristics at finer more local scales when selecting appropriate restoration projects.

3. SEDIMENT SOURCE RATING

A sediment source rating was applied to each mapped sediment source. The ratings indicated the likelihood that sediment will be delivered to the shoreline environment based on the existing evidence. This includes assessment of the relative rate and volume of the source, as well as the connectivity of the source to the shoreline environment.

3.1. Sediment Source Rating Methods

As described above, the Features, Attributes, and Modifiers of each sediment source affect the likelihood for and volume of sediment inputs from the area. To collectively interpret the Features, Attributes, and Modifiers of shorelines in the project area, a rating system was developed. The rating system characterizes mapped sediment sources in terms of their ***potential*** to contribute sediment to the shoreline, as well as and their ***existing*** connectivity to the shoreline given current shoreline conditions. The *potential* rating was based upon the Features, Attributes, and Natural Modifiers of the mapped sediment sources (i.e., assuming no shoreline armoring). The *existing* rating adjusts the *potential* rating based on the extent of the Manmade Modifier (i.e., shoreline armoring). An interpretation of ***percent remaining*** sediment contribution was also calculated based on the potential and existing ratings. Sediment sources along slopes (i.e., landslides and bluffs) were rated separately from tributaries.

The basic equation of the rating system is that numeric scores assigned to each Feature were adjusted by the multiplication factors assigned to each Attribute and Modifier. Scores to a maximum of 1,000 were assigned to all Features. The multiplication factors assigned to Attributes and Natural Modifiers were on a scale of 0.1 to 1.0. The scoring output after the multiplication were on a scale of 0 to 1,000, with higher numbers reflecting higher relative potential to contribute sediment. Those areas that were not mapped as sediment sources were assigned a rating of 0.

For interpretation, the scores of individual sediment source segments were combined to characterize conditions over larger scales; for example, entire drift cells and reaches within drift cells. The combining of segments was achieved by summing the individual segment scores together in a length-weighted manner, such that longer segments contributed more to the overall score than shorter segments.

The following sections describe the scoring assignments for Features, Attributes, and Modifiers, as well as the calculation of potential, existing, and percent remaining ratings.

3.2. Slopes

Sediment source scores for slopes were developed based on the Feature’s Attributes and based on Natural and Manmade Modifiers.

3.2.1. Slope Feature Scores

In assigning scores to sediment source Features, a relatively long-term perspective is considered (i.e., approximately 30 years to consider the life of a project). For this reason, each landslide

Feature was assigned the same score (1,000). The identical scores reflect that over time the sediment inputs of the more frequent shallow landslides are assumed to be equivalent to the sediment inputs of the less frequent, but larger deep-seated landslides.

As described in Section 2.3, bluffs are less likely to contribute significant amounts of sediment unless coastal conditions change significantly. To reflect this lesser contribution of sediment compared to landslides, bluffs were assigned scores of 500.

3.2.2. Slope Attribute Scores

Slopes with higher bank heights were assumed to have a greater capacity to input sediment to the shoreline because there is more material in a higher bank than a lower bank. To reflect the differences in the amount of sediment, the rating is determined by calculating the proportion of the bank height relative to the high category. In this calculation, the high bank category was assumed to be 40 feet, and the midpoint of the height range of all other bank heights was used. For example, for medium to high banks with a height range of 15 to 30 feet, the midpoint of 22.5 feet was divided by 40 feet to arrive at a score of 0.6. The scores applied to the other bank height categories were 0.3 for medium banks, 0.1 for low banks, and 0.4 for variable banks.

3.2.3. Slope Natural Modifier Scores

Two Natural Modifiers were applied to bluffs: net shore drift (referencing position in drift cell as described in Section 2.5.1.), and relative wave exposure.

The position of a sediment source within a drift cell (Figure 1) affects the potential length of the drift cell that may benefit from that sediment source. Sediment sources in divergence zones were assigned scores of 0.5 to reflect the potential for sediment to be transported in either direction from the divergence zone. Sediment sources in divergence zones were included in the calculations of both drift cells; therefore, the total divergence zone contribution was 1.0 (i.e., 0.5 + 0.5). Sediment sources in transport zones were assigned scores of 1.0 to reflect that input sediment will become part of the shoreline habitat in the drift cell. Sediment sources in convergence zones and areas of no appreciable drift will not affect as large an area as sediment sources in transport zones or divergence zones, so a multiplier of 0.2 was applied.

The relative wave exposure categories were used to modify the scores based on the anticipated relative rate of erosion. It was assumed that sediment sources in more exposed locations were more likely to input sediment than those in more protected environments. With this in mind, the following multipliers were applied: 1.0 for exposed, 0.8 for semi-exposed, 0.6 for semi-protected, 0.4 for protected, and 0.2 for very protected.

3.2.4. Slope Manmade Modifier Scores

Rather than applying scores to armoring, the extent of armoring was included as a multiplication factor based on the proportion of the sediment source length with armoring. The armoring multiplier reduced the sediment source scores based on the percentage of the sediment source length that was disconnected from the shoreline.

3.3. Tributaries

Tributaries can also be important sources of sediment to the shoreline environment. The input of sediment from streams depends on a number of factors including the area, geologic characteristics (e.g., landslide density), and topography of the basin. The delivery of sediment to the shoreline is also affected by factors controlling the type of delta at the tributary mouth. Some stream deltas are subject to wind waves that push sediment back toward the shoreline, while others tend to form wide deltas more likely to deposit bedload and suspended load into deeper water away from the shoreline. The sediment source rating was calculated for all 120 mapped tributaries in the County.

3.3.1. Tributary Feature Scores

Based on interpretation of aerial photographs, tributaries were classified as being either wave- or stream-dominated. Wave-dominated systems are the more likely of the two to provide sediment to the shoreline environment and were assigned a score of 1,000. Stream-dominated systems are likely to deposit some sediment into deeper water, where it is unlikely to be moved by net shore drift and available to the shoreline environment. These systems were assigned a score of 600.

3.3.2. Tributary Attribute Scores

While basin size, geologic characteristics, and topography are very important to the overall sediment transport characteristics of a stream, the number of potential variables and the quality of existing data made a robust assessment using these criteria infeasible. Instead, one of three categories was assigned to each tributary based on an interpretation of the relative size of each delta. Aerial photographs of the delta were primarily used to assess delta size. Eight tributaries were assigned to the large (*1.0) category, 33 to the medium (*0.9) category, and the remaining 79 were considered small (*0.8).

3.3.3. Tributary Natural Modifier Scores

The natural conditions used to modify sediment scores were exposure to waves and drift type. It was assumed that the greater the relative wave exposure category (described in Section 2.5.2), the more likely that sediment from tributaries will remain in the shoreline environment. Deltas considered exposed were scored the highest (*1.0) and deltas consider very-protected were scored lowest (*0.2). Other categories used were semi-exposed (*0.8), semi-protected (*0.6), and protected (*0.4). See Appendix D for additional information on relative vulnerability of the shoreline to waves.

Stream mouths in divergence zones were considered to supply one-half of available sediment to each of the two adjacent drift cells. For this reason *divergence zone* was applied as a modifier. Scores were divided by half (*0.5), but counted in both adjacent drift cells.

3.3.4. Tributary Manmade Modifier Scores

Initial tributary mapping provided an assessment of whether a tributary was likely a sediment source or not. If the tributary was not considered a sediment source, it was assigned the manmade modifier score of 0.1. Restriction took into account the presence of sediment sinks and roads or other structures blocking sediment input to Puget Sound. If the tributary was considered a sediment source, it had a manmade modifier score of 1.0.

3.4. Calculation of Sediment Source Ratings

The potential, existing, and percent remaining sediment source ratings were calculated at multiple scales, including individual sediment sources, reaches, and drift cells. In this analysis, individual sediment sources are those sediment sources with identical Features, Attributes, and Modifiers, whereas reaches contain the entire contiguous extent of sediment sources regardless of differences in Features, Attributes, and Modifiers. In this way, reaches contain one or more individual sediment sources. Likewise, drift cells may contain one or more reaches.

3.4.1. Potential Sediment Source Rating

The potential sediment source rating describes the theoretical potential for sediment inputs to the shoreline assuming no Manmade Modifier (i.e., shoreline armoring) interrupts the connection between mapped sediment sources and the shoreline. The following formula describes the calculation of potential sediment source. Table 3 provides a more detailed depiction of the formula.

Potential = (Feature) x (Attributes) x (Natural Modifiers) x (Sediment Source Length in miles)

3.4.2. Existing Sediment Source Rating

To characterize the existing connectivity of sediment sources to the shoreline environment, the potential score has been modified based on the amount of the sediment source's shoreline length that is armored. The potential score was multiplied by 1 minus the fraction of the sediment source length that is armored to determine the existing sediment source rating. For example, if 100 feet of a 1,000-foot-long sediment source is armored, then the potential score for that sediment source will be multiplied by 0.9. The following formula describes the calculation of existing sediment source. Table 2 provides more detail to the formula.

Existing = (Feature) x (Attributes) x (Natural Modifiers) x (1-Manmade Modifier) x (Sediment Source Length in miles)

Table 3. Formulas for Sediment Source Ratings of Individual Slope Segments

POTENTIAL SEDIMENT SOURCE RATING =

Feature Sediment Source Type		**Attribute** Bank Height		**Natural Modifier** Net Shore Drift		**Natural Modifier** Relative Wave Exposure		**Length Weighting Normalization**
Shallow Landslide = 1,000 Deep-seated Landslide = 1,000 Mix of Deep and Shallow = 1,000 Bluff = 500	X	High = 1.0 Medium-High = 0.6 Medium = 0.3 Low = 0.1 Variable = 0.4	X	Divergence Zone = 0.5 Transport Zone = 1.0 Convergence Zone = 0.2 No Appreciable Drift = 0.2	X	Exposed = 1.0 Semi-Exposed = 0.8 Semi-Protected = 0.6 Protected = 0.4 Very Protected = 0.2	X	(Sediment Source Length / 5,280)

EXISTING SEDIMENT SOURCE RATING =

Feature Sediment Source Type		**Attribute** Bank Height		**Natural Modifier** Net Shore Drift		**Natural Modifier** Relative Wave Exposure		**Length Weighting Normalization**		**Manmade Modifier** Armoring
Shallow Landslide = 1,000 Deep-seated Landslide = 1,000 Mix of Deep and Shallow = 1,000 Bluff = 500	X	High = 1.0 Medium-High = 0.6 Medium = 0.3 Low = 0.1 Variable = 0.6	X	Divergence Zone = 0.5 Transport Zone = 1.0 Convergence Zone = 0.2 No Appreciable Drift = 0.2	X	Exposed = 1.0 Semi-Exposed = 0.8 Semi-Protected = 0.6 Protected = 0.4 Very Protected = 0.2	X	(Sediment Source Length / 5,280)	X	1 – (proportion of feature length with armoring)

PERCENT REMAINING SEDIMENT SOURCE RATING =

(EXISTING SEDIMENT SOURCE RATING / POTENTIAL SEDIMENT SOURCE RATING) X 100%

3.4.3. Percent Remaining Sediment Source Rating

The percent remaining sediment source rating was calculated by dividing the existing rating by the potential sediment rating and multiplying by 100%. This number represents the fraction of the potential sediment source rating in the reach that is not impacted by armoring. It informs the degree of sediment source disconnection regardless of whether the area naturally has a greater or lesser potential for sediment input. The following formula describes the calculation of the percent remaining. Table 2 provides more detail to the formula.

Percent Remaining = ([Existing] / [Potential]) x 100%

A reach with a high potential sediment source rating and a high percent remaining would be an ideal protection area, whereas a reach with an exceptionally low potential sediment source rating and a high percent remaining would be less likely to provide sediment to the shoreline. Similarly, a reach with a high potential sediment source rating and a moderate or even low percent remaining could have significant restoration potential.

3.5. Sediment Source Rating Results at Multiple Spatial Scales

Sediment source rating results are presented at two different spatial scales; the drift cell scale and the reach scale. Drift cells have been mapped previously and are discrete sections of shoreline where sediment input, transport, and deposition occur in closed systems relatively separate from other shoreline sections. As described above, reaches were established in this analysis as segments of shoreline with contiguous sediment sources, regardless of any differences in the Features, Attributes, and Modifiers. An individual drift cell is likely to have more than one reach distributed along its length. Site scale analyses are discussed later in this document.

Figures 2a and 3 show sediment source ratings for slopes at the drift cell and reach scales. In each case the ratings are binned into five categories, each containing 20% of the total number of analysis segments (either drift cells or reaches). This binning approach presents the relative distribution of sediment source ratings across the county. This approach was chosen instead of one geared toward presenting the absolute magnitude of scores because it is more consistent with the relative nature of the data and analytic assumptions used in the rating system. The potential sediment source rating results from slopes at the drift cell scale indicate which drift cells have naturally higher potential sediment inputs than others (Figure 2a). As indicated in the description of the Features, Attributes, and Modifiers, this is a reflection of the extent and type of sediment sources, the volume of potentially available material, and natural conditions influencing the likelihood of sediment being delivered into the shoreline environment. The drift cell just south of Hansville has the highest potential sediment inputs in the project area. Other drift cells among those with the highest potential sediment source ratings in the project area include three short drift cells in the County's southernmost extent of Hood Canal, within and north of Port Gamble in northern Hood Canal, the north-facing shoreline at the northernmost tip of the County (Foulweather Bluff), and multiple east-facing shorelines along the eastern extent of the County.

The drift cells with the lowest potential sediment source ratings from slopes tended to be short drift cells in embayments along the eastern portion of the County, including the northern tip of Carr Inlet near Burley, Harper Inlet, and multiple parts of Dyes Inlet and Liberty Bay.

The highest percent remaining sediment source ratings from slopes generally occurred in the drift cells that also had the highest potential, indicating that many of the drift cells that naturally have the highest potential for sediment inputs are still largely intact (see Figure 2a). The distribution of the highest percent remaining connected sediment sources included several drift cells along the County's southernmost extent in Hood Canal, several drift cells between Port Gamble and Kingston, and three smaller drift cells near the Harper Inlet and Blake Island part of the County.

The drift cells with the lowest percent remaining sediment source ratings from slopes were identified among drift cells in the more urbanized inlets and bays on the eastern part of the project area, including Sinclair Inlet, Dyes Inlet, and Liberty Bay, as well as Manchester, Suquamish, and near Kingston. The drift cells in Hood Canal were relatively more intact than along the eastern shoreline of the County as no Hood Canal drift cells were among the lowest percent-remaining drift cells. Among the large bays and inlets along the eastern portion of the County, Liberty Bay had a larger percentage of intact sediment sources than Dyes Inlet and Sinclair Inlet.

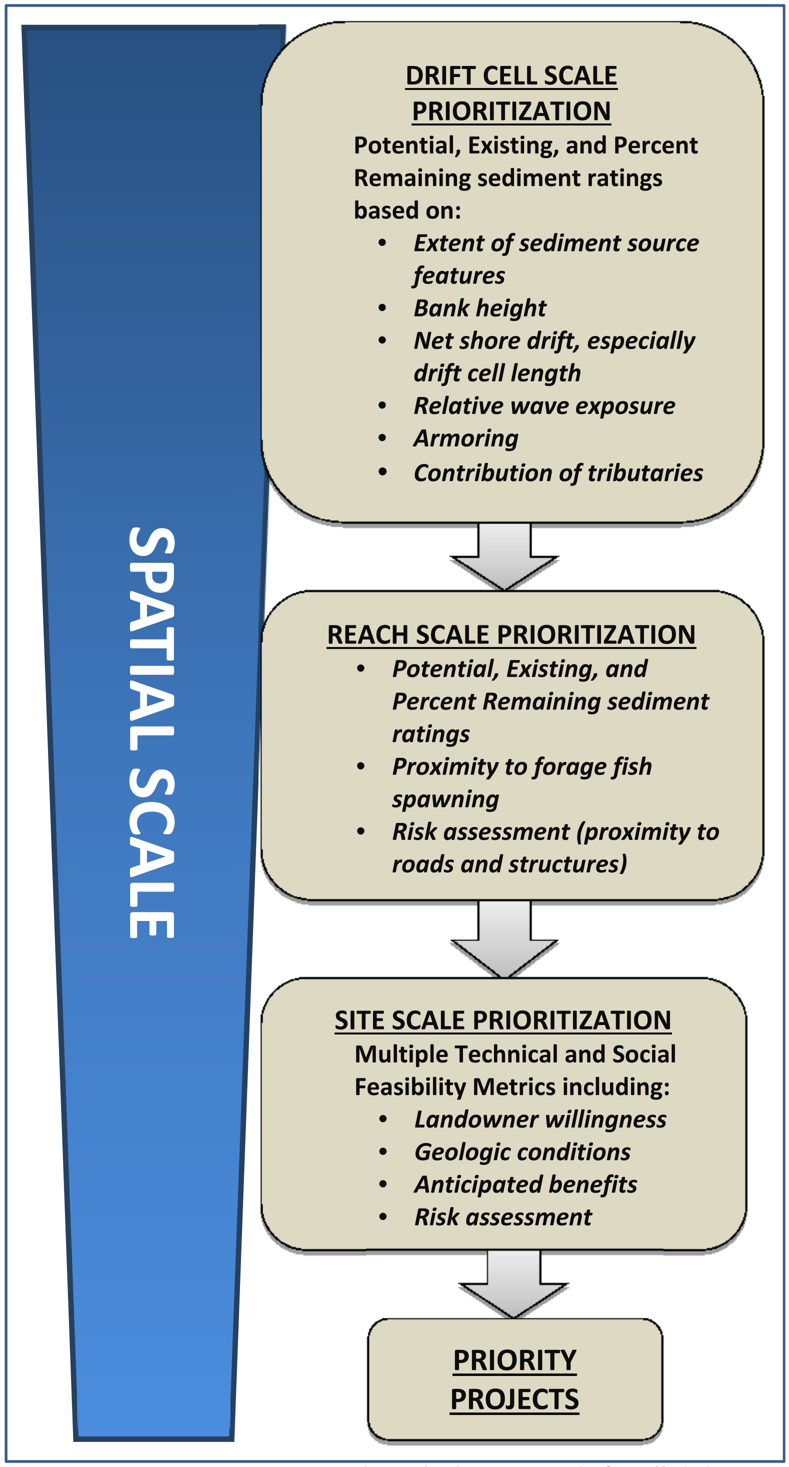
The drift cell scale results for tributary scores are presented in Figure 2b. The drift cells that were estimated to have the highest potential sediment inputs from tributaries were all located in the Puget Sound portion of the project area (i.e., not Hood Canal). These include drift cells in Sinclair Inlet, along the south shoreline of Liberty Bay, and between Kingston and Miller Cove.

3.5.1. Reach Scale Results

The sediment source ratings at the reach scale indicate the sediment conditions within contiguous sediment sources along the shoreline (Figure 3). The reaches with the highest potential sediment inputs were commonly distributed within drift cells with the highest potential rating, but there were exceptions to this observation. Examples of reaches with among the highest potential sediment inputs that are not in drift cells with the highest potential include shorelines near Kingston, Indianola, and central Hood Canal. Reaches with among the highest percent remaining connected sediment source were distributed more evenly throughout the County, including many shorelines outside of the drift cells identified as having the highest percent remaining. Conversely, the reaches with the lowest percent remaining connected sediment tended to be concentrated in and among the drift cells with the lowest percent remaining. The lowest percent remaining reaches were primarily in and between Dyes Inlet and Liberty Bay, with outlying low percent remaining reaches near Kingston and Manchester. As with the drift cell scale analysis, none of the reaches in the lowest percent remaining category were located in Hood Canal.

4. SHORELINE PRIORITIZATION

This section describes how the sediment source ratings and a preliminary risk analysis were used for prioritizing the restoration and/or protection of sediment sources in Kitsap County. The prioritization occurred in multiple steps in order to focus it successively toward smaller areas (see inset box). First, the prioritization was conducted at the drift cell scale. Next, a reach scale analysis was conducted. The reach scale analysis was conducted throughout the entire project area, not only within priority drift cells. As a result, priority reaches may occur within or separate from priority drift cells.



The identification of priority reaches includes the scientific component assessing where restoration and/or protection would provide the most benefits to the nearshore ecosystem, as well as a preliminary risk analysis to characterize whether the increased potential for erosion with armor removal would threaten buildings or roads. The preliminary risk analysis is intended to help inform both the likelihood of identifying willing landowners and the likelihood that armor removal would create unacceptable risk of damage to existing infrastructure. The intent of the reach scale prioritization was to identify those locations within drift cells where a substantial portion of the sediment source currently contributes, or potentially could contribute, sediment inputs to the drift cell. Priority reaches were identified in priority drift cells and outside of priority drift cells. The priority reaches outside of priority drift cells are portions of the shoreline where there are substantial sediment sources warranting protection or restoration even though the entire drift cell did not stand out as a priority. The inclusion of the priority reaches outside of priority drift cells also informs where there are more beneficially strategic locations in which to work if opportunities arise outside the priority drift cells.

The purpose of identifying priorities at multiple scales was to provide recommendations for priority drift cells in which to focus restoration and protection efforts, as well as to provide a narrower focus on key reaches in which to work. The ***top priority*** areas in which to pursue restoration or protection are priority reaches within priority drift cells. Of ***secondary priority*** equally are the remaining areas in priority drift cells and priority reaches that are not in priority drift cells. These secondary priority areas would require additional site information to aid in choosing one opportunity versus another.

Because much of the shoreline land is in private ownership, there is an opportunistic aspect to identifying restoration and protection opportunities. While we recommend that the work necessary to identify and develop project opportunities focus first on the top priority areas (priority reaches in priority drift cells), it is quite possible that an inability to identify willing landowners will require restoration efforts to turn to secondary priority areas.

The prioritization was also planned to be conducted at a site scale (i.e., scale of one or more parcels) if interested landowners were identified through a shoreline landowner survey. However, the identification of interested landowners has not progressed enough at the time of this publication. Instead, Section 5 of this report describes considerations for assessing the suitability benefits of one site versus another, and Section 6 describes considerations for appropriate stewardship actions at any site.

4.1. Drift Cell Scale Prioritization

The drift cell prioritization was based on the sediment source ratings. Drift cell priorities were identified based on the scoring relationships between potential and percent remaining at the drift cell scale. The intent of the relationships selected as priorities was to emphasize working in those areas with relatively higher potential sediment inputs and only low to moderate amounts of armoring, such that restoration and/or protection actions could potentially attain an intact or near intact connection of sediment sources. Opportunities to improve conditions in more urban areas often occur where existing function is currently somewhat impaired. Drift cells in the urban inlets with higher potential but lower percent remaining sediment source connectivity were also included as priorities because these areas have a potential for significantly increased function. Shorelines with no appreciable drift were not included among the drift cell priorities, regardless of their sediment source ratings, because they are not sediment source areas that provide sediment beyond the lineal extent of the source. Drift cells having the following relationships between the potential sediment source rating and the percent remaining sediment inputs were identified as priority drift cells:

- Among the high and highest categories for potential sediment sources and *not* among the lowest percent remaining sediment source connectivity category
- 100% intact sediment source connectivity regardless of potential sediment source category
- Moderate category for potential sediment sources and among the highest percent remaining sediment source connectivity category

Thirty of the County's 79 drift cells[2] were identified as priority drift cells (Figure 5). The priority drift cells were distributed throughout the county. As described above, the prioritization approach included a criterion (high potential, but low percent remaining) to identify priority areas in more urbanized areas where restoration could significantly improve sediment source function. This portion of the analysis resulted in five additional drift cells included as priorities. The five drift cells are along one contiguous section of shoreline extending from Silverdale in Dyes Inlet to the Port Orchard Passage between the Kitsap Peninsula and Bainbridge Island. In Figure 5, the contiguous section ends to the south of Burke Bay (which is across from the "Battle Point" label on Bainbridge Island.)

4.2. Reach Scale Prioritization

The reach scale prioritization included both scientific information related to ecological benefits, as well as a preliminary risk analysis. The scientific information assessed included the sediment source ratings, the proximity to documented forage fish spawning, and the proximity to accretion shoreforms. The proximity to forage fish spawning and accretion shoreforms reflects the need in both areas for finer-grained substrate. For forage fish spawning beaches, the sand and small gravel sediments are used by the fish for spawning. Washington Department of Fish and Wildlife (WDFW) data documenting forage fish spawning were used in this analysis. Accretion shoreforms are depositional features that are commonly made up of finer-grained materials sourced from within the drift cell, transported, then deposited. Accretion shoreforms visible in the aerial photographs were used in this analysis. As described in the drift cell prioritization, the relationship between potential sediment sources and the percent remaining connected sediment sources was considered. The scientific considerations used to identify priority reaches are listed below. For each consideration, the general action strategy of either protecting intact sediment sources or restoring disconnected sediment sources was identified and is indicated in parentheses. Although these are the recommended strategies for the reach, due to the variability in shoreline conditions, it can be expected that priority protection reaches include some opportunities for restoration and vice versa.

- 100% intact sediment source connectivity regardless of potential sediment source rating (protect)
- Among the high and highest categories for potential sediment sources and among the high and highest percent remaining sediment source connectivity category (protect)
- Among the high and highest categories for potential sediment sources and moderate, low, or lowest percent remaining sediment source connectivity categories (restore)
- Among the low category for potential sediment sources with high percent remaining category sediment source connectivity <u>and</u> documented forage fish spawning or accretion shoreform in or immediately downdrift of the reach (protect)
- Moderate potential sediment source category with among the high or highest percent remaining sediment source connectivity category <u>and</u> documented forage fish spawning or accretion shoreform in or immediately downdrift of the reach (protect)

[2] Drift cell count is based on Washington Department of Ecology mapping and differs slightly from drift cell mapping used in the Kitsap County Shoreline Inventory and Characterization

The preliminary risk analysis included both a GIS analysis of the distance of buildings and roads to the shoreline, and a review of aerial oblique photographs. The preliminary risk analysis assumed that the closer structures were to the shoreline, the higher the risk of removing shoreline armoring and the lower likelihood of identifying willing landowners. The GIS analysis of average distance from structures to shoreline was used to categorize shorelines into one of four bins ranging from very high risk to low risk (Figure 4). The average distance calculation was deemed acceptable at the reach scale because conditions in reaches tended to be homogenous; that is, the distances to structures were similar throughout the extent of each reach. The additional review of aerial photography was useful in understanding the distance of structures from the top of bluff as opposed to the measured distance to the shoreline. This process was important as some reaches contained numerous structures that were considered susceptible to landslides due to their position near the top of the slope, not due to their relative proximity to the shoreline. Based on the GIS analysis and photograph review, shorelines with very high preliminary risk were excluded from being identified as priority reaches.

Each priority reach was identified as being either a restoration or a protection priority. Although restoration or protection is the recommended focus of work in the reach, it is expected that some opportunities for both types of action will be possible in any given reach (i.e., restoration actions in protection priority reaches and protection actions in restoration priority reaches). The distribution of priority reaches throughout the project area is illustrated in Figure 5. The priority reaches include three that were identified based on the intent to include more developed areas that are currently highly disconnected, but have the potential to significantly improve sediment source conditions. These three more developed reaches are: along the western shoreline of Dyes Inlet, the east-facing shoreline just south of Miller Bay (on Figure 5, it is the reach located on the Suquamish label), and the reach extending northeast from Kingston.

The preliminary risk analysis results among those reaches identified as priorities are presented in Table 4. Reaches identified as having a very high preliminary risk were excluded from being identified as priority reaches. This process excluded five reaches that met the scientific criteria used to identify priorities.

Table 4. Preliminary Risk Based on Average Distance from Shoreline to Roads and Structures

Number of Priority Reaches	**Preliminary Risk Categories (Average[1] Distance for Reach)**			
	Very High (<500 feet)	High (50 to 100 feet)	Medium (100 to 200 feet)	Low (> 200 feet)
Restore	0	5	7	2
Protect	0	16	17	11

Notes: 1) Average distance to the closest structure or road for parcels on the shoreline, based on available GIS data.

5. IDENTIFYING PROJECT SITES THROUGH LANDOWNER OUTREACH AND SITE ANALYSIS

The identification of sites for restoration and/or protection entails both the social feasibility aspect of identifying interested and willing landowners to work with, and scientific analysis of site conditions. The following sections describe ongoing work to identify willing landowners and recommended considerations for evaluating the benefits of specific site opportunities.

5.1. Landowner Outreach

The Kitsap County Department of Community Development has been actively working to identify potentially willing landowners to voluntarily participate in an armoring removal project. The County led a community workshop open to all and conducted an online survey of shoreline landowners in priority areas.

The community workshop was held in June 2012. The workshop was organized to include a half day on presentations and discussion of the project, nearshore sediment processes, and nearshore ecology, and a half-day session conducted at the shoreline at Anna Smith Park. The workshop was successful in providing an exchange of information and perspectives on the importance of unarmored shorelines and considerations for working with landowners in the County. Additional information about the community workshop is described in Appendix E.

Following the workshop, the County conducted a targeted landowner outreach survey to identify interested landowners within the priority drift cells and reaches. The survey was focused on gaining information on landowner perspectives on shoreline armoring, and their interest in potentially participating in a voluntary program to remove shoreline armoring. Detailed information about the survey is provided in Appendix F. Based on the responses from the landowner survey, those respondents who provided contact information and expressed interest in participating in project objectives were identified and contacted by phone or email. Addresses were mapped to determine if they were located in priority drift cells or reaches. Survey respondents in priority drift cells are presented in Figure 5. The addresses were located (geocoded) based on matching information provided in the responses to parcel addresses in the County parcel database. Some addresses were linked to parcels outside the study area (e.g., inland areas or Bainbridge Island) and were thus excluded from consideration.

5.2. Site Scale Analysis

The purpose of this site scale analysis section is to guide the County's (and others') evaluation of site opportunities, particularly if there are multiple sites to choose between. The drift cell scale and reach scale priorities provide strategic guidance of locations to focus efforts to identify sediment source restoration or protection activities. However, it is common that when working in areas with a large amount of privately owned lands, there is an opportunistic aspect to identifying restoration and/or protection projects. The factors provided in this section are recommended considerations to assess the relative benefits of potential project opportunities. They include considerations beyond sediment source characterization that should be addressed collectively as potential sites are evaluated and selected. As with the drift cell scale and reach scale prioritizations, the considerations identified below are focused on sediment source restoration or protection and could be included in any site scale assessment of restoration.

- Landowner willingness or indication of interest in learning more about restoration and/or protection possibilities
- Identified as a sediment source mapped at the reach or drift cell scale, or upon closer inspection identified at site scale as a sediment source
- Characterization of geologic and geomorphic conditions and processes
- Sediment source ratings for the drift cell and reach
- Located in priority drift cell
- Located in priority reach
- Proximity of structures to top of slope or shoreline; potential vulnerability of structures if armoring is removed (this may require additional study by a qualified geologist or geotechnical engineer)
- Located in an area with net shore drift (i.e., not a “no appreciable drift” area)
- Further updrift locations are more beneficial than downdrift locations in a given drift cell
- Updrift of, or co-located with, documented forage fish spawning
- Updrift of, or co-located with, prominent accretion shoreform (e.g., barrier spit or bar)
- Potential downdrift effects of tributary considering basin characteristics and potential opportunities to increase tributary contributions through stream restoration
- Higher bank heights are more beneficial than lower bank heights
- Unconsolidated sediments are more readily input to the shoreline environment than consolidated sediments
- Longer shoreline opportunities are generally more beneficial than shorter shoreline sections
- Existing shoreline armoring structures encroach below extreme high water levels or even OHW
- Existing shoreline armoring shows evidence of overtopping and would not be expected to withstand sea level rise effects on structures

Following are two example site analyses to describe an application of the considerations identified above. The first example is in a drift cell in the Tracyton area of Dyes Inlet. The second example is in a drift cell between Point Jefferson (near Indianola) and Kingston. These two shoreline segments were selected as examples because of the variety of conditions they represent, and the potential for offering both restoration and protection opportunities. Additionally, both segments were visited during the selection of potential workshop field sites, and subsequent site reviews triggered by survey respondents expressing interest in project participation. Field observations made during the site visits allowed for the in-depth assessment of geologic and geomorphic conditions that would be a part of any final site selection.

5.2.1. Tracyton Site Analysis

The shorelines near Tracyton are part of a 6-mile-long drift cell with net shore drift from right to left (south to north in this case, Figure 6). The drift cell includes two slope sections of possible sediment sources; one predominantly shallow landslide with no-to-low bank height (less than 10 feet) near the updrift end of the drift cell, and one predominantly deep-seated landslide with medium-to-high bank height (10 to 30 feet) near the middle of the drift cell. There is a prominent barrier spit accretionary feature at the downdrift end of the drift cell and smaller accretionary features at other locations in the drift cell. Forage fish spawning has been documented by WDFW along much of the drift cell. Both landslide areas are identified as priority reaches, and the drift cell was also identified as a priority. Both reaches are beneficial areas for restoration (i.e., removal of bulkhead or riprap) or protection (i.e., continuance of no hard shoreline armor). As intended with the priority reach designation, opportunities in either reach are considered higher priorities than opportunities elsewhere in the drift cell.

Providing a more specific analysis of an opportunity in one reach versus another would require site-specific information, as there are considerations of benefit and risk that may differ between sites in the reach. However, some likely site conditions are apparent from data and aerial photographs of the reaches. Along the shallow landslide reach, there is a series of houses varying in distance from the shoreline. There is continuous shoreline armoring along this reach. Due to the presence of houses and armoring throughout the reach, the potential effects of armor removal on the property and adjacent parcels needs to be carefully considered. The potential effects to consider include risks to buildings and adjacent armoring from continuing erosion, as well as changes to the shape and location of the shoreline in the armor removal area, possibly as a result of sea level changes. Along the deep-seated landslide reach, the shoreline is largely within a County park that is mostly undeveloped. There is little to no infrastructure that would be at risk with armor removal in the reach. Based on this cursory analysis, potential restoration sites with interested landowner(s) and along longer reaches may be more feasible within the deep-seated landslide reach, where less development has occurred.

In fact, this area had already been selected by the County prior to this project for restoration and bulkhead removal. Restoration was feasibile because of its status as a public park, minimal infrastructure in or adjacent to the property, and the fact that the existing bulkhead was already failing. Although sediment input potential had likely not been evaluated as a selection criteria, it does offer chronic long-term input from the deep-seated landslide, as well as a shorter reach of potential low to medium bank shallow landslide sediment input. Geologic mapping (Deeter 1979; Appendix C) shows pre-Vashon non-glacial and early Vashon proglacial lake sediments locally, suggesting that both sediment input sources are likely to contribute relatively fine-grained sediment, and that any exposed slope sediment will be relatively resistent to erosion.

In terms of location in the drift cell, the shallow landslide reach is closer to the updrift end of the drift cell than the deep-seated landslide; therefore, sediment inputs from the shallow landslide would potentially benefit a longer stretch of shoreline. The shallow landslide reach is also located near documented forage fish spawning beaches that are updrift of the deep-seated landslide reach, although both reaches are along and updrift of some other documented forage fish spawning beaches. A consideration favoring the deep-seated landslide reach is the fact that the bank height is higher (10 to 30 feet) than the shallow landslide (0 to 10 feet), thus more material is potentially available when the slide is active.

In summary, within the Tracyton area, there are two priority reaches to focus on for restoration or protection. In comparing between priority reaches, there are pros and cons to both opportunities. If a choice had needed to be made between reaches (or sites within reaches), the previous discussion highlights how site-specific information is necessary to compare the benefits and risks.

5.2.2. Point Jefferson Site Analysis

The shorelines between Point Jefferson and Kingston are part of a 3-mile-long drift cell with net shore drift from south to north (Figure 7). The drift cell originates in a divergence zone comprised of a shallow landslide reach with medium-to-high banks (10 to 30 feet). There are two additional shallow landslide reaches, one deep-seated landslide reach, and one mixed landslide reach in the drift cell. These landslide sediment sources compose approximately 50% of the shoreline length of the drift cell. No tributaries were mapped in the drift cell. There are four large accretion shoreforms in the drift cell—two are barrier beaches protecting large closed lagoons, and two are barrier spits protecting a lagoon and estuary, respectively. No forage fish spawning has been documented in the drift cell.

The geology in the Point Jefferson shoreline segment is best viewed and described at its southern (updrift) end, where shallow landslides expose glacial till overlying advance outwash gravel and non-glacial fine sand and lacustrine silt and clay (Deeter 1979; Appendix C). These sediments are characterized by grainsizes varying from coarse to fine, and from poorly-sorted to well-sorted. As in the Tracyton reach, most sediments are dense and, therefore, relatively resistent to erosion.

The drift cell is identified as a priority drift cell, but no priority reaches were identified among the sediment source areas in the drift cell. As described for the Tracyton site, a more specific analysis of sites within the Point Jefferson area would require site-specific information, as there are considerations of benefit and risk that may differ between sites within the reach. The sediment source areas with higher banks and closer to accretion shoreforms would appear to offer greater benefits for restoring or protecting sediment sources than other sediment sources. Although not sediment source focused, restoration or protection of the accretion shoreforms protecting large lagoons would also provide benefits to these fairly rare and productive shoreforms. The residential development along the shoreline is located at varying distances from the top of slopes; therefore, the potential risks and concerns with removing shoreline armoring are variable along the drift cell.

6. RESTORATION ACTIONS

Stewardship of the County shoreline environment includes actions that increase public awareness of nearshore processes and threats, and build support for voluntary participation in restoration and protection efforts. This can include the education and involvement of private property owners for the purpose of restoring or protecting their own private lands, as well as education and involvement of the rest of the community to garner support for shoreline restoration in general. This section focuses on the former group (shoreline landowners), but is also applicable to the latter. With rising sea levels, the notion of restoring the shoreline environment will be counterintuitive to many who wish to "harden" their shoreline rather than consider the overall resiliency of the shoreline environment to changes. Sea level changes affect the way shoreline ecosystems respond to shoreline armoring. With adequate sediment supply, shorelines have the capacity to adjust naturally to sea level changes. This does require adequate setback from the shoreline and can be accompanied by increased erosion.

The recommendations below include the criteria necessary to appropriately characterize sites, reaches, and/or drift cells for subsequent short-term treatment or long-term management. Recommendations include a wide range of shoreline restoration activities within different categories based on the conditions found in the County. The sediment source ratings and prioritization in Section 4 provides a coarser scale approach to understanding restoration opportunities. At the site scale, the specific restoration actions and their effect on sediment delivery and transport will depend on site-specific opportunities and constraints. These actions also affect the delivery of nutrients, water, sunlight and other ecosystem products and services that support shoreline ecology. While the focus of this document is on sediment delivery and transport, the actions described in this section are also intended to provide other benefits important to shoreline ecosystems. The stewardship recommendations include specific objectives for the various actions and the range of sites for which each action is potentially appropriate. The eventual outcome will depend on both the potential of the site to deliver and transport sediment *and* the project proponents having the ability to protect or restore these functions. The actions described are based on the need to address upland and shoreline processes and conditions, both naturally-occurring and human-caused.

Stewardship of the shoreline in the County has been divided in to the following categories for the purposes of this discussion:

1. **Beach Restoration:** This category can range from complete restoration of the shoreline by removing bulkheads; restoring the natural beach substrate and shape; removing fill and debris from the subtidal, intertidal, and backshore; to simply modifying existing structures to reduce their impact, or removing derelict structures.
2. **Bulkhead Alternatives:** In situations where beach restoration is infeasible, there are still often significant opportunities to improve the ecological function of the shoreline by replacing traditional bulkheads with alternative structures that provide similar levels of protection.
3. **Slope Restoration:** This category can involve a number of different strategies including management of stormwater runoff at the top of the slope, restoring vegetation on the slope, and other measures to address unnaturally high rates of slope erosion.

4. **Shoreline Plantings:** This category includes the restoration of backshore (roughly from mean higher high water [MHHW] to the extent reached by salt spray or extreme high tides) and riparian vegetation communities to help attenuate the impact of high tides, storm surges, and wind waves on the backshore and riparian zone.

These actions may or may not address issues of lost sediment supply on their own. In general the scale at which the effects of interrupted sediment supply and transport operate is across entire drift cells. These recommendations are intended to provide options that can be combined across multiple sites to naturalize the supply of sediment and maintain other key ecological processes.

The impact of these actions – individually or cumulatively – will not be well understood without pre- and post-construction monitoring and a plan for adaptive management in place. Monitoring of shoreline restoration activities is crucial, both to enhance the understanding of project effectiveness and to improve and refine the techniques used. In any natural setting—and particularly in a setting as dynamic at Kitsap County's marine shoreline—an adaptive management framework is needed to provide flexibility to adapt to changing conditions and unforeseen effects. This type of study will help to refine scientific understanding of the effectiveness of restoration actions and should be applied to future restoration planning efforts.

The choice of which actions are appropriate for a specific site should be made based on a combination of considerations. These include consideration of specific ecological functions provided and/or ecosystem processes restored, as well as a consideration for how the site will respond over time. Consideration should be given to what risks are specific to the site, and to coastal processes such as erosion potential. Table 5 provides an approach to understanding some of the possible outcomes of these considerations.

Table 5. Risk-based Approach to Determining Appropriate Restoration Strategies

<table>
<tr><th></th><th>Low Risk to Structures</th><th>High Risk to Structures</th></tr>
<tr><td>Low Rate of Erosion
No evidence of recent erosion
Low bank
Consolidated geologic unit</td><td>Opportunity to fully restore shoreline including:
Armor removal
Riparian and backshore vegetation
Beach and upper intertidal substrate</td><td>Opportunity for bulkhead alternatives and/or slope restoration, including:
Maximize shoreline restoration of beach substrate and vegetation
Consider use of logs (anchored if necessary) or similar features to stabilize slopes immediately below structures.
Additional analysis of risk to structures and flooding risk is necessary</td></tr>
<tr><td>High Rate of Erosion
Evidence of past erosion
High bank
Unconsolidated geologic unit</td><td>Greatest potential as sediment source, therefore opportunity to fully restore shoreline including:
Armor removal
Riparian and backshore vegetation
Beach and upper intertidal substrate
Necessarily analyze the mechanism(s) of failure (i.e., midbank at geologic contact or toe of slope) and current rates of erosion</td><td>Highest risk situation with limited opportunities if structures are present.

Likely limited opportunity for bulkhead alternatives and/or slope restoration, possibly including:
Restore vegetation on slopes
Consider softshore armoring of toe
Manage stormwater appropriately</td></tr>
</table>

6.1. Beach Restoration

Beaches naturally absorb and disperse wave energy in several ways. First, when wind waves or boat wakes strike a beach, the angle of the beach causes waves to break and often push the beach material upward with greater force than the returning swash pulls material downward. Second, beaches are ‘soft’ in that they can change shape based on the tides, direction of winds, and seasons. This makes them more resilient to changing conditions than some ‘hardened’ shorelines. Beside considerations of risks to structures or adjacent properties, there are several key elements to a successful beach restoration, including the following:

- The beach slope and backshore position must be appropriate to conditions
- The beach material must be appropriately sized
- The sediment supply must be maintained (either naturally or through renourishment)
- The backshore should be intact, although backshore conditions are naturally variable

Beach restoration can include the removal of bulkheads, removal of fill, and the removal or modification of groins. These actions can be undertaken individually or in combination with each other and/or the other stewardship actions described in this section. When considering beach restoration options, understanding the existing sources of sediment is crucial for determining the sustainability of the restoration. Some beach restorations require regular nourishment of beach material (typically brought in by truck or barge) to mitigate for lost sediment supply updrift (or upstream). Beaches in the County are typically classified as either barrier beaches or bluff backed beaches (Shipman 2008). Both types are dependent on sediment supply from updrift, but barrier beaches are typically not associated with a direct sediment input from the bluff above, whereas many bluff backed beaches do receive sediment from the bluff above as well as from updrift. A thorough understanding of the site is crucial to adequately identify the sustainability of beach restoration and predict the level of ongoing maintenance that may be required.

The scope and detail of geologic and engineering studies required for a given beach restoration project vary widely depending on the specific location and necessary degree of certainty. The degree of certainty required depends on the risk associated with project failure. Risk can vary based on the proximity of infrastructure (e.g., homes and roads) to the shoreline, and the potential for erosion, which can range from intermittent minor erosion to rapid and catastrophic erosion or widespread flooding. Professional judgment should be used to determine the appropriate risk and level of certainty of any project.

Management Measures for Protecting and Restoring the Puget Sound Nearshore (Clancy et al. 2009) describes potential studies that may be associated with beach restoration and groin removal or modification design, and these include the following:

- The scope and design factor of safety should be consistent with the anticipated outcome of the project.
- Feasibility Assessment.
- Coastal geomorphic assessment of the drift cell.
- The coastal geomorphic conditions such as sediment transport, particle sizing, and downdrift effects to ensure sustainability and adequacy of the restoration approach.
- The scale of the assessment should include the entire drift cell to understand the current sediment supply regime.
- The geologic setting of the site, littoral drift dynamics, and erosion/accretion trends for the project area.
- The areas that are currently being influenced by the existing groin, bulkhead, or fill.
- The volume or rate of erosion and deposition related to changes affected by the original installation of the groin, bulkhead, or fill (typically this is done by examining historical aerial photographs and maps).
- Development of a quantitative sediment budget may be warranted depending on the risks associated with the site. A local sediment transport budget can be used to estimate the effects of the project on off-site areas. Field studies and historical maps can also be used to determine existing and historical conditions and evaluate sediment transport rates and patterns over time.
- An assessment of the risk to nearby properties from the existing conditions and the proposed actions.

6.1.1. Beach Slope and Sediment Grainsize

Steeper beaches are typically associated with higher energy areas and coarser substrate, while flatter beaches are typically associated with lower energy and finer substrate (Komar 1998). The choice of the appropriate combination of materials and beach slope is typically performed by a trained coastal geomorphologist and is often based on a review of reference sites. Reference sites are sites that are in relatively undisturbed natural condition with similar physical and environmental conditions such as fetch, aspect, and slope geology.

The configuration of the beach is also important. While bulkheads above the MHHW line do not require some permits, they still have the ability to reflect wave energy and cause sediment to be eroded from the shoreline into deeper water instead (Shipman et al. 2010). Beaches that include a healthy, vegetated backshore are able to absorb waves even under storm surges and extreme high tides. This often coincides in significant movement of sediment and accretion of driftwood and other debris. Some areas are unlikely to have a well-developed backshore due to their natural configuration. These beaches typically have a limited backshore that is immediately adjacent to the slope with little or no beach vegetation. In these cases driftwood and downed trees (sometimes still partially rooted in the slope) may provide important structure to help hold sediment in place during storms. Unlike bulkheads that are generally vertical and immobile, this wood has complex shapes that disperse waves and often moves, further attenuating wave energy.

6.1.2. Groin Removal or Modification

Groins are cross-shore structures designed to trap sediment on the updrift side. These structures are often built with the intention of improving beach condition (width) on the updrift side, but can have important adverse impacts on the shoreline. First, most groins create a scour on the beach on the downdrift side. This scour is caused by the interruption of net shore drift created by the groin and, in many cases, by wave reflection off the groin itself. This impact can be localized, but in some cases can cause significant erosion of the backshore or undermine shoreline protection. A second phenomenon of some groins is to cause sediment to be deposited in deeper water, outside the ability of waves to transport it past the groin downdrift. When this material is lost to the shoreline environment it reduces the supply of sediment downdrift to the rest of the drift cell (Barnard 2010).

6.1.3. Fill Removal

The removal of fill from the shoreline environment can provide several ecological benefits. These include better connectivity of sediment from slope erosion to the shoreline environment; improved integrity of net shore drift transport processes; greater resilience to storms, high waves, and extreme tides; and improved backshore and riparian vegetation functions. The removal of fill from the shoreline environment can be challenging. Often chemically affected soils are encountered related to past uses or management of the site. Compaction of the native sediments can also occur, requiring additional excavation and re-creation of the beach.

Regrading the site to restore the shoreline environment can also be complicated by the need to tie the project in to adjacent, filled areas, or to preserve existing homes and infrastructure.

In many cases, geotechnical borings are advisable to characterize the fill material for potential chemical contamination and to delineate the depth of fill above native substrate. The number of borings and the need for chemical testing will depend on the scale of the fill removal and the site history.

6.2. Alternatives to Bulkheads

Development directly in the shoreline environment may make complete restoration of the beach and backshore infeasible. In these cases, alternatives to traditional bulkheads can increase the ecological function of the site while protecting homes, roads, and other developed infrastructure. The appropriate methods will be limited by the need for certainty and risk tolerance, as previously described. A number of techniques for protecting shorelines without traditional bulkheads have been described (Zelo et al. 2000; Johannessen 2001; Gerstel and Brown 2006; Barnard 2010).

In general, these include a wide range of site-specific techniques. In lower energy, lower risk environments, bulkheads can often be removed and replaced with fast-growing woody vegetation on appropriately shaped beach slopes, or by the creation of a beach berm that mimics naturally formed features. As energy and risk of failure increase, the use of anchored large woody debris or large rock revetments buried beneath a constructed beach may be more appropriate. Any alternative should minimize the amount of wave energy reflected back on to the beach to limit the amount of erosive force pulling sediment into deeper water. Care should also be given to keeping structures as high as possible on the beach profile to limit the disruption of net shore drift and to accommodate future sea level rise.

6.3. Slope Restoration

Landslides along the slopes of Puget Sound are triggered in a number of different ways. When considering the opportunity to restore a slope, the first consideration is to the slope’s vulnerability to erosion. Erosion can occur from wave cutting at the toe, but is often triggered at midslope or from above. When a less consolidated geologic unit that can convey groundwater readily lies above a more compacted geologic unit, groundwater often escapes where the slope intersects the contact between the two units. In this case, the flow of groundwater can cause significant erosion along the slope. This phenomenon is common and natural on many of the slopes above Puget Sound shorelines. Poorly managed stormwater from driveways, roofs, or other impermeable surfaces can result in increased rates of erosion. When stormwater is routed onto slopes it increases saturation of soils, and can result in shallow landslides. When stormwater is infiltrated into the ground at too rapid a rate it can result in deeper slides.

Understanding the mechanism(s) of erosion present at a given site and addressing them as needed is the first step in a successful slope restoration. Most slopes above Puget Sound shorelines are relatively young due to active erosion. As a result, they often lack well-developed soils. For this reason, the restoration of shoreline slopes often involves the planting of trees and shrub species known as *pioneers.* Pioneers is a term for the community of native plants that establishes first after a disturbance. These species are particularly well adapted to full sun and poorly developed soils, and often are very fast growing. The choice of specific species should be tailored to site conditions, and any restoration planting effort will probably also require control of invasive species. Table 6 includes some of the more common species that should be considered in a slope restoration.

Table 6. Common Slope Restoration Pioneer Plant Species Native to Kitsap County

Wetter Sites		Drier Sites	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Sitka willow	*Salix sitchensis*	Shore pine	*Pinus contorta*
Hooker's willow	*Salix hookeriana*	Nootka rose	*Rosa nutkana*
Pacific willow	*Salix lucida*	Cascara	*Rhamnus purshiana*
Sitka spruce	*Picea sitchensis*	Vine maple	*Acer circinatum*
Red osier dogwood	*Cornus sericea*	Big leaf maple	*Acer macrophyllum*
Peafruit (swamp) rose	*Rosa pisocarpa*	Snowberry	*Symphoricarpos albus*
Black twinberry	*Lonicera involucrata*	Thimbleberry	*Rubus parviflorus*
Pacific ninebark	*Physocarpus capitatus*	Douglas fir	*Pseudotsuga menziesii*
Black cottonwood	*Populus balsamifera*	Coastal strawberry	*Fragaria chiloensis*
Red alder	*Alnus rubra*	Oceanspray	*Holodiscus discolor*
Salmonberry	*Rubus spectabilis*	Tall Oregon grape	*Mahonia aquifolium*

6.4. Beach and Backshore Plantings

The recruitment and stabilization of sediment in the backshore portion of the shoreline environment is often dependent on the establishment of native, salt-tolerant vegetation. This vegetation is often associated with driftwood, which acts to protect it by providing a small amount of resistance to wind and waves and by absorbing and releasing water and nutrients into the very sandy soils of the backshore. Salt-tolerant species typically persist from near the mean high tide line to the upper extent of regular tidal inundation or sea spray. Table 7 lists some common salt-tolerant plant species common to the Puget Sound shoreline environment.

Table 7. Common Backshore or Salt-tolerant Plant Species Native to Kitsap County

Common Name	Scientific Name
Gumweed	*Grindellia integrifolia*
Saltweed or Fat Hen	*Atriplex patula*
Saltgrass	*Distichlis spicata*
Pickleweed	*Salicornia virginica*
Fleshy jaumea	*Jaumea carnosa*
Seaside arrowgrass	*Triglochin maritimum*
Seaside plantain	*Plantago maritima*
Dune grass	*Elymus mollis*

As noted above, the presence of driftwood and large woody debris still anchored by some roots to the slope provides important functions in the establishment of the backshore vegetation community. The design of any restoration should attempt to maintain the connectivity of the backshore community with the riparian community.

6.5. Additional Resources

The following documents include additional resources that may be useful in planning restoration:

Marine Shoreline Design Guidelines are being prepared by the Washington Department of Fish and Wildlife. This manual is intended to support the design of shoreline projects to protect and restore habitat and habitat forming processes (Barnard and Carman [in Prep.]).

Management Measures for Protecting the Puget Sound Nearshore is a publication of the Puget Sound Ecosystem Project that describes 21 specific actions that can be implemented alone or in combination to restore the nearshore ecosystem (Clancy et al. 2009).

Alternative Shoreline Stabilization Evaluation is a review and comparison of non-traditional shoreline stabilization methods already in use in Puget Sound. This publication was funded by the Puget Sound Action Team and written by Gerstel and Brown (2006).

Alternative Bank Protection Methods for Puget Sound Shorelines (Zelo and Shipman 2000) is a publication from the Washington State Department of Ecology that describes 15 projects installed on Puget Sound shorelines before 2000, many of which are later described by Gerstel and Brown (2006).

Green Shorelines, Bulkhead Alternatives for a Healthier Lake Washington is an online publication that contains options that may be applicable to certain low energy shorelines in Puget Sound. This document can be downloaded from: http://www.govlink.org/watersheds/8/action/greenshorelines/default.aspx

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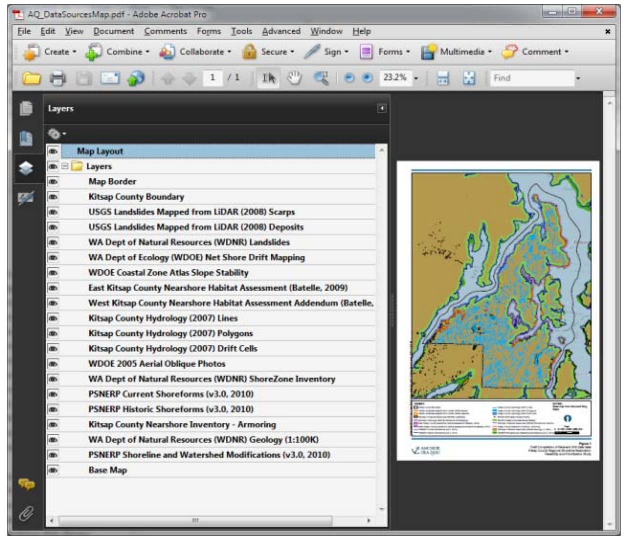
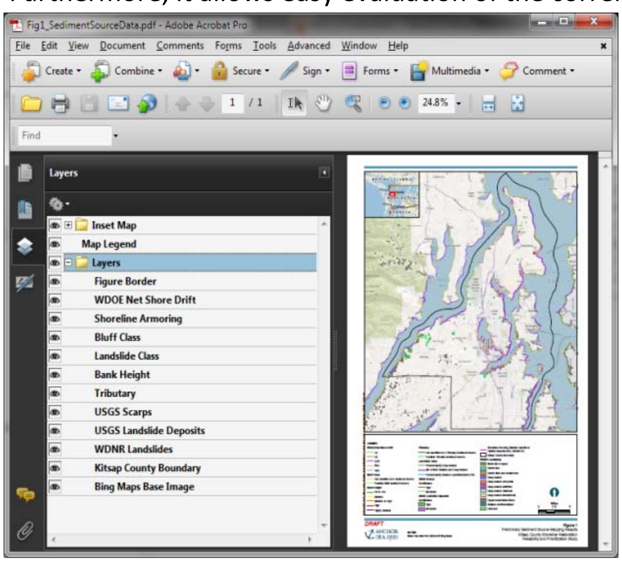
APPENDIX A

Instructions for Interactive DRAFT GeoPDF Files

The map figures in this report are set up so that layers can be turned on and off for easy viewing and correlation between different source datasets or sediment input source categories, depending on which pdf file is being viewed. To view a certain area of a map in more detail, zoom in on the map on the right side of the screen. The layout common to the figures can be seen in the screen capture to the right. In this example, all data source layers are turned **on**.



The advantage of this type of figure is that layers can be turned on and off to provide a strong graphical representation of the relative extent of a particular Feature, Attribute, or Modifier. Furthermore, it allows easy evaluation of the correlation between any two categories. To do this, first turn all layers off (except baseline map attributes). Then turn on one of the two layers of interest. Flash the other layer on and off. For example, in the sediment source mapping figure (Figure 1) a user can see where low banks versus high banks occur within different landslide types, turn on the **Bank Height** layer, look at the **Bank Height Class** color of interest, and flash the **Landslide Class** layer on and off. A sample screen capture is shown to the left.



APPENDIX B

Data Sources

Kitsap County. 2012 The following data sets were provided by Kitsap County GIS for the analysis and are either available for download at http://www.kitsapgov.com/gis/metadata/ or can be obtain by making a request using this form http://www.kitsapgov.com/press/pdf/10006W.pdf

Kitsap County Boundary
Kitsap County Hydrology (2007) Lines
Kitsap County Hydrology (2007) Polygons
Kitsap County Hydrology (2007) Drift Cells
Kitsap County Nearshore Inventory - Armoring
Kitsap County Parcels
Kitsap County Roads
Kitsap County Structures
East Kitsap County Nearshore Habitat Assessment (Battelle 2009)
West Kitsap County Nearshore Habitat Assessment Addendum (Battelle 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP). 2010. Available for download at http://wagda.lib.washington.edu/data/geography/wa_state/#PSNERP

Current Shoreforms (v3.0, 2010)
PSNERP Historic Shoreforms (v3.0, 2010)
PSNERP Shoreline and Watershed Modifications (v3.0, 2010)

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Landslides Mapped from LiDAR (2008) Scarps and Deposits. Data and report available at http://pubs.usgs.gov/of/2008/1292/

Washington State Department of Ecology (WDOE) Net Shore Drift Mapping Available for download at http://www.ecy.wa.gov/services/gis/data/data.htm

WDOE 2005 Aerial Oblique Photographs
WDOE Coastal Zone Atlas Slope Stability

Washington Department of Natural Resources (WDNR) Available for download at http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html

ShoreZone Inventory
WDNR Geology (1:100,000)
WDNR Landslides

APPENDIX C

Deeter (1979) Thesis Geologic Cross-Sections

These maps are presented in a separate PDF file due to the large file size.

APPENDIX D

Relative Shoreline Wave Vulnerability

The vulnerability of a shoreline to high energy waves that could cause slope toe erosion (sediment inputs) and result in longshore sediment transport is directly related to the wave energy environment the shoreline is exposed to. Given the prevailing wind condition of an area, the wave energy environment of shorelines depends primarily upon the distance over water that wind can blow to generate waves (known as fetch), and the shoreline orientation to predominant wind directions.

To characterize the wave exposure of any given section of shoreline in the project area compared to other shorelines in the project area, relative wave exposure was qualitatively estimated. The intent of this portion of the analysis was to conceptually represent the relative degree of vulnerability of shorelines to wave energy and, by extension, to show conceptually those areas where armoring may be more or less necessary to prevent shoreline erosion. The relative wave exposure of shorelines was assessed using fetch[3] data and a project area-specialized version of the exposure calculation presented in the British Columbia Estuary Mapping System (Howes et al. 1999) and the Washington State ShoreZone Inventory (WDNR 2001). Relative wave exposure was assessed using data for maximum fetch and modified effective fetch in each ShoreZone Inventory assessment unit. Maximum fetch refers to the longest distance of fetch for a given shoreline location. Modified effective fetch, as developed by Howes et al. (1999), involves the measurement of three fetch distances: perpendicular to shore and 45 degrees to the left and right of perpendicular. The multiple measurements used in the modified effective fetch calculation provide a more comprehensive interpretation of the potential for wind to generate waves that reach a given stretch of shoreline. For the shorelines of Kitsap County, the modified effective fetch data in WDNR (2001) was used.

The relationship between maximum fetch and modified effective fetch were combined to assign a relative wave exposure category. These categories are assigned based on conditions in the project area in a manner consistent with WDNR (2001) assignments throughout coastal Washington (Table D-1). The number of ShoreZone Inventory assessment units assigned to each relative exposure category is shown in Table D-2. The highest number of assessment units was assigned to the semi-exposed category (260 of 705) and comprised 37% of Kitsap County's assessment units. Semi-protected and protected categories were the next most numerous categories, comprising 28% and 26% of Kitsap County assessment units, respectively. The results of these calculations are shown in Figure D-1.

[3] Fetch is the distance over water that wind can blow to generate waves. The longer the fetch, the higher the potential wave exposure.

Table D-1. Relative Wave Exposure Categories Assigned to Kitsap County Shorelines

Maximum Fetch	Modified Effective Fetch			
	<1 km	1-5 km	5-10 km	10-50 km
<1 km	Very Protected	--	--	--
1-5 km	Protected	Protected	--	--
5-10 km	Semi-Protected	Semi-Protected	Semi-Protected	--
10-50 km	Semi-Protected	Semi-Exposed	Semi-Exposed	Exposed
>50 km	--	Semi-Exposed	Exposed	Exposed

Table D-2. Number of ShoreZone Inventory Assessment Units Assigned to Each Relative Wave Exposure Category

Maximum Fetch	Modified Effective Fetch			
	<1 km	1-5 km	5-10 km	10-50 km
<1 km	40			
1-5 km	70	116		
5-10 km	16	178	1	
10-50 km	2	167	92	18
>50 km		1	3	1

Legend:

Very Protected
Protected
Semi-Protected
Semi-Exposed
Exposed

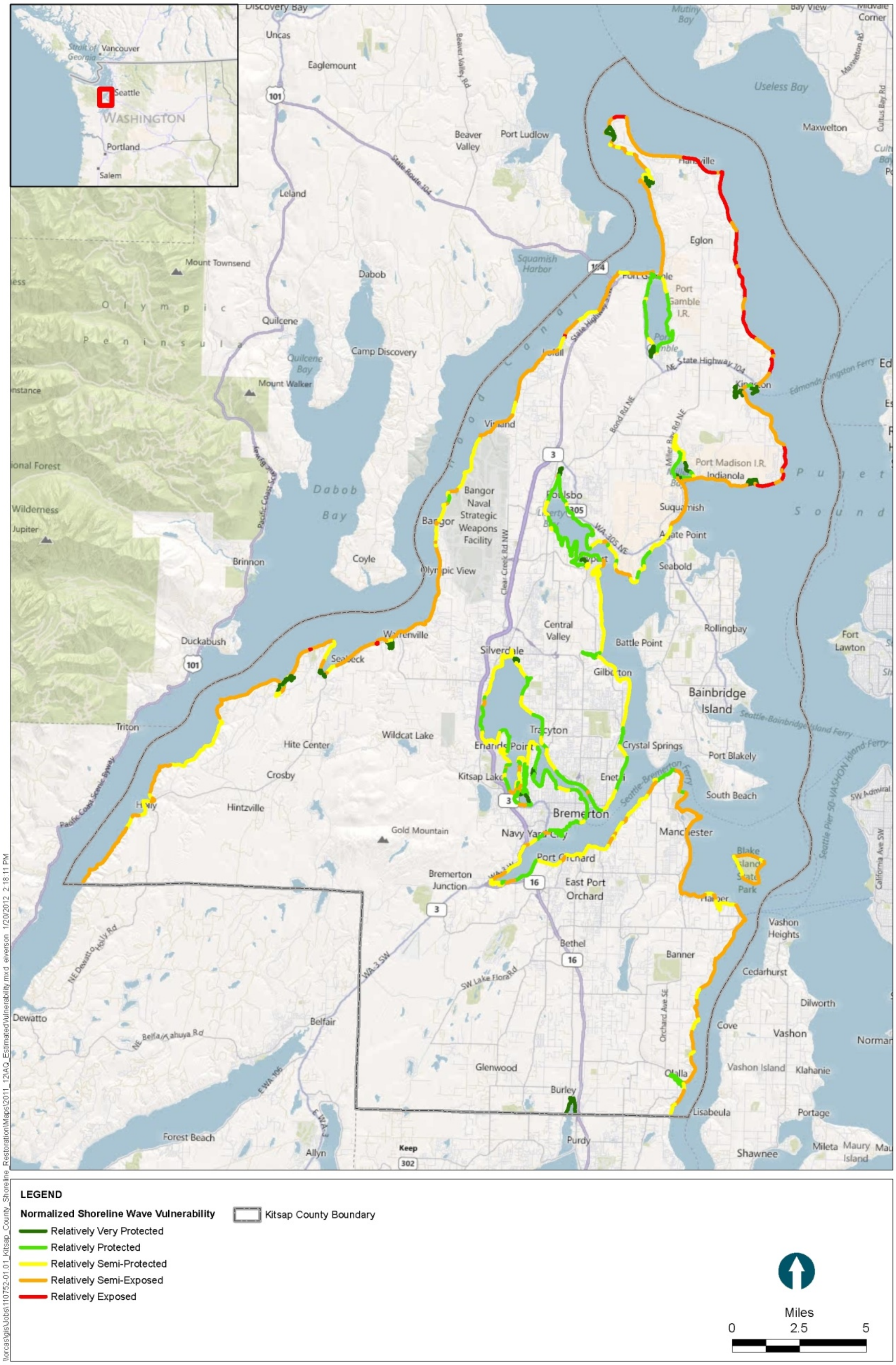


Figure D-1. Relative Shoreline Wave Vulnerability Results

APPENDIX E

Community Workshop Summary

Public input is acknowledged as a key factor in determining the feasibility of restoration or protection activities, particularly on private lands. Public input is, therefore, identified as a parameter in the feasibility analysis for this project, along with structure or road distance from the shoreline. To encourage public interest and involvement, and to introduce the project and its goals for long-term shoreline stewardship, a citizen workshop was held on June 22, 2012. Invitations to the workshop were sent out County-wide several weeks beforehand via the local paper (*The Kitsap Sun*), radio, and relevant email listings. The workshop was held at the Kitsap County Fairgrounds and hosted 26 attendees. Presentations were given by Kitsap County staff, Qwg consulting team members, and Washington Sea Grant staff following the agenda items below, and including a field trip to the then-pending Anna Smith Park restoration site:

- *Welcome and Introductions – Kitsap County Commissioner Josh Brown*
- *"Living" Shorelines (Sediment Processes) – Wendy Gerstel, Geologist/Geomorphologist, Qwg Applied Geology*
- *Kitsap Regional Shoreline Restoration Project – Patty Charnas and Kathlene Barnhardt, Kitsap County Department of Community Development*
- *Sediment Source Mapping and Prioritization – Paul Schlenger, Fisheries Biologist, Confluence Environmental Company*
- *Life in the Nearshore – Jeff Adams, Marine Ecologist, Washington Sea Grant*
- *Anna Smith Park History and Bulkhead Removal – Dori Leckner, Kitsap County Parks and Recreation*
- *Anna Smith Park Site Visit and Monitoring Demonstration – All Presenters*

Questions were entertained during and following each talk, allowing for public feedback. The feedback reflected the many perspectives of shoreline residents. Attendees requested clarification on information being presented and provided examples of their own shoreline observations. Others expressed concerns about the pressure to remove bulkheads, who would identify and assume the associated risks, and whether or not it would still be an issue with the tighter restrictions on placement. There were comments on the uncertainties of scientific evidence for sea level rise.

The original intent was for the County to host three separate workshops. The first would provide general information on Kitsap County shorelines with an introduction to the methods being used to identify ideal restoration sites. Subsequent workshops were intended to be held in areas selected during the prioritization analysis, focusing on the particular conditions, characteristics, and challenges of doing restoration work in those areas. The June 22, 2012 workshop fulfilled the intentions of the general workshop; however, due to time constraints and logistical complexities, the focus workshops did not fall into place. Instead, several visits were made to properties identified as having a high potential to provide restoration benefits AND where property owners had expressed in the shoreline survey an interest in being involved in the restoration process. The results of this survey are discussed in Appendix F.

Results of the shoreline landowner survey necessarily play an important role in locating potential restoration sites, designing follow-up workshops, and finding an appropriate venue. As workshop ideas evolved, it became apparent that the most useful format would be as a “real-time” site-review (a beach walk) conducted with the land owner and adjacent or nearby interested property owners. Survey respondents providing contact information (and expressing willingness to participate in the project) were contacted by telephone or email to arrange for these site visits. It took several weeks to contact willing participants, coordinate schedules with project staff and land owners, and conduct preliminary suitability reviews. Ultimately, and disappointingly, scheduling the coordinated group site review/beach walk ran up against project deadlines and budget constraints.

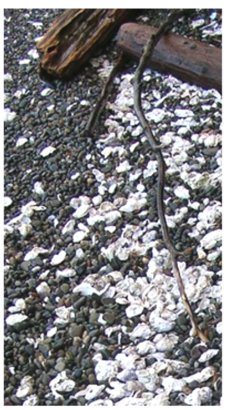
Preliminary site visits were made by Kitsap County staff and a Qwg team geologist and served to characterize geologic and hydrologic site conditions, evaluate shoreline processes, address landowner concerns, and determine the suitability of the site for possible restoration action. Because the visited sites all fell into one of two shoreline segments, and because timelines did not permit final selection of sites within the timeframe of this contract, the decision was made to present these shoreline segments as representative examples of how the selection process would proceed. Together, the two shoreline sections—identified as Tracyton and Point Jefferson—incorporate the range of shore types and project challenges that could be encountered anywhere along the County’s shoreline.

The representative shoreline segments are further discussed in Section 5.2

APPENDIX F

Shoreline Landowner Survey Results

The identification of priority drift cells and reaches allowed the County to focus distribution of a public-input survey of shoreline landowners to those whose participation would help accomplish the ultimate goals of this project—that being to find opportunities within priority reaches in drift cells for restoration or protection of sediment source connectivity to the beach environment. A postcard invitation (Figure E-1) to participate in the survey was sent out by mail to 1,364 addresses on August 2, 2012. Of the 1,364 postcards sent out, 14 were returned as undeliverable. Approximately 178 responses, a return of more than 10%, were received through August 17, 2012, the period compiled and analyzed for this report. A link to the survey was also provided on the Kitsap County Department of Community Development's website. The survey remains open at this time, and can be accessed from the website for those who might still want to express interest in participating in the County's shoreline restoration or protection actions.



Dear Kitsap Shoreline Property Owner,

Kitsap County's Shorelines are beautiful, and critical to keeping the Puget Sound ecosystem healthy.

Through a grant from the US EPA, Kitsap County is asking property owners to take a survey on their interest in voluntary shoreline restoration. Only select shoreline areas with the highest potential to restore healthy beach ecosystems are currently receiving this request.

Please take a moment to log on, learn more and take the

SHORELINE LANDOWNER RESTORATION INTEREST SURVEY at
www.kitsapgov.com/dcd/nr/nr.htm

The survey has 11 short questions and should take only a few minutes. Questions? Call (360) 337-5777 and mention "Shoreline Survey".

Thank you very much for your participation!

Figure F-1. Postcard Invitation

Tabular and graphic summaries from the 178 respondents for each of the 10 questions in the survey are also included in this appendix.

Survey questions were designed to inform the feasibility aspects of this project at the reach and site scales, and to provide information to the County on shoreline landowner perceptions regarding the purpose, necessity, protection priorities, and risks associated with armoring and its possible removal. The survey was also intended to answer the broader question of whether shoreline landowners generally have a good understanding of shoreline and upland processes in their area.

Survey participants were given the opportunity to express interest in implementing restoration actions on their own property, and to provide contact information to the County. Those who provided contact information and were located within priority drift cells or priority restoration reaches were then contacted by County staff to gain more insight into their level of interest and the potential of the site for restoration. On-site meetings were arranged with interested and appropriately located landowners to carry out site feasibility assessments. The assessments were performed by technical experts (County staff and consultant team members). This effort has had the added benefit of building relationships with individual landowners and landowner groups who might work together to accomplish project and broader grant-funding goals.

The following questions, both open-ended and with multiple response options, were asked of survey participants:

1. Does your property have a rock bulkhead, seawall, or other man-made structure, collectively known as shoreline armoring, at the shoreline or on the beach?
2. If you do have shoreline armoring along your property, do you believe it is necessary?
3. If you answered YES above, please explain why you think your armoring is necessary.
4. If your shoreline is armored, do you believe it is providing long-term protection of your home?
5. If you answered YES to the previous question, please let us know what kind(s) of protection you believe the armoring is providing (check all that apply.)
6. Restoring natural shoreline ecosystem function is critical to the overall health of Puget Sound's marine life. If costs were not an issue, would you consider altering or removing the armoring on your property, and planting vegetation as an alternative, if it would help to restore natural shoreline conditions?
7. Do you believe there might be opportunities to work with your neighbors on a shoreline restoration project that involves contiguous properties, incorporating such actions as beach nourishment (bringing in sediment such as sand and gravel), revegetation, habitat restoration, or bulkhead removal?
8. If funds were available to cover the costs of bulkhead removal or other shoreline restoration (water management, restoring shoreline vegetation) on your property, would you be more likely to consider such a project?
9. What factors besides cost affect your decision to undertake a shoreline restoration project on your shoreline? Please select your top two factors.
10. In light of Kitsap County's restoration goals (described in the introduction of this survey), and supposing your property is located in an area identified as prime nearshore restoration potential, would you be interested in additional information? Please check ALL of the following that might apply.

The following are some key results provided by the survey data:

- About 44% of respondents have some sort of armoring in front of their property. This is slightly higher than the approximate 37% mapped for the total miles of County shoreline. About 54% of the respondents do not have any armoring, and about 2% were not sure. The latter could be due to the sometimes odd materials used to armor shorelines, or the disrepair of some armoring.

- Of those with armoring, more than 64% feel it is necessary and provides long-term protection of their home, slightly more than 22% did not, the rest were unsure.
- Of those who have armoring, the top 4 types (of 11 possible choices) of protection believed to be provided are, in descending order of importance: to protect against high tides, storm waves and waves from large ships; control erosion; protect the house; and reduce landslides.
- Other armoring functions offered included to extend lawns, improve views, provide better beach access, extend neighbor's shoreline structure, and protect trees and other vegetation from falling. Respondents offered the additional armoring functions of protecting a septic system and a frontage road.
- Asked if those with armoring would consider some sort of softer alternatives to hard armor if cost were not an issues, 26% answered 'yes', 39% answered 'no', and 35% would consider it with more information. Several subsequent questions also addressed cost-sharing with neighbors and public or non-profit entities with a similar break-down of responses.
- The top factor (of six possible) affecting the decision to undertake a shoreline restoration project is the uncertainty of impacts to property, with the second being equally distributed between permitting obstacles and neighbor willingness for a shared structure.

Additional inferences from the survey data include the following:

- Of the total armored shoreline, 22% or more might be practicable for removal.
- Increased technical assistance from County staff and other appropriate professionals is necessary to address public perceptions of erosion and evaluate upland versus coastal causes of erosion.
- Responses to questions addressing concerns of cost and risks associated with restoration clearly indicate that fiscal incentives would need to be part of restoration planning.
- Risks, benefits, and logistical constraints for both the landowner and the County will need to be addressed for any proposed restoration project.

This last point speaks to the components of the site feasibility assessments already being carried out by County staff, on occasion with a member of the consultant team. Using contact information provided in the survey responses, site visits were arranged with interested shoreline landowners located within priority drift cells or reaches. Site visits were used to evaluate risks associated with the following:

- Bank height
- Slope length, gradient, and general stability
- Distance of structure(s) to slope break and to shoreline

Site visits were also used to weigh the cost/benefit relationships of the following:

- Logistics of equipment mobilization and material removal
- Combined objectives of the homeowner and project goals

Along with the insight provided by the survey responses, questions arose that should be considered as the County's broader grant-funded efforts move forward:

1. Is there a specific type of shoreline (high bank, low bank, structure close to shore, etc.) common to those properties where landowners felt strongly that armoring is needed?
2. Are there other relevant physical processes or social issues that factor into landowner interest in considering restoration actions?
3. What common site conditions exist for those who felt armoring might not be necessary on their property?

Two shoreline segments became the focus of the first priority site assessment efforts. These two segments were chosen to be representative of the three-tiered scaled analysis process, with detailed discussion on each presented in the prioritization section of this report (Section 4). The segments are defined by the extent of the drift cell within which they fall and both are identified as *priority* drift cells. The Point Jefferson segment (or cell) is the north-south oriented shoreline located between Point Jefferson and Kingston. It is described as being among the high and highest drift cells for potential sediment sources and moderate percent remaining sediment source connectivity. It is characterized by relatively short reaches of mixed shallow and deep-seated landslide sediment sources, with a significant high-bank reach of shallow landsliding at its updrift end. Except for along accretionary shore forms, the cell is heavily armored.

Two survey respondent's properties were visited within the Point Jefferson cell. The first offers examples of both the benefits and risks of a potential restoration project. Benefits include but are not limited:

- Easy access for large construction equipment
- More than adequate setback of any existing structures
- Opportunity to recontour slope and vegetate with native plants
- Relatively dense substrate of glacial till and non-glacial sediments more resistant to wave erosion, although field observations suggest sediment input potential

Some of the risks or potential challenges associated with the potential restoration site include but are not limited to:

- Potential for erosion enhanced by neighbor's adjacent rock bulkhead
- Springs and seeps contributing to general slope instability
- Not identified as a sediment source during the remote mapping for this project

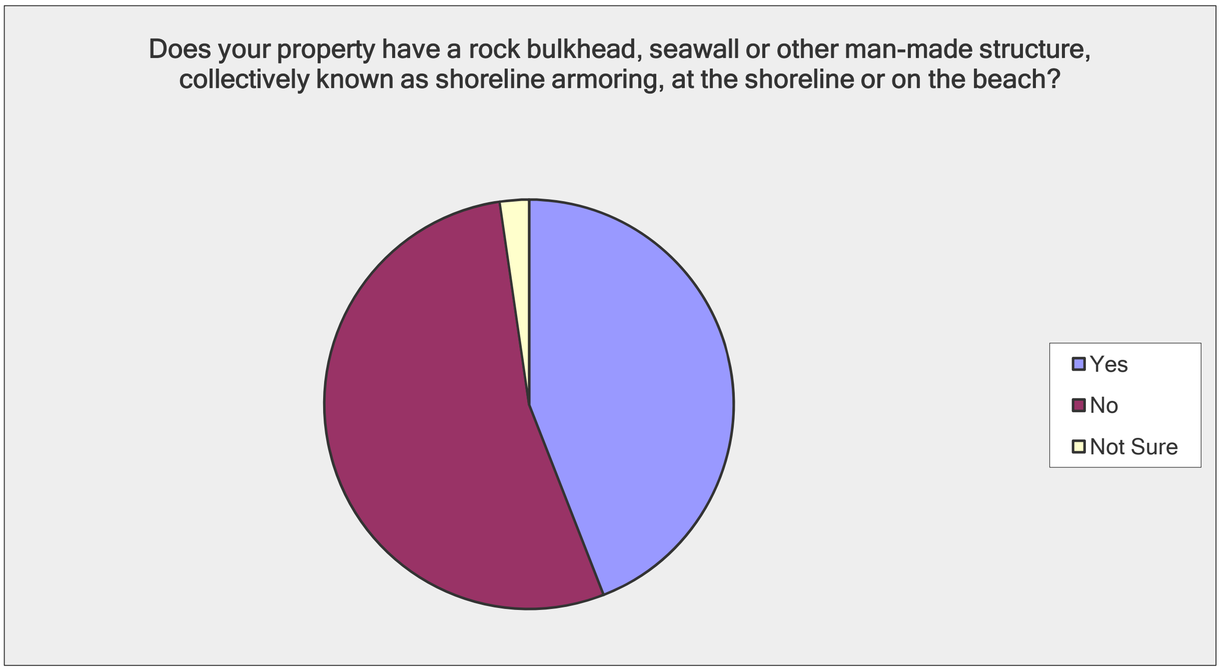
The second property visited within the Point Jefferson cell offers an example of a protection priority reach. In this case, the property falls on an accretionary shoreform backed by deep-seated landsliding. Just updrift is a high bank reach of shallow landsliding.

By contrast, the Tracyton segment (or cell), located along the east shore of Dyes Inlet, is characterized by relatively long reaches of both deep-seated and shallow landslide sediment sources, and also includes tributary streams. It includes the recent bulkhead removal project at Anna Smith Park, which falls within a priority restoration reach underlain by an active deep-seated landslide. An additional property visited within this cell includes a low bank property with a degrading bulkhead.

Question 1

New Survey

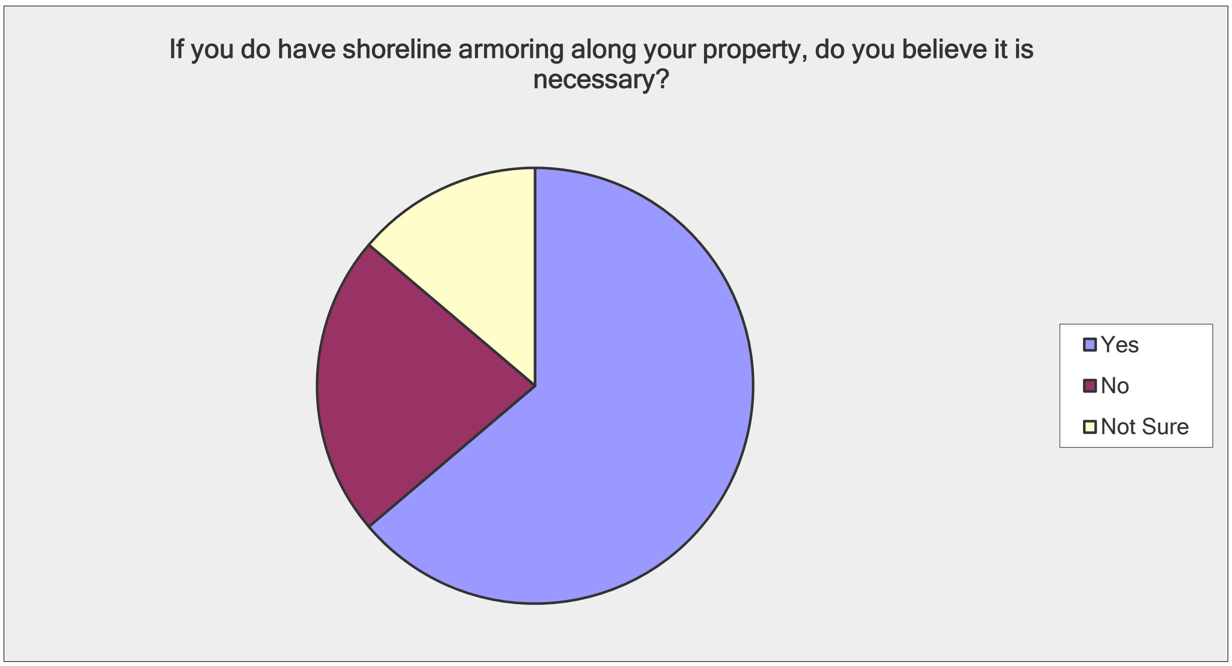
Does your property have a rock bulkhead, seawall or other man-made structure, collectively known as shoreline armoring, at the shoreline or on the beach?		
Answer Options	Response Percent	Response Count
Yes	44.1%	78
No	53.7%	95
Not Sure	2.3%	4
	answered question	177
	skipped question	1



Question 2

New Survey

If you do have shoreline armoring along your property, do you believe it is necessary?		
Answer Options	Response Percent	Response Count
Yes	63.8%	74
No	22.4%	26
Not Sure	13.8%	16
	answered question	116
	skipped question	62



Question 3

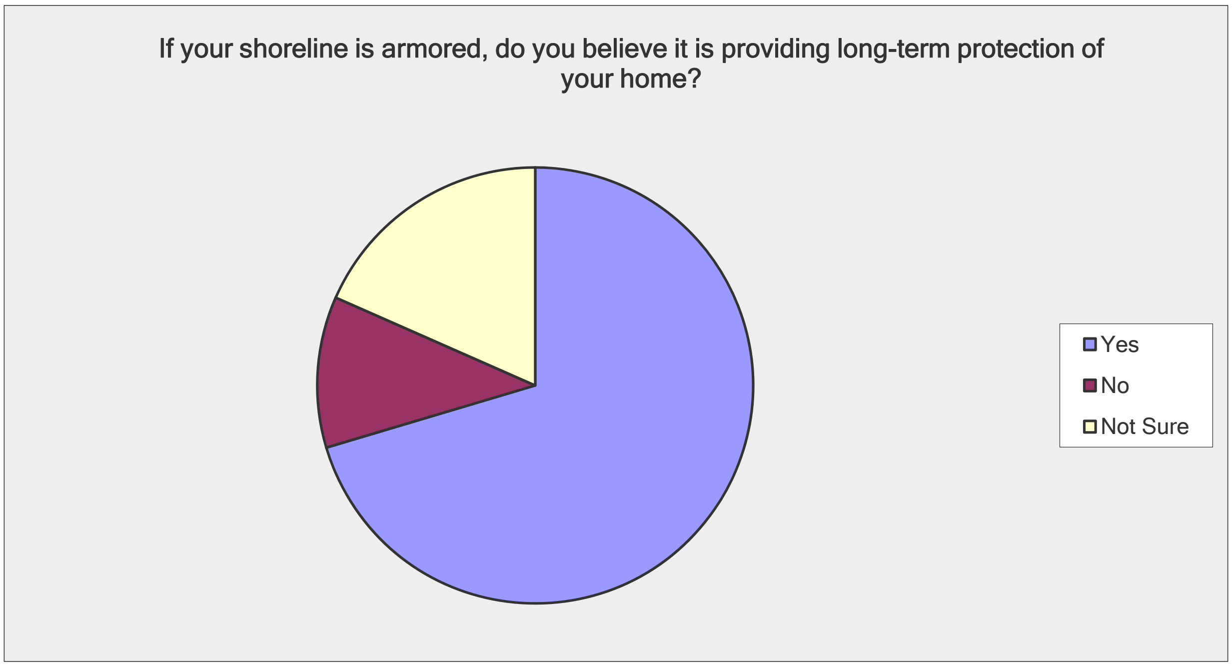
New Survey

If you answered YES above, please explain why you think your armoring is necessary.	
Answer Options	Response Count
	76
answered question	76
skipped question	102

Question 4

New Survey

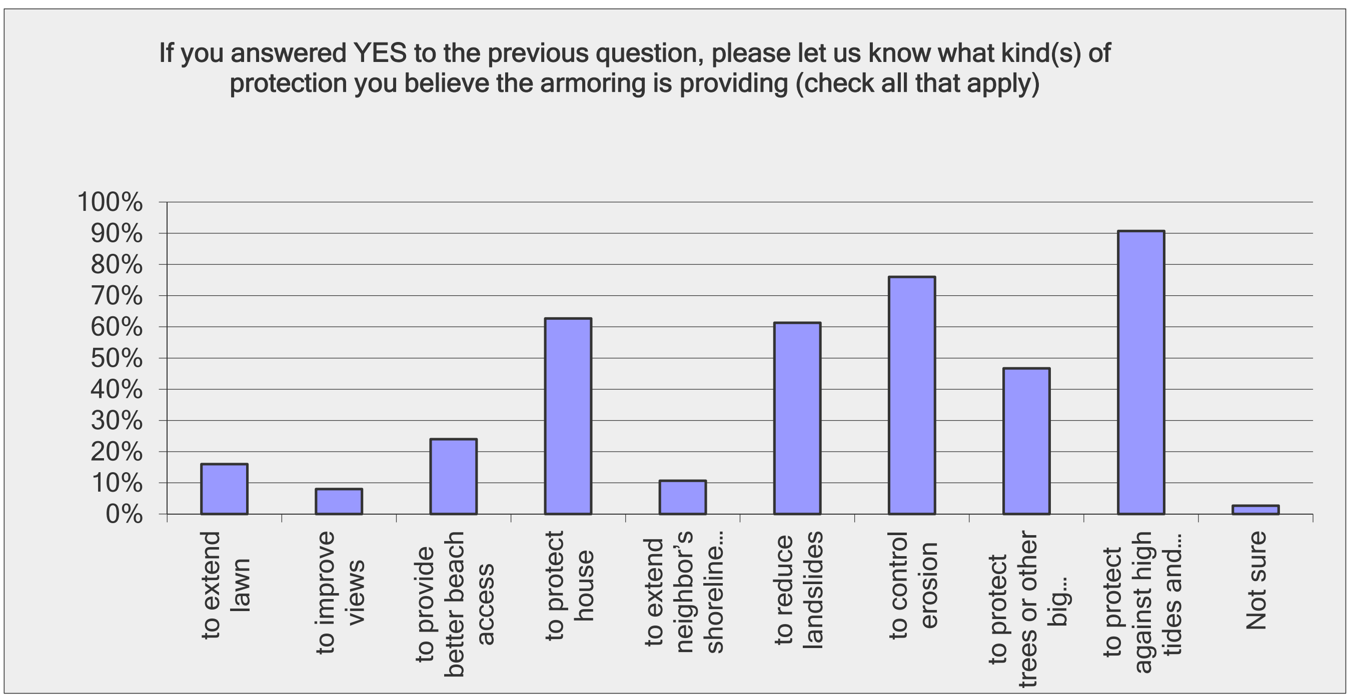
If your shoreline is armored, do you believe it is providing long-term protection of your home?		
Answer Options	Response Percent	Response Count
Yes	70.4%	69
No	11.2%	11
Not Sure	18.4%	18
	answered question	98
	skipped question	80



Question 5

New Survey

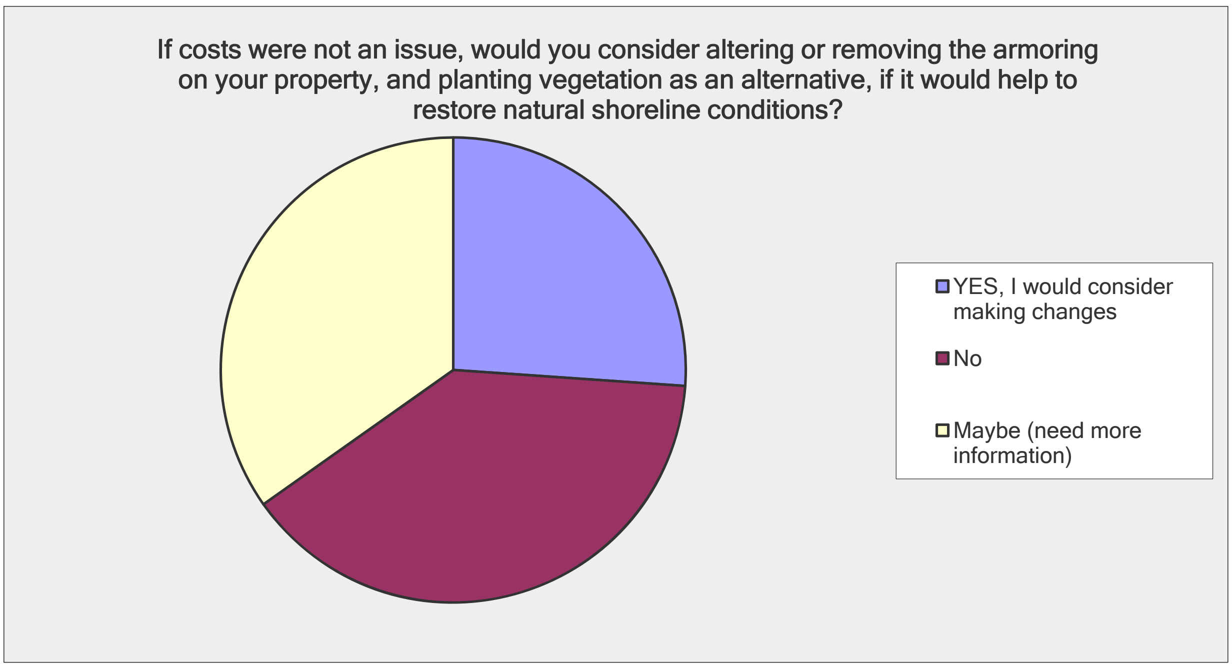
If you answered YES to the previous question, please let us know what kind(s) of protection you believe the armoring is providing (check all that apply)		
Answer Options	Response Percent	Response Count
to extend lawn	16.0%	12
to improve views	8.0%	6
to provide better beach access	24.0%	18
to protect house	62.7%	47
to extend neighbor's shoreline structure	10.7%	8
to reduce landslides	61.3%	46
to control erosion	76.0%	57
to protect trees or other big vegetation from falling down	46.7%	35
to protect against high tides and storm waves	90.7%	68
Not sure	2.7%	2
Other (please specify)		13
	answered question	75
	skipped question	103



Question 6

New Survey

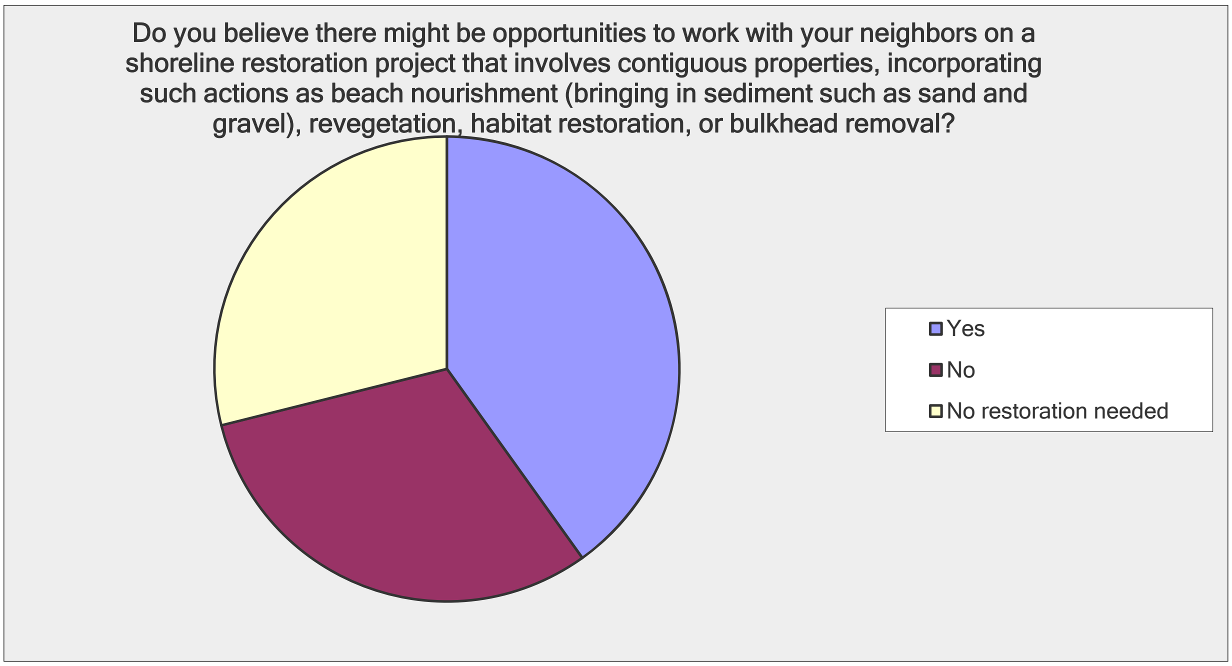
Restoring natural shoreline ecosystem function is critical to the overall health of Puget Sound's marine life. If costs were not an issue, would you consider altering or removing the armoring on your property, and planting vegetation as an alternative, if it would help to restore natural shoreline conditions?		
Answer Options	Response Percent	Response Count
YES, I would consider making changes	26.1%	30
No	39.1%	45
Maybe (need more information)	34.8%	40
	answered question	115
	skipped question	63



Question 7

New Survey

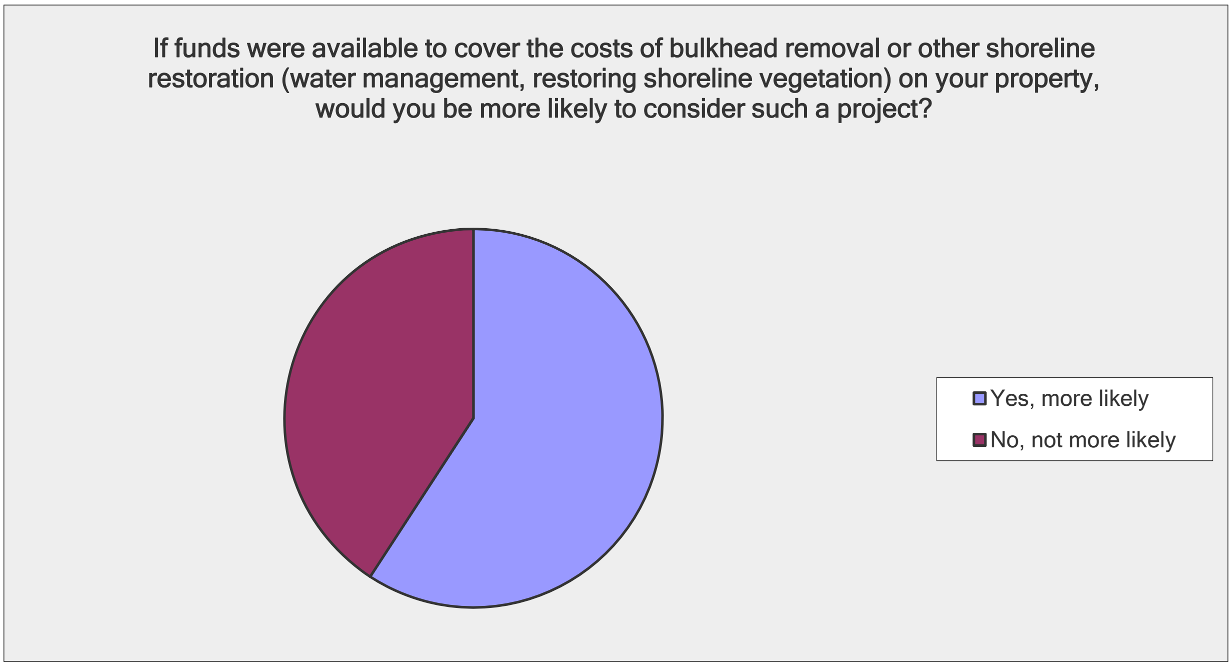
Do you believe there might be opportunities to work with your neighbors on a shoreline restoration project that involves contiguous properties, incorporating such actions as beach		
Answer Options	Response Percent	Response Count
Yes	40.1%	57
No	31.0%	44
No restoration needed	28.9%	41
Other (please specify)		32
	answered question	142
	skipped question	36



Question 8

New Survey

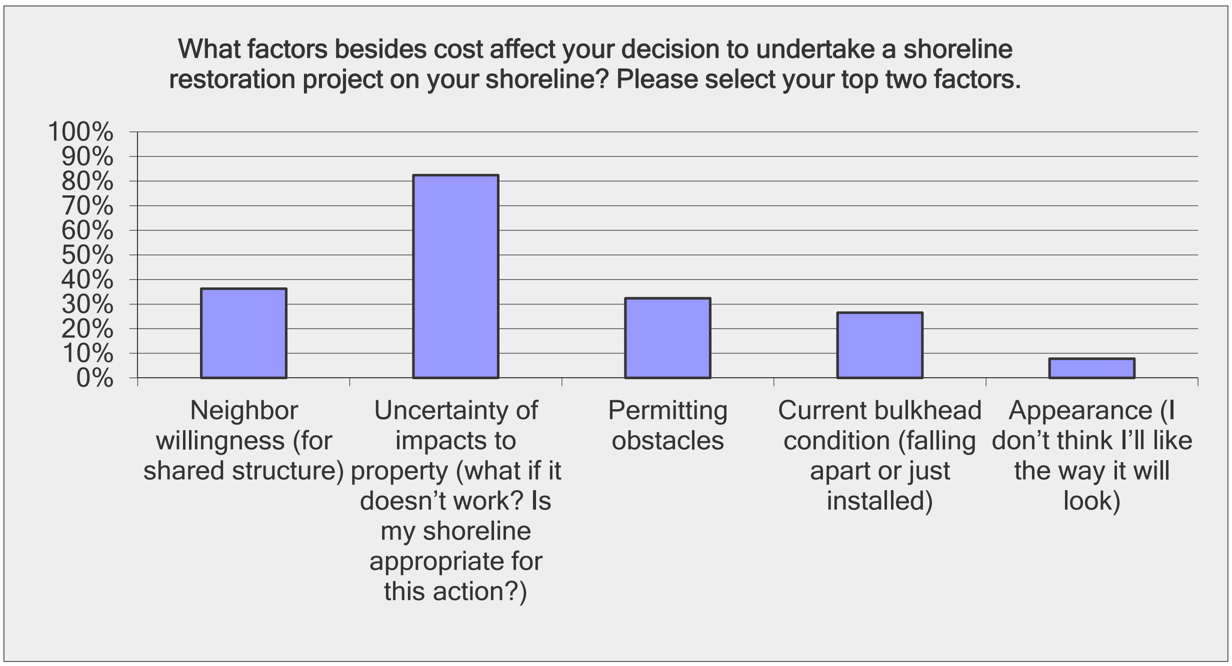
If funds were available to cover the costs of bulkhead removal or other shoreline restoration (water management, restoring shoreline vegetation) on your property, would you be more likely to consider such a project?		
Answer Options	Response Percent	Response Count
Yes, more likely	59.2%	74
No, not more likely	40.8%	51
Other (please specify)		20
	answered question	125
	skipped question	53



Question 9

New Survey

What factors besides cost affect your decision to undertake a shoreline restoration project on your shoreline? Please select your top two factors.		
Answer Options	Response Percent	Response Count
Neighbor willingness (for shared structure)	36.3%	37
Uncertainty of impacts to property (what if it doesn’t	82.4%	84
Permitting obstacles	32.4%	33
Current bulkhead condition (falling apart or just installed)	26.5%	27
Appearance (I don’t think I’ll like the way it will look)	7.8%	8
Other (please specify)		45
	answered question	102
	skipped question	76



Question 10

New Survey

In light of Kitsap County's restoration goals (described in the introduction of this survey), and supposing your property is located in an area identified as prime nearshore restoration		
Answer Options	Response Percent	Response Count
Interested in information on potential cost-share opportunities for restoration actions	35.4%	57
Interested in attending a general information workshop on Puget Sound coastal processes	26.1%	42
Interested in attending a workshop designed specifically to address concerns and share information about your specific shoreline area	47.8%	77
Willing to providing my name and contact information to the county (enter in box below)	37.3%	60
Thank you, but none of the above	34.2%	55
Contact information - please state if we can share your contact information with other non-profit groups who do restoration around Puget Sound.		77
	answered question	161
	skipped question	17