Feeder Bluff Mapping of Puget Sound

Prepared for: The Washington State Department of Ecology and Washington Department of Fish and Wildlife

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Executive Summary

The term "feeder bluff" is used in the Puget Sound region to describe bluffs that provide a significant volume of sediment to the beach. Beaches and spits, sustained by the ongoing supply of sand and gravel from feeder bluffs, are key elements in the Puget Sound nearshore ecosystem. The objective of this project was to produce comprehensive mapping of Puget Sound feeder bluffs and related coastal landforms suitable for guiding improved shoreline management.

The project consisted of three major tasks:

- Develop a detailed Quality Assurance Project plan (QAPP)
- Compile and assess all existing feeder bluff mapping datasets
- Complete feeder bluff mapping Sound-wide and compile the Sound-wide data set

Feeder bluff mapping differs from coastal landform mapping, such as the shoreline classification scheme or typology (Shipman 2008) applied in the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) Change Analysis, in that feeder bluffs are definitively linked with a physical process—the delivery of new beach-quality sediment to the littoral system. Feeder bluff mapping follows some of the general geomorphic principles of net shore-drift (drift cell) mapping completed in Washington State (Schwartz et al. 1991, Johannessen 1993).

In recent years, different mapping efforts conducted in the region have attempted to integrate general principles and concepts of coastal geomorphology. Coastal Geologic Services (CGS) developed a mapping method, in collaboration with a technical advisory group consisting of local coastal processes experts, which had been applied across 11 counties and over 1,150 miles of Puget Sound shore (Johannessen and Chase 2005, Johannessen 2010). However, neither this method nor any other which sufficiently addressed these principles had been applied across Puget Sound. Several previous Sound-wide mapping efforts fell short either due to coarse resolution, frequent errors, or by being focused only on the mapping of coastal landforms rather than morphology and processes.

The CGS team compiled 26 data sets to characterize and evaluate how feeder bluffs or similar landforms were mapped (Table 1). Data sets had been produced to address various objectives by a wide range of authors. At least eleven data sets originally had been created by CGS, spanning a total of 1,150 miles with individual mapping areas ranging from tens to hundreds of miles. Data sets by other authors covered a similar range of areas from tens of miles to the entire Puget Sound. Many of the data sets had been compiled for specific objectives that did not directly align with the objectives of feeder bluff mapping. The majority of the data sets had been created to improve aspects of shoreline management, such as habitat protection, or to aid in the Inventory and Characterization phase of local Shoreline Master Programs updates.

The objective of the data assessment portion of this study was to measure the relative quality of data, identify consistencies and differences among the data sets, and identify the best quality data for inclusion (with minor revisions if necessary) into the interim geodatabase of existing feeder bluff mapping. Assessment criteria were developed as part of the Quality Assurance Project Plan (QAPP) to aid in the screening process and to establish standards that all data included in the (GIS) geodatabase would meet (Figure 1). The assessment criteria were designed to function as filters so once a data set did not meet a fundamental criterion, it would no longer be eligible to be included in the geodatabase. Data sets were also evaluated for their potential utility in supporting new remote mapping of feeder

bluffs and related shoreforms as ancillary or supporting data sets. Each data set was evaluated by review in ArcGIS and ArcCatalog and by referencing text reports when available. The characteristics of each data set associated with each assessment criterion were recorded in a spreadsheet and included data availability, format (digital or paper), feature type (point, line, or polygon), amount of adaptation required to incorporate the data into the project geodatabase, spatial coverage, feature classification (e.g., landslides or contiguous geomorphic shoreforms), mapping resolution (scale and minimum mapping unit), and methods (field or remote); as well as whether remote mapping efforts were verified on-the-ground ("ground-truthing"), and whether or not the data set would be useful for remote mapping. Once the spreadsheet was fully populated, each data set was systematically evaluated for inclusion using the criteria shown in Figure 1. The rationale behind each element included in the criteria is shown in Table 2.

Ten existing feeder bluff mapping data sets covering approximately 700 miles of shore met the assessment criteria for inclusion into the Sound-wide data set (Table 4, Figure 5). These data sets formed the foundation for the final feeder bluff mapping geodatabase. CGS had created each of the accepted data sets using mapping that was largely field-based with a consistent resolution and had applied consistent criteria that were also utilized in new data collection. Figure 5 shows the spatial extent of the existing data sets that were accepted for integration into the Sound-wide geodatabase of feeder bluff mapping.

After data were assessed and compiled into a single coverage, the data were loaded into a Geographic Information System (GIS) along with shores in which No Appreciable Drift occurs (commonly referred to as NAD shores, an element of the net shore-drift data set). The remaining unmapped shores determined the areas in which new mapping would focus. A review of conditions throughout the shore to be mapped helped classify areas in which remote mapping would be as accurate as field mapping and potentially cost effective. Most of the remaining portions of the study area within drift cells (575 miles) were mapped using the field-based approach. This is the same approach applied by CGS across approximately half of the Puget Sound region shore. Remote mapping was conducted along approximately 22% of the Puget Sound shore that remained to be mapped. The remote mapping methods adhered to the same mapping criteria as field mapping, following investigation which showed this to be possible based on the quality of aerial photography and available data. Detailed methods are described in the *Methods* section of the report.

All data were compiled and analyzed to enhance understanding of the occurrence of feeder bluffs and other geomorphic shoretypes throughout the Puget Sound region. Shoretype data were analyzed Sound-wide, within each drift cell, and within each county, to support county-wide shoreline management. A set of 1:100,000 scale maps of the final mapping product are in the attached map folio along with net shore-drift mapping which was corrected and updated in this study. The project geodatabase contains both all shoretype and net shore-drift data mapping reported in results.

Of Puget Sound's 2,459 miles of shoreline, sediment delivery and transport processes occur within the 1,383 miles in which net shore-drift cells are mapped. Feeder bluffs were mapped along more than 365 miles of shore (15%), with an additional 51 miles of feeder bluff exceptional shore (2%, Table 10, Figure 11). Feeder bluff exceptional units deliver greater quantities of sediment to the nearshore and deliver it more frequently than do typical feeder bluffs. In addition eighteen percent of shore was armored. Although mapping of historic conditions was not a primary objective of this project, at least 32% of the modified shores were likely to have been feeder bluffs prior to modification. Accretion shoreforms and transport zones were slightly less prevalent than feeder bluffs and represented comparable portions of the larger region.

Outside of net shore-drift cells, 1,076.5 miles of Puget Sound shoreline are mapped as areas with no appreciable drift (NAD). These shores account for 44% of the region's shore (Table 10, Figure 11). The net shore drift mapping was updated as part of this effort. Net shore-drift updates addressed the spatial extent of drift in several locations throughout the region (based on field observations) as well as additional attribution of why there is an absence of littoral drift, due to bedrock geology, low wave energy, being part of a large river delta or due to highly altered conditions (such as fill and armor).

Data assessment, compilation, and new data collection have resulted in a high-quality, comprehensive, geomorphic data set spanning the Puget Sound region. This data set documents regional variability in nearshore geomorphic conditions, forms a foundation for future coastal geomorphic research, and will enhance greater understanding of geomorphic processes in the region over time. Ideally, these data will aid in the preservation of feeder bluff functions in the Puget Sound, particularly in shoreline jurisdictions that mandate feeder bluff protection but that did not previously have spatially-explicit documentation of where feeder bluffs occur. These data can also be paired with habitat data to enhance nearshore ecosystem management and salmon recovery planning.

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Glossary

Accretion	The gradual addition of sediment to a beach or to a marsh surface as a result of deposition by flowing water or air. Accretion leads to increases in the elevation of a marsh surface, the seaward building of the coastline, or an increase in the elevation of a beach profile (the opposite of erosion) (Shipman 2008).
Anthropogenic	Caused or produced by humans.
Backshore	The upper zone of a beach beyond the reach of normal waves and tides, landward of the beach face. The backshore is subject to periodic flooding by storms and extreme tides, and is often the site of dunes and back-barrier wetlands (Clancy et al. 2009).
Beach	The gently sloping zone of unconsolidated sediment along the shoreline that is moved by waves, wind, and tidal currents (Shipman 2008).
Bluff	A steep bank or slope rising from the shoreline, generally formed by erosion of poorly consolidated material such as glacial or fluvial sediments (Shipman 2008).
Convergence zone	A broad reach of shore where two drift cells converge and sediment deposition occurs or has occurred in the past, which created an accretion shoreform without a distinct spit terminus or delineation between drift cells. Convergence zones do not occur where a tide channel is present. The precise location of the converging drift cell termini oscillate across the “zone” due to variability in wind and wave conditions.
Delta	A deposit of sediment formed at a stream or river mouth, or other location where the slowing of water flow results in sediment deposition (Clancy et al. 2009).
Divergence zone	A broad reach of shore that encompasses the origin of two drift cells in which the exact location of divergence oscillates due to temporal variability in regional conditions (winds and waves).
Drift cell	A littoral [drift] cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks. The cell boundaries delineate the geographical area within which the budget of sediment is balanced, providing the framework for the quantitative analysis of coastal erosion and accretion. See Johannessen and MacLennan (2007) for further description of drift cells.
Erosion	The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or deflation (wind action) (opposite of accretion) (Shipman 2008).
Feeder bluff	Coastal bluff with active erosion and/or mass wasting which periodically supplies moderate volumes of sediment to the nearshore with a longer

	recurrence interval than feeder bluff exceptional segments. The bluff face typically has vegetation indicative of disturbance with evidence of landslides and toe erosion.
Feeder bluff exceptional	Coastal bluff with active erosion and/or mass wasting which periodically supplies substantial volumes of sediment to the nearshore in greater quantities with a shorter recurrence interval than feeder bluffs. The bluff face typically has little to no vegetation with active landslides and toe erosion, and may include colluvium and toppled large woody debris.
Longshore transport	Transport of sediment parallel to the shoreline by waves and currents (Shipman 2008). Also referred to as littoral transport.
Morphology	The shape or form of the land surface or of the seabed and the study of its change over time (Clancy et al. 2009).
Nearshore	As defined by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP), the area from the deepest part of the photic zone (approximately 10 meters below Mean Lower Low Water [MLLW]) landward to the top of shoreline bluffs, or in estuaries upstream to the head of tidal influence (Clancy et al. 2009).
No appreciable drift	Areas in which no appreciable littoral drift occurs.
Progradation	Forward or outward growth of a shoreline into a sea or lake by deposition and accumulation as in a delta.
Process-based restoration	Intentional changes made to an ecosystem to allow natural processes such as erosion, accretion, accumulation of wood debris, etc., to occur. Process-based restoration aims to return the landscape to its pre-disturbance, self-sustaining state. Also defined as the restoration of processes that shape an ecosystem, such as sediment transport or erosion, rather than the restoration of ecosystem features, such as tidal marshes or species populations (Van Cleve et al. 2004).
Sediment transport	Bedload and suspended transport of sediments and other matter by water and wind along (longshore) and across (cross-shore) the shoreline. The continuity of sediment transport strongly influences the longshore structure of beaches.
Sediment input	Delivery of sediment from bluff, stream, and marine sources into the nearshore. Depending on landscape setting, inputs can vary in scale from acute, low-frequency episodes (hillslope mass wasting from bluffs) to chronic, high-frequency events (some streams and rivers). Sediment input interacts with sediment transport to control beach structure.
Shoreform	A term often used in Puget Sound to describe a coastal landform. The term is generally used to describe landscape features on the scale of hundreds to thousands of meters, such as coastal bluffs, estuaries, barrier beaches, or river deltas.

Transport zone	A bluff or bank which supplies minimal but not appreciable sediment input to the nearshore from erosion/mass wasting, and does not have an accretion shoreform present. Littoral sediment is typically transported alongshore. The bluff face typically has considerable coniferous vegetation with few signs of disturbance from landslide activity or is of very low relief such that sediment input is very limited.

Acronyms and Abbreviations

ART	artificial landform
AS	accretion shoreform
CGS	Coastal Geologic Services
DG	data gap
FB	feeder bluff
FBE	feeder bluff exceptional
GIS	geographic information systems
H	high
HFB	historic feeder bluff
L	low
LWD	large woody debris
M	medium
MHHW	mean higher high water
MLLW	mean lower low water
MOD	modified
NA	not applicable
ND	no data
NAD	no appreciable drift
NAD-ART	no appreciable drift –-artificial
NAD-B	no appreciable drift - bedrock
NAD-D	no appreciable drift - delta
NAD-LE	no appreciable drift - low energy
PB	pocket beach
PL	plunging rocky shore
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
RP	rocky platform shore
SMP	Shoreline Master Program
TZ	transport zone
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WDNR	Washington Department of Natural Resources (also noted as DNR)
WRIA	water resource inventory areas
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

Introduction

The term “feeder bluff” is used in the Puget Sound region to describe bluffs that provide a significant volume of sediment to the beach. Beaches, sustained by the ongoing supply of sand and gravel from feeder bluffs, are a key element in the Puget Sound nearshore ecosystem. Feeder bluffs are the focus of intense development pressure due to the views they offer and their abundance relative to other shoretypes. Property owners understandably seek to reduce erosion along their shorelines, inadvertently upsetting the balance between beaches and their sediment supply. Many local jurisdictions have policies that discourage shoreline modifications, such as bulkheads, on feeder bluffs but implementation of these policies requires feeder bluff mapping to be effective. In addition, Sound-wide feeder bluff mapping can provide a baseline to help achieve “no net loss” of this valued nearshore resource. The objective of this project was to produce comprehensive mapping of Puget Sound feeder bluffs and related coastal landforms suitable for guiding improved shoreline management.

The project consisted of three major tasks:

- Develop a detailed quality assurance project plan (QAPP).
- Compile and assess all existing feeder bluff mapping datasets.
- Complete feeder bluff mapping Sound-wide and compile the Sound-wide data set.

This report summarizes the methods and results of the latter tasks and includes the following:

- The methods used and results obtained in assessing available data sets for inclusion into the final Sound-wide feeder bluff mapping geodatabase
- The methods used and results of all new mapping including both field and remote mapping.

The map folio includes both updated net shore-drift mapping and feeder bluff mapping Sound-wide. Appendices include additional detailed analysis and the Geographic information system (GIS) processing tasks applied to complete the mapping process and relevant quality assurance and control efforts

The Evolution of Feeder Bluff Mapping

Feeder bluff mapping differs from coastal landform mapping, such as the shoreline classification scheme or typology (Shipman 2008) applied in the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) Change Analysis, in that feeder bluffs are definitively linked with a physical process—the delivery of new beach-quality sediment to the littoral system. Feeder bluff mapping follows some of the general geomorphic principles of net shore-drift mapping completed in Washington State (Schwartz et al. 1991, Johannessen 1993). Some of these principles include a systems approach in which an idealized drift cell is composed of shoretypes that incorporate sediment inputs (sediment sources, locally referred to as feeder bluffs), through-puts (neutral shores or transport zones), and sediment sinks or depositional shores (accretion shoreforms). In general, these geomorphic shoretypes only occur in net shore-drift cells along shores in which littoral sediment transport occurs and are not intended to capture the scale of complexity associated with the interaction of large-scale fluvial systems.

Drift cell mapping was first conducted in Puget Sound by Wolf Bauer, who coined the term “feeder bluff” in the 1970s. Bauer went on to map feeder bluffs along the shores of Whatcom County (Bauer 1974). Although the mapping was later considered to be of insufficient resolution for the needs of shoreline management, it set an early standard for the preservation of intact physical processes as a means of maintaining other nearshore resources such as recreational beaches and habitats. Bauer completed this first feeder bluff mapping effort using high-quality oblique aerial photos and field reconnaissance of the Whatcom County shoreline, which he had enjoyed in his youth and studied portions of in his professional life. Bauer's coastal mapping efforts did not extend much beyond Whatcom County. However, he also mapped accretion beaches ("Class 1" beaches) in Puget Sound, Hood Canal, and San Juan County (Bauer 1975). Decades later, the concepts that he developed and promoted, including maintaining feeder bluff processes as a means of preserving down-drift landforms and habitats, have become critical elements of Shoreline Master Programs (SMPs) throughout the state of Washington.

In recent years, the many different mapping efforts conducted in the region have attempted to fully utilize the general principles and concepts of coastal geomorphology that Bauer promoted. Coastal Geologic Services (CGS) developed a mapping method, in collaboration with a technical advisory group consisting of local coastal processes experts, which has been applied across 11 counties and over 1,150 miles of Puget Sound shore (Johannessen and Chase 2005, Johannessen 2010). The CGS field-based mapping approach adhered to Bauer's concepts while documenting coastal geomorphic conditions at higher resolution using global positioning systems (GPS) to delineate continuous geomorphic units across broad reaches of shore in GIS. However, neither this method nor any other which sufficiently addressed these principles has been applied Sound-wide. Several of the mapping efforts which were attempted, such as the Washington State Coastal Zone Atlas (for Washington Dept. of Ecology in 1977–1979), contained many errors (described below). Other data sets focused only on mapping coastal landforms and did not include morphology and processes. For example, a number of local data sets exist which focus only on landslide areas, rather than the entire beach system and the natural gradient upon which these geomorphic processes occur. The following section describes all of the potentially useful data sets for Puget Sound that were identified and assessed for their relative utility and quality for use in the development of a Sound-wide feeder bluff mapping data set.

Data Assessment Methods and Results

Existing Data Compilation and Assessment

The objective of this task was to conduct an inventory of relevant mapping data, and assess the relative quality, consistency, and adequacy of the data for inclusion into a Sound-wide feeder bluff mapping (GIS) coverage. Data were compiled and an assessment approach was developed. Data sets that required minor refinements before inclusion into the Sound-wide data set were identified. Data sets that could be utilized to complete feeder bluff mapping in areas that had not yet been mapped were also highlighted. Areas where adequate mapping was not available were outlined. The final result of the assessment included a geodatabase with comprehensive coverage of Puget Sound, showing the extent of acceptable existing feeder bluff mapping, the areas in which new mapping would be conducted, and the methods by which new data would be collected (remotely or in the field). Additionally, a list of available data sets that could aid in the new feeder bluff mapping effort was compiled.

Status of Existing Data

The CGS team compiled a total of 26 data sets to characterize and evaluate how feeder bluffs or similar landforms were mapped (Table 1). Data sets were produced to address various objectives by authors ranging from consultants to agencies. At least eleven data sets were originally created by CGS, spanning a total of 1,150 miles with individual mapping areas ranging from tens to hundreds of miles. Data sets by other authors covered a similar range of areas from tens of miles to the entire Puget Sound. Many of the data sets were compiled for specific objectives that did not directly align with the objectives of feeder bluff mapping. The majority of the data sets were created to improve aspects of shoreline management, such as habitat protection, or to aid in the Inventory and Characterization aspect of local Shoreline Master Programs updates.

Data sets ranged in age from 25 years old (Keuler 1988) to not yet finalized. The most contemporary data set, produced for Kitsap County (Gerstel et al. 2012; Kitsap County sediment supply), did not have a methods report at the time the data were evaluated. The digital data and personal communication with the authors enabled the CGS team to assess the data adequately. Several older data sets were not available in a digital format (e.g., GIS coverage or shapefiles) and were only available as paper maps at scales ranging from 1:24,000 to 1:100,000. Additionally, not all GIS products were in the same format. For example, AMEC (2004) produced point-based landslide mapping for Skagit County, while Herrera Environmental Consultants (2007) produced landslide polygons in Thurston County. Most of the data assessed did not focus exclusively on feeder bluffs or include continuous coverage of shoretypes but instead mapped only landslide areas. Continuous coverage of geomorphic shoretypes was a required element of this project, therefore any data set in which continuous coverage was absent could function only as a tool for the interpretation of shoretypes, and would require further interpretation and work to complete the final mapping typology. Each of these issues will be discussed separately in the *Assessment Results* section below.

Assessment Criteria

The objective of the assessment was to measure the relative quality of data, identify consistencies and differences among the data sets, and identify the best quality data for inclusion (with minor revisions if necessary) into the interim geodatabase of existing feeder bluff mapping. Assessment criteria were developed as part of the Quality Assurance Project Plan (QAPP) to aid in the screening process and to establish standards that all data included in the final geodatabase would meet (Figure 1). The assessment criteria were designed to function like filters so once a data set did not meet a fundamental criterion, it would no longer be eligible to be included in the geodatabase. Data sets were also evaluated for their potential utility in supporting new remote mapping of feeder bluffs and related shoreforms as ancillary or supporting data sets. The rationale supporting each criterion is described below.

Each data set was evaluated by review in ArcGIS and ArcCatalog and by referencing text reports when available. The characteristics of each data set associated with each assessment criterion were recorded in a spreadsheet and included data availability, format (digital or paper), feature type (point, line, or polygon), amount of adaptation required to incorporate the data into the project geodatabase, spatial coverage, feature classification (e.g., landslides or contiguous geomorphic shoreforms), mapping resolution (scale and minimum mapping unit), and methods (field or remote); as well as whether remote mapping efforts were verified on-the-ground (“ground-truthing”), and whether or not the data set would be useful for remote mapping. Once the spreadsheet was fully populated, each data set was systematically evaluated for inclusion using the criteria shown in Figure 1. The rationale behind each element included in the criteria is shown in Table 2.

Table 1. General status and basic characteristics of existing feeder bluff data sets evaluated.

Author, year	Coverage (spatial)	Feature classification	Format	GIS format[a]	Adaptable data classification[b]	Available
Gerstel et al. 2012	Kitsap County	Sediment sources	Digital	Lines	FB only	For review only
McKenna et al. 2008	Kitsap County	Landslides	Digital	Lines	FB only	Yes
Herrera 2007	Thurston County	Sed. sources, landslides	Digital	Polygons	FB only	Yes
WDNR surface geology – many authors 1998–2012	Various 7.5-minute quadrangles	Landslides	Digital (limited)	Polygons		Yes
Sarikhan 2010	State-wide	Landslides	Digital	Polygons		Yes
WDGER 2009	Thurston County	Landslides	Digital	Polygons		Yes
WDNR 2010	Puget Sound-wide	Geology - landslides	Digital	Polygons		Yes
Pessl el al. 1989	Port Townsend 1:100K Quad	Geology – landslides	Paper	Paper		Yes
Gerstel 2007	Tulalip Reservation	Landslides	Digital	Polygons and lines	FB only	Yes
AMEC 2004	Skagit County	Similar to CGS	Digital (limited)	Points		No
WDOE 2004	Puget Sound-wide	Eroding bluffs, landslides	Digital	Polygons		Yes
Anchor Environmental 2002	Bainbridge Island	Feeder bluffs	Digital	Lines	Yes	Yes
Keuler 1988	Port Townsend 1:100K Quad	Wave erosion, landslides	Paper	NA		Yes
WDNR 2001	Puget Sound-wide	Cross-shore features	Digital	Lines		Yes
Simenstad et al. 2011	Puget sound-wide	Continuous landform classification	Digital	Lines		Yes
Johannessen 1999	Tala Pt to Kala Pt	CGS shoreforms, CB	Paper	NA	CB to FB	Yes
Johannessen 2003	North Mason County	CGS shoreforms, CB	Digital	Lines	CB to FB	Yes
Johannessen and Chase 2005	Island County	All CGS shoretypes	Digital	Lines	NAD areas	Yes
Johannessen et al. 2005	WRIA 8 and 9 (King and parts of Snohomish County)	All CGS shoretypes	Digital	Lines	NAD areas	Yes
Johannessen and Chase 2006	Pt Roberts to Sandy Pt, Whatcom County	All CGS shoretypes	Digital	Lines	NAD areas	Yes

Table 1. continued.

Author, year	Coverage (spatial)	Feature classification	Format	GIS format[a]	Adaptable data classification[b]	Available
Johannessen and MacLennan 2007, MacLennan and Johannessen 2008a, MacLennan et al 2010a	Marchs Pt, Fidalgo Is, Skagit Bay, Skagit County	All CGS shoretypes	Digital	Lines	FB-T, NAD	Yes
MacLennan and Johannessen 2007	Drift Cell SNO-1 origin to Kayak Pt	All CGS shoretypes	Digital	Lines	NAD areas	Yes
MacLennan et al. 2010b	Bainbridge Island	All CGS shoretypes	Digital	Lines	FB-T, NAD	Yes
MacLennan et al. 2009	Point Defiance to Nisqually Delta	All CGS shoretypes	Digital	Lines	NAD areas	Yes
MacLennan et al. 2010c	San Juan County	All CGS shoretypes	Digital	Lines	FB-T, NAD	Yes
MacLennan and Johannessen 2011	Clallam County	All CGS shoretypes	Digital	Lines	NAD areas	Yes

[a] NA = not applicable [b] CB = contributing bluff; FB = feeder bluff; FB-T = feeder bluff-talus; NAD = no apparent drift

Assessment Discussion

The assessment data were compiled and reviewed in the project spreadsheet. It was a challenge to integrate the contrasting data sets into a single data set of reasonable quality and resolution that would accurately represent the geomorphic character of the region's shorelines. No single data set that was not authored by CGS was found to accurately map feeder bluffs and related shoretypes at an appropriate scale. Even the closest data set to meet the criteria would have required substantial geoprocessing and would have resulted in mapping with a lower level of certainty than the other CGS mapping data sets. Therefore it was concluded that it would be far more accurate and efficient to field map the area and reference the existing data in order to enhance the quality of the data. Throughout the assessment process the goal of achieving a high level of data quality (resolution and certainty) was viewed as a greater priority than incorporating all existing data sets. A snapshot of the assessment criteria applied to each data set is displayed in Table 3.

Data sets that were not finalized at the time of the assessment were not eligible for inclusion into the geodatabase. Several older data sets were not available in a digital format (e.g., GIS coverage or shapefiles) and were only available on paper. Digitizing existing data would have been an inefficient use of time and the quality of the mapping could have been sacrificed in the process. Therefore data that were available only on paper maps were excluded from the analysis.

Most of the mapping products that were reviewed did not focus exclusively on feeder bluffs or include continuous coverage of shoretypes but instead focused only on areas in which landslides had occurred.

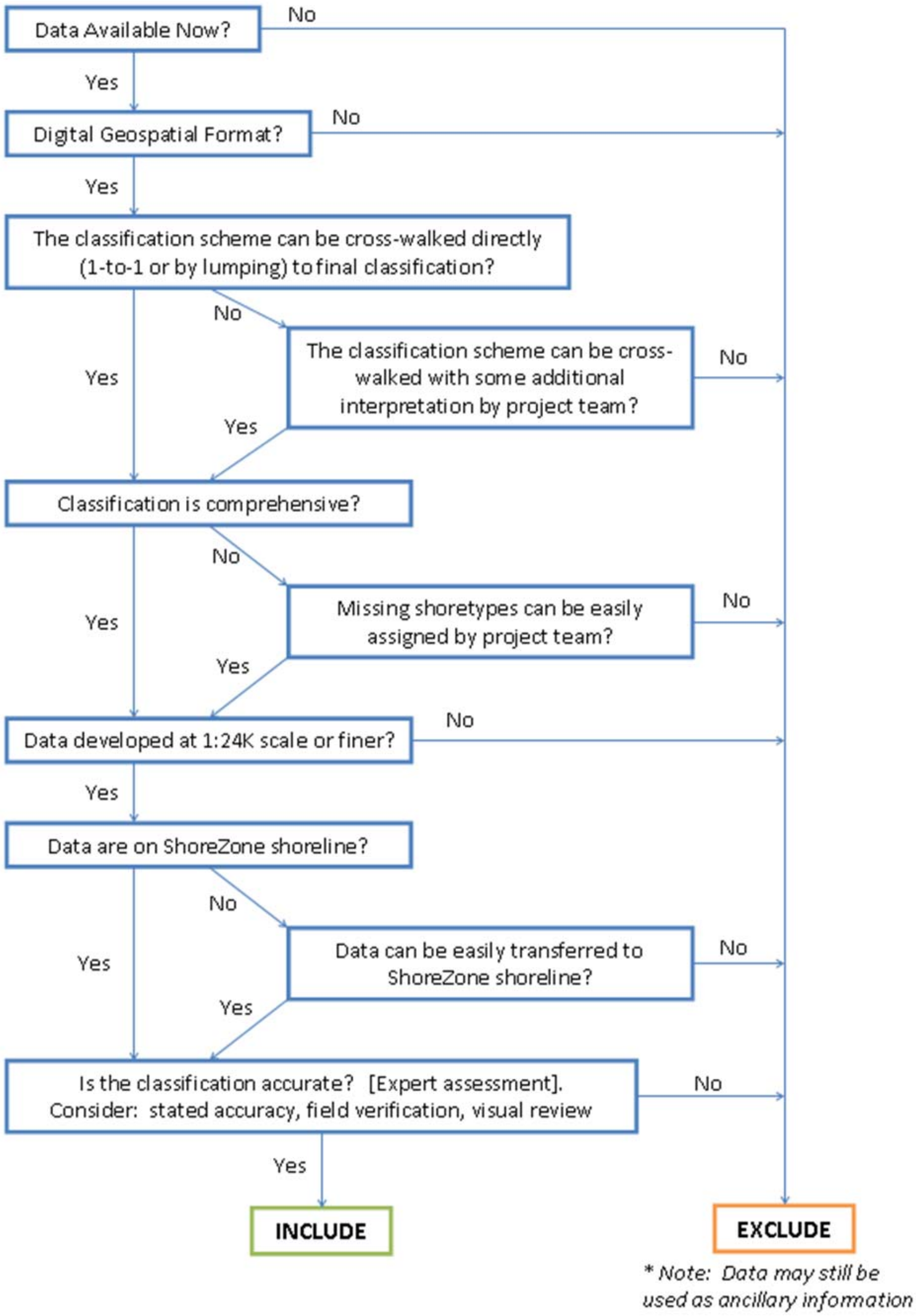

Figure 1. Flow chart showing the criteria used for including or excluding existing mapping projects from the Puget Sound-wide feeder bluff data set.

Table 2. Assessment criteria and supporting rationale for each element of the criteria.

Criterion	Rationale
Data availability	Only data that had been finalized (QA/QC'd) were acceptable for inclusion into the dataset. Interim data sets that had not been fully vetted and accepted by reviewers could have had erroneous results with a lower level of certainty than was acceptable for inclusion in the geodatabase.
Digital geospatial format	Only digital data were accepted into the geodatabase. Paper maps are likely over 10 years in age and are likely of coarser resolution. One of the paper maps reviewed did not use GPS or landmarks to delineate shoreform positions and therefore had a low mapping resolution (less than 1:24,000). The other paper map was 1:100,000 scale.
Capable of direct cross-walk	The classification scheme needed to be able to translate directly to the CGS mapping typology without considerable additional analysis or interpretation. For example, in sections of Mason County, contributing bluffs and feeder bluffs were mapped in lieu of feeder bluffs and feeder bluff exceptional shoreforms (respectively). A direct cross-walk was applied between the two shoreform types. In some cases the data had changed due to the construction of new armor. Armor data was integrated in order to update the dataset. If the translation process is too complex, time consuming, or results in decreased accuracy, it may be more efficient to remap the area.
Classification comprehensive	Data sets that did not include comprehensive coverage of the shoreline required interpretation of the non-feeder bluff shoreforms. For example, where only feeder bluffs were mapped, all other shoreforms also had to be mapped. This could be achieved with an acceptable level of certainty only if the mapping area met the basic conditions for remote mapping: linear/straight shoreline, *not* north-facing, more exposed/less sheltered for the Puget Sound region, and good oblique aerial photography.
Scale	Data sets needed to be at a 1:24,000 scale or finer resolution. As most existing data was at this scale it became the standard for the Sound-wide data set. Accepting data at a coarser scale would have compromised the resolution of the greater data set.
Data on ShoreZone shoreline	Accepted data sets had to be on the standard shoreline for the State. This will enable users to apply spatial queries of the data in tandem with other data that are also on this shoreline. The ShoreZone shoreline is a high water shoreline which is optimal for characterizing geomorphic processes that largely occur at the marine/terrestrial ecotone.
Accuracy assessment	The assessment of accuracy considered the scale and resolution of the source data, whether or not remote mapping was field-verified, and a brief visual review of the data by an in-house coastal geomorphologist. Field verification was considered a requirement as it reduces uncertainty. For example, visiting the shoreline enabled the mapper to view the bluff face and assess vegetation age and assemblages that can function as indicators of disturbance at the site.

Each of these issues will be discussed separately. Recent studies of Kitsap County (Gerstel et al. 2012) and Thurston County (Herrera 2007) sediment source data were both focused on nearshore sediment sources, but neither data set took into account grain size with regard to the varying quality of the landslide material as beach substrate, and each study employed different approaches from the methods employed by CGS. The Kitsap sediment source data (Gerstel et al. 2012) was not finalized at the time of the assessment, and therefore was not eligible for inclusion into the existing feeder bluff mapping data set.

The Thurston County work was exclusively focused on landslides of various form and age and was largely a remote sensing effort. The mapping was field verified and appeared to be an effort toward building a nearshore sediment budget. The Thurston County sediment source data was close to meeting the assessment criteria but lacked the interpretation of other geomorphic shoreforms (complete coverage is a contract requirement for this project). As a result, the data would have required considerable geoprocessing time as the study area would have needed to be remapped remotely due to inconsistencies in the data and approach, and the lack of other shoreforms. Remote mapping in Thurston County is suboptimal due to very sheltered conditions and an abundance of north-facing shores, which are often shaded in aerial photography. The cumulative time required to get the Thurston County data to the current mapping standard would have been substantial and would have resulted in a lower level of certainty than field mapping.

Several other data sets were reviewed that focused on shoreline geology or landslides; however, it is important to recognize that landslides do not always directly correspond with feeder bluffs (Figure 2). For example, some deep-seated landslides are reactivated very infrequently and slide areas can take on the properties of other geomorphic shoreforms for tens to hundreds of years before again showing signs of movement. There are many examples of accretion shoreforms and transport zones in deep-seated slide areas in Puget Sound (Figure 2). Shallow landslide mapping is generally more useful for feeder bluff mapping; however, shallow landslides can also occur within transport zones (non-feeder bluff shoreforms). Based on this understanding, CGS has mapped landslides as ancillary data in all previous CGS feeder bluff mapping field efforts. The co-occurrence of landslides and transport zones has been documented by CGS in many areas throughout the Puget Sound.

LIDAR data is an effective and often-used tool for mapping landslides in the region. However, mapping feeder bluffs using LIDAR data alone is not ideal. Because many landslides in the Puget Sound are too small and thin to be resolved by LIDAR and their deposits are often quickly removed or modified (Schulz 2007), broad reaches of feeder bluff shore can easily be overlooked. Deep-seated prehistoric and historic landslides are more clearly delineated using LIDAR; however, these features do not directly correspond with feeder bluffs as previously discussed and shown in Figure 2 (Schulz 2007).

The most comprehensive landslide mapping data in the state are the “recent” and “historic” landslides found in the Coastal Zone Atlas slope stability GIS layers (WDOE 2004). These landslides were commonly deep-seated slides rather than shallow slides. The GIS maps were digitized from original data that were on the order of 30-plus years old and therefore would have been a less than ideal data source for interpreting feeder bluffs. The most contemporary landslide mapping effort was conducted by WDNR (Sarikhan 2010) and is a compilation of landslide mapping from the (digital) 7.5-minute quadrangle surface geology mapping. Deep-seated landslide coverage appears to be far more extensive than shallow landslide mapping. This is likely due to the origin of the data and the limited number of quadrangles mapped (and digitally available). Therefore relying on this data source to complete feeder bluff mapping would have presented considerable inconsistencies in data resolution as well as large data gaps.

Table 3. Assessment criteria applied to data sets considered for inclusion into the existing feeder bluff mapping geodatabase.

Author, year	Adaptable data classification	Method	Ground truthing	Minimum mapping unit (ft)[b]	On ShoreZone shoreline?	Resolution (1:24K preferred)	Geomorph. review
Gerstel et al. 2012	FB only	Remote	No	0.5	Yes	Yes	NA
McKenna et al. 2008	FB only	Remote	No	50	No	Yes	Low cover, low energy
Herrera 2007	FB only	Both	Yes	26	No	Yes	Low cover, low energy
WDNR surface geology – many authors 1998-2012	Limited	Field (limited)	Yes	NA	No	Yes	Low cover
Sarikhan 2010	Limited	Field	Unknown	5	No	Yes	Low cover
WDGER 2009	-	Field	Unknown	87	No	Yes	Low cover, low energy
WDNR 2010	-	Field	Yes	NA	No	No	Low resolution
Pessl el al. 1989	-	Field	Yes	NA	No	No	Low resolution
Gerstel 2007	FB only	Field	Yes	111	No	Yes	CGS overlap
AMEC 2004	-	Field via air	Yes	NA	No	Yes	CGS overlap
WDOE 2004	-	Field	Unknown	NA	No	Yes	Low cover, outdated
Anchor Environmental 2002	-	Remote	Yes	150	Yes	Yes	Low resolution
Keuler 1988	-	Field	Yes	NA	No	No	Low resolution
WDNR 2001	-	Field	Yes	60	Yes	Yes	Low resolution
Simenstad et al. 2011	-	Remote	Yes (limited)	23.2	Yes	No	Low resolution
Johannessen 1999	Yes - CB to FB	Field	Yes	NA	No	Yes	Low resolution
Johannessen 2003	Yes - CB to FB	Field	Yes	125	No	Yes	Acceptable
Johannessen and Chase 2005	Yes - NAD areas	Field	Yes	18	Yes	Yes	Acceptable
Johannessen et al. 2005	Yes - NAD areas	Field	Yes	18	Yes	Yes	Acceptable
Johannessen and Chase 2006	Yes - NAD areas	Field	Yes	42	Yes	Yes	Acceptable
MacLennan and Johannessen 2007	Yes - NAD areas	Field	Yes	25	Yes	Yes	Acceptable

Table 3 Cont. Assessment criteria applied to data sets considered for inclusion into the existing feeder bluff mapping geodatabase.

Author, year	Adaptable data classification	Method	Ground truthing	Minimum mapping unit (ft)[b]	On ShoreZone shoreline?	Resolution (1:24K preferred)	Geomorph. review
Johannessen and MacLennan 2007, MacLennan and Johannessen 2008a, MacLennan et al. 2010a	Yes - FB-T, NAD	Field	Yes	16	Yes	Yes	Acceptable
MacLennan et al. 2010b	Yes - FB-T, NAD	Field	Yes	17	Yes	Yes	Acceptable
MacLennan et al. 2009	Yes - NAD areas	Remote	Yes	52	Yes	Yes	Acceptable
MacLennan et al. 2010c	Yes - FB-T, NAD	Field	Yes	10	Yes	Yes	Acceptable
MacLennan and Johannessen 2011	Yes - NAD areas	Both	Yes	25	Yes	Yes	Acceptable

[a] CB = contributing bluff; FB = feeder bluff; FB-T = feeder bluff-talus slope; NAD = no apparent drift [b] NA = not applicable

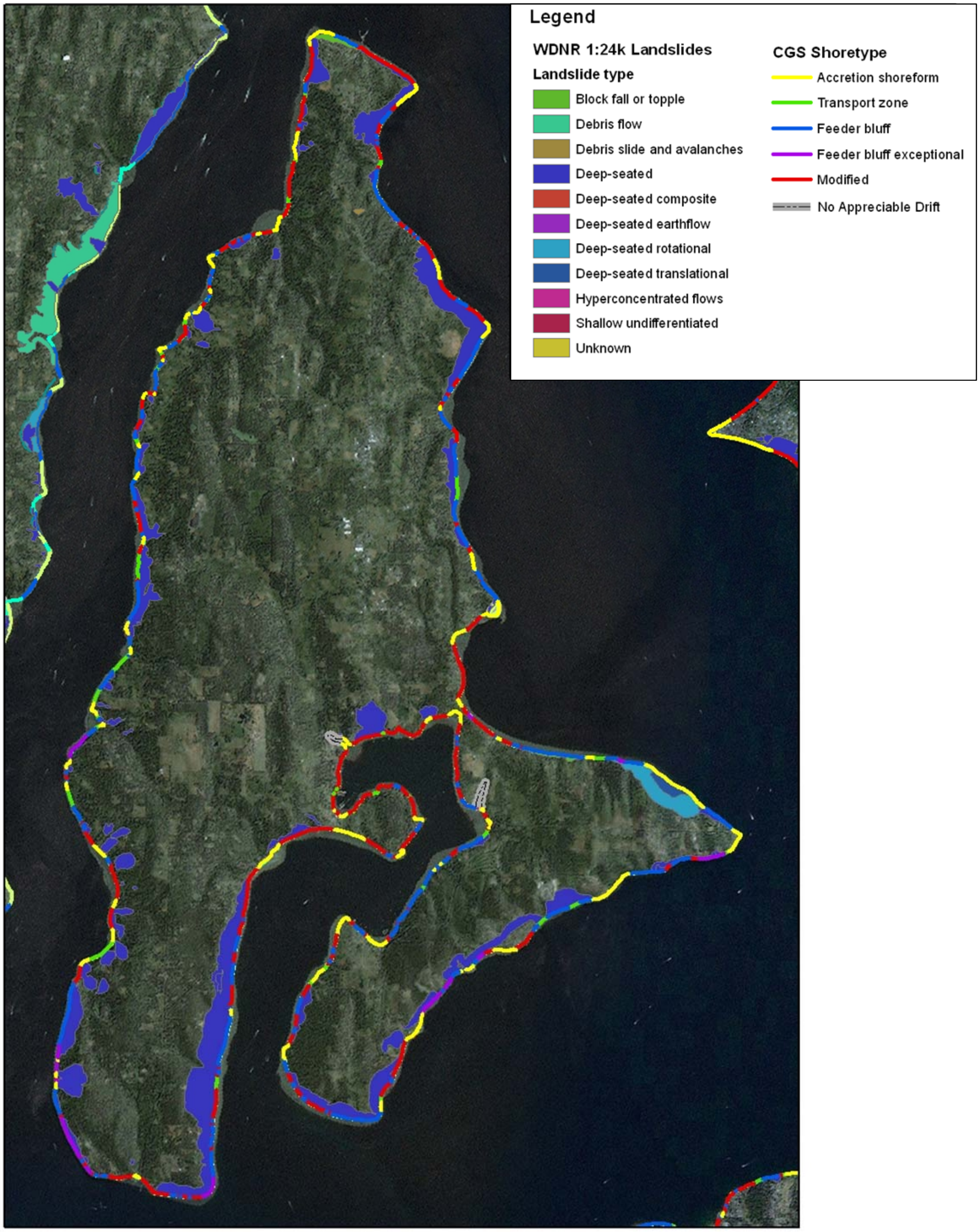

Figure 2. 1:24,000 landslide mapping (land side) and CGS feeder bluff mapping (on shoreline) on Vashon and Maury Islands. Note number of different CGS shoreforms occurring within deep-seated landslide areas and few shallow landslides.

Coastal landform mapping of the Puget Sound has been conducted for two major efforts: the ShoreZone Inventory database (WDNR 2001) and the Puget Sound Change Analysis (Simenstad et al. 2011). Both data sets have Sound-wide coverage, and had potential utility for this mapping effort. Sound-wide landform (Simenstad et al. 2011) and sediment source data (WDNR 2001) could have been used to interpret feeder bluffs and associated geomorphic shoreforms remotely.

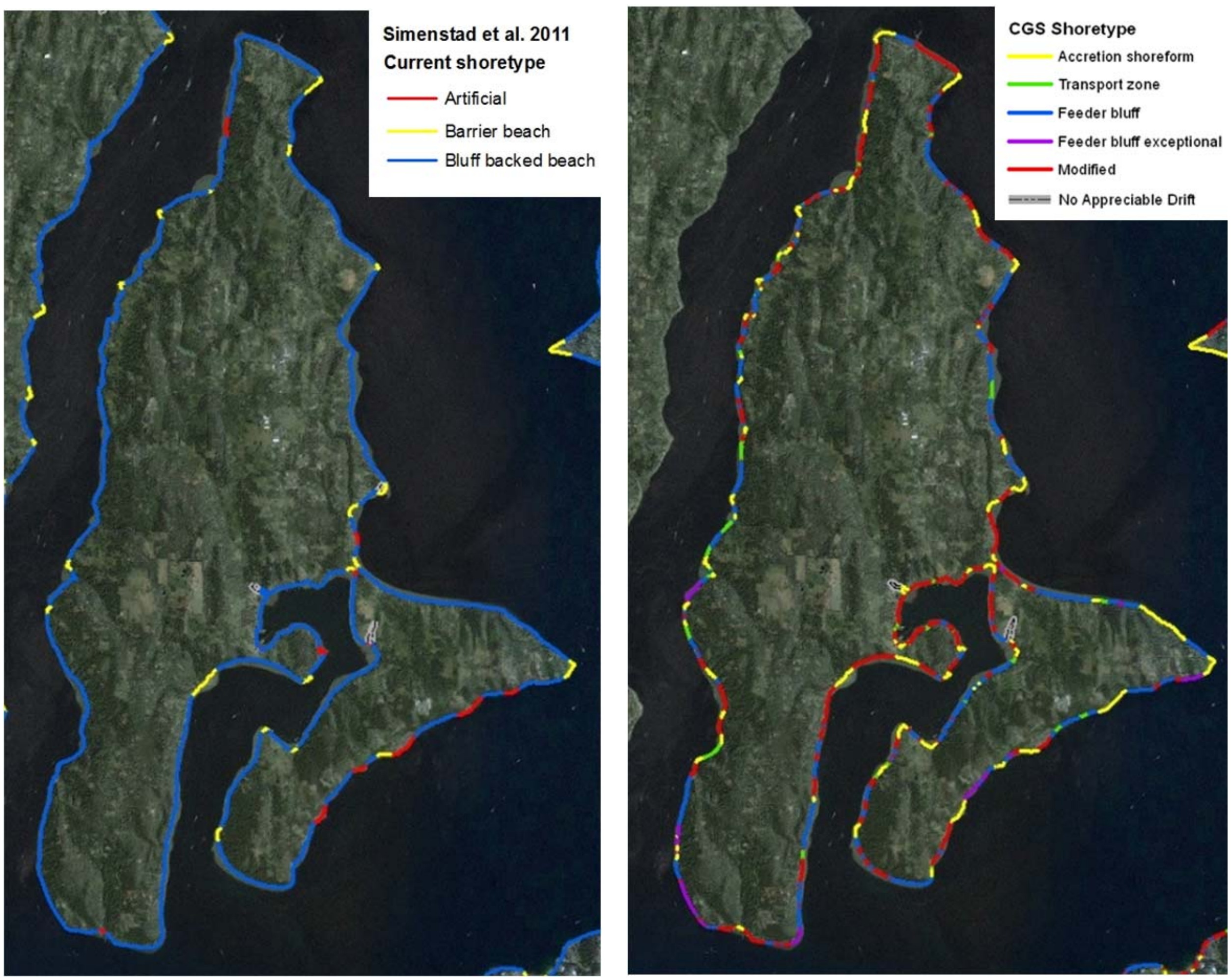

Figure 3. Comparison of coastal landform mapping from the Puget Sound Change Analysis (Simenstad et al. 2011) and CGS feeder bluff mapping (Johannessen et al. 2005).

The Change Analysis (Simenstad et al. 2011) was a remote-mapping effort that applied simple mapping rules that referenced data sets that ranged in scale and age (1:24,000 to 1:100,000). Oblique aerial photos, as well as coarser data sets were used to delineate bluff-backed beaches and barrier beaches, including surface geology (1:100,000) and topography data (1:24,000 and 10-meter digital elevation models) (Figure 3). It was thought that feeder bluffs could potentially be identified within areas mapped as bluff-backed beaches using landslide data to supplement the Change Analysis data. However, data comparison between available landslide data and CGS mapping proved that the landslide data did not closely correspond with feeder bluff mapping. Comparisons between the Change Analysis mapping and CGS mapping affirmed that bluff-backed beaches were far more widespread and more coarsely mapped than the CGS data (Figure 3). Maps of other shoreforms were also compared to explore if the Change Analysis barrier beach mapping would translate or cross-walk to the CGS accretion shoreform unit. Unfortunately the Change Analysis mapping again proved too coarse for this utility (Simenstad et al. 2011); the Change Analysis identified 19 barrier beaches, in contrast to 62 accretion shoreforms identified by CGS in the Vashon-Maury comparison area (Figures 3 and 4).

The ShoreZone Inventory was produced by WDNR in 2001, with data collected by helicopter while traversing the shore at rapid speeds. Within the database, the "backshore sediment source" attribute was thought to have potential for helping to delineate feeder bluffs. However, comparing the two data sets had discouraging results. Similar to Simenstad et al. (2011), the ShoreZone (WDNR 2001) backshore sediment source mapping was considerably coarser than the CGS mapping, with fewer than half the feeder bluffs mapped in the Vashon-Maury comparison area (21 sediment sources by WDNR 2001; 46 feeder bluffs by CGS). There were also potential errors as large feeder bluffs that were mapped by CGS (Johannessen et al. 2005) were not mapped as sediment sources by WDNR (2001). Other areas that were mapped by CGS as accretion shoreforms, such as those along the northwest shore of Vashon Island, were mapped as backshore sediment sources by WDNR (2001; Figure 4).

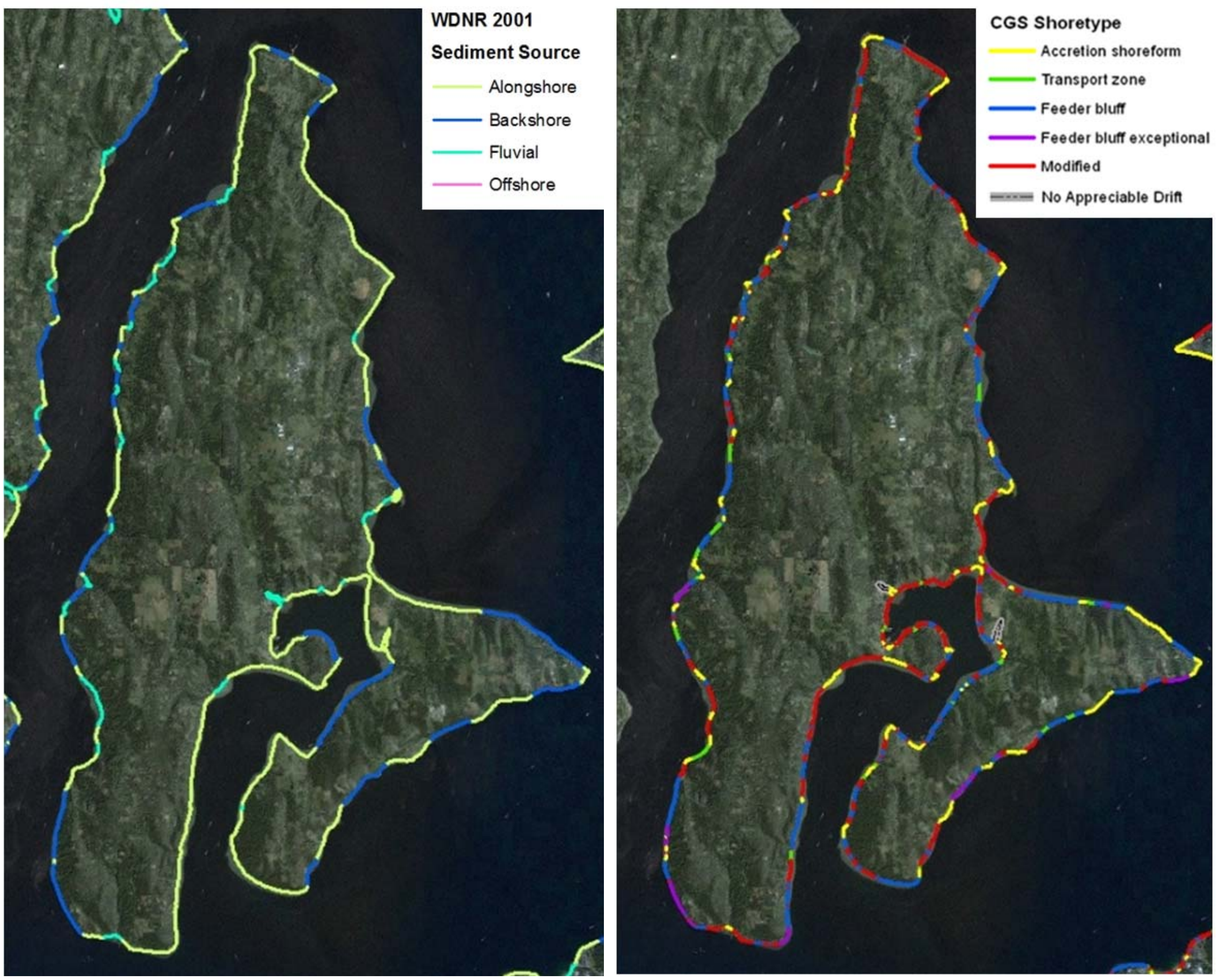

Figure 4. Comparison of ShoreZone (WDNR 2001) sediment source mapping and CGS mapping (Johannessen et al. 2005).

Assessment Results

Ten existing feeder bluff mapping data sets covering approximately 700 miles of shore met the assessment criteria for inclusion into the Sound-wide data set (Table 4, Figure 5). These data sets form the foundation for the final feeder bluff mapping geodatabase. CGS created each of the accepted data sets using mapping that was largely field-based with a consistent resolution and applied consistent criteria that were utilized in new data collection. There were some inconsistencies in how modified or armored shores were mapped across the 10 existing feeder bluff mapping data sets. For example, armor was only mapped along bluffs, and not along other shoreforms, in Island County. And the resolution of armor mapping in areas that were mapped remotely was considerably lower than areas mapped in the field due to poor resolution of imagery and shading from marine riparian vegetation. In addition, mapping armor was not the objective of most remote mapping of feeder bluff efforts. In some areas Figure 5 shows the spatial extent of the existing data sets (shown in blue) that were accepted for integration into the Sound-wide geodatabase of feeder bluff mapping. For methods on the geoprocessing required for all acceptable existing data sets see Appendix A *GIS Data Processing*.

Table 4. Accepted data sets for integration into the feeder bluff mapping geodatabase.

Author, year	Cover	Adaptable data classification	Method	Ground truthing	On ShoreZone shoreline?	Resolu -tion (1:24K pref'd)	Status
Johannessen 2003	Mason County, partial	Yes - CB to FB	Field	Yes	No	Yes	Acceptable
Johannessen and Chase 2005	Island County	Yes - NAD areas	Field	Yes	Yes	Yes	Acceptable
Johannessen et al. 2005	King and south Snohomish County	Yes - NAD areas	Field	Yes	Yes	Yes	Acceptable
Johannessen and Chase 2006	Whatcom County, partial	Yes - NAD areas	Field	Yes	Yes	Yes	Acceptable
Johannessen and MacLennan 2007, MacLennan and Johannessen 2008, MacLennan et al. 2010a	Skagit County, partial	Yes - NAD	Field	Yes	Yes	Yes	Acceptable
MacLennan and Johannessen 2007	North Snohomish County	Yes - NAD areas	Field	Yes	Yes	Yes	Acceptable
MacLennan et al. 2010b	Bainbridge Island	Yes – NAD areas	Field	Yes	Yes	Yes	Acceptable
MacLennan et al. 2009	North Pierce County	Yes - NAD areas	Remote	Yes	Yes	Yes	Acceptable
MacLennan et al. 2010c	San Juan County	Yes - FB-T	Field	Yes	Yes	Yes	Acceptable
MacLennan and Johannessen 2011	Clallam County	Yes	Both	Yes	Yes	Yes	Acceptable

[a] CB = contributing bluff; FB = feeder bluff; FB-T = feeder bluff-talus slope; NAD = no apparent drift

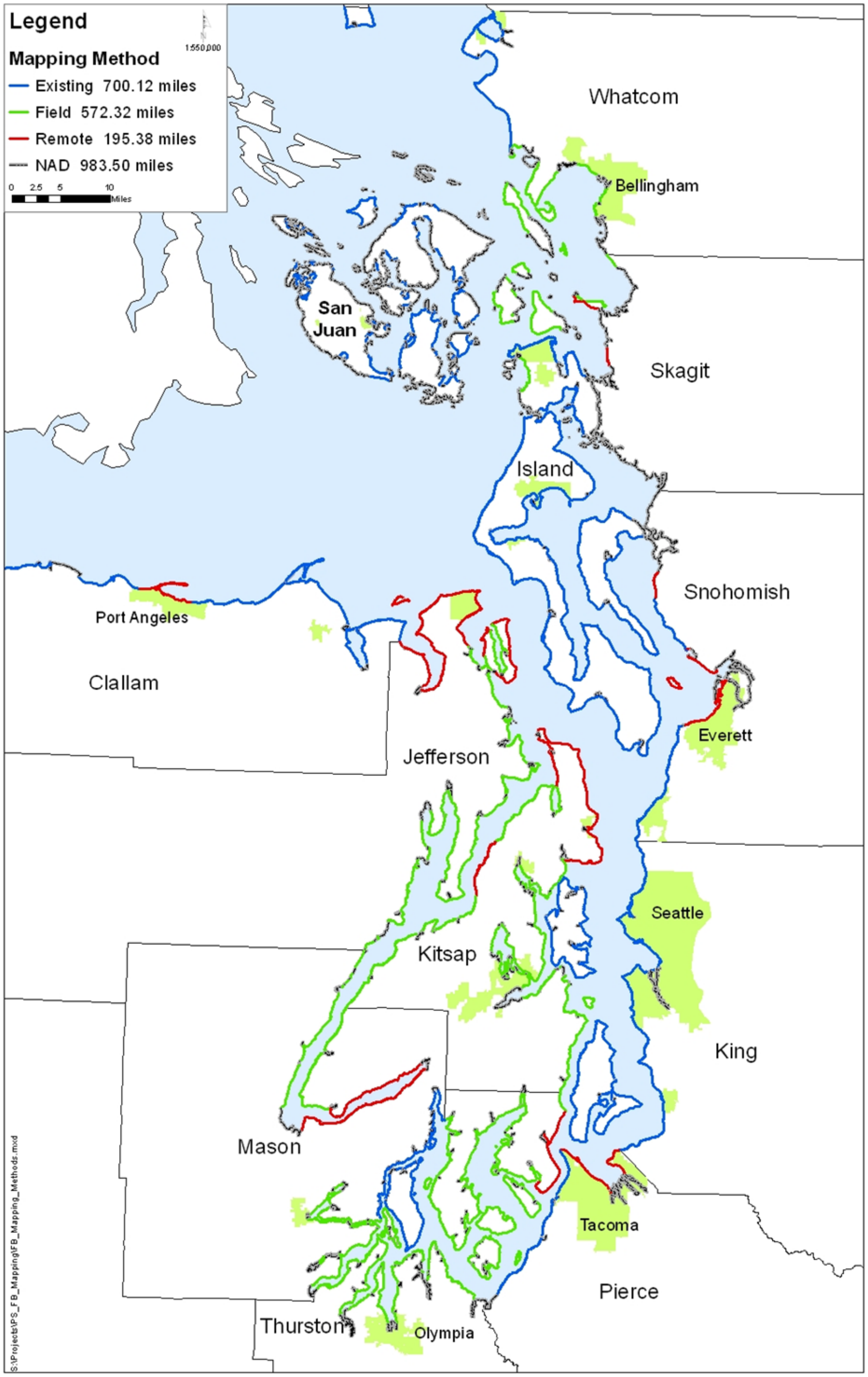

Figure 5. Complied existing feeder bluff mapping data sets (shown in blue). New mapping conduced in the field shown in green. New mapping conducted remotely shown in red.

Table 5. Rejected data sets and the element for which they did not meet the assessment criteria.

Author, year	Adaptable data classification[a]	Method	Ground truthing	On ShoreZone shoreline?	Resolution (1:24K preferred)	Reason for rejection
Gerstel et al. 2012	FB only	Remote	No	Yes	Yes	Unavailable and difficult to interpret other shoreforms due to protected shores
McKenna et al. 2008	FB only	Remote	No	No	Yes	Difficult cross-walk and interpretation of other shoreforms due to protected shores
Herrera 2007	FB only	Both	Yes	No	Yes	Difficult cross-walk and interpretation of other shoreforms due to protected shores
WDNR surface geology – many authors 1998–2012	Limited	Field (limited)	Yes	No	Yes	Inconsistent coverage, inconsistent resolution
Sarikhan 2010	Limited	Field	Unknown	No	Yes	Inconsistent coverage, inconsistent resolution
WDGER 2009	FB only	Field	Yes	No	Yes	Inconsistent coverage, inconsistent resolution
WDNR 2010	Limited	Field	Yes	No	No	Low resolution
Pessl el al. 1989	Limited	Field	Yes	No	No	Low resolution
Gerstel 2007	Yes-FB only	Field	Yes	No	Yes	CGS mapping overlap
AMEC 2004	FB only	Field via air	Yes	No	Yes	CGS mapping overlap
WDOE 2004	FB only	Field	?	No	Yes	Low cover, outdated
Anchor Environmental 2002	Yes	Remote	?	Yes	Yes	Low resolution
Keuler 1988	Yes	Field	Yes	No	No	Low resolution, no digital data
WDNR 2001	Yes	Field	Yes	Yes	Yes	Low resolution
Simenstad et al. 2011	Yes	Remote	Yes (limited)	Yes	No	Low resolution
Johannessen 1999	Yes - CB to FB	Field	Yes	No	No	Low resolution, no digital data

[a] CB = contributing bluff; FB = feeder bluff

Seven data sets were rejected due to insufficient resolution, lack of digital data, or incompatible feature classifications (Table 5). Anchor Environmental (2002) mapping of feeder bluffs on Bainbridge Island and geology and landslide mapping of the Tulalip Tribe's marine shoreline were both rejected in favor of existing CGS mapping of these areas. CGS mapping was preferred because it benefits the quality of the larger data set to employ a consistent approach and field verification of all mapping. Kitsap County sediment-source data (Gerstel et al. 2012) were not available for review or integration at the time of the data assessment. This dataset had different objectives as it was developed specifically to support restoration planning by identifying and characterizing sediment sources and their relative potential for contributing to the beach environment. Sediment sources were not limited to bluffs but also included streams. Additionally, this mapping effort did not address other geomorphic shoreforms. Interpreting geomorphic shoreforms remotely would be very difficult in the highly complex shores of Kitsap County.

Thurston County landslide mapping (Herrera 2007) focused only on landslides rather than all areas actively feeding beach sediment supply. Similar to the Kitsap County mapping, interpretation of other geomorphic shoreforms would have been very challenging to achieve with a high level of certainty in the sheltered, complex nature of south Puget Sound.

AMEC's mapping of geomorphic shoretypes in Skagit County (AMEC 2004) applied a feature classification similar to that of CGS, but the digital files had unresolved projection problems and would have required significant time to redigitize. CGS has already completed feeder bluff mapping throughout most of Skagit County's net shore-drift cells, therefore the AMEC data were not required. One early CGS mapping effort (Tala Point to Kala Point, Jefferson County; Johannessen 1999) was rejected as it was not available in digital format and hard-copy maps were of insufficient resolution to reinterpret digitally. For example, mapping units were hand-drawn on 1:24,000 USGS topographic maps. Because GPS was not used in the field and landmarks or specific latitude and longitude coordinates were not used to delineate units, the potential mapping error associated with digitizing from these maps was anticipated to be greater than National Map Accuracy Standards for 1:24,000 scale mapping (67 ft for 90% of the points), which is the defined accuracy standard for this project and all other CGS feeder bluff mapping products. In addition, the relatively small study area made remapping a practical alternative.

Nine data sets were identified as containing valuable supporting data for the remote mapping effort and enhancement of the quality assurance of field data (Table 6). These data sets primarily included landslide and surface geology data and paper maps that can be referenced during remote mapping "fly-by" efforts. Remote mapping methods rely heavily on concurrence between existing data sets, as multiple data sets are referenced in GIS while viewing oblique aerial photography of the shoreline.

Table 6. Data sets valuable for remote mapping and efforts to verify field mapping. LS = Landslide.

Author, year	Data set	Coverage (spatial)	Feature classification	Useful for remote mapping
Gerstel et al. 2012	Shoreline Restoration Prioritization and Feasibility Study	Kitsap County	Sediment sources	Yes
McKenna et al. 2008	Kitsap LIDAR interpreted LS mapping	Kitsap County	Landslides	Yes
Herrera 2007	Thurston County landslides mapping	Thurston County	Sediment sources, landslides	Yes
WDNR surface geology – many authors 1998–2012	Other WDNR geologic mapping - 1:24K	Variable	Landslides	Yes
Sarikhan 2010	WDNR compiled LS mapping 1:24K	State-wide	Landslides	Yes
WDGER 2009	WDNR compiled LS Thurston County 1:24K	Thurston County	Landslides	Yes
WDNR 2010	WDNR geologic mapping -1:100K	Puget Sound-wide	Geology – landslides	Yes
Pessl el al. 1989	USGS geologic mapping - 1:100K	Port Townsend 1:100K Quad	Geology – landslides	Yes
Gerstel 2007	Geology and landslide mapping of Tulalip	Tulalip Reservation	Landslides	Yes
WDOE 2004	Coastal Zone Atlas of WA mapping	Puget Sound-wide	Eroding bluffs, landslides	Yes
Keuler 1988	USGS mapping Port Townsend 1:100,000	Port Townsend 1:100K Quad	Wave erosion, landslides	Yes
WDNR 2001	WDNR ShoreZone database	Puget Sound-wide	Cross-shore features	Yes
Simenstad et al. 2011	PSNERP Change Analysis mapping	Puget Sound-wide	Landform classification	Yes

New Mapping Methods

After data were assessed and compiled into a single coverage, the data were loaded into GIS along with the net shore-drift data set in which no appreciable drift was displayed (commonly abbreviated as NAD, an element of the net shore-drift data set). The remaining unmapped shorelines determined the areas in which new mapping would focus. A review of conditions throughout the shore to be mapped helped classify areas in which remote mapping would be as accurate as field mapping and potentially more cost effective. Figure 5 shows the shores for which existing feeder bluff mapping was available and the shores where field mapping and remote mapping were conducted to complete Sound-wide coverage of the feeder bluff mapping data set.

Most of the remaining portions of the study area (about 575 miles) were mapped using the field-based approach. This is the same approach applied by CGS across approximately half of the Puget Sound region's shore. Remote mapping was conducted along approximately 22% of the Puget Sound shoreline that remained to be mapped. The remote mapping methods adhered to the same general mapping criteria but was applied using aerial photography rather than field-based observations. Preliminary investigations of air photo quality and data availability showed remote mapping to be possible in the selected locations. Detailed methods are described below.

Field Mapping Methods

All feeder bluff mapping (field and remote mapping) adhered to a specific set of mapping rules that were developed for identifying geomorphic shoretypes, as outlined in Table 7 and Figure 6. Mapping criteria demanded a systematic review of the uplands, bluff face, bluff vegetation type, age and species, signs of landslides, beach substrate, sediment transport indicators and driftwood age and abundance. Having awareness of the degree of regional variability of Puget Sound bluffs and experience applying the CGS typology across different nearshore environments enhanced the consistency of delineating shoretypes. Aerial photography, nautical charts, net shore-drift, and geology data were regularly referenced throughout the field and digital mapping process.

Field mapping was conducted by interpreting field characteristics and mapping criteria while traversing the shore in a small boat at mid to high tides, close to shore. The minimum mapping unit was 20 feet alongshore. Field mapping was conducted by 2 different mapping teams across multiple field ventures (Figure 7). Continuous mapping units were delineated by placing a waypoint, using a hand-held GPS. Waypoint numbers were recorded on a field form along with other observations such as landmarks and field photo numbers. The detailed methods associated with GPS field data collection and GIS data processing is described in detail in Appendix B *GPS Standard Operating Procedures*.

The standard CGS feeder bluff mapping criteria entailed delineating the shoreline into one of 9 different alongshore segments, or shoretypes, including feeder bluff exceptional, feeder bluff, feeder bluff-talus, transport zone, accretion shoreform, no appreciable drift bedrock (NAD-B), no appreciable drift low energy (NAD-LE), no appreciable drift delta (NAD-D), and modified. All shoretypes occurred in net shore-drift cells, except for areas with no appreciable drift (NAD), which by definition are found outside of shorelines where net shore-drift occurs. Toe erosion and landslides were mapped as ancillary data within and across the shoretypes within drift cells as they occur. The methods applied to all revisions to net shore-drift mapping are described in detail in Appendix C *Net Shore-drift Revisions Methods*.

Quality assurance and quality control protocols pertaining to new field mapping are described in detail in Appendix D.

Table 7. Criteria to define feeder bluffs and related coastal landforms for remote and field mapping. Note criteria are listed in order of priority within each category. Modified from Johannessen and Chase (2005).

Presence of:	Absence of:
Feeder Bluff Exceptional (FBE)	
1. Steep bluff/ bank 2. Recent landslide scarps 3. Bluff toe erosion 4. Abundant sand/gravel in bluff 5. Colluvium/ slide debris 6. Primarily unvegetated or vegetated slumps 7. Trees across beach 8. Boulder/ cobble lag	1. Shore protection/fill 2. Backshore 3. Old/ rotten logs 4. Coniferous bluff vegetation 5. Bulkhead
Feeder Bluff (FB)	
1. Steep bluff/ bank 2. Past landslide scarps 3. Intermittent toe erosion 4. Moderate amount sand/gravel in bluff 5. Intermittent colluvium 6. Minimal vegetation 7. Trees across beach 8. Boulder/ cobble lag	1. Shore protection/fill 2. Backshore 3. Old/rotten logs 4. Coniferous bluff vegetation 5. Bulkhead
Feeder Bluff - Talus (FB-T)	
1. Steep bluff/ bank 2. Past landslide scarps, mapped landslides 3. Bedrock lithology, bedding/ jointing conducive to breaking 4. Intermittent toe erosion 5. Intermittent colluvium 6. Minimal vegetation on bluff face 7. Trees across beach 8. Boulder/ cobble lag	1. Shore protection/fill 2. Backshore 3. Old/rotten logs 4. Basalt, or other moderate-high strength rock 5. Bulkhead
Transport Zone (TZ)	
1. Coniferous bluff vegetation 2. Apparent relative bluff stability 3. Gentle slope bluff (relative alongshore)	1. Visible landslide scarps 2. Toe erosion 3. Backshore and backshore vegetation 4. Old/rotten logs 5. Colluvium 6. Trees across beach 7. Shore protection/fill
Accretion Shoreform (AS)	
1. Backshore and backshore vegetation 2. Lagoon/wetland/marsh behind berm 3. Backshore "platform" 4. Old/rotten logs 5. Fine, well-sorted sediment (alongshore)	1. Bluff/bank in backshore 2. Toe erosion at bank 3. Landslide scarps 4. Boulders on beachface 5. Shore protection/fill
Modified	
1. Shore armor/seawall, revetment/bulkhead 2. Boat ramp, groin, rubble, 3. Large quantity of debris/fill	1. Toe erosion at bank
NAD-B (No Appreciable Drift - Bedrock)	
1. PSNERP mapping: bedrock ramp, plunging rocky or pocket beach 2. Bedrock in intertidal and backshore (WDNR) 3. Bedrock in shallow subtidal	1. Sand/gravel in bank 2. Continuous, active beach
NAD-LE (No Appreciable Drift - Low Energy)	
1. Salt marsh vegetation 2. Silt/fine sand in intertidal	1. Continuous, active beach 2. Toe erosion at bank and landslide scarps
NAD-D (No Appreciable Drift - Delta)	
1. PSNERP mapping: delta 2. Sand flats/ marsh 3. Distributary channels	1. Continuous, active beach 2. Bank or bluff
NAD-AR (No Appreciable Drift – Artificial	
1. PSNERP mapping: artificial	1. Within area mapped with net shore-drift

a) Feeder bluff exceptional - Double Bluff, Island County

b) Feeder bluff – Anderson Island, Pierce County

c) Feeder bluff-talus - South Lummi Island, Whatcom Co.

d) Transport zone - Guemes Island, Skagit County

e) Accretion shoreform - Indian Cove, Shaw Island

f) Modified - Puget Sound, Bainbridge Island

g) No appreciable drift – bedrock, Stuart Island

h) No appreciable drift - low energy, Sequim Bay

i) No appreciable drift – delta, Nooksack Delta

j) No appreciable drift – artificial, City of Bellingham

Figure 6. Representative geomorphic shoretypes from CGS feeder bluff mapping projects.

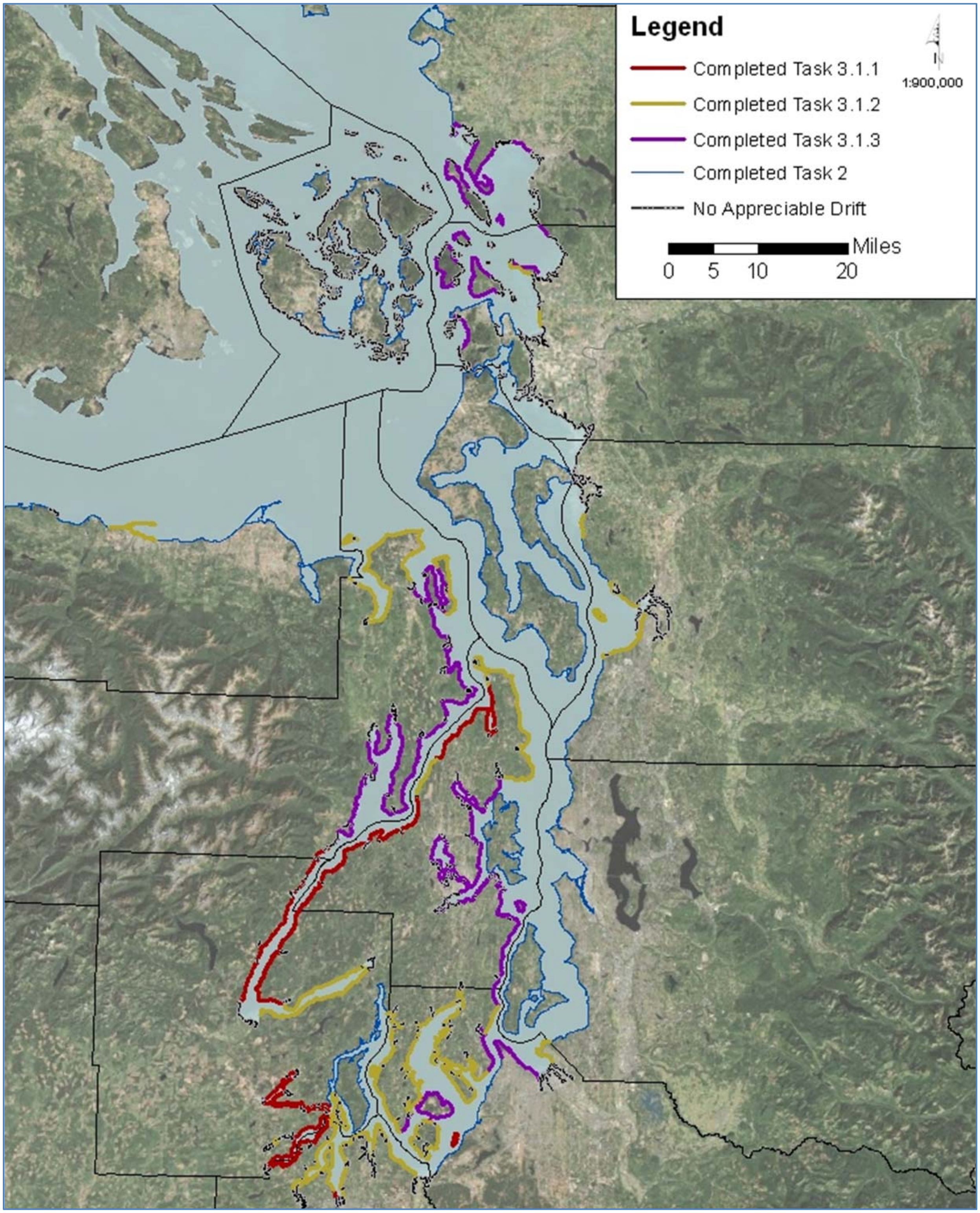

Figure 7. Spatial extent of field mapping subtasks.

Digitizing Methods

Shoretype mapping was digitized into separate personal geodatabases for each field venture or where multiple field ventures were focused within a specific geographic area (such as Skagit County). Using multiple geodatabases enabled CGS staff to digitize, edit, or review digital data from different areas simultaneously throughout the larger Puget Sound study area. After completing the digitizing process and quality assurance and control protocols, each of the geodatabases (including existing data and remote mapping) were merged into a single Sound-wide data set.

Shoretype maps were developed from field data by following the (abbreviated) steps shown below.

- GPS points from field mapping were displayed in ArcMap along with supporting digital imagery such as orthorectified vertical aerial photography, USGS quadrangles, WDGER surface geology data, the ShoreZone shoreline, and net shore-drift data.
- ShoreZone shoreline was split into shoretypes using way points (collected normal to shore) and field notes to guide the precise delineation location. Shoretype delineations were conducted at a scale no larger than 1:3,000. Field photos and WDOE shoreline oblique air photos were referenced in areas of uncertainty along with other data sets identified during the data assessment as valuable supporting information at the regional scale.
- The attribute table was populated based on field data forms, except for net shore-drift. Net shore-drift data was brought into the attribute table from the most recent data set for the area that reflected current conditions. Areas with No Appreciable Drift were further classified based on why no drift occurs: lack of wave energy (NAD-LE, low energy), lack of sediment due to bedrock shores (NAD-B), part of a large scale delta (NAD-D), or heavily altered or artificial shores (NAD-AR).
- Progress was documented by each GIS technician in the geoprocessing log. A brief summary of task status was documented on the subject geodatabase by each technician daily to track project progress in detail.
- Call outs were created in each GIS project file (.mxd) to highlight areas in which questions or considerable uncertainty remained, for the field team lead to review with additional supporting data sets, such as LIDAR or regional data sets.

Final data were compiled into an ESRI geodatabase format according to WDOE standards. Field data were transferred to or directly mapped onto Washington Department of Natural Resources (WDNR) ShoreZone shoreline geography, which meets WDOE's specified map accuracy standard of ±40 feet. The delineation of the shoreline was the only feature retained from ShoreZone; all attributes were dissolved and replaced with attributes specific to this data product. The attributes found in the geodatabase are described in Table 8 and include shoretype (and if modified, whether the unit was a historic source of sediment), the presence of landslides and toe erosion, drift cell information, data source and year, mapping method, unit length, and documentation of the QA/QC process. Screen captures of this process are shown in Figure 8.

Table 8. Attribute table of Puget Sound feeder bluff mapping geodatabase.

Attribute name	Description	Allowed values
Shoretype	Code for Final Shoretype	FBE, FB, FB-T, TZ, AS, NAD-B, NAD-LE, NAD-D, NAD-AR, MOD
Historic_FB	Flag for presence of historic feeder bluff	Yes, No, Unknown, Not Applicable, No Data,
Landslide	Flag for presence of landslide	Yes, No, Not Applicable, No Data
Toe_Erosion	Flag for presence of toe erosion	Yes, No, Not Applicable, No Data
DCELL_NR	Drift Cell Name	From Net shore-drift data set
CELL_TYP	Drift Cell direction or type	RtoL, LtoR, NAD
HistFB_Method	Method used to determine historic feeder bluff presence	Field, HSSI, Remote, Not Applicable, No Data
Data_Source	Shortened data source name	Abbreviation for each source, including the year. Full reference will be provided in metadata.
Shoretype_Certainty	Certainty of remote mapping. For remote mapped areas ONLY.	High, Moderate, Low, Not Applicable
Review_Date	Date that the segment was validated/reviewed	A valid date
Reviewer	Initials of the person who validated/reviewed	WG, JJ, AM, SW, JW
Mapping_Method	Description of mapping method used, either from a compilation of previously existing data sets, or via new field or remote mapping	Existing, Field, Remote

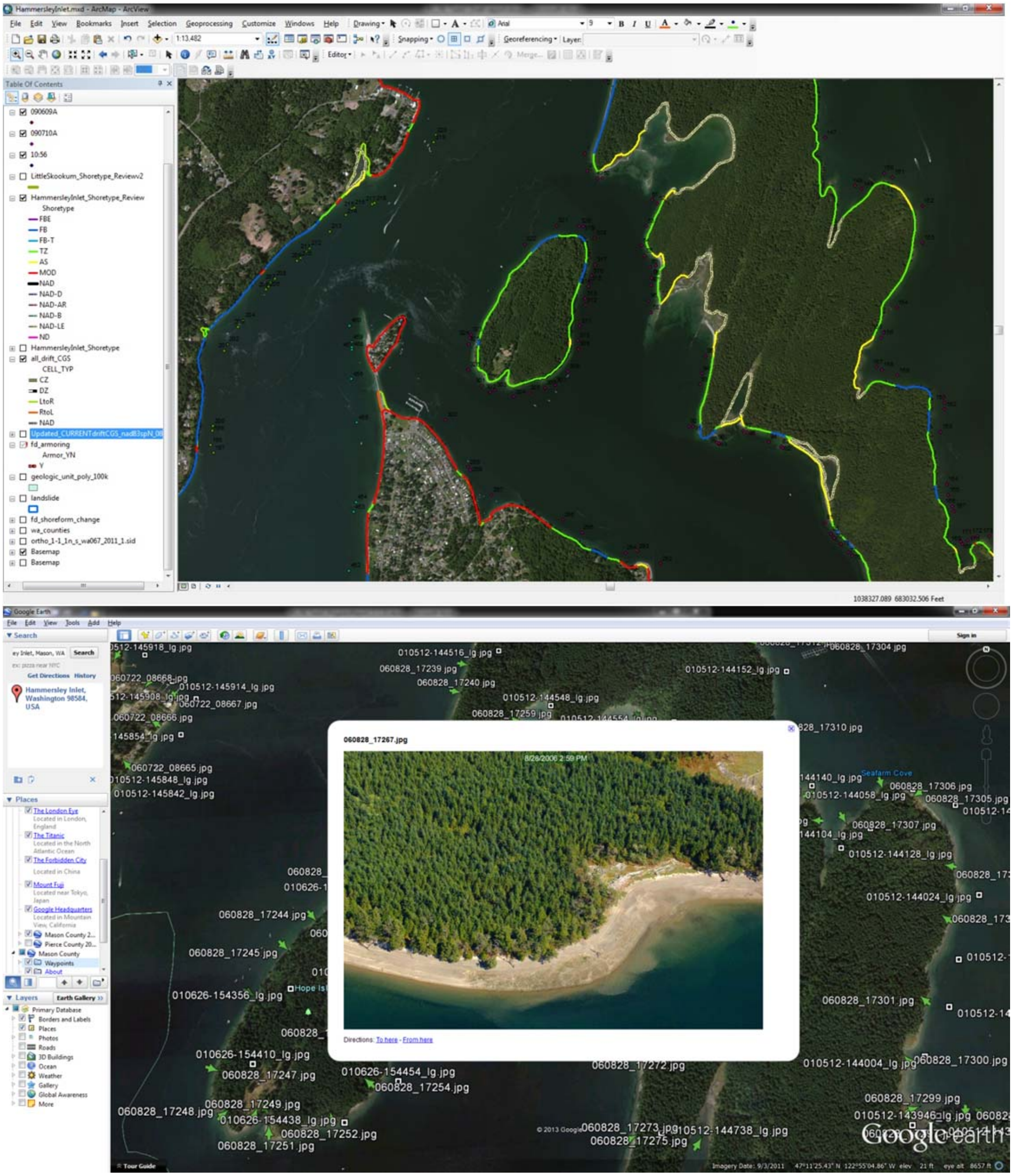

Figure 8. Screen captures of the digitizing process, showing way points (offshore), digitized shoretypes, and shoreline oblique imagery used to confirm conditions and interpret precise shoretype.

Remote Mapping Methods

Reaches of Puget Sound shorelines deemed appropriate for remote mapping were selected based on the mapping team's knowledge of regional shoreline characteristics and review of aerial photos for adequate visibility. Shores identified as appropriate for remote mapping met the criteria shown in Table 9 and included the more exposed portions of the eastern Strait of Juan de Fuca, South Hood Canal, Tacoma Narrows, and the central portion of the main basin of Puget Sound (Figure 5). Aerial photography and other supporting data sets were required to be of sufficient quality to view shoreline conditions clearly. Approximately 250 miles of Puget Sound were mapped remotely, while the remaining 890 miles were mapped in the field. Where data were lacking, or did not meet the criteria, shores were flagged for field mapping. See Appendix D for quality assurance and control protocols associated with remote mapping.

Areas mapped as NAD were also subject to remote mapping for further classification to inform the specific reason that net shore-drift does not occur. Because NAD areas are a part of the Sound-wide net shore-drift mapping data set, the NAD classification methods are described in the Net Shore-drift mapping methods section of this report (below).

Table 9. Criteria for determining remote and field mapping locations.

Remote mapping	Field mapping
High-wave-energy shores, not in major embayments	Bays and inlets
Relatively linear shorelines	Shores with moderate to high complexity
Bedrock shores	Mapping areas that needs revisiting or field verification
Digital visibility: no or low shading of landform	Low digital visibility: shaded or north-facing shores
1:24k Surface geology mapping available	No large-scale mapping available
LIDAR data available	Poor-quality LIDAR data

Remote mapping was conducted by using two adjacent computers, each with two screens (Figure 9). As with field mapping, two sets of eyes making observations and unit calls provided quality control through virtual "on-site" discussion (similar to the dialogue that might occur at an outcrop). Computer 1 was operated by a GIS specialist with a background in geology who is familiar with established Puget Sound feeder bluff mapping protocol. Computer 1 displayed the following data sets:

- GIS
- Geology (1:24k where available)
- LIDAR
- ShoreZone
- PSNERP
- Kitsap landslide mapping
- Orthorectified aerial photos

Computer 2 was operated by a senior level coastal geomorphologist, and displayed the following data:

- Running log/notes
- WA Dept. of Ecology oblique shoreline photos (2006)

- KMZ photo locator

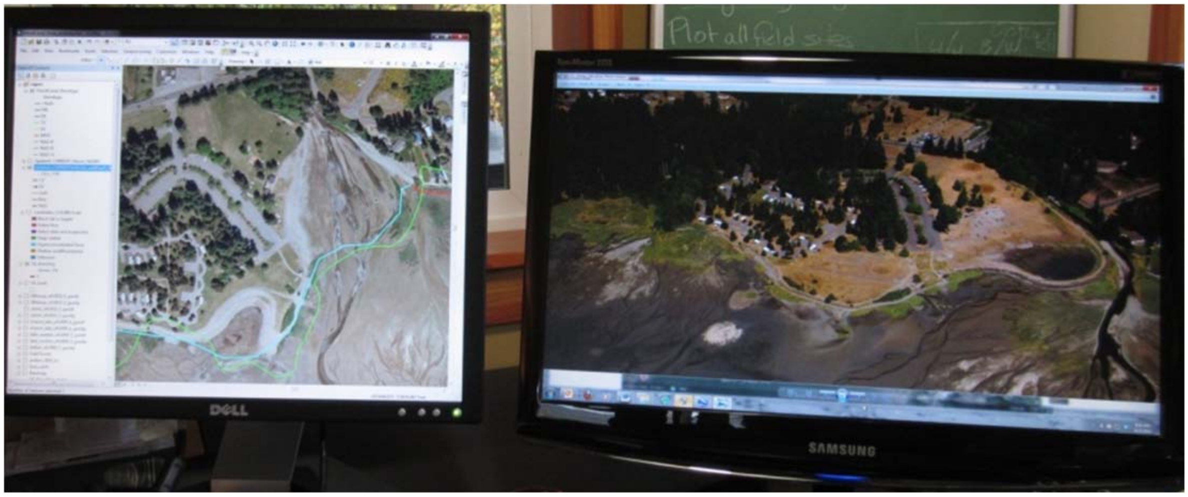

Figure 9. Snapshot of remote mapping effort with two computers actively viewing GIS and air photo data.

Shoretypes were delineated based on the criteria shown in Table 7 and Figure 6, which were consistent with the definitions and protocols applied in previous feeder bluff mapping efforts (such as Johannessen and Chase 2005). Where conditions transitioned from one shoretype to another a break was placed along the shoreline by using the split tool in GIS and entering the appropriate data into the attribute table. Remote mapping, in the place of making direct field observations, provided broader geographic context for shoreforms through viewing the adjacent uplands. It also allowed mapping calls to be input directly into GIS in a single effort, rather than having to process field data as a separate step. This consolidation of observation and data input eliminated the potential for errors in data or information transfer that can result from producing intermediate products such as additional maps or photo/LIDAR overlays.

A log was kept to document progress, questions that arose on unit assignments, unusual landforms or shoreline features (natural or manmade), and any other issues for subsequent team discussion. Additional data was recorded by the GIS technician:

- data sources used to inform shoretype interpretation
- areas mapped
- shoretype with geographic description
- secondary determination of historic conditions (behind modified shoreline)
- level of certainty of all determinations
- areas needing drift cell mapping revision
- additional notes to provide assignment justification

Shoretype delineations were largely based on observations made using the 2006 shoreline oblique photos. Orthophotos taken in 2009 and used in the GIS framework offered less image and perspective clarity. LIDAR shaded relief images were used as a mapping tool and LIDAR data were analyzed during subsequent mapping review prior to field verification.

Interpreting geomorphic conditions along these shores was often challenging, particularly in areas with dense or overhanging marine riparian vegetation, few visible erosional scarps, or shading of the bluff face (in photographs) due to shore orientation. All mapping unit calls were given a level of certainty (or confidence level) of low, moderate, or high. Areas with moderate or low certainty commonly occurred where shadows precluded a clear view of the shoreline, or where shoreline features indicating one shoretype vs. another were generally equivocal. Other examples of conditions in which mapping was of low certainty included a shore reach where armor was minimal and could be deemed nonexistent by different mappers or at a closer scale, or where an accretion shoreform appeared to be adjacent to a feeder bluff where one might expect a transport zone to separate the two. Another area of uncertainty was associated with roads that ran adjacent to the shoreline and were likely built over the historic (upper) beach. Many of these areas appeared to be only slightly above (approximately 10 ft) beach grade and placed atop a prism of fill material. These areas were commonly mapped as “Modified”, even where no armoring structure was visible. However, some probable fill areas have been since naturalized, and therefore would not be considered modified in current conditions. This typically occurs in accretion shoretypes where 10 to 20 feet of backshore have been established.

Ground Truthing Methods

Approximately 6.6 miles of remotely mapped areas were field verified. The objective of the “ground truthing” of remote mapping was to refine and resolve some of the uncertainties that arose during remote mapping. Reaches selected for ground truthing were those that received moderate to low confidence rating in remote mapping calls, where photo review by the project lead was not able to resolve the uncertainty, and in which the QA/QC measures identified the probability of error when compared to field-based mapping. Ground truthing was carried out by Wendy Gerstel and Stephanie Williams.

The three geographic areas selected for ground truthing (each with several discrete segments), included the east and north shore of Kitsap County north of Kingston, the east shore of Discovery Bay in Jefferson County, and the east shore of Pierce County near Gig Harbor, for a total of 6.6 miles as noted above.

Field data collected depended somewhat on the specific shoreform being evaluated, but in general included the following information:

- weather, time, location
- geomorphic bluff characteristics
- geology exposed in bluff or determined from published mapping
- sediment grain size, relative erodibility
- beach substrate characteristics – sediment and wood
- human impacts, characteristics of development, drainage, etc.
- type and stability of vegetation on bluff
- any other relevant observations

Results

All data were compiled and analyzed to enhance understanding of the occurrence of feeder bluffs and other geomorphic shoretypes throughout the Puget Sound region. Shoretype data were analyzed Sound-wide, within each drift cell, and within each county, to support countywide shoreline management. A set of 1:100,000 scale maps of the final mapping product are in the attached map folio, which includes both shoretype and net shore-drift mapping. The following data summaries can be used together with the maps to gain greater understanding of the extent and condition of feeder bluffs and other geomorphic shoretypes in the Puget Sound region. The accuracy assessment of all data is included in Appendix D.

Sound-wide Summary

Of Puget Sound's 2,459 miles of shoreline, 1,076 miles were identified as areas with No Appreciable Drift (NAD) and the remaining 1,383 were classified as part of a net shore-drift cell (Table 10). Over one-thousand miles of Puget Sound consist of areas with no appreciable drift, due to a variety of conditions and contrasting nearshore environments. The majority NAD areas occurred along shores with bedrock geology, where minimal sediment transport occurs (Table 11, Figure 10). These areas also typically include pocket beaches, which are distinctively different from the bedrock shores that contain them. Sheltered shores such as inner lagoon shores, bayheads, and exceptionally sheltered inlets accounted for approximately 27% of the NAD shoreline (NAD-LE). Large deltas (NAD-D) and artificial shores (NAD-AR) represent the remaining NAD shore in near equal proportions.

Table 10. Summary of shoretypes Sound-wide (across the entire Puget Sound region, not just in drift cells). FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Shoretype	FBE	FB	FB-T	TZ	AS	MOD	NAD	TOTAL
Length (mi)	51.5	365.6	19.3	224.6	269.2	452.9	1076.5	2459.7
Percent	2%	15%	1%	9%	11%	18%	44%	100%

Table 11. NAD type breakdown Sound-wide.

NAD Class	Low Energy (LE)	Bedrock (B)	Delta (D)	Artificial (AR)	Total
Miles	287.2	414.5	185.7	189.2	1,076.5
Percent	27%	38%	17%	18%	100%

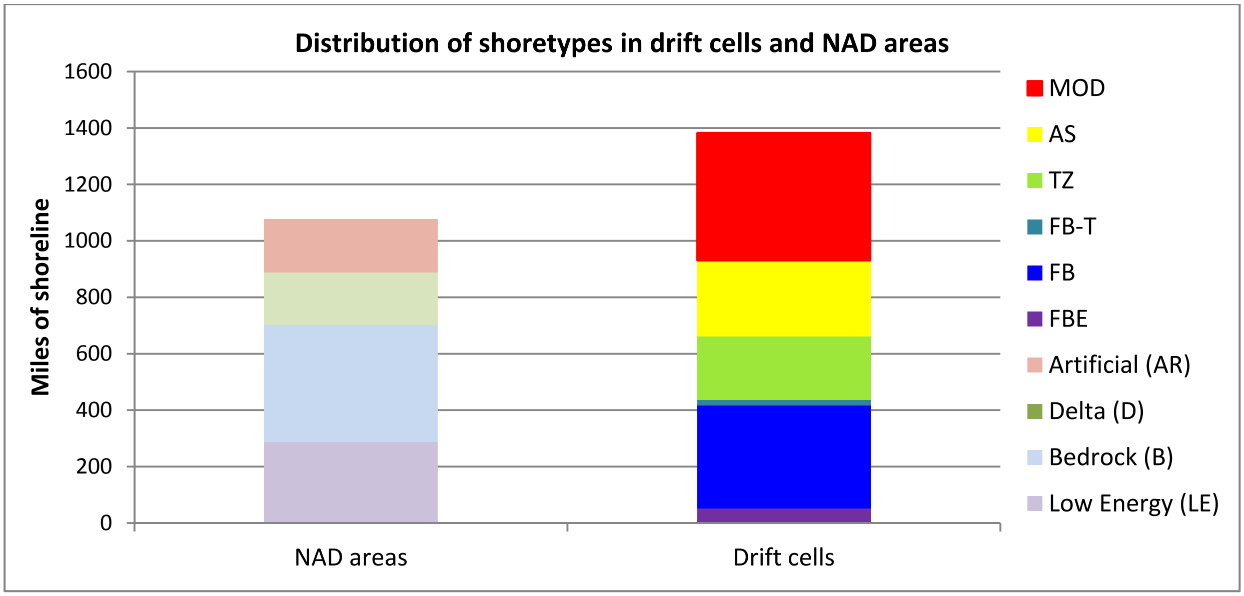

Figure 10. Miles of shoretypes found in drift cells and NAD areas in the Puget Sound region. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Feeder bluff mapping was limited to the 1,383 miles of shore in which net shore-drift cells are mapped. Feeder bluffs were mapped along over 365 miles of shore (15%), with an additional 51 miles of feeder bluff exceptional shore (2%, Table 10, Figure 10). Feeder bluff exceptional units typically deliver greater quantities of sediment to the nearshore and deliver it more frequently than do feeder bluffs. Therefore these units are highly valued sediment sources. Feeder bluff – talus units were mapped along approximately 19 miles of shore (1%), primarily in the northern reaches of the region (Table 10, Figure 11).

Within Puget Sound drift cells only (excluding NAD shores), feeder bluffs accounted for an average of 22% of the drift cell. The median percent feeder bluff per Puget Sound drift cell is on the order of 16% (Table 12). The lower median value indicates that most drift cells have less than 22% feeder bluff and that few drift cells have considerably higher ratios of feeder bluff. The high standard deviations of feeder bluffs, transport zones, accretion shoreforms, and modified shores are indicative of the highly variable abundance of those shoretypes across Puget Sound drift cells. In contrast, feeder bluff-talus and feeder bluff exceptional units were consistently rarer across drift cells.

Table 12. Summary statistics of the percent of each shoretypes found within all Puget Sound net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	2.1	22.1	1.2	21.8	17.9	34.9
Median	0.0	16.1	0.0	14.3	11.4	24.9
Std Dev	8.0	23.0	7.6	23.6	20.6	33.0

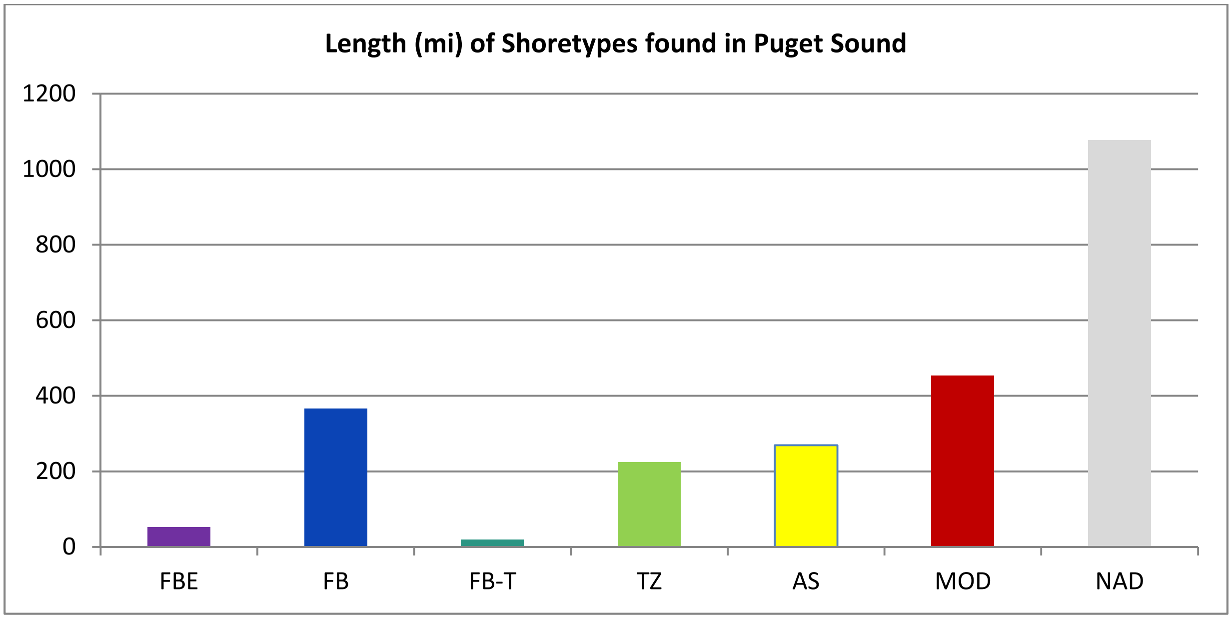

Figure 11. Summary statistics of the percent of each shoretypes found Sound-wide. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Landslides and toe erosion were mapped as ancillary data throughout much of the Sound-wide data set. The presence or absence of landslides and toe erosion are documented in the attribute table for each shoretype unit. Cumulatively over 50% of feeder bluffs had either landslides, toe erosion, or both, to support the classification of that shoretype unit. Approximately 30% of feeder bluff units had neither landslides nor toe erosion. Landslides and toe erosion were not mapped as part of feeder bluff mapping efforts in some areas, resulting in approximately 16% of the feeder bluffs with no landslide or toe erosion data.

Armored or modified shores were more prevalent than any other shoretype (excluding NAD shores), cumulatively accounting for 18% of the study area. The average drift cell in Puget Sound is close to 35% modified (Table 12). Together, the various types of feeder bluffs accounted for the same fraction of Puget Sound shoreline as modified shores, with feeder bluffs as a whole representing the greatest length of shoreline (365.6 miles; Table 10). Accretion shoreforms and transport zones were slightly less prevalent than feeder bluffs and represented comparable portions of the larger Sound-wide region (Table 10, Figure 11). The average Puget Sound drift cell is comprised of roughly 18% accretion shoreforms and 22% transport zones (Table 12). It is important to be mindful that modified shores were not mapped within NAD areas, and these totals do not represent Sound-wide shoreline armor mapping. Armor was also not comprehensively mapped in several of the existing feeder bluff mapping data sets, including parts of Island, Clallam and parts of Whatcom Counties. Additionally, if armor was dilapidated to the point that sediment transport was occurring landward of the structure then that area was not mapped as modified.

All modified shores were classified, where possible, based on whether or not the reach of shore was a historic feeder bluff. Previous research on the historic conditions of armored shores has been conducted by CGS in Bainbridge Island, San Juan County, and portions of Pierce, Island, and Skagit Counties. Throughout field mapping all modified shores were classified based on field observations of whether or not a modified shore was a historic feeder bluff or if more research was required to classify the unit. If the mapping classification could not be made without considerable uncertainty, then the unit was classified as "Unknown". Both existing mapping in which no historic had been applied and most new remote mapping were classified as having "No Data (ND)" with regard to whether or not a modified shore was historically a feeder bluff. Mapping results show that approximately 32% of the modified shores, measuring a total of 147 miles, were clearly feeder bluffs prior to being modified, while 34% (156.1 miles) were not historic feeder bluffs (Table 13). Further research would be required to understand the historic condition of shores classified as unknown as well as those modified shores that were mapped in previous efforts that did not include interpretation of the historic condition of modified shores (classified as no data).

Table 13. Historic classification of bluffs for modified shores throughout Puget Sound drift cells.

Modified shores	No data	Not historic feeder bluff	Unknown	Historic feeder bluffs	Total
Miles	46.2	156.1	113.4	147.4	462.9
Percent	10%	34%	24%	32%	100%

County Summary

The variability in mapping results between counties as revealed in the data reflects the broad variability throughout Puget Sound in geology, topography, tidal range, and wave energy from north to south, and to a lesser extent from east to west. The effects of glaciation (ice thickness and sediment distribution), superimposed on regional tectonics (faulting), have resulted in a predominance of bedrock; younger, more erodible, and generally thicker glacial sediments; greater post-glacial uplift; and more localized topographic relief in the northern portions of the region. Wave erosion of exposed bluff sediments tends to be more active in the northern reaches of Puget Sound due to the greater fetch and therefore higher wave energies, and the smaller tidal range results in more persistent wave attack over time.

The types of NAD shores varied across counties based on regional conditions, and in some cases, were far greater than the length of shore with drift cells (Tables 14 and 15, Figure 12). NAD-D areas were only mapped in areas that have large river deltas. NAD-AR areas were typically associated with urban and industrial waterfront areas and were considerably less abundant in more rural areas, such as in Mason County. The BNSF rail lines and associated major armor and causeways contributed considerable NAD-AR shore to the counties in which the railway runs along shore including portions of Whatcom, Snohomish, King, and Pierce counties. NAD-B shores were most abundant in the northern counties (San Juan, Clallam, and Whatcom Counties), with the greatest length of NAD-B shore occurring in San Juan County. NAD-LE areas were abundant throughout most counties; however, the greatest lengths occurred in South Puget Sound counties (Kitsap, Mason, Pierce, and Thurston Counties).

The greatest percentages of feeder bluffs were mapped in Jefferson County, followed by Island, Kitsap, Mason, and Pierce Counties (Table 15, Figure 13). Feeder bluff exceptional units were most abundant in Island and Clallam Counties, where high bluffs are exposed to some of the longest fetch in the region. Feeder bluff-talus shores occurred where eroding bedrock geology occurs, including Clallam County, with lesser prevalence in Jefferson, Whatcom, and Skagit Counties (Table 15 and 16). Accretion shoreforms comprised the greatest proportion of county shoreline in Island, Clallam, and Jefferson Counties (Figure 13, Table 15).

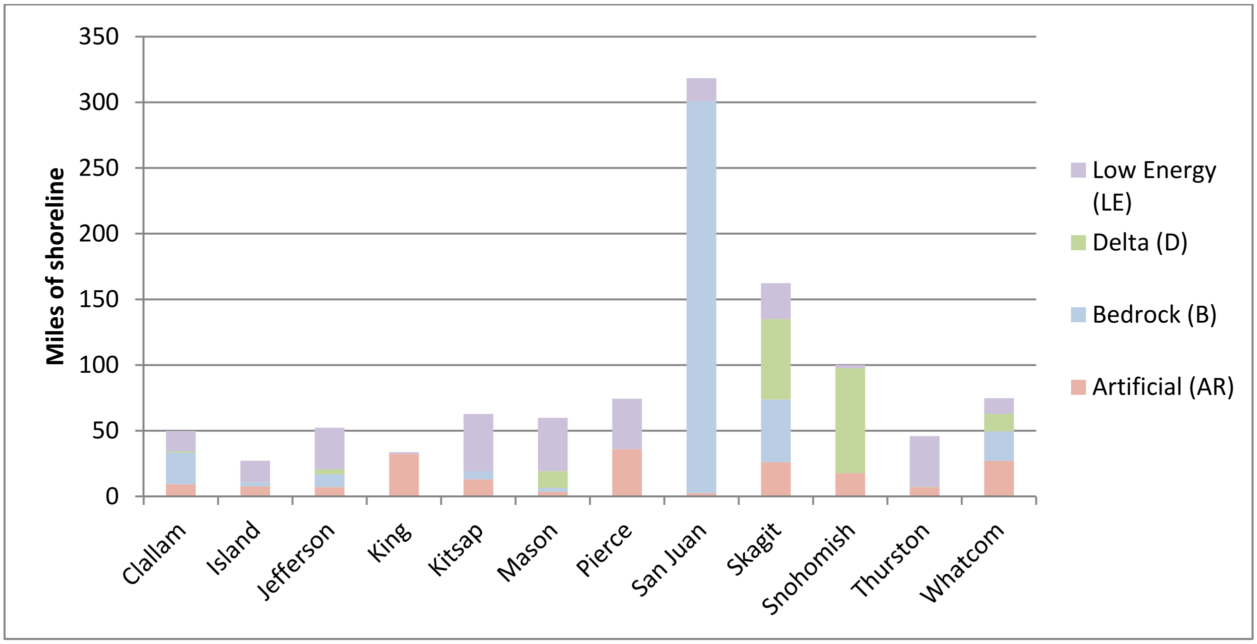

Figure 12. Miles of NAD-type by county.

Table 14. NAD types by length (in miles) and percent across Puget Sound counties.

County	NAD-Artificial		NAD-Bedrock		NAD-Delta		NAD-Low Energy		Total
	Length	%	Length	%	Length	%	Length	%	
Clallam	9.3	19%	24.0	48%	0.9	2%	15.6	31%	49.8
Island	7.7	28%	3.1	11%	0.0	0%	16.4	60%	27.2
Jefferson	7.1	14%	9.7	18%	3.9	7%	31.6	60%	52.3
King	32.3	96%	0.0	0%	0.0	0%	1.3	4%	33.7
Kitsap	13.1	21%	6.0	10%	0.0	0%	43.7	70%	62.8
Mason	3.4	6%	3.0	5%	12.8	21%	40.6	68%	59.8
Pierce	35.9	48%	0.0	0%	0.1	0%	38.5	52%	74.4
San Juan	2.6	1%	298.2	94%	0.0	0%	17.6	6%	318.4
Skagit	25.9	16%	47.8	29%	61.3	38%	27.3	17%	162.3
Snohomish	17.6	18%	0.0	0%	80.1	80%	2.4	2%	100.1
Thurston	7.1	16%	0.0	0%	0.3	1%	38.5	84%	45.9
Whatcom	27.1	36%	22.5	30%	13.3	18%	11.9	16%	74.7

Table 15. Percent of each shoretype by county. Drift cells that crossed county lines were included in both countywide summaries, resulting in some double-counting, however this source of error is relatively minor. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift. Length is recorded in miles.

County	Length	FBE	FB	FB-T	TZ	AS	MOD	NAD	Total
Clallam	161.9	6%	8%	7%	12%	23%	13%	31%	100%
Island	213.8	7%	28%	0%	11%	31%	10%	13%	100%
Jefferson	201.7	4%	30%	2%	11%	16%	11%	26%	100%
King	125.8	3%	14%	0%	4%	7%	45%	27%	100%
Kitsap	258.4	1%	21%	0%	11%	9%	34%	24%	100%
Mason	230.2	0%	19%	0%	16%	9%	30%	26%	100%
Pierce	250.3	2%	19%	0%	11%	5%	34%	30%	100%
San Juan	408.2	1%	4%	0%	8%	5%	3%	78%	100%
Skagit	227.0	1%	8%	1%	5%	6%	8%	72%	100%
Snohomish	139.1	1%	5%	0%	1%	3%	19%	72%	100%
Thurston	109.8	0%	15%	0%	11%	3%	30%	42%	100%
Whatcom	146.3	1%	14%	1%	7%	19%	7%	51%	100%

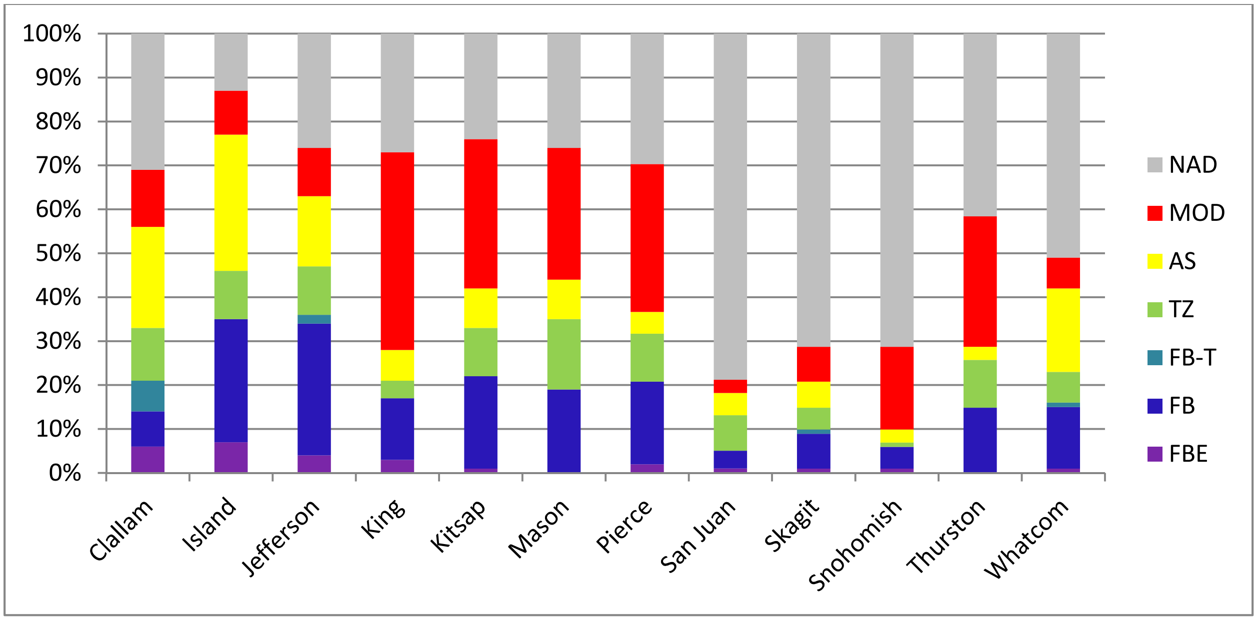

Figure 13. Percent of each shoretype by county. Drift cells that crossed county lines were included in both countywide summaries, resulting in some double-counting, however this source of error is relatively minor. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift. Length is recorded in miles.

Table 16. Cumulative length in miles of each shoretype by county. Drift cells that crossed county lines were included in both countywide summaries, resulting in some double-counting, however this source of error is relatively minor. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift. Length is recorded in miles.

County	Length	FBE	FB	FB-T	MOD	TZ	AS	NAD
Clallam	161.9	10.1	12.9	11.4	21.7	19.4	36.5	49.8
Island	213.8	15.7	59.0	0.0	20.9	24.1	66.8	27.2
Jefferson	201.7	8.7	59.7	3.9	22.0	22.1	33.1	52.3
King	125.8	3.9	18.0	0.0	56.7	4.9	8.7	33.7
Kitsap	258.4	1.4	54.5	0.0	87.6	28.7	23.4	62.8
Mason	230.2	0.1	44.0	0.0	69.8	36.4	20.1	59.8
Pierce	250.3	4.2	47.2	0.0	84.8	26.7	13.0	74.4
San Juan	408.2	2.7	18.3	1.5	12.3	32.7	22.3	318.4
Skagit	227.0	1.8	17.9	1.3	18.6	12.3	12.8	162.3
Snohomish	139.1	0.9	6.7	0.0	25.9	0.8	4.7	100.1
Thurston	109.8	0.1	15.9	0.0	32.8	11.7	3.4	45.9
Whatcom	146.3	2.0	20.3	1.5	9.8	10.6	27.4	74.7

Similar to the shoretype percentages across counties, the combined length of each shoretype was highly variable throughout the region (Table 16). The greatest lengths of accretion shoreforms were mapped in counties that also had the greatest lengths of feeder bluffs: Island and Jefferson Counties. Similarly, Clallam County had considerable lengths of both feeder bluff exceptional and accretion shoreforms. The greatest lengths of modified shore were mapped in Kitsap County, closely followed by Pierce County. Mason and King Counties also had considerable lengths of modified shore.

The greatest percentages of modified shores were mapped in King, Kitsap, Pierce, Mason and Thurston Counties, all of which were more than 30% modified (Table 15). Lesser, yet considerable, portions of modified shore were mapped in Snohomish, Jefferson and Clallam Counties. The lengths and percentages of each shoretype within each drift cell throughout each county are summarized in the Tables displaying drift cell data for each county are found in Appendix E.

The greatest lengths of modified shore that were clearly identified as historic feeder bluffs were mapped in Pierce, Kitsap, King, and Mason Counties (Table 17, Figure 14). The mapping of this data can easily be displayed in GIS using the feeder bluff mapping geodatabase, but was not included in the attached map folio due to scale issues. There were no data available and no field assessment to accurately classify the historic condition of certain modified shores including portions of Clallam Island, Kitsap and Whatcom Counties, although uncertainty exists in the historic interpretation of feeder bluffs in all counties. In addition, remote mapping efforts did not include characterizing if a modified reach of shore was a historic feeder bluff. Additional research is required to determine if considerable lengths of armored shore were historically feeder bluffs (labeled as Unknown, Table 17). In Figure 14, both the armored shores that are unknown with those that have not previously been assessed (no data) lumped together. Together these shores represent an opportunity for additional research, and potentially the identification of more historic feeder bluffs. Comparing this data with unarmored feeder bluffs and armored feeder bluffs, can provide insight into the degree to which armor has impounded feeder bluffs across the different Puget Sound counties. All feeder bluff types are also lumped together in this figure.

Table 17. Historic feeder bluff classification of modified county shore by length (in miles) and by percent. ND = No Data, Not HFB = Not Historic Feeder Bluff, Unknown = Needs more research, HFB = Likely Historic Feeder Bluff.

County	No Data		Not HFB		Unknown		HFB		Total MOD Length
	Length	%	Length	%	Length	%	Length	%	
Clallam	12.7	59%	6.3	29%	0.9	4%	1.8	8%	21.7
Island	18.1	87%	0.5	2%	0.2	1%	2.2	11%	20.9
Jefferson	0.0	0%	13.3	60%	1.9	9%	6.8	31%	22.0
King	11.5	20%	12.0	21%	9.4	17%	23.7	42%	56.7
Kitsap	0.0	0%	38.0	43%	25.6	29%	24.0	27%	87.6
Mason	0.0	0%	33.9	49%	16.0	23%	20.0	29%	69.8
Pierce	0.0	0%	24.1	28%	31.4	37%	29.3	35%	84.8
San Juan	0.0	0%	4.7	38%	2.5	20%	5.1	41%	12.3
Skagit	0.0	0%	7.3	39%	5.0	27%	6.3	34%	18.6
Snohomish	1.1	4%	6.7	26%	2.3	9%	15.9	61%	25.9
Thurston	0.0	0%	6.5	20%	17.5	53%	8.8	27%	32.8
Whatcom	2.8	29%	2.8	29%	0.7	7%	3.5	36%	9.8

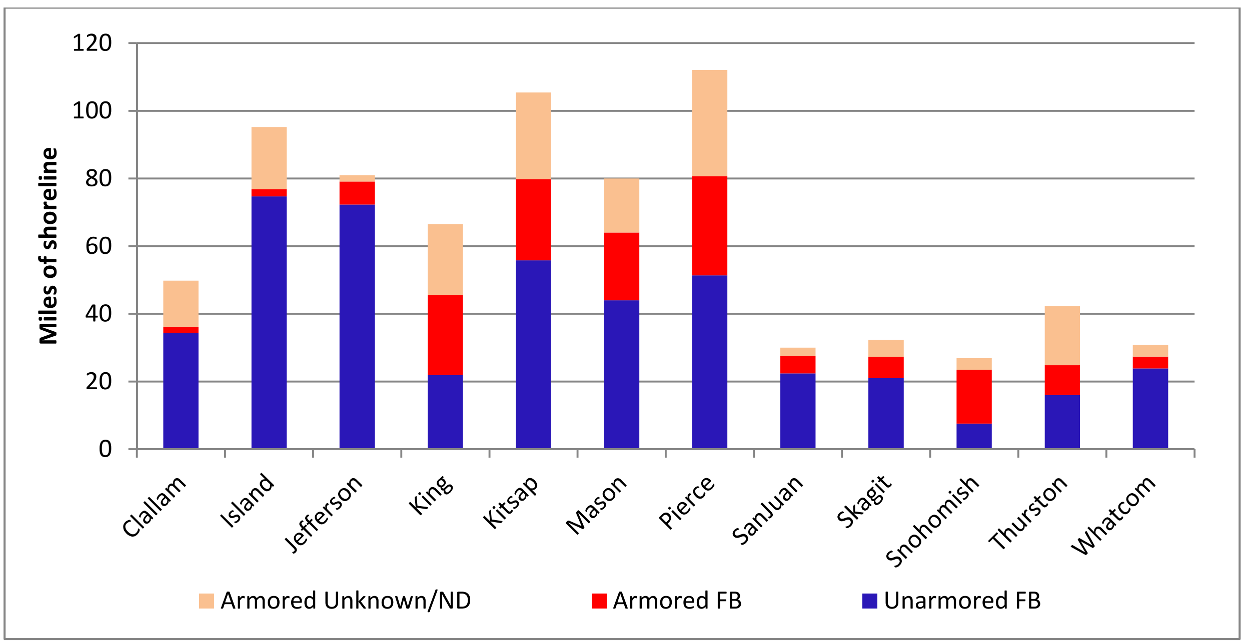

Figure 14. Unarmored feeder bluffs, armored feeder bluffs, other armored shores and armored shores that require more research.

Discussion

Sound-wide feeder bluff mapping enhances understanding of regional variability of bluffs and other geomorphic shoreforms in the Puget Sound region, provides a valuable foundation for furthering local understanding of coastal geomorphic processes, and provides a needed tool for improved shoreline management.

The ubiquitous nature of feeder bluffs in Puget Sound has long been known; however, the diverse character of these bluffs and their larger systemic value as a source of nearshore sediment input has only gained attention in recent decades. Not all Puget Sound bluffs are feeder bluffs. Hundreds of miles of bluffs are mapped as transport zones, contributing sediment less actively at negligible to low rates. Wave exposure, stratigraphy, upland topography, and land cover are all contributing factors to whether or not a bluff is "feeding" sediment to the nearshore. The gradient between transport zones and actively eroding feeder bluffs is difficult to discern and exact boundaries are subject to interpretation. Boundary delineation is often guided by the age and assemblages of vegetation observed on the bluff face in combination with long-term factors within the mapping criteria such as bluff height. Interpreting the precise points of delineation requires examination of these multiple criteria at bluffs where the vegetation has been cleared or topography altered.

There is a large range in the character of feeder bluffs, particularly the angle of repose (primarily a function of bluff geologic composition and consolidation), vegetative cover, and wave energy (Figure 15). Feeder bluff and feeder bluff exceptional classifications can differ by approximately an order of magnitude in the volume of sediment they supply.

Feeder bluffs exhibit varying degrees of regional and local significance, depending on their location in each drift cell. Some drift cells are composed of miles of high-elevation bluffs that are actively contributing large volumes of sediment. At the other end of the spectrum, some drift cells in low-wave-energy areas have no feeder bluffs, only transport zones with intermittent toe erosion as sediment sources. Drift cell length plays a role in the relative importance of bluff sediment supply, as shorter drift cells typically have shorter lengths of feeder bluffs.

Once sediment is delivered from the bluff the fate of that sediment is also relevant. In some drift cells sediment sinks—in the form of dredged channels, tide channels, and deep water sinks—receive large volumes of littoral sediment. Sediment delivered from divergence zones is of high local significance, as in those cases bluffs are supplying sediment to two down-drift coastal systems. The shoreforms, habitat structure, and function of down-drift shores also appear directly related to the local distribution of feeder bluffs.

Accretion shoreforms across the region also exhibit considerable variability in their character and configuration. Many accretion shoreforms developed as a result of accretion but are not currently accreting or actively prograding, although their name implies otherwise. Accretion shoreforms are dynamic features reliant upon up-drift sediment sources and adjusted by large wave events; they are highly sensitive to alterations that prohibit the self-regulating processes, such as littoral transport and overwash, which preserve the dynamic equilibrium. Other variables that influence the character of accretion shoreforms across the region include volume of sediment supply, presence or absence of fluvial sediment supply, tidal range, LWD abundance, shoreline complexity, and tectonic uplift.

Qgt (Vashon till) – Pitt Island, south Puget Sound

Qps (formerly Kitsap Formation) – Pitt Passage near Filucy Bay

Qps (formerly Kitsap Formation) – Nisqually Reach

Qc(w) (Whidbey Formation) – Colvos Passage, Deep seated LS

Qgd(d) (Double Bluff Frm) – Double Bluff, Whidbey Island

Qgom(ee)(glacial outwash, marine) – Lummi Peninsula

Figure 15. Range of character of Puget Sound feeder bluffs. Surficial geology is noted for each site.

Sound-wide feeder bluff mapping data can be used to guide additional research endeavors across the incredibly diverse and complex 2,500 miles of shore. There are many directions from which to build upon these data. The qualitative nature of this mapping approach could be enhanced by linking or calibrating the mapping categories with quantitative data. Stratified sampling across shoreforms exploring the relative erosion rates, sediment input volumes, and associated drivers would be very informative. CGS recently explored similar patterns in San Juan County. Statistical analyses of the variable shoretype composition of drift cells throughout the region could help to identify patterns across the larger landscape. Initial investigations of this nature documented a correlate (of moderate strength) between feeder bluff length and accretion shoreform lengths within drift cells. Research that would build toward a suite of representative sediment budgets for the range of drift cells in the region would inform better management of feeder bluffs as well as begin to quantify the long-term impacts to sediment supply resulting from armored feeder bluffs. Additionally, understanding the degree of landscape sensitivity to degraded sediment supply would prove valuable. Sensitivity is likely associated with the magnitude of degradation, in addition to other local variables of influence (such as sediment transport rates, etc.); however, because time lags are thought to exist, the temporal scale will be an important parameter in the successful design of research of this nature.

Having Sound-wide feeder bluff maps available for resource managers should result in improved management that integrates physical processes with the needs of both humans and fish and wildlife. Feeder bluff maps may provide baseline measures of current conditions to aid management agencies—county and city governments and other entities—in assessing the efficacy of current feeder bluff protection regulations and needs for improvement, as well as suggesting how no net-loss of feeder bluff shoreline (i.e., prevention of new armor on feeder bluffs) might be achieved.

Feeder bluff mapping also provides an opportunity to take some of the first steps towards regional sediment management, through evaluating sediment management issues at the drift cell scale. Regional management of sediment derived from feeder bluffs has been applied in several other areas in the country as well as internationally. Reviewing the effective approaches to sediment management applied elsewhere could help to develop a similar program(s) in the Puget Sound region. Additionally, concepts such as “sand rights” that merge sediment supply issues with societal laws of public trust can develop from feeder bluff mapping data, which could be useful in the face of large-scale sediment supply degradation.

Conclusion

Data assessment, compilation, and new mapping have resulted in a high-quality, comprehensive Puget Sound-wide feeder bluff and related geomorphic data set. This data set is valuable in many ways, including the potential to provide a foundation for achieving greater understanding of geomorphic processes in the Puget Sound region over time. Ideally, these data will aid in the preservation of feeder bluffs in the Puget Sound region, particularly in the many shoreline jurisdictions that mandate feeder bluff protection but that did not previously have spatially explicit documentation of where feeder bluffs occur. These data can also be paired with habitat data, to enhance nearshore ecosystem management and salmon recovery planning.

Despite the completion of Sound-wide coverage, several opportunities exist to fill in minor gaps in the data as well as to build on existing data. More research could be conducted to elucidate the historic condition of a limited extent of armored or modified shores that have not previously been studied or have been identified as requiring more research to fully characterize (Table 17). Incorporating the direction of net shore-drift could also enhance this data product so it can be used to better inform regional sediment management at the drift cell scale.

Finally, the mapping of bedrock shores could be improved to incorporate pocket beaches. Current pocket beach mapping is very coarse in scale and contains a significant amount of error. Also, many additional beaches exist that have not previously been mapped. Pocket beaches are often lumped with bedrock shores which can lead to their value as habitat and for recreation being overlooked.

These data can be fundamental in exploring the relative change rates across different geomorphic shoretypes throughout the region and exploring how change rates may be influenced by other variables such as exposure, geology, sediment supply, sediment transport, and shore armor. Results of this nature could inform managers and potentially lead to better shore management and resource protection, particularly in the context of climate change and sea level rise.

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Appendices

Appendix A: GIS Data Processing

Data processing in GIS constituted a large and very important role in the Feeder Bluff Mapping project, as GIS provided the platform for the final data delivery of a geodatabase. Much consideration was given to data processing procedures prior to the commencement of the project to ensure a seamless, high quality data product. GIS data processing procedures applied over the duration of the project are detailed below.

Geoprocessing Existing Data Sets

Following assessment and acceptance of existing feeder bluff mapping data sets, a number of geoprocessing tasks were performed to ready the data sets for inclusion into the larger Puget Sound-wide feeder bluff geodatabase. The sequence of tasks is displayed in Figure A-1 and included the following:

- transfer of the existing mapping to the statewide best available science shoreline projected in NAD 1983 State Plane South - Feet (WDNR ShoreZone shoreline; WDNR 2001)
- review and revision of shoreform boundaries as necessary
- population of the attribute table accordingly
- application of topology to detect mapping errors such as additional mapping units that were not clearly visible or adjacent shoreline units that were not contiguous, and correction of all errors

After completing these processing steps, a final technical review was performed by a senior geomorphologist and all necessary changes were applied to appropriate fields in the attribute table.

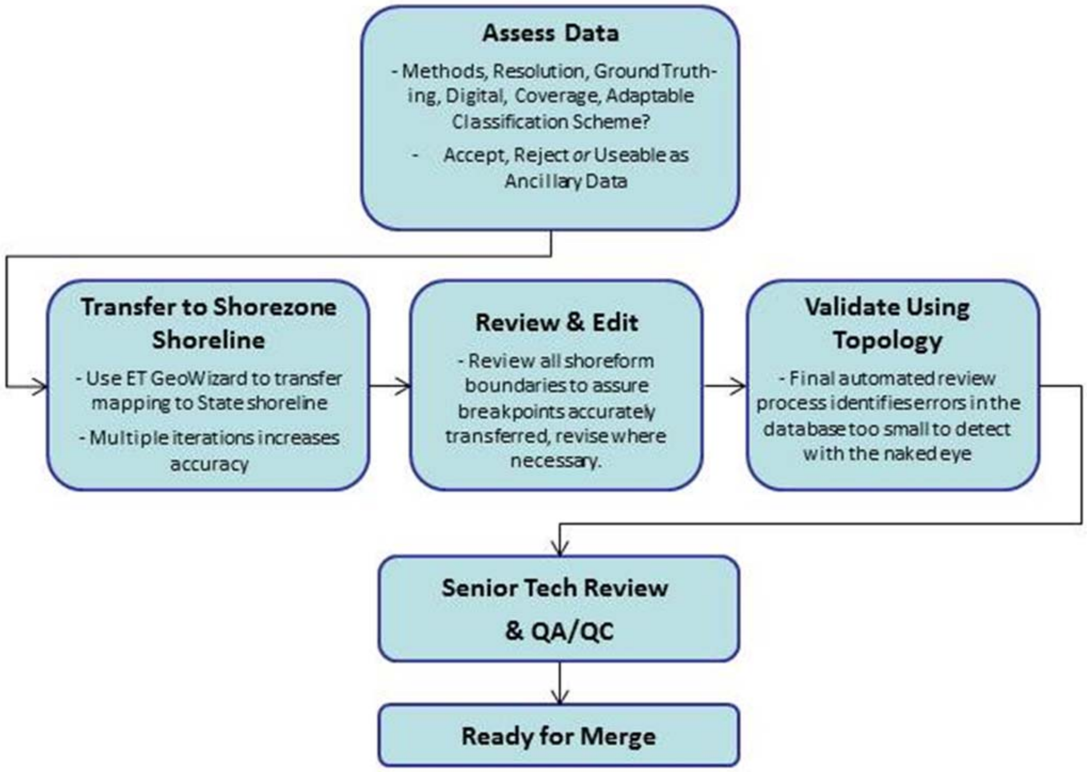

Figure A-1. Flow chart showing data processing steps taken to refine existing data for inclusion into Sound-wide geodatabase.

Most data sets were originally digitized (and snapped) to a WDNR ShoreZone shoreline. Unfortunately the original data sets had a considerably lower density of vertices on the shoreline than the state data set, which could both sacrifice resolution and impair the usability of the new data by producing erroneous query results. These data were transferred to the original ShoreZone shoreline using ET GeoWizard's Global Snap Polyline Wizard. Multiple iterations of snapping were run until the old and new shoreline delineations matched acceptably.

Once the shoretypes were accurately delineated on the ShoreZone shoreline, the attributes were reviewed and corrected as necessary. Some minor revisions were necessary for all the data sets to be in a consistent format (Figure A-1). Table A-1 shows each of the attributes and allowed values included in the geodatabase structure.

For example, the Mason County feeder bluff mapping data set (Johannessen 1999) was created when the CGS mapping typology was still under development and an alternative feeder bluff category was applied for slowly eroding bluffs, referred to as "contributing bluffs." Each of the areas mapped as contributing bluffs (Source_Stype) were reassigned to the feeder bluff shoretype (First_Stype) and areas mapped as feeder bluff (Source_Stype) were reassigned to feeder bluff exceptional (First_Stype) shoretypes. Modified shores were also not mapped comprehensively as part of this data set; so armored shores were integrated from the Puget Sound Change Analysis (Simenstad et al. 2011). Because shoretypes in Mason County data set were mapped regardless of the presence of shoreline modification, the historic feeder bluff attribute was populated by referencing existing mapping for currently armored shores. For example, where a feeder bluff (or contributing bluff) was mapped along a segment of armored shore, that unit would be reclassified as "modified" and the historic feeder bluff attribute was assigned a "Yes" value, as the original field mapping had verified a feeder bluff in that armored reach of shore.

The most recent shoretype to be appended into the CGS mapping typology is the feeder bluff-talus unit (FB-T). Feeder bluff-talus shoretypes represent areas in which bedrock is actively eroding and contributing to the structure and substrate composition of adjacent beaches (MacLennan et al. 2011). While CGS was reviewing all accepted feeder bluff mapping data sets to be incorporated into the final Sound-wide coverage, a number of mapped shoreline reaches in San Juan County (mostly in East Sound, Orcas Island) required additional updates to incorporate the FB-T unit, as the shoretype was introduced after the CGS San Juan County field mapping occurred.

After fully populating and applying necessary revisions to the attribute table, topology was applied to identify any minor errors in the mapping units. Each minor error point was addressed and revisions were applied as necessary. Senior technical review was then conducted by coastal geomorphologist Andrea MacLennan. A minimum of 10% of the shoreforms (by count) were randomly reviewed to assure accurate spatial location and attributes for each data set. A number of queries were then performed in GIS to identify any potential errors in the geodatabase that could have resulted from typos and other simple oversights. These quality assurance protocols helped to assure that the data sets could merge easily and maintain a high level of quality. Before finalizing the complete data set Status, Source_Stype and First_Stype were removed from the attribute table, however these data can be accessed as interim products delivered to Ecology.

Table A-1. Attribute table of Puget Sound feeder bluff mapping geodatabase.

Attribute Name	Description	Type	Allowed values
Shoretype	Code for Final Shoretype	Text (6)	FBE, FB, FB-T, TZ, AS, NAD-B, NAD-LE, NAD-D, NAD-AR, MOD
Historic_FB	Flag for presence of historic feeder bluff	Text (25)	Yes, No, Unknown, Not Applicable, No Data
Landslide	Flag for presence of landslide	Text (25)	Yes, No, Not Applicable, No Data
Toe_Erosion	Flag for presence of toe erosion	Text (25)	Yes, No, Not Applicable, No Data
DCELL_NR	Drift Cell Identifier	Text (20)	From Net shore-drift data set -- alphanumeric identifier
CELL_TYP	Drift Cell direction or type	Text (4)	From Net shore-drift data set -- RtoL, LtoR, NAD
HistFB_Method	Method used to determine historic feeder bluff presence	Text (25)	Field, HSSI, Remote, Not Applicable, No Data
Data_Source	Shortened data source name	Text (40)	Abbreviation for each source, including the year. Metadata provides full reference .
Shoretype_Certainty	Certainty of remote mapping. For remote mapped areas ONLY.	Text (20)	High, Moderate, Low, Not Applicable
Source_Stype	Shoretype from original data source. This is the basis for the translation from the source classification to the final shoretype. This attribute is NA for all new mapping.	Text (6)	AS, AS-MB, AS-MH, AS-MI, AS-SM, AS-SM, CB, FB, FBE, FB-T, M, MH, MOD, M-RR, NA, NAD, NAD_B, NAD-B, NAD-LE, ND, PB, TZ
First_Stype	First_Stype was used to translate from Source_Stype of existing data,, if changes were required. For new mapping, First Stype is the initially assigned shoretype. These values were compared to the review shoretype for the accuracy assessment.	Text (6)	FBE, FB, FB-T, TZ, AS, NAD-B, NAD-LE, NAD-D, NAD-AR, MOD
Review_Stype	Shoretype assigned by the reviewer for QA/QC of the originally assigned shoretype and the basis of the error matrix.	Text (6)	FBE, FB, FB-T, TZ, AS, NAD-B, NAD-LE, NAD-D, MOD
Review_Date	Date that the segment was validated/reviewed	Date	A valid date
Reviewer	Initials of the person who validated/reviewed	Text (2)	WG, JJ, AM, SW, JW
Status	Status of shoreline regarding completion, need for revision, or need for new mapping	Text (20)	Complete, Needs Revision, To be Mapped
Mapping_Method	Description of mapping method used: a compilation of previously existing data sets, or via new field or remote mapping	Text (20)	Existing, Field, Remote

Appendix B: GPS Standard Operating Procedures

Global Positioning System Unit

Positional waypoint data are recorded using a handheld *Trimble GeoXH 2008* GPS unit in the WGS84 coordinate system. The GPS unit is WAAS (wide area augmentation system) enabled, the range of accuracy is a function of the number of satellites within range, but is typically less than 1 m real time. The GPS automatically calculates and records the dilution of precision for each position, and alerts the user if the value falls below a given threshold, thereby assuring a certain standard of accuracy. The estimated accuracy of these positions is ± 1.5 ft. Base data from the Washington Continually Operating Reference Stations (CORS) will be used to post-process the waypoint locations.

Operating Procedures

Collecting Field Data

Features are mapped by collecting GPS waypoints based on field observations from a small boat offshore at mid to high tides with good visibility. Field mapping criteria (Table 7) are applied to map individual segments in the field based on observed shoreline features. GPS waypoints are collected and noted at the beginning and end of each field-mapped segment as close inshore to the position of mean high water (MHW) as possible.

Field Form Notation

The waypoints are correlated to shoretype segments that occur between the noted waypoints. For instance, the start of a segment noted as FB starts at waypoint 50 and ends at waypoint 51 as noted on the field form, so the segment between these waypoints is identified as a feeder bluff. Corresponding photographs and notes are recorded on field forms. As well, ancillary data such as landslides, toe erosion, or potential restoration areas may be noted on the field form. See Appendix 2 of the QAPP for field forms and Tables 7 and A-1 of this report for shoretype abbreviations.

Data Backup and Processing

Data collected from each field day will be transferred to a laptop after each working day (if electrical power is available). This includes GPS waypoint data, field photographs, and photographs of each field sheet. Batteries for GPS and camera will be charged each night and an extra battery will be on hand.

The GPS data are then downloaded for processing using Pathfinder Office (Trimble Corporation), where the data were post-processed using reference station SC02 from Washington State Reference Network (http://www.wsrn.org/). Post-processed data are then exported into ESRI shapefile format. The shapefile is then renamed and assigned the appropriate projection that the data were collected in (Washington State Plain South), and then ready for use in ArcMap 10.0 where the waypoint number will correspond with field data forms.

Appendix C: Net Shore-drift Revisions Methods

Revisions to net shore-drift were applied over the course of this project based on field observations while conducting new feeder bluff mapping. Although revising net shore-drift data was not the primary goal of the field mapping, shoretype classification was dependent on the location of net shore-drift or areas of no appreciable drift, and field mapping enabled the identification of areas in which some revisions were necessary. Changes to net shore-drift are reflected in the attribute table of the feeder bluff mapping data set and recorded in a data processing work log. Most of the changes made can be categorized into one of the following:

- No appreciable drift observed, e.g. area more strongly influenced by delta processes;
- Drift observed in an area previously mapped with as no appreciable drift;
- Change in direction of drift based on field indicators (this rarely occurred);
- Revisions aimed to reflect current conditions: drift cell segmented, truncated, or removed entirely due to NAD-Artificial;
- Small adjustments to the drift cell mapping due to a different shoreline, ie. moving to the ShoreZone shoreline;
- Small adjustments to the drift cell mapping as described in the original net shore-drift thesis mapping (Schwartz et al. 1991, Johannessen 1993, and Keuler 1988).

Net Shore-drift Cell Mapping

Digital net shore-drift mapping data were fundamental to this mapping effort, functioning as units of analyses and guiding the extent of the study area. The feeder bluff mapping criteria were exclusively applied within areas in which net shore-drift occurs (the long-term result of longshore sediment transport [littoral drift]). Areas in which net shore-drift does not occur have been mapped as No appreciable drift (NAD) in the regional net shore-drift data set.

Many revisions have been applied to the digital net shore-drift data set. New revisions identified and applied as part of this study were integrated with previous updates to create a new version of the net shore-drift data set. The methods and types of net shore-drift revisions are described further below following a brief background on the evolution of net shore-drift data in Puget Sound.

Several net shore-drift mapping data sets exist in the Puget Sound region. The original digital version of the data set was created from a compilation of paper maps and descriptive text published in Western Washington University Geology Department master's theses. These included mapping compiled in Schwartz et al. (1991) and Johannessen (1992). These hard copy maps were digitized by WDOE in the late 1990s. However, extensive areas were highlighted as "Unknown", blank areas (no data) were included, and net shore-drift was mapped in areas where no net shore-drift occurs (MacLennan and Johannessen 2008b). In addition, the original mapping was conducted on a WDOE mean high water shoreline, which is considerably different from the WDNR high water shoreline.

CGS has conducted many geomorphic assessments and mapping projects in the Puget Sound region. The first step for most of these studies entailed reviewing the net shore-drift data. In many areas, errors were found, and in other cases observations made during field mapping either confirmed or contradicted the digital net shore-drift mapping. Net shore-drift revisions and updates were predominantly applied as a result of field mapping, although some areas were reviewed and revised using shoreline oblique imagery (Clallam County). CGS maintained an updated net shore-drift layer in which all changes to the WDOE digital net shore-drift mapping were cataloged. Net shore-drift was mapped following relative changes in beach and bluff characteristics (as described in Jacobson and Schwartz 1981), including the following:

- In the direction of net shore-drift
  - sediment fines are found alongshore;
  - beach width increases;
  - streams are often deflected;
  - spit progradation occurs;
  - bluffs experience less mass wasting and become better vegetated.
- Sediment often accumulates on the up-drift side of anthropogenic features such as groins.

To determine the extent of a littoral drift cell when transitioning to an area of No appreciable drift (NAD), the point where littoral drift was no longer substantial was determined using the following criteria:

- The upper beach narrowed to a barely visible band or was composed of fines (mud and silt).
- Contiguous salt marsh vegetation occurred and an extensive mud/sand flat or low tide terrace dominated the intertidal.
- No other shoreforms created by littoral drift were present (e.g., nearshore bars, spits etc).

In 2008, under contract with Anchor QEA for the US Army Corps of Engineers, Coastal Geologic Services applied hundreds of revisions and refinements to the WDOE net shore-drift data set for the Puget Sound Change Analysis (MacLennan and Johannessen 2008b, Simenstad et al. 2011). In addition to addressing the specific problems listed above, the Change Analysis revisions also entailed interpreting historic net shore-drift in areas in which shoreline processes had been affected by shoreline modifications, such as ferry landings and marinas, and mapping divergence zones and convergence zones.

Over the course of this project many new net shore-drift revisions were identified and applied to the net shore-drift data set. The final net shore-drift data associated with this project represent a contemporary iteration of the data set that can be further refined and released if the client wishes to do so. Updates associated with this project entailed integrating all previous revisions by CGS, new revisions identified during field and remote mapping, and all revisions applied in the Change Analysis (Simenstad et al. 2011) *excluding* those that referenced historic net shore-drift conditions. For areas where historic drift was interpreted, current net shore-drift conditions were mapped, referencing the original WDOE data (Schwartz et al. 1991, Johannessen 1992).

For areas in which no appreciable drift was mapped, CGS staff noted the reason why no littoral drift occurred in the shoretype field of the attribute table. Data from the Puget Sound Change Analysis (Simenstad et al. 2011) was referenced to classify the appropriate type of NAD area. This remote mapping approach was applied by performing simple spatial queries with the net shore-drift data and the C_type field of the Change Analysis geodatabase (Simenstad et al. 2011). A limited degree of individual interpretation was necessary in few locations. The type of NAD areas directly corresponds with the C_Type attribute of the Change Analysis shoreform layer as shown in Table C-1. For example, if the NAD area was due to a lack of sediment such as along bedrock shores, “NAD-B” was noted in the attribute table. The extent of the NAD-B area was spatially coincident with the extent of the C_Type bedrock shoretype boundaries in Simenstad et al. (2011). It is important to note that NAD-B areas were not exclusively bedrock shores, and also included pocket beaches, which are by definition found outside of littoral drift cells. Additionally, the NAD-D classification was limited to the large-scale river systems analyzed in the Change Analysis.

Table C-1. NAD types, reason for why no net shore-drift occurs, and the current shoretype as mapped in Simenstad et al. (2011).

NAD type	Why NAD?	C_Type (Simenstad et al. 2011)
NAD-B (Bedrock)	Lack of sediment. Bedrock geology of nearshore precludes the presence of a beach.	Plunging Rocky shore (PL) or Rocky Platform (RP)
NAD-LE (Low Energy)	Low energy precludes alongshore continuous littoral transport.	Barrier Estuary (BE), Barrier Lagoon, Open Coastal Inlet (OCI)
NAD-D (Delta)	Fluvial-dominated system.	Delta (D)
NAD-AR (Artificial)	Large scale alteration of the shoreline precludes natural geomorphic function.	Artificial (ART)

By definition net shore-drift cells do not have exact boundaries and typically exhibit spatial and temporal variability in the precise location of their origin and terminus. This variability can occur seasonally, annually, or over the course of several years or several tens of years. Net shore-drift mapping includes drift cells as right to left or left to right movement along shore, divergence zones, convergence zones, and no appreciable-drift. Divergence zones represent a broad reach of shoreline that spans across the origins of two adjacent drift cells in which the precise location of diverging drift can oscillate throughout this zone. In contrast, convergence zones represent reaches of shore in which two net shore-drift cells converge, commonly resulting in sediment deposition that eventually leads to progradation of nearshore features. Similarly, the exact location of convergence or boundary of one drift cell meeting another can oscillate.

For the purposes of this study, divergence and convergence zones were excluded from the data set and shoretypes were reported as belonging to only a drift cell or was in an area of no appreciable-drift (NAD). This has been typical practice for prior feeder bluff mapping projects where assigning a precise boundary for drift cells was necessary to accurately attribute shoretypes for analysis of shoretype composition across the region's drift cells.

Determining where to place the origin and terminus of the drift cell, thereby excluding divergence and convergence zones, was done by splicing the shoretype at the center point of the divergence and convergence zones and attributing them with the corresponding adjacent net shore-drift cells. In some cases indicators clearly supported a precise origin or terminus location of the drift cell; splicing location was straightforward and not at the center point. For example, the extent of net shore-drift and location of the terminus can often clearly be interpreted at the extent of recurve at the distal end of a spit.

As a result, divergence zones and convergence zones were not included in this Puget Sound data set representing revised net shore-drift. Resource limitations precluded the CGS staff from integrating divergence and convergence zones back into the data set; however, this can likely be achieved with limited effort by WDOE or others.

NSD Quality Assurance Protocols

Several quality assurance and control measures were taken during the revision of net shore-drift mapping. During the mapping process the drift cell name and type were noted in shoretype feature class.

These attributes were reviewed as part of the larger QA/QC process. Following completion of Sound-wide coverage of feeder bluff mapping, additional revisions to the net shore-drift cell mapping were applied, which entailed additional QA/QC of the entire data set.

Appendix D: QA/QC Protocols & Accuracy Assessment Results

QA/QC Protocols

Data quality assurance protocols were developed for this project to achieve the quality objectives of producing a high quality consistent data set across Puget Sound. Working with several team members to conduct new mapping, processing data in GIS, and different methods of collecting data were all areas within the project methodology which could affect the quality of the data set. These quality assurance protocols were built into the project at the onset to mitigate areas where data consistency could be compromised or provide an opportunity to achieve the quality objectives of the project.

New Field Mapping Quality Assurance Protocols

Several quality assurance and control protocols were developed for the field mapping element of this project to meet the quality objectives outlined in the QAPP. Each of the protocols described below were adhered to by CGS staff throughout the duration of the field mapping.

- Expert mappers: The field mapping was conducted by two separate field teams, each of which was led by an experienced coastal geomorphologist with a minimum of 10 years of experience mapping bluff and beach shoreforms in Puget Sound.
- Team-based mapping: In addition to practical and safety considerations, team-based mapping provided an opportunity to check mapping decisions and criteria during the mapping process.
- Group training: Prior to the field mapping effort, a group training session was conducted to enhance the shared understanding of the field mapping protocols, operations, and classification methods as well as to test the mapping consistency between the two mapping teams.
- Field data backups: Photos of each field form were taken at the end of each field day to provide a backup in the case of lost field forms.
- Data backup: Data collected from each field day were transferred to a laptop after each working day. These included GPS waypoints data, field photographs, and photographs of each field sheet.
- Field mapping cross-check: 1-2% of the linear extent of mapping was visited by both field teams independently (Figure D-1). The second field team assigned a shoretype to the site to compare to the shoretype assigned by the first team. Results were compiled in an error matrix (see *Results*).

GIS processing Quality Assurance Protocols

Several quality assurance and control protocols were developed for the digitizing process of this project to meet the quality objectives outlined in the QAPP. Each of the protocols described below were adhered to by CGS staff throughout the duration of the digitizing process.

- Review all “call-outs” – Shoreform mapping that had a lower level of certainty was reviewed by a senior geomorphologist with additional supporting data sets to increase certainty and finalize shoretype delineation.
- Validate data – Random sampling of shoretypes to validate shoretype mapping and boundaries.
- Check attribute values – Attribute queries were performed to assure that all data in the attribute tables included only the allowed values defined in Table 8. This applied to both the smaller scale regional data and the final merged Sound-wide data set.

- Confirm shoretype – ArcGIS topology tools were used to confirm that final shoretype data were coincident with ShoreZone shoreline. This applied to both the smaller scale regional data and the final merged Sound-wide data set.

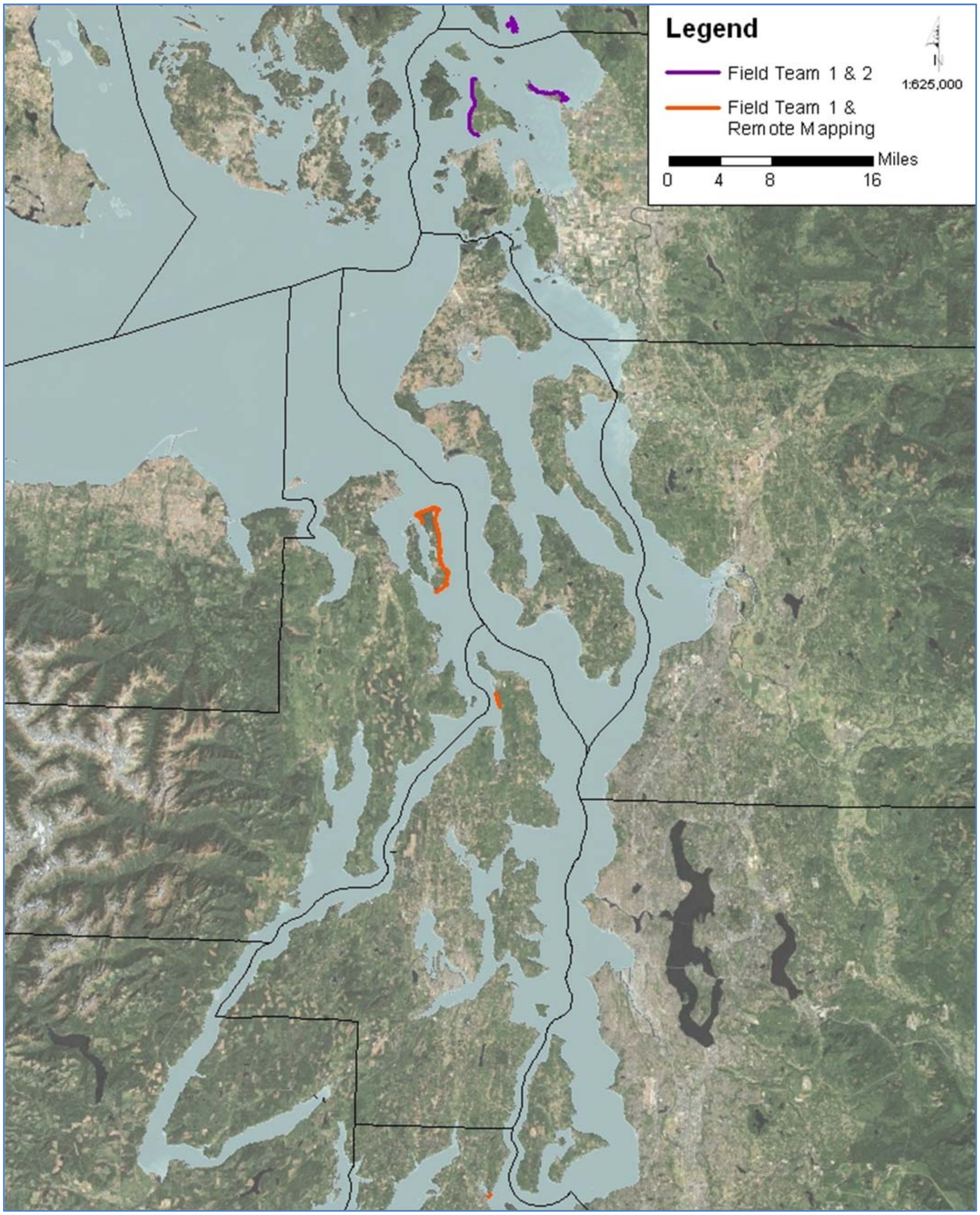

Figure D-1. Overlapping mapping areas among field teams and field versus remote mapping approaches.

Remote Mapping Quality Assurance Protocols

Several quality assurance measures were followed throughout the duration of the remote mapping effort. Each of the quality assurance and control protocols listed below was designed to capture different potential sources of error and ultimately produce a highly accurate mapping product.

- Expert mappers: The remote mapping was led by conducted by experienced geologists with several years of experience in both field and remote mapping of shoreforms in Puget Sound.
- Team-based mapping: One member of the remote mapping team was also part of the field mapping team to provide consistency between the field and remote mapping approaches.
- Group training: Prior to commencing the remote mapping effort, the remote mapping lead joined field mappers to enhance consistency between the field and remote mapping efforts.
- Remote mapping cross-check: 1-2 % of the linear extent of remote mapping was also mapped by one of the field mapping teams (Figure D-1). Results were recorded in an error matrix (see accuracy assessment in *Results*).
- Remote mapping certainty classification: All remote mapping shoretypes were classified by the relative certainty (Low, Moderate, High). Areas with lower certainty were subject to further assessment and concurrence with the senior technical lead, Jim Johannessen, and with supporting data sets. Areas of low certainty were later field verified as part of the remote mapping ground truthing effort.
- Ground truthing: Ground truthing was performed along 2.5% of the remote mapping area to enhance the certainty of the remote mapping process. Additionally, areas of low certainty and a random selection of remotely mapped shoretypes were also field verified to enhance certainty.

Accuracy Assessment Results

As part of the larger quality assurance and control protocols developed for the QAPP, several measures of accuracy were developed. The accuracy assessment entailed review and comparison of data from both field teams, the field and remote mapping efforts, and the draft and final mapping products. These results highlight specific elements of the mapping project in which inconsistencies most commonly occurred and the efforts applied to mitigate them in the final mapping product. The final accuracy assessment documents the refinement of the final mapping product resulting from a detailed review process. Table D-1 shows the percentage and number of shoretypes reviewed for each major element of this mapping project as part of the overall quality assurance effort. Overall over one-fifth of the shoretype units were reviewed to assure mapping quality.

Table D-1. Number of shoreline segments reviewed from existing and new mapping (remote and field mapped).

Mapping data	Total # shoreline segments	# Shoretypes reviewed	% Reviewed
Existing	5,895	1,431	24%
Remote	1,206	259	21%
Field	7,251	1,303	18%
Total	14,352	2,993	21%

Field Mapping Accuracy Assessment

Two areas of overlap, cumulatively measuring 6 miles of shoreline (or 1% of the field mapping area), were mapped by both field teams (Figure D-1). Error matrices documenting inconsistencies among the two field mapping teams were created and results were used to inform QA/QC efforts and to assure adherence to data quality standards. The most common inconsistencies between teams were associated with the exact location of the boundaries between transport zones and feeder bluffs as well as feeder bluff and feeder bluff exceptional units. These shoretype transitions were a focus during the review process and the overall accuracy assessment clearly shows a large number of revisions to this specific area within the larger Sound-wide data set.

Areas of field mapping overlap:

- North Samish Island, Skagit County
- West and South Guemes Island, Skagit County

Table D-2 compares the shoretype assignment between the two teams. The values along the diagonal of the matrix are the shore segments that were consistently mapped by both teams. Overall agreement between the two field teams for all shoretype assignments was 81.5%, which meets the data quality requirements outlined in the QAPP (MacLennan et al. 2012). The green-shaded values, on the diagonal, show the level of agreement in shoretype classifications between the two field teams. Based on these results, additional measures were taken to apply more detailed review of feeder bluff exceptional units, the boundaries between feeder bluffs and transport zones, and the boundaries of NAD areas. For example, in addition to the randomly selected shoretype review, additional shoreline segments that spanned the boundary between feeder bluffs, transport zones and NAD areas were reviewed. Similarly, feeder bluff exceptional units were more heavily reviewed.

Table D-2. Error matrix displaying consistency between two field mapping teams' shoretype classifications. Only the shoretypes that occurred in the mapping area are included in this table.

	Team AM															
	FBE		FB		TZ		AS		MOD		NAD-B		NAD-LE		Total Length	Total count
Team JJ	Length	count	Length	count	Length	count	Length	count	Length	count	Length	count	Length	count		
FBE	63.8%	3	4.7%	3	0.0%		0.0%		0.0%	1	0.0%		0.0%		8.2%	7
FB	36.2%	3	89.2%	17	18.9%	5	0.0%		2.7%	7	0.0%		0.0%		24.6%	32
TZ	0.0%		3.7%	5	46.1%	11	2.3%	4	3.8%	11	0.0%		98.9%	2	8.8%	33
AS	0.0%		0.0%		23.7%	4	91.3%	22	4.3%	15	0.0%		0.0%		26.7%	41
MOD	0.0%		1.8%	4	11.3%	7	5.4%	10	89.1%	35	0.0%		1.1%	1	26.6%	57
NAD	0.0%		0.0%		0.0%		1.0%	1	0.0%		0.0%		0.0%		0.3%	1
NAD-B	0.0%		0.6%	1	0.0%		0.0%		0.0%		100%	1	0.0%		4.8%	2
Grand Total	100%	6	100%	30	100%	27	100%	37	100%	69	100%	1	100%	3	100%	173

Remote to Field Mapping Accuracy Assessment

Close to twelve miles (11.8 miles; Figure D-1) of shore were mapped both remotely and in the field to assure consistent interpretation of shoretypes between the two mapping approaches, as outlined in the project QAPP. The results of this effort showed that field and remote mapping were in agreement approximately 81.8% of the time, which meets the threshold for acceptability as specified in the QAPP. Review of the outputs revealed some useful information that aided in the refinement of the remote mapping product (Table D-3). The greatest inconsistencies among (shoretype) mapping units were along shores mapped as feeder bluff exceptional units and transport zones. Feeder bluff exceptional units were mapped less frequently during remote mapping and more frequently during field mapping. Similarly, transport zones were more frequently mapped in the field and less frequently during remote mapping. Remote mappers more frequently classified shores as feeder bluffs that were mapped in the field as transport zones. The error matrix shown in Table D-3 displays the consistency across the two mapping approaches as applied within the test areas. The green-shaded values along the diagonal of the matrix are shoretype segments where the two methods were in agreement.

<u>Areas of remote and field mapping overlap:</u>

- Kitsap County – South of Point Julia (2 miles)
- Marrowstone Island (8 miles)

The accuracy assessment informed the QA/QC protocols used to refine the remote mapping effort. LIDAR analysis was conducted specifically to reaches identified as FB where bluff heights exceeded 80 ft. This effort compared the mapping data from both field and remote efforts with the LIDAR data. Additional review was applied to these areas to assure that those bluffs were not better classified as FBE units. To assure consistent classification of FBEs following the full suite of mapping criteria (Table 7), bluff heights using LIDAR were reviewed along with oblique air photos and other data to determine if the mapping criteria for FBE shores were met. Results of this exercise affirmed the consistency of FBE calls and only a few changes were identified as a result of the process.

Table D-3. Error matrix displaying consistency between remote and field shoretype classifications. Only the shoretypes that occurred in the mapping area are included in this table.

	Field													
	FBE		FB		TZ		AS		MOD		NAD-LE		Total Length	Total count
Remote	Length	count	Length	count	Length	count	Length	count	Length	count	Length	count		
FBE	45.5%	6	4.8%	4	0.0%		0.0%		1.6%	1	0.0%		9.3%	11
FB	53.9%	8	92.7%	27	45.8%	11	9.0%	5	13.3%	6	0.0%		57.6%	57
TZ	0.0%		2.0%	9	54.1%	8	6.1%	7	0.0%		0.0%		5.0%	24
AS	0.0%		0.0%		0.0%		81.7%	13	1.6%	2	0.0%	1	15.4%	16
MOD	0.6%	1	0.5%	4	0.1%	1	2.1%	4	82.5%	7	0.0%		3.1%	17
NAD-LE	0.0%		0.0%		0.0%		1.1%	1	1.0%	1	100%	1	9.6%	3
Grand Total	100%	15	100%	44	100%	20	100%	30	100%	17	100%	2	100%	128

Accuracy Assessment of Existing Mapping

The error matrix comparing the initial shoretype classification and a review classification for all existing mapping data is shown in Table D-4. Overall accuracy of shoretype classification for the synthesized existing shoretypes is 78%. The most confusion was between accretion shoreforms and NAD types, which were typically, associated with the transition between accretion shoreforms and NAD areas. In addition, there was some confusion between NAD-AR and modified shores. This was largely due to the addition of the NAD-AR shoretype. Therefore MOD shores that were mapped as Artificial by Simenstad et al. (2011) within NAD areas were reclassified as NAD-AR shores.

Table D-4. Error matrix displaying consistency between initial and final shoretype classifications for existing mapping.

Length	First_Stype									
Review_Stype	FBE	FB	FB-T	TZ	AS	MOD	NAD-AR	NAD-B	NAD-LE	Grand Total
FBE	100%	0%	0%	0%	0%	0%	0%	0%	0%	100 %
FB	0%	99%	0%	0%	0%	0%	0%	0%	0%	100 %
FB-T	0%	0%	100%	0%	0%	0%	0%	0%	0%	100 %
TZ	0.0%	0.5%	0.0%	98.8%	0.6%	0.0%	0.0%	0.0%	0.0%	100.0%
AS	0%	0%	0%	0%	100%	0%	0%	0%	0%	100 %
MOD	0%	0%	0%	0%	0%	100%	0%	0%	0%	100 %
NAD-AR	0%	0%	0%	0%	6%	73%	18%	0%	3%	100 %
NAD-B	0%	1%	0%	14%	6%	1%	0%	79%	0%	100 %
NAD-D	0%	0%	0%	0%	100%	0%	0%	0%	0%	100 %
NAD-LE	0%	0%	0%	3%	12%	20%	0%	0%	66%	100 %

Accuracy Assessment of New Mapping

Overall results of the Sound-wide accuracy assessment compared the first shoretype and the final shoretype assigned to all shoretypes. Table D-5 reports the total number of reviewed shoretypes (not necessarily units in which changes were applied), resulting from the quality assurance/control efforts applied for this project. Revisions were applied with the guidance of one of the field mapping leads (Johannessen or MacLennan) and can generally be combined into 4 general categories:

- changes applied during the random review of shoretypes
- changes applied during the focused review based on field-to-field or field-to-remote accuracy assessments
- changes associated with the refinement of the net shore-drift mapping
- changes applied by senior tech review resulting from questions that arose during field mapping or digitizing

Table D-5. Matrix showing the number of units reviewed for consistency between initial and final shoretype classifications for all new mapping.

Mapping source	Total # units	# Units Reviewed	Percent Reviewed
Existing	5,895	138	2%
Remote	1,206	118	10%
Field	7,251	122	2%
Total	**14,352**	**378**	**14%**

Across all shoretypes from new mapping agreement between the initial and final shoretype categories was just under 70% overall. Shoretypes in which review efforts resulted in changes to the mapping show a lower percentage of agreement between the First and Review Stype. Table D-6 shows the degree to which changes were applied to the different shoretypes during this review process for new mapping. Feeder bluff-talus and feeder bluff exceptional shoretypes both incurred considerable changes. Accretion shoreforms, NAD-AR, and NAD-LE areas were also subject to considerable revisions.

Table D-6. Error matrix displaying consistency between initial and final shoretype classifications for all new mapping.

	First_Stype										
Review_Stype	**FBE**	**FB**	**FB-T**	**TZ**	**AS**	**MOD**	**NAD-AR**	**NAD-B**	**NAD-D**	**NAD-LE**	**Grand total**
FBE	52%	48%	0%	0%	0%	0%	0%	0%	0%	0%	100%
FB	0%	95%	0%	3%	0%	1%	0%	0%	0%	1%	100%
FB-T	0%	32%	31%	25%	0%	0%	0%	11%	0%	0%	100%
TZ	0%	4%	0%	78%	3%	4%	0%	11%	0%	0%	100%
AS	0%	3%	0%	6%	87%	3%	0%	0%	1%	0%	100%
MOD	0%	1%	0%	2%	1%	95%	0%	0%	0%	0%	100%
NAD-AR	0%	0%	0%	0%	1%	46%	14%	0%	33%	6%	100%
NAD-B	0%	1%	0%	7%	0%	3%	0%	79%	0%	10%	100%
NAD-D	0%	0%	0%	0%	2%	0%	0%	0%	95%	3%	100%
NAD-LE	0%	0%	0%	3%	9%	11%	0%	1%	0%	75%	100%
Grand total	0%	9%	0%	7%	9%	23%	3%	6%	21%	23%	100%

Appendix E: Results by County

Clallam County

Table E-1. Summary of shoretypes across Clallam County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
*JEF-29	0.0	27.0	7.0	35.7	17.2	13.0
JF-10-1	0.0	3.2	38.1	39.0	10.1	9.5
JF-10-2	0.0	6.2	12.3	10.7	47.0	23.7
JF-1-1	0.0	49.1	0.0	37.5	13.3	0.0
JF-12-1	1.8	14.1	0.5	20.9	19.1	43.6
JF-12-2	0.0	0.0	0.0	0.0	28.9	71.1
JF-13-1	0.0	0.0	0.0	0.0	7.4	92.6
JF-13-2	0.0	0.0	0.0	0.0	7.0	93.0
JF-13-3	0.0	0.0	0.0	0.0	37.1	62.9
JF-16-1	35.2	4.3	0.0	6.8	47.6	6.0
JF-16-4	0.0	0.0	0.0	0.0	100.0	0.0
JF-16-5	0.0	29.5	0.0	34.4	8.1	28.0
JF-16-6	0.0	0.7	0.0	0.3	97.9	1.2
JF-17-1	35.0	4.9	0.0	5.2	52.7	2.2
JF-17-2	12.3	22.8	0.0	5.3	14.6	45.1
JF-17-3	0.0	30.8	0.0	27.5	14.0	27.8
JF-17-6	0.0	35.1	0.0	12.8	51.7	0.4
JF-17-7	0.0	29.8	0.0	28.0	26.2	15.9
JF-18-1	10.1	59.1	0.0	1.0	29.8	0.0
JF-18-4	0.0	50.1	0.0	11.9	19.0	19.0
JF-18-5	31.8	41.1	0.0	0.0	16.1	11.0
JF-2-1	0.0	0.0	0.0	8.9	41.1	50.0
JF-2-2	0.0	0.0	0.0	38.2	52.3	9.5
JF-3-1	0.0	0.0	0.0	55.4	29.7	14.9

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
JF-4-1	0.0	0.0	0.0	23.9	29.5	46.5
JF-4-2	0.0	0.0	0.0	91.6	0.0	8.4
JF-4-3	0.0	0.0	24.1	57.6	18.3	0.0
JF-4-4-1	0.0	0.0	0.0	25.4	7.4	67.2
JF-4-4-2	0.0	0.0	0.0	0.0	31.6	68.4
JF-4-5	0.0	0.0	0.0	3.8	96.2	0.0
JF-6-1	0.00	0.0	50.7	49.3	0.0	0.0
JF-7-1	0.0	0.0	77.4	22.6	0.0	0.0
JF-7-2	0.0	0.0	0.0	14.2	85.8	0.0
JF-7-3	0.0	0.0	7.2	53.5	23.2	16.1
JF-7-4	0.0	0.0	65.2	30.4	0.0	4.4
JF-7-5	0.0	0.0	60.3	25.0	9.2	5.4
JF-7-6	10.8	11.4	56.7	12.0	9.2	0.0
JF-7-7	0.0	0.0	100	0.0	0.0	0.0

*only partially within county

Table E-2. NAD type breakdown for Clallam County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
JF-10-2/JF-10-1	0.0	0.7	0.0	0.0	0.7
JF-10-2/JF-12-1	0.0	4.9	0.0	0.0	4.9
JF-10-2-NAD	0.0	0.0	0.0	1.5	1.5
JF-1-1/C-5-3	0.0	1.2	0.0	0.0	1.2
JF-1-1/JF-2-1	3.0	1.5	0.0	0.0	4.6
JF-12-1/JF-12-2	0.3	0.0	0.0	0.0	0.3
JF-12-1-NAD	0.0	0.0	0.9	0.0	0.9
JF-12-2/JF-13-1	3.0	0.0	0.0	1.0	4.0
JF-13-3/JF-16-1	0.0	0.0	0.0	0.7	0.7
JF-16-3/JF-16-4	0.0	0.0	0.0	1.9	1.9
JF-16-4/JF-16-5	0.0	0.0	0.0	1.6	1.6
JF-16-6-NAD	0.0	0.0	0.0	0.6	0.6

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
JF-17-1/JF-17-2	0.0	0.0	0.0	1.7	1.7
JF-17-2/JF-17-3	0.9	0.0	0.0	0.0	0.9
JF-17-3/JF-17-7	0.0	0.0	0.0	1.7	1.7
JF-17-6-NAD	0.0	0.0	0.0	0.7	0.7
JF-2-1/JF-2-2	0.0	3.6	0.0	0.4	3.9
JF-2-1-NAD	0.4	0.0	0.0	0.0	0.4
JF-2-2/JF-3-1	0.0	2.1	0.0	0.0	2.1
JF-3-1/JF-4-1	0.0	1.0	0.0	0.0	1.0
JF-4-1/JF-4-2	0.0	0.2	0.0	0.0	0.2
JF-4-1-NAD	0.0	0.0	0.0	1.1	1.1
JF-4-2/JF-4-3	0.0	0.1	0.0	0.0	0.1
JF-4-3/JF-4-4-1	0.7	0.9	0.0	0.0	1.6
JF-4-4-1/JF-4-4-2	0.3	0.0	0.0	0.0	0.3
JF-4-5/JF-4-4-2	0.0	0.0	0.0	1.7	1.7
JF-4-5/JF-6-1	0.0	6.7	0.0	0.0	6.7
JF-7-1/JF-7-2	0.0	1.2	0.0	0.0	1.2
JF-7-2/JF-7-3	0.0	0.0	0.0	1.1	1.1
JF-7-4/JF-7-5	0.5	0.0	0.0	0.0	0.5
JF-7-5/JF-7-6	0.3	0.0	0.0	0.0	0.3
JF-7-7/JF-7-6	0.0	0.0	0.0	0.0	0.0
Grand Total	9.3	24.0	0.9	15.6	49.8

Table E-3. Summary statistics of the percent of each shoretype found across all Clallam County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	3.6	11	13.1	20.8	28.9	22.5
Median	0	0	0	13.5	19.1	10.3
Std Dev	9.5	17.3	26.2	21.3	27.8	27.8

Table E-4. Modified shores that were likely historic feeder bluffs throughout Clallam County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	1.8	8.2
MOD without Historic FB	6.3	29.1
MOD marked Unknown	13.6	62.6
Total MODs	21.7	**100**

Island County

Table E-5. Summary of shoretypes across Island County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
CAM-1	0.0	29.8	0.0	17.4	51.3	1.4
CAM-10	0.0	7.7	0.0	3.1	86.6	2.5
CAM-11	13.0	14.9	0.0	11.0	61.1	0.0
CAM-12	0.0	36.4	0.0	0.0	63.6	0.0
CAM-2	0.0	37.1	0.0	3.9	32.8	26.2
CAM-3	2.8	32.9	0.0	12.5	33.7	18.1
CAM-4	28.9	7.5	0.0	6.4	42.5	14.7
CAM-5	12.7	29.1	0.0	3.1	16.7	38.4
CAM-6	0.0	54.0	0.0	15.4	10.6	19.9
CAM-7	10.5	30.4	0.0	19.6	25.5	14.0
CAM-8	5.1	21.8	0.0	22.9	32.8	17.5
CAM-9	59.8	20.3	0.0	14.3	5.5	0.0
IS-1	2.4	46.5	0.0	1.3	39.4	10.5
IS-2	32.2	10.9	0.0	0.0	41.5	15.4
IS-3	0.0	4.4	0.0	10.3	50.8	34.5
IS-4	17.7	28.7	0.0	3.7	47.7	2.2
IS-5	27.5	0.0	0.0	0.0	72.5	0.0
IS-6	22.2	22.4	0.0	6.2	48.2	1.0
SM-1	16.9	0.0	0.0	10.5	72.7	0.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
SM-2	26.1	7.7	0.0	0.0	66.2	0.0
WHID 8.1	2.0	39.3	0.0	19.1	29.0	10.6
WHID-1	0.0	52.4	0.0	6.5	21.0	20.1
WHID-10	0.0	10.6	0.0	69.5	13.1	6.8
WHID-11	0.0	27.5	0.0	12.1	25.0	35.3
WHID-12	0.0	18.1	0.0	24.9	21.0	36.0
WHID-13	4.3	54.5	0.0	13.0	20.6	7.6
WHID-14	0.0	43.0	0.0	5.8	37.8	13.3
WHID-15	4.8	30.0	0.0	0.0	58.9	6.3
WHID-16	7.9	43.0	0.0	3.7	3.2	42.2
WHID-17	6.0	42.1	0.0	4.4	41.9	5.6
WHID-18	44.8	18.5	0.0	0.0	36.7	0.0
WHID-19	45.6	34.9	0.0	0.0	16.1	3.4
WHID-2	0.0	60.1	0.0	1.3	24.7	13.9
WHID-20	8.6	16.3	0.0	40.0	33.3	1.8
WHID-21	0.0	28.2	0.0	46.6	9.7	15.5
WHID-22	0.0	24.4	0.0	42.3	30.1	3.1
WHID-23	0.0	42.8	0.0	52.7	4.4	0.0
WHID-24	0.0	18.2	0.0	51.3	23.2	7.4
WHID-25	18.9	21.3	0.0	7.8	49.5	2.4
WHID-26	18.9	26.0	0.0	16.8	38.4	0.0
WHID-27	11.2	30.1	0.0	6.7	39.3	12.7
WHID-28	5.7	52.3	0.0	7.8	34.3	0.0
WHID-3	1.8	45.9	0.0	9.2	11.2	31.9
WHID-3.1	18.6	59.5	0.0	0.0	21.9	0.0
WHID-3.2	17.3	42.0	0.0	0.0	40.8	0.0
WHID-4	0.0	51.3	0.0	27.7	5.9	15.1
WHID-5	0.0	32.2	0.0	7.1	60.7	0.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
WHID-6	0.0	45.9	0.0	0.0	54.1	0.0
WHID-7	0.0	50.1	0.0	0.0	8.9	41.0
WHID-8.1	0.0	87.1	0.0	0.0	0.0	12.9
WHID-8.2	0.0	33.7	0.0	16.3	50.0	0.0
WHID-8.3	0.0	30.3	0.0	1.5	36.7	31.6
WHID-9	0.0	36.1	0.0	18.0	26.9	19.0
Grand Total	**8.4**	**31.6**	**1.0**	**12.9**	**35.8**	**11.2**

Table E-6. NAD type breakdown for Island County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
CAM-4/CAM-5	0.0	0.0	1.4	1.4	0.0
CAM-8/CAM-9	0.0	0.0	2.6	2.6	0.0
IS-1/IS-3	0.6	0.0	0.0	0.6	0.6
IS-2/IS-3	0.6	0.0	1.3	2.0	0.6
IS-4/IS-5	1.7	0.0	0.0	1.7	1.7
SK-G-1.1/SK-D-3	0.0	0.6	0.0	0.6	0.0
WHID-11-NAD	0.0	0.0	0.6	0.6	0.0
WHID-12/WHID-13	0.0	0.0	0.8	0.8	0.0
WHID-14/WHID-15	0.9	0.0	2.7	3.6	0.9
WHID-14-NAD	0.2	0.0	0.0	0.2	0.2
WHID-20-NAD	1.1	0.0	0.0	1.1	1.1
WHID-23/WHID-22	0.0	0.0	0.3	0.3	0.0
WHID-24/WHID-25	0.0	2.6	0.0	2.6	0.0
WHID-26	0.0	0.0	1.7	1.7	0.0
WHID-26-NAD	0.3	0.0	0.0	0.3	0.3
WHID-27/WHID-28-NAD	0.0	0.0	2.5	2.5	0.0
WHID-28	2.2	0.0	0.0	2.2	2.2
WHID-8-NAD	0.0	0.0	2.5	2.5	0.0
Grand Total	7.7	3.1	16.4	27.2	7.7

Table E-7. Summary statistics of the percent of each shoretype found across all Island County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	9.3	31.9	0.0	12.7	34.5	11.5
Median	2.4	30.3	0.0	7.1	33.7	7.4
Std Dev	13.6	17.3	0.0	15.7	20.1	12.7

Table E-8. Modified shores that were likely historic feeder bluffs throughout Island County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	2.2	10.6
MOD without Historic FB	0.5	2.2
MOD marked Unknown	18.3	87.2
Total MODs	**20.9**	**100.0**

Jefferson County

Table E-9. Summary of shoretypes across Jefferson County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified, NAD = No appreciable drift.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
JE-1	0	23	13.7	35.9	10.5	16.9
JE-10	0	45	0	13.5	29.2	12.8
JE-11	0	25	0	25.9	10.2	38.7
JE-12	0	23	0	20.8	43.2	13
JE-13-1	0	34	0	12.5	22	31.9
JE-13-2	0	42	0	2.4	55.9	0
JE-13-3	2.8	70	0	5.7	18.4	3.7
JE-14	0	72	0	2.2	18.2	8.1
JE-15	0	86	0	4.4	9.9	0
JE-16	9.2	51	0	3.1	27.2	9.7

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
JE-17	2.6	61	0	6	22.8	8
JE-18	6.2	46	0	24.4	12.8	10.8
JE-19	0	4	51	32.3	10.5	2.6
JE-2	0	0	0	100	0	0
JE-20	0	35	10.5	37.7	15	1.8
JE-21	0	51	12.4	18.7	12.3	6.1
JE-22	0	0	14.8	32.2	24.5	28.5
JE-23	0	13	30.7	12.3	6.5	37.3
JE-24	0	4	4.7	18.9	44.1	28.6
JE-25	0	36	0	20.7	29	14.3
JE-26	0	28	0	48.1	7.9	16.1
JE-27	0	26	2.5	6.1	28.1	37.3
JE-28	9.8	37	0	18.5	24.7	10.3
JE-29	0	0	21.3	48.2	4.8	25.6
JE-3	0	0	0	33.3	33.6	33
JE-30	0	15	0	46	3.2	36.3
JE-4	0	29	0	20.4	40.1	10.8
JE-5-1	0	12	0	36.1	20.7	31.7
JE-5-2	0	54	0	8	10.5	27.9
JE-6	9.6	30	0	6.9	29.1	24.7
JE-7	2.1	51	0	14.3	19.3	13.1
JE-8	0	72	0	7	21.1	0
JE-9	5.3	20	0	25.1	33.2	16.5
JEF-10	0	36	0	50.9	13.1	0
JEF-11	0	58	0	14.8	26.1	0.9
JEF-12	15	34	0	18.3	19.1	13.7
JEF-13	9.6	19	0	20.4	46.1	4.5
JEF-14	0	63	0	11.4	25.3	0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
JEF-15-1	0	10	1.7	50.1	12.4	25.7
JEF-15-2	0	0	20.5	68.6	0	10.9
JEF-16	0	19	9.5	40.2	16.5	14.5
JEF-17	0	23	0	2.8	36.8	37.9
JEF-18	0	20	0	12.7	62.1	5.4
JEF-19	0	70	0	3.8	25.7	0
JEF-2	15	19	0	5.5	60.2	1.1
JEF-20	0	28	0	0	72.3	0
JEF-21	0	51	0	1.1	48.2	0
JEF-22	0	0	0	0	100	0
JEF-22-1	0	53	0	12.2	17.5	17.6
JEF-22-2	0	0	0	0	8.6	91.4
JEF-22-3	4.1	30	0	10.7	43.7	12
JEF-23	28	53	0	4	5.1	9.7
JEF-24	11	58	0	2.4	5	23.9
JEF-25	1.9	64	0	5.9	11.7	16.8
JEF-26	0	6	9.8	16.8	11.8	56.2
JEF-27	0	48	0	21.3	10.4	20.7
JEF-28	0	36	12.7	27.4	10.9	13.3
*JEF-29	0	27	7	35.7	17.2	13
JEF-3	15	62	0	7	15.2	1.2
JEF-4	73	0	0	0	0	26.9
JEF-5	15	23	0	3.8	58.1	0
JEF-6	0	59	0	4.4	32.3	4.6
JEF-7-1	0	30	0	11.1	27.8	31
JEF-7-2	0	25	0	45	11.7	18.2
JEF-8-1	0	8	0	51.1	8.1	32.5
JEF-8-2	0	0	38.1	48.7	13.2	0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
JEF-9	0	30	12.6	22.4	4.4	30.4
PROT-1	60	0	0	0	40.3	0
PROT-2	12	5	0	12.9	57	13.2
PROT-3	35	32	0	0	33.3	0
PROT-4	65	0	0	0	34.8	0
Grand Total	**5.8**	**40**	**2.6**	**14.8**	**22.1**	**14.7**

*only partially within county

Table E-10. NAD type breakdown for Jefferson County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
JE-1/JEF-15-2	0.6	0.2	0.0	0.9	1.6
JE-11/JE-12	0.0	0.0	0.0	0.5	0.5
JE-12/JE-13-1	0.2	0.0	0.0	0.9	1.1
JE-13-2/JE-13-3	0.0	0.0	0.0	1.8	1.8
JE-15	0.0	0.0	0.0	0.0	0.0
JE-15-NAD	0.0	0.0	0.0	1.7	1.7
JE-16/JE-17	0.0	0.0	0.0	5.3	5.3
JE-16-NAD	0.0	0.0	0.0	0.9	0.9
JE-17-NAD	0.0	0.0	0.0	0.3	0.3
JE-18/JE-19	0.7	0.0	2.3	1.4	4.4
JE-18-NAD	0.0	0.0	0.0	0.3	0.3
JE-20/JE-21	0.0	0.0	0.0	0.5	0.5
JE-21/JE-22	0.0	1.9	0.0	0.7	2.6
JE-22/JE-23	0.0	0.4	0.0	0.0	0.4
JE-23/JE-24	0.0	0.0	0.0	0.5	0.5
JE-25/JE-26	0.0	0.1	0.0	1.2	1.3
JE-26/JE-27	0.0	0.4	0.0	0.0	0.4
JE-28/JE-29	0.1	1.8	1.6	0.2	3.6
JE-29/JE-30	0.0	0.5	0.0	0.0	0.5
JE-3/JE-4	0.0	0.2	0.0	0.0	0.2
JE-30	0.0	0.0	0.0	0.0	0.0
JE-4/JE-5-1	0.6	2.3	0.0	2.1	5.0

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
JE-5-1	0.0	0.2	0.0	0.0	0.2
JE-5-2/JE-6	0.6	1.3	0.0	1.8	3.8
JE-9/JE-10	0.0	0.0	0.0	1.5	1.5
JEF-13/JEF-14	0.0	0.0	0.0	0.7	0.7
JEF-16/JEF-17	0.0	0.2	0.0	0.8	1.0
JEF-18/JEF-19	0.0	0.0	0.0	1.3	1.3
JEF-20	0.0	0.0	0.0	0.8	0.8
JEF-22-1/JEF-22-2	0.5	0.0	0.0	0.0	0.5
JEF-22-2/JEF-22-3	3.4	0.0	0.0	0.0	3.4
JEF-26/JEF-27	0.0	0.0	0.0	2.7	2.7
JEF-29-NAD	0.0	0.0	0.0	0.8	0.8
JEF-2-NAD	0.0	0.0	0.0	0.8	0.8
JEF-30/MA-1-2	0.0	0.1	0.0	0.0	0.1
JEF-7-1/JEF-7-2	0.0	0.0	0.0	0.2	0.2
JEF-7-2/JEF-8-1	0.0	0.0	0.0	0.6	0.6
JEF-9/JEF-10	0.1	0.0	0.0	0.4	0.5
PROT-2-NAD	0.5	0.0	0.0	0.0	0.5
Grand Total	7.1	9.7	3.9	31.6	52.3

Table E-11. Summary statistics of the percent of each shoretype found across all Jefferson County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	5.7	30.8	3.9	19.6	24.5	15.5
Median	0.0	28.7	0.0	13.5	19.3	13.0
Std Dev	14.4	22.6	9.3	19.1	18.9	16.0

Table E-12. Modified shores that were likely historic feeder bluffs throughout Jefferson County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	6.8	31.1
MOD without Historic FB	13.3	60.4
MOD marked Unknown	1.9	8.5
Total MODs	22.0	**100.0**

King County

Table E-13. Summary of shoretypes across King County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
KI-10-2	0.0	40.2	0.0	37.5	17.9	4.4
KI-11-1	0.0	0.0	0.0	0.0	0.0	100.0
KI-11-12	0.0	0.0	0.0	0.0	0.0	100.0
KI-11-2	0.0	6.1	0.0	7.2	5.8	81.0
KI-11-3	0.0	0.0	0.0	21.6	23.1	55.3
KI-11-4	0.0	0.0	0.0	9.0	31.0	60.0
KI-11-5	0.0	30.2	0.0	3.2	10.4	56.2
KI-11-6	0.0	24.5	0.0	8.4	27.9	39.2
KI-11-7	0.0	22.7	0.0	15.8	13.3	48.2
KI-11-8	0.0	44.0	0.0	16.9	5.4	33.7
KI-12-1	0.0	27.6	0.0	0.0	2.6	69.8
KI-12-2	0.0	20.1	0.0	9.1	19.1	51.7
KI-12-3	0.0	36.3	0.0	0.8	8.0	54.9
KI-13-1	0.0	47.0	0.0	1.4	8.4	43.3
KI-13-10	0.0	56.8	0.0	14.4	6.9	21.8
KI-13-11	0.0	70.0	0.0	0.0	0.0	30.0
KI-13-15	0.0	6.6	0.0	3.0	0.9	89.5
KI-13-16N	0.0	0.0	0.0	0.0	88.1	11.9
KI-13-16S	0.0	0.0	0.0	0.0	16.2	83.8
KI-13-17	0.0	0.0	0.0	6.9	7.1	86.0
KI-13-18	0.0	6.5	0.0	22.3	2.2	69.0
KI-13-19	0.0	0.0	0.0	0.0	16.1	83.9
KI-13-2	0.0	50.1	0.0	11.5	14.1	24.4
KI-13-20	2.2	28.1	0.0	2.8	6.2	60.7
KI-13-21	14.4	8.6	0.0	1.4	5.0	70.7
KI-13-22	40.0	9.9	0.0	3.0	0.0	47.0

Drift Cell	CGS Shoretypes (%)					
	FBE	**FB**	**FB-T**	**TZ**	**AS**	**MOD**
KI-13-23	12.6	28.9	0.0	13.1	7.1	38.2
KI-13-24	81.1	13.5	0.0	0.0	0.0	5.5
KI-13-25	0.0	28.0	0.0	27.5	35.9	8.6
KI-13-26	0.0	33.0	0.0	54.1	12.8	0.0
KI-13-27N	0.0	70.3	0.0	0.0	16.0	13.7
KI-13-27S	0.0	26.8	0.0	50.8	22.4	0.0
KI-13-3	0.0	0.0	0.0	0.0	9.4	90.6
KI-13-5	0.0	0.0	0.0	0.0	8.8	91.2
KI-13-8	0.0	27.8	0.0	4.6	7.2	60.4
KI-13-9	0.0	51.7	0.0	0.0	0.0	48.3
KI-14-1	5.8	36.4	0.0	6.2	7.9	43.8
KI-14-2	15.8	28.5	0.0	8.5	9.9	37.3
KI-2-1	0.0	0.0	0.0	0.0	22.6	77.4
KI-2-2	0.0	0.0	0.0	4.1	0.0	95.9
KI-2-3	0.0	7.2	0.0	0.0	0.0	92.8
KI-3-1	0.0	17.6	0.0	2.2	15.0	65.2
KI-3-2	22.5	11.8	0.0	1.5	11.5	52.8
KI-3-3	0.0	0.0	0.0	0.0	0.0	100.0
KI-5-1	2.3	3.0	0.0	0.7	7.3	86.7
KI-7-2	0.0	0.7	0.0	0.0	4.3	95.0
KI-8-2	0.0	0.0	0.0	0.0	32.8	67.2
KI-8-3	5.1	14.8	0.0	2.5	12.1	65.6
KI-9-2	0.0	16.9	0.0	4.2	2.8	76.0
*PI-1-1	0.0	43.4	0.0	5.1	5.8	45.8
*SN-3	0.0	0.0	0.0	0.0	18.8	81.2
Grand Total	**4.2**	**19.6**	**1.0**	**5.3**	**9.4**	**61.5**

*only partially within county

Table E-14. NAD type breakdown for King County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
KI-13-10/KI-13-11	0.0	0.7	0.7	0.0	0.7
KI-13-16/KI-13-16	0.0	0.4	0.4	0.0	0.4
KI-13-2/KI-13-3	0.0	0.3	0.3	0.0	0.3
KI-2-1/KI-2-2	3.3	0.0	3.3	3.3	0.0
KI-2-2/KI-2-3	0.6	0.0	0.6	0.6	0.0
KI-3-2/KI-3-3	1.4	0.0	1.4	1.4	0.0
KI-3-5/KI-5-1	25.4	0.0	25.4	25.4	0.0
KI-8-2/KI-8-3	1.6	0.0	1.6	1.6	0.0
Grand Total	32.3	1.3	33.7	32.3	1.3

Table E-15. Summary statistics of the percent of each shoretype found across all King County net shore-drift cells FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	4.0	19.5	0.0	7.5	11.9	57.2
Median	0.0	14.8	0.0	2.8	8.0	60.0
Std Dev	13.1	19.8	0.0	12.2	14.2	29.2

Table E-16. Modified shores that were likely historic feeder bluffs throughout King County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	23.7	41.9
MOD without Historic FB	12.0	21.2
MOD marked Unknown	20.9	36.9
Total MODs	**56.7**	**100**

Kitsap County

Table E-17. Summary of shoretypes across Kitsap County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretype (%)					
	FBE	FB	FB-T	TZ	AS	MOD
KS-10-1	1.5	41.0	0.0	5.9	17.9	33.7
KS-10-2	0.0	65.7	0.0	15.6	0.0	18.7
KS-10-3	0.0	7.9	0.0	0.6	13.3	78.2
KS-10-4	0.0	70.8	0.0	4.2	10.4	14.6
KS-1-1	3.6	70.5	0.0	2.4	11.2	12.2
KS-11-1	0.0	23.0	0.0	7.0	11.1	58.9
KS-11-2	6.2	36.9	0.0	8.4	15.3	33.3
KS-1-2	6.3	37.1	0.0	11.5	11.9	33.2
KS-12-10	0.0	17.5	0.0	19.5	17.0	46.0
KS-12-1a	0.0	65.2	0.0	4.4	1.0	29.5
KS-12-1b	0.0	0.0	0.0	4.3	9.3	86.3
KS-12-2	0.0	3.3	0.0	17.4	2.5	76.8
KS-12-3	0.0	0.0	0.0	22.5	9.4	68.1
KS-12-4	0.0	3.2	0.0	8.3	8.0	80.5
KS-12-5	0.0	0.0	0.0	0.0	0.0	100.0
KS-12-6a	0.0	45.7	0.0	28.6	0.0	25.7
KS-12-6b	0.0	25.9	0.0	48.3	25.8	0.0
KS-12-6c	0.0	22.4	0.0	8.2	10.4	59.0
KS-12-6d	0.0	0.0	0.0	0.0	2.9	97.1
KS-12-7	0.0	16.6	0.0	29.9	3.6	49.9
KS-12-7a	0.0	0.0	0.0	0.0	16.7	83.3
KS-12-8	0.0	6.9	0.0	32.0	2.2	58.9
KS-12-9	0.0	0.0	0.0	46.0	0.0	54.0
KS-1-3	0.0	42.4	0.0	8.7	48.8	0.0
KS-13-2	0.0	1.7	0.0	18.5	3.1	76.8
KS-13-3	0.0	31.8	0.0	5.0	6.7	56.4

Drift Cell	CGS Shoretype (%)					
	FBE	FB	FB-T	TZ	AS	MOD
KS-1-4	0.0	43.4	0.0	11.4	32.8	12.4
KS-14-1	1.8	27.1	0.0	8.0	18.9	44.2
KS-14-2	0.0	24.9	0.0	18.2	16.2	40.6
KS-14-3	0.0	1.7	0.0	14.5	30.4	53.4
KS-14-4	0.0	16.5	0.0	2.8	5.5	75.1
KS-14-5	0.0	8.4	0.0	7.4	0.0	84.2
KS-1-5	0.0	29.1	0.0	0.0	13.5	57.4
KS-15-1	0.0	8.6	0.0	4.4	0.0	87.0
KS-15-2	0.0	7.5	0.0	1.7	0.0	90.8
KS-15-3	0.0	0.0	0.0	0.0	0.0	100.0
KS-15-6	0.0	0.0	0.0	9.0	6.1	84.8
KS-15-7	0.0	3.7	0.0	18.3	0.0	78.0
KS-15-8	0.0	0.0	0.0	2.4	0.0	97.6
KS-15-9	0.0	15.8	0.0	5.7	9.3	69.2
KS-1-6	2.8	53.9	0.0	14.2	10.0	19.2
KS-16-1	0.0	26.2	0.0	8.5	22.9	42.4
KS-16-2	0.0	4.9	0.0	0.0	36.9	58.2
KS-17-1	0.0	1.7	0.0	10.0	0.0	88.3
KS-17-10	0.0	0.0	0.0	0.0	47.6	52.4
KS-17-11	0.0	15.3	0.0	10.2	9.6	64.9
KS-17-12	0.0	6.5	0.0	56.7	6.7	30.2
KS-17-13	0.0	0.0	0.0	23.4	22.9	53.7
KS-17-14	0.0	3.5	0.0	3.4	20.0	73.1
KS-17-15	0.0	4.0	0.0	6.5	0.0	89.5
KS-17-16	0.0	3.0	0.0	15.9	18.9	62.3
KS-17-18	0.0	32.4	0.0	55.6	12.0	0.0
KS-17-19	0.0	0.0	0.0	46.7	5.5	47.8
KS-17-2	0.0	0.6	0.0	21.8	1.1	76.5

Drift Cell	CGS Shoretype (%)					
	FBE	FB	FB-T	TZ	AS	MOD
KS-17-20	0.0	62.9	0.0	14.2	3.3	19.6
KS-17-21	0.0	70.7	0.0	29.3	0.0	0.0
KS-17-3	0.0	1.3	0.0	3.4	28.0	67.3
KS-17-4	0.0	0.0	0.0	65.1	0.0	34.9
KS-17-5	0.0	21.7	0.0	2.6	0.0	75.7
KS-17-9	0.0	12.0	0.0	14.9	13.9	59.1
KS-18-1	0.0	10.8	0.0	24.8	0.0	64.4
KS-18-10	0.0	6.8	0.0	44.4	0.0	48.7
KS-18-11	0.0	0.7	0.0	8.0	0.0	91.3
KS-18-13	0.0	1.2	0.0	17.1	10.4	71.2
KS-18-14	0.0	0.0	0.0	30.9	20.6	48.6
KS-18-15	0.0	4.1	0.0	12.4	20.3	63.3
KS-18-16	0.0	0.0	0.0	23.7	0.0	76.3
KS-18-17	0.0	2.3	0.0	20.9	0.0	76.8
KS-18-18.1	0.0	2.1	0.0	6.0	13.9	78.0
KS-18-18.2	0.0	0.0	0.0	0.0	0.0	100.0
KS-18-19	0.0	10.8	0.0	21.6	13.9	53.7
KS-18-2	0.0	11.2	0.0	19.3	0.0	69.5
KS-18-20	0.0	20.9	0.0	15.3	8.1	55.7
KS-18-3	0.0	3.9	0.0	24.2	10.2	61.8
KS-18-4	0.0	0.0	0.0	38.7	0.0	61.3
KS-18-5	0.0	0.0	0.0	69.0	0.0	31.0
KS-18-6	0.0	0.0	0.0	78.4	4.7	16.8
KS-18-7	0.0	0.0	0.0	0.0	12.5	87.5
KS-18-8	0.0	16.7	0.0	16.6	6.0	60.7
KS-18-9	0.0	11.7	0.0	88.3	0.0	0.0
KS-19-1.1	0.0	0.0	0.0	9.9	8.3	81.8
KS-19-1.2	0.0	0.0	0.0	6.7	0.0	93.3

Drift Cell	CGS Shoretype (%)					
	FBE	FB	FB-T	TZ	AS	MOD
KS-19-1.3	0.0	10.6	0.0	4.0	4.9	80.5
KS-19-2	0.0	2.8	0.0	0.0	0.0	97.2
KS-19-4	0.0	20.7	0.0	15.4	9.9	54.0
*KS-20-1	0.0	33.2	0.0	33.2	4.0	29.5
KS-20-2	0.0	5.9	0.0	23.0	10.2	61.0
KS-20-3	0.0	0.0	0.0	100.0	0.0	0.0
KS-20-4	0.0	0.0	0.0	6.3	0.0	93.7
KS-2-1	0.0	55.1	0.0	8.6	31.6	4.8
KS-2-2	0.0	72.4	0.0	4.7	10.1	12.8
KS-2-3	0.0	15.1	0.0	21.9	16.4	46.6
KS-2-4	0.0	48.8	0.0	9.7	24.9	16.6
KS-2-4b	0.0	61.6	0.0	17.0	1.6	19.8
KS-5-1	0.0	40.5	0.0	12.4	13.9	33.2
KS-6-1	5.2	12.0	0.0	4.2	11.5	67.1
KS-6-2	0.0	22.2	0.0	7.9	32.6	37.3
KS-6-3	1.5	32.3	0.0	5.1	33.5	27.6
KS-6-4	0.0	38.7	0.0	7.1	43.6	10.7
KS-7-1	4.6	43.9	0.0	20.0	14.9	16.7
KS-7-2	0.0	59.0	0.0	7.0	15.4	18.6
KS-8-1	0.0	58.2	0.0	12.6	12.9	16.3
KS-8-2	0.0	53.7	0.0	3.9	11.2	31.2
KS-8-3	0.0	0.0	0.0	74.0	0.0	26.0
KS-9-1	0.0	42.5	0.0	19.4	16.2	21.9
KS-9-2	0.0	48.2	0.0	32.4	19.4	0.0
Grand Total	**0.7**	**27.8**	**0.0**	**14.7**	**12.0**	**44.8**

*only partially within county

Table E-18. NAD type breakdown for Kitsap County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
KS-10-1/KS-10-2	1.1	0.0	0.0	0.5	1.5
KS-10-2/KS-10-1	0.0	0.0	0.0	1.8	1.8
KS-11-1/KS-11-2	0.2	0.0	0.0	4.6	4.8
KS-11-1-NAD	0.0	0.0	0.0	0.3	0.3
KS-11-2-NAD	0.0	0.0	0.0	1.1	1.1
KS-12-1/KS-12-2	0.5	0.0	0.0	1.2	1.8
KS-12-10-NAD	0.0	0.0	0.0	0.2	0.2
KS-12-1a/KS-12-1b	0.1	0.0	0.0	0.0	0.1
KS-12-1a-NAD	0.0	0.0	0.0	0.8	0.8
KS-12-3/KS-12-4	0.3	0.0	0.0	0.5	0.8
KS-12-5/KS-12-6a	0.0	0.0	0.0	0.3	0.3
KS-12-6b/KS-12-6c	0.0	0.0	0.0	0.2	0.2
KS-12-6d/KS-12-7a	0.0	0.0	0.0	0.2	0.2
KS-12-7/KS-12-8	0.6	0.0	0.0	2.1	2.8
KS-12-7a/KS-12-7b	0.0	0.0	0.0	0.4	0.4
KS-12-9/KS-12-10	0.0	0.0	0.0	0.4	0.4
KS-13-2/KS-15-6	0.0	0.0	0.0	0.7	0.7
KS-14-1/KS-14-2	0.0	0.0	0.0	0.9	0.9
KS-14-3/KS-14-4	0.2	0.0	0.0	3.1	3.2
KS-1-4-NAD	0.0	0.0	0.0	1.0	1.0
KS-1-5/KS-1-6	1.8	0.0	0.0	0.0	1.8
KS-15-1/KS-19-4	0.0	0.0	0.0	0.1	0.1
KS-15-2/KS-15-3	0.1	0.0	0.0	1.2	1.3
KS-15-7/KS-15-8	0.0	0.0	0.0	0.2	0.2
KS-16-1/KS-16-2	0.0	0.0	0.0	0.5	0.5
KS-16-1/KS-17-15	0.0	0.0	0.0	2.0	2.0
KS-17-11/KS-17-12	0.0	0.9	0.0	0.0	0.9
KS-17-12/KS-17-13	0.1	0.0	0.0	0.4	0.4
KS-17-14/KS-17-13	0.0	0.3	0.0	0.0	0.3
KS-17-14/KS-17-15	0.0	0.0	0.0	0.1	0.1
KS-17-16a-NAD	0.1	0.0	0.0	0.1	0.3
KS-17-16b-NAD	0.0	0.0	0.0	0.1	0.1
KS-17-19-NAD	0.3	0.0	0.0	0.0	0.3
KS-17-2/KS-17-1	0.0	0.0	0.0	0.0	0.0
KS-17-3/KS-17-4	0.0	0.6	0.0	0.0	0.6

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
KS-17-4/KS-17-5	0.0	0.0	0.0	0.2	0.2
KS-17-5/KS-19-1	0.0	2.5	0.0	0.0	2.5
KS-17-9-NAD	0.0	0.0	0.0	2.2	2.2
KS-18-1.1/KS-18-19	0.1	0.0	0.0	0.4	0.5
KS-18-1/KS-18-2	0.0	0.6	0.0	0.0	0.6
KS-18-1/KS-19-2	0.1	0.0	0.0	0.0	0.1
KS-18-10/KS-18-11	0.0	0.0	0.0	1.2	1.2
KS-18-12/KS-18-13	0.0	0.0	0.0	0.1	0.1
KS-18-13/KS-18-14	0.0	0.0	0.0	0.8	0.8
KS-18-16/KS-18-17	0.0	0.0	0.0	1.1	1.1
KS-18-18.1/18-18.2	0.3	0.0	0.0	0.0	0.3
KS-18-19-NAD	0.0	0.0	0.0	0.9	0.9
KS-18-2/KS-18-3	0.2	0.0	0.0	1.4	1.6
KS-18-20/KS-18-19	0.0	0.1	0.0	0.0	0.1
KS-18-4/KS-18/5	0.0	1.0	0.0	0.0	1.0
KS-18-5/KS-18-6	0.0	0.0	0.0	0.5	0.5
KS-18-9/KS-18-10	0.0	0.0	0.0	0.6	0.6
KS-19-1.1-NAD	0.1	0.0	0.0	0.2	0.3
KS-19-1.3/KS-19-2	6.2	0.0	0.0	1.4	7.6
KS-20-1-NAD	0.0	0.0	0.0	1.4	1.4
KS-20-3/KS-20-4	0.0	0.0	0.0	0.4	0.4
KS-2-3/KS-2-4	0.0	0.0	0.0	0.9	0.9
KS-2-3-NAD	0.0	0.0	0.0	0.4	0.4
KS-5-1-NAD	0.5	0.0	0.0	0.0	0.5
KS-6-1/KS-6-2	0.0	0.0	0.0	0.9	0.9
KS-6-1-NAD	0.1	0.0	0.0	0.9	1.0
KS-6-3/KS-6-4	0.0	0.0	0.0	1.9	1.9
KS-6-3-NAD	0.0	0.0	0.0	0.5	0.5
KS-8-4/KS-9-1	0.0	0.0	0.0	0.4	0.4
Grand Total	**13.1**	**6.0**	**0.0**	**43.7**	**62.8**

Table E-19. Summary statistics of the percent of each shoretype found across all Kitsap County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	0.3	19.5	0.0	17.9	10.5	51.8
Median	0.0	10.8	0.0	11.5	9.3	55.7
Std Dev	1.2	22.0	0.0	19.7	11.1	29.2

Table E-20. Modified shores that were likely historic feeder bluffs throughout Kitsap County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	24.0	27.3
MOD without Historic FB	38.0	43.4
MOD marked Unknown	25.6	29.2
Total MODs	**87.6**	**100**

Mason County

Table E-21. Summary of shoretypes across Mason County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-10-1	0.0	0.0	0.0	1.0	2.6	96.4
MA-10-2	0.0	0.0	0.0	0.0	0.0	100.0
MA-10-3	0.0	0.0	0.0	0.0	3.9	96.1
MA-10-4	0.0	0.0	0.0	0.0	25.7	74.3
MA-10-7	0.0	0.0	0.0	0.7	38.9	60.4
MA-10-8	0.0	0.0	0.0	3.8	0.0	96.2
MA-11-1	0.0	0.0	0.0	8.4	8.6	82.9
MA-11-2	0.0	0.0	0.0	19.3	1.3	79.4
MA-11-3	0.0	0.0	0.0	25.8	44.8	29.4
MA-11-5	0.0	0.0	0.0	0.0	0.0	100.0
MA-11-6	0.0	0.0	0.0	7.1	8.0	84.9
MA-1-2	0.0	14.2	0.0	63.0	0.0	22.8

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-12-1	0.0	0.0	0.0	8.2	41.5	50.3
MA-12-3	0.0	0.0	0.0	100.0	0.0	0.0
MA-12-4	0.0	5.3	0.0	20.6	9.5	64.6
MA-12-5	0.0	4.0	0.0	16.5	28.0	51.5
MA-12-6	0.0	0.0	0.0	0.0	0.0	100.0
MA-1-3	0.0	5.6	0.0	44.1	5.7	44.7
MA-13-1	0.0	38.7	0.0	38.4	9.2	13.7
MA-13-10	0.0	50.1	0.0	0.0	0.0	49.9
MA-13-11	0.0	0.0	0.0	0.0	32.1	67.9
MA-13-12	0.0	0.0	0.0	0.0	0.0	100.0
MA-13-13	0.0	0.0	0.0	0.0	0.0	100.0
MA-13-14	0.0	0.0	0.0	3.9	6.7	89.4
MA-13-15	0.0	0.0	0.0	0.0	0.0	100.0
MA-13-16	0.0	0.0	0.0	0.0	0.0	100.0
MA-13-17	0.0	0.0	0.0	0.0	0.0	100.0
MA-13-2-1	0.0	41.2	0.0	58.8	0.0	0.0
MA-13-2-2	0.0	0.0	0.0	100.0	0.0	0.0
MA-13-3	0.0	69.8	0.0	2.6	11.8	15.8
MA-13-4	0.0	45.2	0.0	0.0	54.8	0.0
MA-13-5	0.0	4.5	0.0	16.7	41.2	37.5
MA-13-6	0.0	25.9	0.0	26.0	14.5	33.6
MA-13-7	0.0	5.2	0.0	4.6	51.5	38.6
MA-13-8	0.0	17.7	0.0	15.7	24.2	42.3
MA-13-9	0.0	20.8	0.0	15.5	16.5	47.2
MA-1-4	0.0	15.2	0.0	3.3	8.9	72.5
MA-14-10	0.0	93.5	0.0	0.0	0.0	6.5
MA-14-10-2	0.0	0.0	0.0	0.0	0.0	100.0
MA-14-11	0.0	80.9	0.0	3.5	3.4	12.1

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-14-1-1	0.0	82.6	0.0	16.0	1.4	0.0
MA-14-12	0.0	75.0	0.0	6.6	2.3	16.0
MA-14-13	0.0	100.0	0.0	0.0	0.0	0.0
MA-14-14	0.0	56.5	0.0	2.6	40.9	0.0
MA-14-2	0.0	30.1	0.0	0.0	69.9	0.0
MA-14-3	0.0	60.6	0.0	0.0	39.4	0.0
MA-14-4	0.0	58.6	0.0	41.4	0.0	0.0
MA-14-5	0.0	35.3	0.0	64.7	0.0	0.0
MA-14-6	0.0	65.1	0.0	34.9	0.0	0.0
MA-14-8	0.0	76.3	0.0	20.6	3.1	0.0
MA-14-9	0.0	24.9	0.0	23.8	0.0	51.3
MA-1-5	0.0	11.8	0.0	11.3	0.0	76.9
MA-15-2	0.0	79.1	0.0	16.3	4.6	0.0
MA-15-3	0.0	79.9	0.0	9.3	10.8	0.0
MA-15-4	0.0	0.0	0.0	0.0	100.0	0.0
MA-15-5	0.0	0.0	0.0	36.9	63.1	0.0
MA-15-6	0.0	33.5	0.0	28.0	22.0	16.5
MA-15-7	0.0	60.6	0.0	3.3	17.5	18.5
MA-16-1	0.0	31.7	0.0	23.6	18.6	26.0
MA-17-1	0.0	0.0	0.0	0.0	7.2	92.8
MA-17-10	0.0	0.0	0.0	0.0	100.0	0.0
MA-17-13	0.0	81.3	0.0	5.3	0.0	13.4
MA-17-2	0.0	0.0	0.0	46.8	31.3	21.9
MA-17-3	0.0	11.6	0.0	50.7	5.7	32.0
MA-17-4	0.0	0.0	0.0	22.4	65.0	12.6
MA-17-5	0.0	47.1	0.0	31.9	21.0	0.0
MA-17-6	0.0	6.3	0.0	28.8	23.2	41.7
MA-17-7	0.0	0.0	0.0	0.0	58.0	42.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-17-8	0.0	0.0	0.0	37.7	42.9	19.3
MA-17-9	0.0	45.4	0.0	6.4	11.8	36.3
MA-18-1	0.0	21.3	0.0	5.1	9.7	63.9
MA-18-2	0.0	0.0	0.0	26.7	22.3	50.9
MA-18-4	0.0	0.0	0.0	21.4	26.7	51.9
MA-18-8	0.0	100.0	0.0	0.0	0.0	0.0
MA-19-1	0.0	47.6	0.0	17.8	3.7	30.8
MA-19-2	0.0	91.6	0.0	0.0	0.0	8.4
MA-19-4	0.0	73.4	0.0	26.6	0.0	0.0
MA-19-5	0.0	30.4	0.0	63.8	0.0	5.9
MA-19-6	0.0	50.9	0.0	37.0	0.0	12.1
MA-19-8	0.0	0.0	0.0	100.0	0.0	0.0
MA-19-9	0.0	19.4	0.0	78.1	2.5	0.0
MA-20-1	0.0	25.6	0.0	43.2	6.7	24.6
MA-2-1	0.0	10.1	0.0	54.3	20.5	15.2
MA-21-1	0.0	34.8	0.0	51.8	0.0	13.4
MA-21-2	0.0	31.1	0.0	58.3	2.0	8.5
MA-21-3	0.0	43.2	0.0	37.5	0.0	19.3
MA-21-4	0.0	70.7	0.0	13.6	3.3	12.4
MA-21-5	0.0	9.2	0.0	14.9	0.0	75.9
MA-2-2	0.0	49.4	0.0	28.8	0.0	21.8
MA-22-1	0.0	0.0	0.0	100.0	0.0	0.0
MA-22-3	0.0	0.0	0.0	81.3	18.7	0.0
MA-22-4	0.0	0.0	0.0	60.1	30.8	9.1
MA-2-3	0.0	25.5	0.0	12.6	10.3	51.5
MA-23-1	0.0	13.7	0.0	46.7	5.4	34.2
MA-23-1-2	0.0	26.6	0.0	6.0	0.0	67.5
MA-23-4	0.0	16.2	0.0	46.3	14.2	23.3

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-24-1	0.0	24.6	0.0	68.9	0.0	6.5
MA-24-11	0.0	60.4	0.0	28.9	0.0	10.7
MA-24-13	0.0	68.3	0.0	27.9	0.0	3.8
MA-24-14	0.0	12.5	0.0	38.9	3.2	45.4
MA-24-15	0.0	0.0	0.0	26.9	0.6	72.6
MA-24-16	0.0	0.0	0.0	35.3	0.0	64.7
MA-24-17	0.0	0.0	0.0	100.0	0.0	0.0
MA-24-4	0.0	26.4	0.0	30.0	14.3	29.3
MA-24-5	0.0	5.7	0.0	31.0	9.2	54.0
MA-24-8	0.0	0.0	0.0	24.0	22.1	53.9
MA-24-9	0.0	9.4	0.0	60.0	0.0	30.6
MA-3-2	0.0	0.8	0.0	4.2	27.9	67.2
MA-3-3	0.0	22.8	0.0	4.7	5.1	67.4
MA-4-2	0.0	40.3	0.0	0.0	1.5	58.2
MA-4-3	0.0	0.0	0.0	19.2	2.8	77.9
MA-4-3/MA-5-2	0.0	0.0	0.0	0.0	100.0	0.0
MA-4-5	0.0	42.2	0.0	36.3	16.0	5.5
*MA-4-6	0.0	64.7	0.0	23.2	9.1	3.0
MA-5-2	0.0	0.0	0.0	5.8	4.7	89.5
MA-6-2	0.0	8.1	0.0	7.0	27.5	57.4
MA-7-1	0.7	35.5	0.0	19.6	16.3	27.8
MA-7-4	0.0	0.0	0.0	5.3	0.0	94.7
MA-8-1	0.0	6.4	0.0	2.9	22.6	68.1
MA-8-2	0.0	0.0	0.0	7.4	4.7	88.0
MA-8-5	0.0	0.0	0.0	28.5	0.0	71.5
MA-8-6	0.0	0.0	0.0	0.3	0.3	99.4
MA-9-1	0.0	0.0	0.0	0.7	0.0	99.3
MA-9-2	0.0	0.0	0.0	0.0	22.2	77.8

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
MA-9-3	0.0	0.0	0.0	0.0	0.0	100.0
MA-9-4	0.0	0.0	0.0	4.8	3.7	91.5
*PI-14-15	0.0	6.3	0.0	14.4	20.8	58.5
SQX-1	0.0	31.3	0.0	60.0	8.6	0.0
SQX-10	0.0	0.0	0.0	0.0	100.0	0.0
SQX-11	0.0	0.0	0.0	70.2	29.8	0.0
SQX-12	0.0	0.0	0.0	11.7	88.3	0.0
SQX-13	0.0	51.3	0.0	30.8	17.9	0.0
SQX-2	0.0	0.0	0.0	100.0	0.0	0.0
SQX-3	0.0	0.0	0.0	84.1	15.9	0.0
SQX-4	0.0	0.0	0.0	19.3	80.7	0.0
SQX-5	0.0	30.4	0.0	67.0	2.6	0.0
SQX-6	0.0	0.0	0.0	67.6	30.6	1.8
SQX-7	0.0	38.9	0.0	32.9	28.2	0.0
SQX-8	0.0	36.4	0.0	15.9	47.8	0.0
SQX-9	0.0	13.5	0.0	64.4	22.1	0.0
Grand Total	**0.0**	**25.8**	**1.0**	**21.3**	**11.8**	**41.0**

*only partially within county

Table E-22. NAD type breakdown in Mason County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
MA-11-3/MA-11-6	0.0	0.0	5.1	0.0	5.1
MA-1-2/MA-1-3	0.0	0.4	0.0	0.0	0.4
MA-12-1-NAD	0.0	0.0	0.0	0.9	0.9
MA-12-2/MA-12-3	0.0	0.0	0.0	1.1	1.1
MA-12-4/MA-12-5	0.0	0.0	0.0	1.4	1.4
MA-12-4-NAD	0.0	0.0	0.0	0.4	0.4
MA-1-3/MA-1-4	0.0	0.6	0.0	0.0	0.6
MA-13-1/MA13-2-2	0.0	0.0	0.0	1.3	1.3
MA-13-12/MA-13-15	0.0	0.0	0.0	0.5	0.5

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
MA-13-13/MA-13-14	0.0	0.0	0.0	0.3	0.3
MA-13-16/MA-13-17	0.0	0.0	0.0	0.4	0.4
MA-13-2-1/MA-13-2-2	0.0	0.0	0.0	0.2	0.2
MA-13-3/MA-13-4	0.0	0.0	0.0	1.2	1.2
MA-13-6/MA-13-7	0.0	0.0	0.0	0.2	0.2
MA-14-10-1/14-10-2	0.0	0.0	0.0	0.1	0.1
MA-14-1-1/MA-14-2	0.0	0.0	0.0	0.3	0.3
MA-14-12/MA-14-11	0.0	0.0	0.0	0.3	0.3
MA-14-3/MA-14-4	0.0	0.0	0.0	0.1	0.1
MA-14-5/MA-14-6	0.0	0.0	0.0	0.0	0.0
MA-14-8/MA17-13	0.0	0.0	0.0	0.2	0.2
MA-14-9/MA-14-10	0.0	0.0	0.0	2.0	2.0
MA-1-5/MA-2-1	0.0	0.4	0.0	0.0	0.4
MA-15-7-NAD	0.0	0.0	0.0	0.2	0.2
MA-16-1/MA-18-7	0.0	0.0	0.0	0.1	0.1
MA-16-1-NAD	0.0	0.0	0.0	0.3	0.3
MA-17-1/MA-17-2	0.0	0.0	0.0	0.4	0.4
MA-17-12/MA-17-13	0.0	0.0	0.0	0.1	0.1
MA-17-13-NAD	0.0	0.0	0.0	0.0	0.0
MA-17-1-NAD	0.0	0.0	0.0	0.2	0.2
MA-17-2-NAD	0.0	0.0	0.0	0.2	0.2
MA-17-3-NAD	0.0	0.0	0.0	0.0	0.0
MA-17-4	0.0	0.0	0.0	0.2	0.2
MA-17-5/MA-17-6	0.0	0.0	0.0	0.0	0.0
MA-17-7/MA-17-8	0.0	0.0	0.0	0.6	0.6
MA-17-9/MA-17-10	0.0	0.0	0.0	0.5	0.5
MA-18-1-NAD	0.0	0.0	0.0	0.0	0.0
MA-18-8-NAD	0.0	0.0	0.0	0.1	0.1
MA-19-1/MA-19-2	0.0	0.3	0.0	0.0	0.3
MA-19-1-NAD	0.0	0.0	0.0	0.4	0.4
MA-19-2/MA-24-13	0.0	0.3	0.0	0.0	0.3
MA-19-4/MA-19-5	0.0	0.0	0.0	0.2	0.2
MA-19-4MA-24-11	0.0	0.1	0.0	0.0	0.1
MA-20-1/MA-22-4	0.0	0.0	0.0	0.0	0.0
MA-2-1/MA-2-2	0.0	0.2	0.0	0.0	0.2
MA-21-1-NAD	0.0	0.0	0.0	0.3	0.3

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
MA-21-5/MA-22-3	0.0	0.0	0.0	2.8	2.8
MA-2-2/MA-2-3	0.5	0.0	1.7	0.0	2.2
MA-22-3/MA-22-4	0.0	0.0	0.0	6.5	6.5
MA-22-4-NAD	0.0	0.0	0.0	0.1	0.1
MA-23-1/MA-23-4	0.0	0.0	0.0	4.6	4.7
MA-24-1/MA-23-1-2	2.5	0.0	0.0	0.0	2.5
MA-24-1/MA-24-13	0.0	0.0	0.0	0.8	0.8
MA-24-11-NAD	0.0	0.0	0.0	0.1	0.1
MA-24-14/MA-24-15	0.0	0.2	0.0	0.0	0.2
MA-24-3/MA-24-4	0.0	0.0	0.0	2.6	2.6
MA-4-2/MA-4-3	0.1	0.0	0.0	0.8	0.9
MA-4-3/MA-5-2	0.0	0.5	0.0	0.0	0.5
MA-4-5/MA-7-1	0.0	0.0	0.0	1.9	1.9
MA-6-2/MA-7-3	0.0	0.0	1.0	0.0	1.0
MA-6-2/MA-7-4	0.0	0.0	5.0	0.0	5.0
MA-7-1-NAD	0.0	0.0	0.0	0.1	0.1
MA-8-1/MA-8-2	0.2	0.0	0.0	2.2	2.4
SQX-11/SQX-12	0.0	0.0	0.0	0.9	0.9
SQX-1-NAD	0.0	0.0	0.0	0.2	0.2
SQX-2/SQX-3	0.0	0.0	0.0	0.2	0.2
SQX-4/SQX-5	0.0	0.0	0.0	0.1	0.1
SQX-5/SQX-6	0.0	0.0	0.0	0.1	0.1
SQX-7/SQX-8	0.0	0.0	0.0	0.4	0.4
SQX-7-NAD	0.0	0.0	0.0	0.6	0.6
SQX-9-SQX-10	0.0	0.0	0.0	0.5	0.5
Grand Total	**3.4**	**3.0**	**12.8**	**40.6**	**59.8**

Table E-23. Summary statistics of the percent of each shoretype found across all Mason County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	0.0	22.3	0.0	24.9	16.0	36.8
Median	0.0	8.7	0.0	16.6	5.7	26.9
Std Dev	0.1	27.8	0.0	26.9	23.1	35.6

Table E-24. Modified shores that were likely historic feeder bluffs throughout Mason County.

MOD type	Total (mi)	Percentage
MOD with Historic FB	33.9	48.5
MOD without Historic FB	20.0	28.6
MOD marked Unknown	16.0	22.9
Total MODs	69.8	**100**

Pierce County

Table E-25. Summary of shoretypes across Pierce County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
*KS-20-1	0.0	33.2	0.0	33.2	4.0	29.5
P-19-6	0.0	2.8	0.0	25.1	0.0	72.1
PI-10-1	0.0	5.3	0.0	2.4	2.6	89.6
PI-10-2	0.0	0.0	0.0	57.0	0.0	43.0
PI-10-3	6.3	41.2	0.0	8.9	5.8	37.8
PI-10-4	0.0	62.4	0.0	5.2	8.8	23.6
*PI-1-1	0.0	43.4	0.0	5.1	5.8	45.8
PI-11-10	0.0	75.7	0.0	24.3	0.0	0.0
PI-11-11	0.0	25.6	0.0	34.3	0.0	40.1
PI-11-12	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-13	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-16	0.0	0.0	0.0	1.4	2.3	96.3
PI-11-17	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-18	0.0	4.3	0.0	20.7	31.0	44.0
PI-11-19	0.0	27.8	0.0	17.5	11.4	43.4
PI-11-21	0.0	8.8	0.0	5.7	0.0	85.5
PI-11-22	0.0	13.1	0.0	4.4	0.9	81.6
PI-11-23	0.0	0.0	0.0	0.0	3.7	96.3
PI-11-24	0.0	0.0	0.0	0.0	13.8	86.2

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
PI-11-25	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-26	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-27	0.0	36.4	0.0	0.0	21.9	41.7
PI-11-28	0.0	13.1	0.0	2.3	17.4	67.1
PI-11-29	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-30	0.0	11.1	0.0	6.6	0.0	82.3
PI-11-31	0.0	17.3	0.0	4.2	11.3	67.2
PI-11-4	0.0	0.0	0.0	26.6	0.0	73.4
PI-11-5	0.0	0.0	0.0	20.5	17.3	62.3
PI-11-6	0.0	0.0	0.0	0.0	64.4	35.6
PI-11-7	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-8	0.0	0.0	0.0	0.0	0.0	100.0
PI-11-9	0.0	0.0	0.0	0.0	0.0	100.0
PI-1-2	0.0	47.7	0.0	0.0	0.0	52.3
PI-12-1	0.0	85.3	0.0	7.1	7.5	0.0
PI-12-10	0.0	0.0	0.0	0.0	0.0	100.0
PI-12-11	0.0	4.8	0.0	8.6	22.6	64.0
PI-12-12	0.0	3.4	0.0	6.9	2.6	87.1
PI-12-14	0.0	18.5	0.0	0.9	5.2	75.4
PI-12-16	0.0	7.6	0.0	25.2	9.2	57.9
PI-12-2	5.9	53.4	0.0	12.4	11.0	17.3
PI-12-4	0.0	0.0	0.0	8.2	0.0	91.8
PI-12-5	0.0	0.0	0.0	24.0	0.0	76.0
PI-12-6	0.0	0.0	0.0	0.0	0.0	100.0
PI-12-7	0.0	0.0	0.0	0.0	0.0	100.0
PI-12-8	0.0	0.0	0.0	10.3	0.0	89.7
PI-12-9	0.0	0.0	0.0	6.4	0.0	93.6
PI-1-3	0.0	17.8	0.0	4.6	0.0	77.6

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
PI-13-2	0.0	15.5	0.0	70.7	0.0	13.8
PI-13-3	0.0	35.8	0.0	39.5	0.0	24.7
PI-1-4	0.0	11.0	0.0	5.1	5.9	78.0
PI-14-1	0.0	31.2	0.0	3.5	3.3	62.0
PI-14-10	1.3	1.8	0.0	4.8	0.0	92.0
PI-14-11	8.3	8.1	0.0	0.0	64.4	19.3
PI-14-12	0.0	0.0	0.0	16.8	0.0	83.2
PI-14-13	0.0	0.0	0.0	22.6	23.0	54.5
PI-14-14	0.0	0.0	0.0	0.0	0.0	100.0
PI-14-15	0.0	5.5	0.0	25.9	18.0	50.7
PI-14-2	11.1	21.8	0.0	7.8	17.9	41.5
PI-14-3	0.0	36.0	0.0	0.0	34.6	29.4
PI-14-4	0.0	9.7	0.0	17.8	0.0	72.4
PI-14-5	0.0	9.3	0.0	50.5	0.0	40.2
PI-14-7	2.8	22.7	0.0	9.6	11.1	53.8
PI-14-9	0.0	0.0	0.0	32.6	0.0	67.4
PI-1-5	0.0	81.0	0.0	0.0	0.0	19.0
PI-15-1	2.8	18.9	0.0	6.3	19.3	52.7
PI-15-2	0.0	8.6	0.0	0.0	0.0	91.4
PI-15-3	0.0	35.7	0.0	18.7	14.3	31.4
PI-15-4	0.0	12.8	0.0	23.5	10.9	52.8
PI-15-5	11.1	42.2	0.0	13.5	10.4	22.8
PI-16-2	0.0	0.0	0.0	7.3	5.9	86.8
PI-17-2	0.0	15.4	0.0	2.4	34.2	48.0
PI-17-3	4.3	13.5	0.0	14.6	9.3	58.3
PI-17-4	17.2	25.7	0.0	10.4	34.0	12.7
PI-17-5	0.0	0.0	0.0	8.0	10.9	81.0
PI-19-1	0.0	27.1	0.0	18.8	7.5	46.6

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
PI-19-2	24.1	39.1	0.0	14.7	4.9	17.3
PI-19-3	0.0	19.4	0.0	45.2	2.3	33.1
PI-19-4	0.0	0.0	0.0	12.9	0.0	87.1
PI-19-5	0.0	16.1	0.0	23.2	0.0	60.7
PI-19-7	0.0	24.3	0.0	16.5	0.0	59.2
PI-19-8	0.0	31.6	0.0	17.4	5.2	45.8
PI-19A-10	0.0	54.7	0.0	0.0	0.0	45.3
PI-19A-11	0.0	59.5	0.0	14.2	16.5	9.8
PI-19A-2	0.0	7.5	0.0	22.1	3.4	67.0
PI-19A-3	0.0	17.0	0.0	5.9	19.0	58.1
PI-19A-4	0.0	16.1	0.0	34.8	0.0	49.1
PI-19A-5	0.0	18.7	0.0	29.5	14.1	37.8
PI-19A-6	0.0	0.0	0.0	88.0	12.0	0.0
PI-19A-7	0.0	41.6	0.0	47.7	10.7	0.0
PI-19A-8	0.0	25.7	0.0	30.7	2.8	40.8
PI-19A-9	0.0	57.3	0.0	23.6	6.7	12.4
PI-20-2	0.0	27.3	0.0	0.0	72.7	0.0
PI-20-3	11.7	54.2	0.0	10.3	8.7	15.0
PI-20-4	12.4	43.3	0.0	11.9	27.4	5.0
PI-20-5	0.0	35.3	0.0	26.0	14.8	23.9
PI-2-1	0.0	0.0	0.0	15.9	19.0	65.1
PI-21-1	0.0	56.8	0.0	15.4	11.8	16.1
PI-21-3	3.7	59.6	0.0	22.6	11.5	2.6
PI-21-5	0.0	94.9	0.0	5.1	0.0	0.0
PI-22-1	2.5	50.7	0.0	23.7	7.1	16.0
PI-22-10	0.0	57.5	0.0	29.9	12.7	0.0
PI-22-11	0.0	53.7	0.0	21.4	0.0	24.9
PI-22-2	0.0	68.7	0.0	11.2	11.2	8.9

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
PI-22-3	39.5	3.6	0.0	35.2	17.7	4.0
PI-22-4	8.8	13.6	0.0	29.1	20.7	27.8
PI-22-5	0.0	0.0	0.0	55.4	44.6	0.0
PI-22-6	0.0	20.2	0.0	76.3	3.4	0.0
PI-22-7	0.0	0.0	0.0	0.0	0.0	100.0
PI-22-9	10.0	26.4	0.0	22.5	16.2	24.9
PI-2-3	0.0	0.0	0.0	0.0	8.0	92.0
PI-23-1	0.0	0.0	0.0	100.0	0.0	0.0
PI-23-2	0.0	0.0	0.0	100.0	0.0	0.0
PI-23-3	0.0	0.0	0.0	100.0	0.0	0.0
PI-23-4	0.0	0.0	0.0	100.0	0.0	0.0
PI-2-4	0.0	0.0	0.0	0.0	2.5	97.5
PI-24-1	0.0	88.5	0.0	0.0	11.5	0.0
PI-24-2	0.0	28.2	0.0	32.7	39.1	0.0
PI-24-3	0.0	60.1	0.0	39.9	0.0	0.0
PI-24-4	0.0	47.1	0.0	52.9	0.0	0.0
PI-25-1	0.0	49.4	0.0	20.7	16.0	13.9
PI-25-10	0.0	14.3	0.0	75.9	4.4	5.4
PI-25-11	0.0	63.9	0.0	23.5	12.7	0.0
PI-25-12	0.0	5.0	0.0	51.9	16.3	26.8
PI-25-13	0.0	6.2	0.0	91.7	2.1	0.0
PI-25-14	0.0	69.1	0.0	30.9	0.0	0.0
PI-25-2	0.0	64.4	0.0	23.7	5.9	6.1
PI-25-3	0.0	7.3	0.0	68.2	24.5	0.0
PI-25-4	0.0	57.6	0.0	28.2	13.0	1.1
PI-25-6	0.0	35.5	0.0	55.1	1.5	7.9
PI-25-7	0.0	42.4	0.0	49.7	0.0	7.9
PI-25-8	0.0	55.2	0.0	40.6	4.2	0.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
PI-25-9	0.0	48.6	0.0	34.3	17.0	0.0
PI-3-3	10.0	30.9	0.0	2.2	7.9	49.1
PI-3-4	2.1	17.5	0.0	5.5	0.0	75.0
PI-4-2	0.0	0.0	0.0	0.0	0.0	100.0
PI-4-3	0.0	0.0	0.0	0.0	0.0	100.0
PI-4-4	0.0	0.0	0.0	0.0	0.0	100.0
PI-5-1	0.0	0.0	0.0	0.0	0.0	100.0
PI-5-2	0.0	0.0	0.0	0.0	0.0	100.0
PI-5-4	0.0	68.4	0.0	6.2	5.3	20.1
PI-5-5	0.0	77.1	0.0	6.2	16.7	0.0
PI-5-6	4.0	71.6	0.0	11.2	13.2	0.0
PI-5-7	0.0	61.0	0.0	21.3	17.7	0.0
PI-6-1	0.0	0.0	0.0	0.0	0.0	100.0
PI-6-2	0.0	0.0	0.0	0.0	0.0	100.0
PI-6-3	0.0	0.0	0.0	0.0	0.0	100.0
PI-7-2	0.0	29.4	0.0	21.8	0.0	48.8
PI-7-3	0.4	49.9	0.0	4.9	0.0	44.8
PI-8-2	0.0	19.2	0.0	0.0	30.4	50.4
PI-8-3	0.0	0.0	0.0	0.0	3.7	96.3
PI-8-4	0.0	0.0	0.0	2.5	0.0	97.5
PI-8-5	0.0	26.5	0.0	0.0	5.8	67.7
PI-9-1	19.8	78.0	0.0	0.0	0.0	2.2
PI-9-2	4.6	75.7	0.0	10.8	0.0	9.0
PI-9-3	1.5	10.4	0.0	4.0	2.4	81.7
Grand Total	**2.4**	**26.8**	**0.0**	**15.2**	**7.4**	**48.2**

*only partially within county

Table E-26. NAD type breakdown for Pierce County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
KS-20-1-NAD	0.0	0.0	0.0	1.4	1.4
PI-10-2/PI-10-3	0.0	0.0	0.0	0.6	0.6
PI-10-3-NAD	0.0	0.0	0.0	0.2	0.2
PI-11-22-NAD	0.0	0.0	0.0	0.2	0.2
PI-11-26/PI-11-27	0.0	0.0	0.0	0.1	0.1
PI-11-28/PI-11-29	0.0	0.0	0.0	0.2	0.2
PI-11-29/PI-11-30	0.0	0.0	0.0	0.5	0.5
PI-11-4/PI-10-1	0.0	0.0	0.0	0.2	0.2
PI-11-9/PI-11-12	0.0	0.0	0.0	0.8	0.8
PI-12-10/PI-12-11	0.0	0.0	0.0	1.1	1.1
PI-12-16-NAD	0.0	0.0	0.0	1.0	1.0
PI-12-2/PI-12-1	0.0	0.0	0.0	0.2	0.2
PI-12-2/PI-21-1	0.0	0.0	0.0	0.7	0.7
PI-12-4/PI-13-2	0.0	0.0	0.0	2.4	2.4
PI-12-5/PI-12-6	0.0	0.0	0.0	0.5	0.5
PI-12-6/PI-12-7	0.0	0.0	0.0	1.1	1.1
PI-13-3/PI-13-4	0.0	0.0	0.0	0.8	0.8
PI-14-1/PI-14-2	0.0	0.0	0.0	2.9	2.9
PI-14-11/PI-14-12	0.0	0.0	0.0	0.5	0.5
PI-14-14/PI-14-15	0.0	0.0	0.0	1.2	1.2
PI-14-15-NAD	0.0	0.0	0.0	0.4	0.4
PI-14-3/PI-14-4	0.0	0.0	0.0	0.1	0.1
PI-14-5/PI-14-7	0.0	0.0	0.0	0.8	0.8
PI-14-7-NAD	0.0	0.0	0.0	0.7	0.7
PI-14-9/PI-14-10	0.0	0.0	0.0	0.7	0.7
PI-14-9/PI-15-1	0.0	0.0	0.0	0.8	0.8
PI-1-5/PI-2-1	0.4	0.0	0.0	0.0	0.4
PI-15-2/PI-15-3	0.0	0.0	0.0	1.6	1.6
PI-15-3-NAD	0.0	0.0	0.0	0.5	0.5
PI-15-5/PI-15-4	0.1	0.0	0.0	0.4	0.5
PI-15-5-NAD	0.0	0.0	0.0	0.2	0.2
PI-16-2/PI-19A-2	0.0	0.0	0.0	0.2	0.2
PI-17-4-NAD	0.0	0.0	0.0	0.4	0.4
PI-19-3/PI-19-4	0.0	0.0	0.0	0.7	0.7
PI-19-5/PI-19-6	0.0	0.0	0.0	1.0	1.0

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
PI-19-7/PI-19-8	0.0	0.0	0.0	0.7	0.7
PI-19A-3/PI-19A-4	0.0	0.0	0.0	0.3	0.3
PI-19A-4/PI-19A-5	0.0	0.0	0.0	0.8	0.8
PI-20-4/PI-20-5	0.0	0.0	0.0	0.7	0.7
PI-20-4-NAD	0.0	0.0	0.0	0.4	0.4
PI-2-1/PI-2-3	29.5	0.0	0.0	0.0	29.5
PI-21-1-NAD	0.0	0.0	0.0	0.7	0.7
PI-21-3-NAD	0.0	0.0	0.0	0.6	0.6
PI-22-10/PI-22-11	0.0	0.0	0.0	0.2	0.2
PI-22-1-NAD	0.0	0.0	0.0	0.3	0.3
PI-22-4/PI-22-5	0.0	0.0	0.0	1.6	1.6
PI-22-6/PI-22-7	0.0	0.0	0.0	1.8	1.8
PI-2-3/PI-2-4	0.1	0.0	0.0	0.0	0.1
PI-3-2/PI-3-3	2.2	0.0	0.0	0.0	2.2
PI-4-2/PI-4-3-NAD	1.4	0.0	0.0	0.3	1.7
PI-4-2-NAD	0.1	0.0	0.0	0.2	0.3
PI-4-3/PI-4-4-NAD	0.0	0.0	0.0	0.1	0.1
PI-4-3-NAD	0.7	0.0	0.0	1.3	2.1
PI-6-3/TH-1-1-NAD	0.0	0.0	0.1	0.0	0.1
PI-8-4/PI-8-5	1.2	0.0	0.0	1.3	2.5
PI-9-3/PI-11-21	0.0	0.0	0.0	2.0	2.0
Grand Total	**35.9**	**0.0**	**0.1**	**38.5**	**74.4**

Table E-27. Summary statistics of the percent of each shoretype found across all Pierce County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	1.5	23.2	0.0	18.7	8.4	48.2
Median	0.0	15.4	0.0	10.4	3.4	46.6
Std Dev	4.8	25.2	0.0	23.3	12.4	36.7

Table E-28. Modified shores that were likely historic feeder bluffs throughout Pierce County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	29.3	34.6
MOD without Historic FB	24.1	28.4
MOD marked Unknown	31.4	37
Total MODs	**84.8**	**100**

San Juan County

Table E-29. Summary of shoretypes across San Juan County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
BL-1	0.0	12.5	0.0	62.5	25.0	0.0
BL-10	0.0	13.8	0.0	12.3	55.8	18.1
BL-2	0.0	3.4	6.3	86.8	3.6	0.0
BL-3	0.0	0.0	34.1	58.0	7.9	0.0
BL-4	0.0	86.4	0.0	0.0	13.6	0.0
BL-5	0.0	24.7	0.0	46.2	23.7	5.4
BL-6	0.0	0.0	0.0	75.6	20.2	4.2
BL-7	0.0	30.7	0.0	55.3	5.8	8.1
BL-8	0.0	63.6	0.0	31.7	3.6	1.1
BL-9	0.0	9.2	0.0	50.3	35.5	5.0
BR-1	0.0	19.3	0.0	65.9	1.7	13.1
BR-2	0.0	31.7	0.0	25.4	0.0	42.9
CE-1	0.0	38.4	0.0	40.4	1.7	19.5
CL-1	0.0	45.1	0.0	32.8	22.0	0.0
DE-1	0.0	11.3	0.0	63.0	24.4	1.2
DE-2	0.0	32.4	0.0	30.5	36.8	0.3
DE-3	10.4	70.9	0.0	15.4	3.3	0.0
DE-4	0.0	2.7	0.0	64.0	31.8	1.6
DE-5	0.0	29.4	0.0	11.3	34.4	24.9
DE-6	0.0	0.0	0.0	51.1	48.9	0.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
HE-1	0.0	0.0	0.0	47.4	43.7	8.9
HE-2	0.0	13.4	0.0	55.2	9.2	22.2
HE-3	0.0	0.0	0.0	45.3	54.7	0.0
HE-4	0.0	50.6	0.0	29.7	14.5	5.1
HE-5	0.0	16.7	0.0	24.8	58.5	0.0
HE-6	0.0	0.0	0.0	20.4	79.6	0.0
HE-7	0.0	0.0	0.0	22.7	77.3	0.0
HE-8	0.0	48.2	0.0	27.3	24.5	0.0
JN-1	0.0	40.1	0.0	45.1	14.4	0.5
LO-1	0.0	34.1	0.0	31.6	12.5	21.8
LO-10	0.0	11.0	0.0	19.3	19.0	50.8
LO-11	0.0	0.0	0.0	28.7	71.3	0.0
LO-12	0.0	0.0	0.0	34.9	65.1	0.0
LO-13	0.0	40.4	0.0	31.2	10.3	18.1
LO-14	7.0	19.4	0.0	32.2	23.7	17.8
LO-15	0.0	0.0	0.0	16.8	83.2	0.0
LO-16	0.0	0.0	0.0	12.2	74.7	13.1
LO-17	0.0	2.2	0.0	54.1	19.6	24.1
LO-18	0.0	0.5	0.0	5.1	44.3	50.0
LO-19	0.0	0.0	0.0	18.2	24.1	57.7
LO-2	0.0	6.6	0.0	20.2	20.8	52.3
LO-20	0.0	36.5	0.0	2.5	14.0	47.0
LO-21	4.7	31.1	0.0	42.4	17.8	4.0
LO-22	0.0	56.1	0.0	10.0	33.5	0.4
LO-23	0.0	55.7	0.0	10.4	30.3	3.6
LO-3	0.0	25.8	0.0	10.3	28.2	35.7
LO-4	0.0	30.1	0.0	17.9	23.4	28.6
LO-5	4.0	26.3	0.0	2.1	67.6	0.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
LO-6	2.4	56.0	0.0	16.5	12.2	12.8
LO-7	0.0	11.4	0.0	36.0	12.6	40.0
LO-8	0.0	18.4	0.0	25.8	41.1	14.6
LO-9	0.0	43.1	0.0	17.1	29.0	10.8
OB-1	0.0	33.9	0.0	55.5	10.6	0.0
OB-2	0.0	0.0	29.8	55.2	12.8	2.2
OB-3	0.0	0.0	0.0	86.7	13.3	0.0
OR-1	0.0	10.1	0.0	25.2	61.1	3.6
OR-10	0.0	10.5	12.8	68.9	7.8	0.0
OR-11	0.0	32.5	0.0	16.6	0.0	50.9
OR-12	0.0	27.7	0.0	36.2	36.1	0.0
OR-13	0.0	40.9	0.0	0.0	17	42.1
OR-13a	0.0	0.0	0.0	55.7	23.6	20.8
OR-14	0.0	3.9	0.0	54.0	0.0	42.1
OR-15	0.0	0.0	0.0	66.5	22.6	10.9
OR-16	0.0	39.2	0.0	21.7	11.8	27.3
OR-17	0.0	17.8	0.0	43.2	19.7	19.3
OR-18	0.0	20.1	0.0	48.5	18.2	13.2
OR-1a	0.0	12.6	0.0	0.0	15.4	72.0
OR-2	0.0	8.7	21.1	55.0	0.0	15.2
OR-3	0.0	13.0	0.0	67.7	0.0	19.3
OR-4	0.0	0.0	0.0	4.2	31.4	64.4
OR-5	0.0	11.1	0.0	65.6	12.4	10.9
OR-6	0.0	0.0	13.1	71.3	5.6	10.1
OR-7	22.5	19.5	0.0	21.3	28.4	8.3
OR-8	0.0	14.6	0.0	80.9	0.0	4.4
OR-9	0.0	1.0	54.5	41.7	2.1	0.7
PE-1	0.0	0.0	0.0	38.8	40.2	21.0

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
SH-1	0.0	9.3	0.0	30.1	0.0	60.6
SH-2	0.0	5.5	0.0	54.1	8.4	32.1
SH-3	0.0	0.0	0.0	33.6	0.0	66.4
SH-4	0.0	20.8	0.0	27.4	4.8	47.0
SH-5	3.1	34.8	0.0	5.3	38.4	18.4
SJ-1	0.0	2.7	0.0	50.8	26.6	19.8
SJ-10	37.2	3.4	0.0	14.1	45.3	0.0
SJ-11	0.0	41.5	0.0	34.7	1.2	22.6
SJ-12	0.0	35.8	0.0	58.6	5.6	0.0
SJ-13	0.0	33.9	0.0	60.6	5.5	0.0
SJ-14	0.0	0.0	0.0	8.9	0.0	91.1
SJ-15	0.0	0.0	0.0	85.3	0.0	14.7
SJ-16	0.0	0.0	0.0	92.8	0.0	7.2
SJ-17	0.0	0.0	0.0	63.7	30.2	6.1
SJ-18	0.0	9.9	0.0	83.3	2.3	4.5
SJ-19	0.0	0.0	0.0	66.1	22.3	11.6
SJ-2	0.0	5.1	0.0	40.1	43.9	10.9
SJ-20	0.0	0.0	0.0	61.1	19.2	19.7
SJ-21a	0.0	0.0	0.0	59.9	39.3	0.8
SJ-21b	0.0	9.1	0.0	75.6	15.3	0.0
SJ-22	0.0	44.3	0.0	47.0	8.6	0.0
SJ-23	0.0	0.0	0.0	88.5	11.5	0.0
SJ-24	0.0	5.8	0.0	51.7	12.2	30.3
SJ-25	0.0	6.4	0.0	65.7	11.5	16.3
SJ-26	0.0	19.1	0.0	25.0	0.0	55.9
SJ-27	0.0	20.3	0.0	44.2	17.2	18.3
SJ-28	0.0	3.8	0.0	19.4	53.6	23.2
SJ-2a	0.0	9.2	0.0	17.7	0.0	73.1

Drift Cell	CGS Shoretypes (%)					
	FBE	**FB**	**FB-T**	**TZ**	**AS**	**MOD**
SJ-2b	0.0	0.0	0.0	30.0	12.5	57.5
SJ-3	0.0	0.0	0.0	0.0	80.1	19.9
SJ-4	0.0	36.4	0.0	55.0	0.0	8.6
SJ-5	0.0	32.2	0.0	53.4	0.0	14.4
SJ-6	0.0	0.0	0.0	53.2	28.1	18.7
SJ-7	0.0	18.2	0.0	38.0	40.0	3.9
SJ-8	0.0	22.6	0.0	20.5	56.8	0.0
SJ-9	0.0	10.4	0.0	40.5	49.1	0.0
ST-1	0.0	27.8	0.0	12.0	38.8	21.4
ST-2	0.0	35.9	0.0	56.9	0.0	7.2
ST-3	0.0	9.6	0.0	67.8	22.6	0.0
ST-4	0.0	30.1	0.0	24.7	34.1	11.1
ST-5	0.0	5.7	0.0	50.6	43.7	0.0
ST-6	0.0	0.0	0.0	0.0	93.7	6.3
ST-7	0.0	0.0	0.0	64.7	35.3	0.0
ST-8	0.0	0.0	0.0	79.1	19.5	1.3
TU-1	0.0	49.5	0.0	23.3	27.2	0.0
TU-2	0.0	0.0	0.0	46.1	53.9	0.0
WL-1	58.9	0.0	0.0	17.4	23.7	0.0
WL-2	20.4	11.3	0.0	25.8	42.4	0.0
WL-3	5.2	19.2	0.0	50.6	22.2	2.8
WL-4	10.1	15.2	0.0	25.2	49.5	0.0
Grand Total	**3.0**	**20.4**	**1.6**	**36.4**	**24.9**	**13.7**

Table E-30. NAD type breakdown for San Juan County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
BA-1	0.0	1.3	0.0	0.0	1.3
BL-1/BL-10	0.5	0.5	0.0	0.0	0.9
Bl-1/BL-2	0.0	2.8	0.0	0.0	2.8
BL-3/BL-4	0.0	2.2	0.0	0.0	2.2
BL-5/BL-6	0.0	1.2	0.0	0.0	1.2
BL-6/BL-7	0.0	0.1	0.0	0.0	0.1
BL-7/BL-8	0.0	0.4	0.0	0.0	0.4
BR-1/BR-2	0.0	0.9	0.0	0.0	0.9
CE-1/CE-1	0.0	1.6	0.0	0.0	1.6
CL-1-NAD	0.0	2.5	0.0	0.0	2.5
CR-1	0.0	3.1	0.0	0.0	3.1
CT-1	0.0	1.0	0.0	0.0	1.0
CT-2	0.0	0.5	0.0	0.0	0.5
DE-1/DE-2	0.0	0.0	0.0	0.3	0.3
DE-1-NAD	0.0	0.1	0.0	0.0	0.1
DE-3/DE-4	0.0	3.2	0.0	0.0	3.2
DE-7/DE-8	0.0	5.1	0.0	0.0	5.1
FR-1	0.0	2.0	0.0	0.0	2.0
FT-1	0.0	1.6	0.0	0.0	1.6
HE-1/HE-2	0.0	0.0	0.0	0.9	0.9
HE-1/HE-8	0.0	2.2	0.0	0.0	2.2
HE-7/HE-8	0.0	5.4	0.0	0.0	5.4
JA-1	0.0	2.4	0.0	0.0	2.4
JN-1-NAD	0.0	3.8	0.0	0.0	3.8
JO-1	0.0	3.2	0.0	0.0	3.2
LO-1/LO-23	0.0	2.6	0.0	0.0	2.6
LO-10/LO-11	0.0	0.0	0.0	0.9	0.9
LO-12/LO-13	0.0	2.7	0.0	0.0	2.7
LO-13/LO-14	0.0	35.2	0.0	0.2	35.5
LO-13-NAD	0.0	0.0	0.0	0.0	0.0
LO-14/LO-15	0.0	0.1	0.0	0.5	0.6
LO-15/LO-16	0.0	0.2	0.0	0.3	0.4
LO-17/LO-18	0.0	0.0	0.0	1.8	1.8
LO-19/LO-20	0.0	0.0	0.0	0.5	0.5
LO-2/LO-1	0.0	0.0	0.0	0.3	0.3

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
LO-2/LO-3	0.0	1.8	0.0	0.0	1.8
LO-5-NAD	0.0	0.0	0.0	0.7	0.7
LO-6/LO-7	0.0	0.7	0.0	0.0	0.7
LO-7/LO-8	0.0	4.5	0.0	0.0	4.5
LO-9-NAD	0.0	0.0	0.0	0.6	0.6
LP-1	0.0	0.7	0.0	0.0	0.7
MT-1	0.0	4.3	0.0	0.0	4.3
No Data	0.0	0.6	0.0	0.0	0.6
OB-1/OB-2	0.0	2.0	0.0	0.0	2.0
OB-1/OB-3	0.0	0.3	0.0	0.0	0.3
OR-1/OR-18	0.0	0.8	0.0	0.0	0.8
OR-1/OR-2	0.0	1.0	0.0	0.2	1.2
OR-10/OR-11	0.0	10.0	0.0	1.6	11.6
OR-11/OR-12	0.0	0.3	0.0	0.1	0.4
OR-12/OR-13	0.1	0.8	0.0	0.1	1.0
OR-13/OR-14	0.2	3.4	0.0	0.2	3.8
OR-14/OR-15	0.0	0.9	0.0	0.0	0.9
OR-14-NAD	0.0	0.0	0.0	0.1	0.1
OR-15/OR-16	0.0	8.6	0.0	0.0	8.6
OR-16/OR-17	0.0	9.7	0.0	1.2	10.8
OR-17/OR-18	0.0	0.5	0.0	0.0	0.5
OR-18-NAD	0.0	0.2	0.0	0.0	0.2
OR-1-NAD	0.5	0.0	0.0	0.0	0.5
OR-2/OR-3	0.0	14.8	0.0	0.0	14.8
OR-3-NAD	0.0	0.1	0.0	0.0	0.1
OR-4/OR-5	0.0	1.3	0.0	0.0	1.3
OR-5/OR-6	0.0	1.7	0.0	0.2	1.9
OR-6/OR-7	0.0	0.4	0.0	0.2	0.6
OR-6-OR-7	0.0	3.1	0.0	0.1	3.2
OR-7/OR-8	0.0	2.4	0.0	0.0	2.4
OR-9/OR-10	0.0	0.7	0.0	0.0	0.7
PA-1	0.0	3.9	0.0	0.0	3.9
PE-1/PE-1	0.0	1.1	0.0	0.0	1.1
SA-1	0.0	3.1	0.0	0.0	3.1
SH-1/SH-2	0.0	2.6	0.0	0.0	2.6
SH-1/SH-5	0.0	15.5	0.0	1.4	16.9

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
SH-2/SH-3	0.0	0.4	0.0	0.1	0.6
SH-4/SH-5	0.0	5.6	0.0	0.0	5.6
SJ-1/SJ-2	0.0	0.0	0.0	0.1	0.1
SJ-1/SJ-28	0.0	1.1	0.0	0.0	1.1
SJ-10/SJ-11	0.0	6.1	0.0	0.0	6.1
SJ-12/SJ-13	0.0	0.1	0.0	0.0	0.1
SJ-13/SJ-14	0.0	13.2	0.0	0.0	13.2
SJ-15/SJ-16	0.0	0.1	0.0	0.0	0.1
SJ-18/SJ-19	0.0	0.0	0.0	0.4	0.4
SJ-2/SJ-3	0.5	19.4	0.0	0.6	20.6
SJ-20/SJ-21	0.0	2.4	0.0	1.8	4.2
SJ-21/SJ-22	0.0	0.1	0.0	0.0	0.1
SJ-22/SJ-23	0.0	0.2	0.0	0.0	0.2
SJ-23/SJ-24	0.0	0.0	0.0	0.2	0.2
SJ-24/SJ-25	0.0	0.0	0.0	0.5	0.5
SJ-25/SJ-26	0.0	0.4	0.0	0.0	0.4
SJ-26/SJ-27	0.0	0.7	0.0	0.0	0.7
SJ-27/SJ-28	0.5	2.4	0.0	0.4	3.2
SJ-3/SJ-4	0.4	0.3	0.0	0.7	1.4
SJ-4/SJ-5	0.0	0.3	0.0	0.0	0.3
SJ-5/SJ-6	0.0	3.1	0.0	0.0	3.1
SJ-7-NAD	0.0	0.1	0.0	0.0	0.1
SJ-8/SJ-9	0.0	1.6	0.0	0.4	2.0
SJ-9/SJ-10	0.0	1.0	0.0	0.0	1.0
SK-1	0.0	1.4	0.0	0.0	1.4
SP-1	0.0	7.1	0.0	0.0	7.1
ST-1/ST-2	0.0	0.2	0.0	0.0	0.2
ST-1/ST-8	0.0	8.1	0.0	0.0	8.1
ST-2/ST-3	0.0	0.2	0.0	0.0	0.2
ST-5/ST-6	0.0	1.7	0.0	0.0	1.7
ST-6/ST-7	0.0	3.2	0.0	0.0	3.2
SU-1	0.0	18.7	0.0	0.0	18.7
TU-1/TU-2	0.0	0.5	0.0	0.0	0.5
WI-1	0.0	0.5	0.0	0.0	0.5
WL-1/WL-4	0.0	0.1	0.0	0.0	0.1
WL-2/WL-3	0.0	4.3	0.0	0.0	4.3

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
WP-1	0.0	1.2	0.0	0.0	1.2
WP-2	0.0	0.7	0.0	0.0	0.7
WP-3	0.0	1.7	0.0	0.0	1.7
Grand Total	2.6	298.2	0.0	17.6	318.4

Table E-31. Summary statistics of the percent of each shoretype found across all San Juan County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	1.5	17.2	1.4	39.5	24.9	15.6
Median	0.0	11.2	0.0	38.4	20.5	8.5
Std Dev	6.8	18.3	6.7	23.2	21.7	19.8

Table E-32. Modified shores that were likely historic feeder bluffs throughout San Juan County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	5.1	41
MOD without Historic FB	4.7	38.4
MOD marked Unknown	2.5	20.6
Total MODs	**12.3**	**100**

Skagit County

Table E-33. Summary of shoretypes across Skagit County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
CYP-1	0.0	24.0	0.0	73.1	3.1	0.0
CYP-2	0.0	19.0	0.0	57.9	23.1	0.0
CYP-3	0.0	14.0	0.0	53.7	17.7	14.2
CYP-4	0.0	7.0	0.0	60.3	33.1	0.0
CYP-5	0.0	58.0	0.0	34.6	7.6	0.0
CYP-6	0.0	45.0	12.0	32.7	10.8	0.0
CYP-7	0.0	0.0	38.3	0.0	53.0	8.8

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
CYP-8	0.0	45.0	28.9	24.4	2.3	0.0
CYP-9	0.0	35.0	0.0	34.2	31.2	0.0
GUE-1	0.0	49.0	0.0	4.0	44.9	2.3
GUE-10	0.0	0.0	0.0	0.0	66.4	33.6
GUE-11	57.0	5.0	0.0	1.9	9.7	27.3
GUE-12	4.2	43.0	0.0	17.3	35.9	0.0
GUE-2	0.0	52.0	0.0	4.3	0.0	43.6
GUE-3	0.0	0.0	0.0	26.3	28.6	45.1
GUE-4	0.0	47.0	0.0	11.7	25.5	15.6
GUE-5	0.0	43.0	0.0	19.4	26.8	11.3
GUE-6	12.0	34.0	0.9	14.4	25.9	12.8
GUE-8	40.0	19.0	0.0	6.4	11.6	22.8
GUE-9	37.0	48.0	0.0	2.7	6.1	6.8
HP-1	0.0	41.0	0.0	56.0	3.4	0.0
HP-2	0.0	0.0	75.1	5.5	19.5	0.0
SIN-1	0.0	12.0	0.0	60.5	23.1	4.1
SIN-2	0.0	40.0	0.0	44.2	13.0	3.3
SIN-3	0.0	71.0	0.0	6.6	5.9	16.6
SIN-4	0.0	23.0	0.0	42.8	34.1	0.0
SK-C-2	0.0	1.0	0.0	41.1	2.0	55.7
SK-C-3	0.0	0.0	0.0	0.0	0.0	100.0
SK-C-4	0.0	20.0	0.0	35.2	7.5	37.6
SK-C-5.1	0.0	76.0	0.0	11.4	12.6	0.0
SK-C-5.2	0.0	0.0	0.0	16.5	46.0	37.5
SK-C-6	0.0	16.0	0.0	3.9	26.4	53.3
SK-C-7	0.0	34.0	0.0	9.2	45.4	11.2
SK-C-8.1	0.0	34.0	0.0	9.6	17.2	38.8
SK-C-8.2	0.0	33.0	0.0	8.9	45.3	12.4

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
SK-C-9	0.0	3.0	0.0	24.1	25.6	46.9
SK-D-1-1	0.0	0.0	0.0	19.8	33.2	47.0
SK-D-1-3	0.0	12.0	0.0	0.0	15.6	72.1
SK-D-1-4-1	0.0	0.0	0.0	0.0	0.0	100.0
SK-D-1-4-2	0.0	4.0	0.0	2.0	4.0	89.8
SK-D-1-5	0.0	0.0	0.0	0.0	28.5	71.5
SK-D-2	0.0	36.0	0.0	19.3	13.0	31.3
SK-D-3	0.0	32.0	2.1	29.2	13.5	23.7
SK-E-1	0.0	49.0	0.0	14.8	21.7	14.5
SK-E-2	0.0	45.0	0.0	3.7	10.5	41.2
SK-E-3	0.0	4.0	0.0	4.8	53.0	38.5
SK-E-4	0.0	4.0	0.0	0.0	70.4	26.1
SK-E-5	0.0	10.0	0.0	4.7	26.5	58.7
SK-G-1.1	0.0	75.0	0.0	7.6	0.0	17.6
SK-G-1.2	0.0	8.0	0.0	14.3	0.0	77.6
SK-G-2	0.0	3.0	0.0	20.2	0.0	77.1
SK-G-3	5.3	17.0	0.0	20.4	17.1	40.1
SK-G-4.1	0.0	11.0	0.0	53.1	13.6	21.9
SK-G-4.2	0.0	0.0	0.0	0.0	49.2	50.8
SK-G-5	0.0	70.0	0.0	10.6	17.2	1.9
SK-G-6	0.0	18.0	0.0	30.7	39.8	11.8
SK-H-1	0.0	31.0	0.0	19.5	19.8	29.7
Grand Total	**2.9**	**28.0**	**2.0**	**19.0**	**19.8**	**28.8**

Table E-34. NAD type breakdown for Skagit County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
ALL-1	0.0	3.1	0.0	0.0	3.1
BUR-1	0.0	4.4	0.0	0.0	4.4
CYP-1/CYP-2	0.0	0.1	0.0	0.0	0.1

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
CYP-1/CYP-9	0.0	2.6	0.0	0.0	2.6
CYP-2/CYP-3	0.0	2.5	0.0	0.0	2.5
CYP-3/CYP-4	0.0	3.2	0.0	0.5	3.7
CYP-4/CYP-5	0.0	1.6	0.0	0.0	1.6
CYP-8	0.0	0.7	0.0	0.0	0.7
GT-NAD	2.2	0.0	1.8	0.0	4.0
GUE-5/GUE-6	0.0	7.3	0.0	0.0	7.3
HP-1/HP-2	0.0	0.1	0.0	0.0	0.1
HP-2/HP-1	0.0	1.6	0.0	0.0	1.6
JAC-1	0.0	0.7	0.0	0.0	0.7
SIN-3/SIN-4	0.0	2.3	0.0	0.0	2.3
SKA-1-NAD	0.6	0.2	1.9	0.0	2.7
SKA-2-NAD	0.0	0.0	35.9	0.0	35.9
SK-C-3/SK-C-4	0.8	0.0	15.4	0.0	16.1
SK-C-7/SK-C-6	0.0	1.1	0.0	0.0	1.1
SK-C-8.2/SK-C-9	0.0	0.0	5.5	0.0	5.5
SK-D-1-2-NAD	2.8	0.0	0.0	0.0	2.8
SK-D-1-3/1-4	0.0	1.1	0.0	0.0	1.1
SK-D-1-4-1-NAD	0.8	0.0	0.0	0.0	0.8
SK-D-1-4-2-NAD	1.3	0.0	0.0	0.0	1.3
SK-D-2	0.0	0.0	0.0	0.6	0.7
SK-D-2/SK-D-3	0.0	1.7	0.0	0.0	1.7
SK-D-3-NAD	1.8	0.0	0.0	0.0	1.8
SK-E-1-NAD	14.7	0.0	0.8	19.9	35.4
SK-E-4-NAD	0.0	0.0	0.0	1.2	1.2
SK-E-5/SK-D-1	1.0	0.1	0.0	2.3	3.4
SK-E-5-NAD	0.0	0.0	0.0	0.5	0.5
SK-G-1.1/SK-D-3	0.0	7.3	0.0	0.3	7.6
SK-G-1.1/SK-G-1.2	0.0	0.9	0.0	0.0	0.9
SK-G-4.2/SK-G-5	0.0	0.0	0.0	1.5	1.5
SK-G-6-NAD	0.0	0.0	0.0	0.2	0.2
SK-G-7-NAD	0.0	1.0	0.0	0.0	1.0
SK-G-8-NAD	0.0	0.7	0.0	0.0	0.7
SK-H-1-NAD	0.0	0.5	0.0	0.3	0.8
VEN-1	0.0	2.8	0.0	0.0	2.8
Grand Total	**25.9**	**47.8**	**61.3**	**27.3**	**162.3**

Table E-35. Summary statistics of the percent of each shoretype found across all Skagit County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	3.0	23.8	0.0	5.3	8.9	59.1
Median	0.0	25.1	0.0	0.6	7.6	52.3
Std Dev	5.8	17.9	0.0	10.1	7.0	22.5

Table E-36. Modified shores that were likely historic feeder bluffs throughout the Skagit County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	33183.2	33.7
MOD without Historic FB	38622.3	39.3
MOD marked Unknown	26535.6	27.0
Total MODs	**98341.1**	**100**

Snohomish County

Table E-37. Summary of shoretypes across Snohomish County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
GED-1	0.0	25.1	0.0	0.6	16.1	58.2
GED-2	0.2	36.4	0.0	0.0	9.6	35.0
GED-3	0.0	38.5	0.0	11.1	12.7	37.8
GED-4	0.0	46.8	0.0	8.3	2.6	42.4
SN-1	0.0	0.0	0.0	0.0	6.1	93.9
SN-2	0.0	0.0	0.0	0.0	7.6	92.4
*SN-3	0.0	0.0	0.0	0.0	18.8	81.2
SNO-1	4.9	39.9	0.0	3.5	18.9	32.8
SNO-2	0.0	14.2	0.0	33.5	0.0	52.3
SNO-3	2.1	39.5	0.0	0.9	5.3	52.2
SNO-4	6.6	21.6	0.0	0.0	0.0	71.8
Grand Total	2.3	17.2	1.0	2.1	12.1	66.5

*only partially within county

Table E-38. NAD type breakdown for Snohomish County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
SKA-2-NAD	0.0	0.0	38.0	0.0	38.0
SN-1/SN-2	0.8	0.0	0.0	0.0	0.8
SN-1/SNO-4	14.5	0.0	42.0	0.0	56.5
SN-2/SN-3	2.3	0.0	0.0	0.0	2.3
SNO-2/SNO-3	0.0	0.0	0.0	2.4	2.4
Grand Total	**17.6**	**0.0**	**80.1**	**2.4**	**100.1**

Table E-39. Summary statistics of the percent of each shoretype found across all Snohomish County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	3.0	23.8	0.0	5.3	8.9	59.1
Median	0.0	25.1	0.0	0.6	7.6	52.3
Std Dev	5.8	17.9	0.0	10.1	7.0	22.5

Table E-40. Modified shores that were likely historic feeder bluffs throughout Snohomish County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	15.9	61.3
MOD without Historic FB	6.7	25.8
MOD marked Unknown	3.3	12.9
Total MODs	**25.9**	**100**

Thurston County

Table E-41. Summary of shoretypes across Thurston County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
TH-10-1	0.0	22.5	0.0	12.3	0.6	64.7
TH-10-10	0.0	0.0	0.0	5.7	24.5	69.8
TH-10-11	0.0	17.8	0.0	10.1	26.4	45.8
TH-10-12	0.0	81.5	0.0	6.1	0.0	12.5
TH-10-2	0.0	19.2	0.0	6.1	19.1	55.6

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
TH-10-3	0.0	11.3	0.0	25.8	0.0	62.9
TH-10-5	0.0	0.0	0.0	3.4	0.0	96.6
TH-10-6	0.0	0.0	0.0	0.0	0.0	100.0
TH-10-7	0.0	0.0	0.0	13.2	0.0	86.8
TH-10-8	5.3	5.5	0.0	0.0	5.0	84.3
TH-10-9	0.0	31.7	0.0	6.1	7.9	54.3
TH-1-1	0.0	38.5	0.0	32.9	19.2	9.3
TH-11-1	0.0	38.7	0.0	16.6	6.1	38.6
TH-11-2	0.0	3.8	0.0	29.3	12.6	54.3
TH-11-3	0.0	1.1	0.0	13.5	1.0	84.3
TH-11-4	0.0	0.0	0.0	0.0	0.0	100.0
TH-1-2	0.0	21.6	0.0	26.2	4.9	47.3
TH-12-2	0.0	0.0	0.0	100.0	0.0	0.0
TH-12-3	0.0	40.2	0.0	58.1	0.4	1.3
TH-2-1	0.0	0.0	0.0	0.0	100.0	0.0
TH-2-2	0.0	35.1	0.0	32.0	6.9	26.0
TH-2-3	0.0	3.9	0.0	18.5	24.6	53.0
TH-2-4	0.0	0.0	0.0	10.1	22.7	67.2
TH-2-5	0.0	5.8	0.0	0.0	0.0	94.2
TH-2-6	0.0	12.6	0.0	13.4	0.0	74.0
TH-3-1	0.0	13.0	0.0	12.3	5.6	69.1
TH-3-2	0.0	63.1	0.0	0.0	36.9	0.0
TH-3-3	0.0	24.9	0.0	20.8	25.5	28.7
TH-3-4	0.0	7.2	0.0	5.1	0.0	87.7
TH-3-5	0.0	27.8	0.0	0.0	3.4	68.8
TH-3-7	0.0	25.8	0.0	10.7	14.0	49.5
TH-3-8	0.0	18.1	0.0	10.2	4.7	67.0
TH-3-9	0.0	0.0	0.0	8.9	10.2	80.9

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
TH-4-1	0.0	18.4	0.0	19.1	3.1	59.4
TH-4-10	0.0	0.0	0.0	69.7	0.0	30.3
TH-4-2	0.0	57.8	0.0	0.0	23.6	18.6
TH-4-3	0.0	0.0	0.0	9.3	3.1	87.5
TH-4-4	0.0	0.0	0.0	72.3	0.0	27.7
TH-4-5	0.0	0.0	0.0	94.2	5.8	0.0
TH-4-6	0.0	25.3	0.0	69.9	0.0	4.9
TH-4-7	0.0	0.0	0.0	100.0	0.0	0.0
TH-4-8	0.0	0.0	0.0	82.9	17.1	0.0
TH-4-9	0.0	0.0	0.0	100.0	0.0	0.0
TH-5-1	5.5	28.6	0.0	14.6	4.6	46.7
TH-5-2	0.0	29.5	0.0	11.4	27.4	31.7
TH-5-3	0.0	31.1	0.0	12.2	8.5	48.2
TH-5-4	0.0	55.1	0.0	17.9	0.0	27.0
TH-5-5	0.0	13.6	0.0	6.7	8.9	70.8
TH-5-6	0.0	0.0	0.0	1.5	0.0	98.5
TH-6-1	0.0	51.8	0.0	17.1	6.8	24.3
TH-6-2	0.0	87.1	0.0	0.0	12.9	0.0
TH-7-1	0.0	39.2	0.0	20.2	6.6	33.9
TH-7-2	0.0	92.6	0.0	7.4	0.0	0.0
TH-7-3	0.0	24.5	0.0	22.1	9.0	44.4
TH-7-4	0.0	0.0	0.0	4.6	0.0	95.4
TH-7-5	0.0	23.1	0.0	15.0	0.0	61.9
TH-7-6	0.0	17.1	0.0	0.0	7.7	75.2
TH-7-7	0.0	0.0	0.0	0.0	0.0	100.0
TH-8-1	0.0	9.2	0.0	8.4	1.3	81.0
TH-8-3	0.0	35.6	0.0	9.8	3.9	50.7
TH-8-4	0.0	16.9	0.0	39.3	6.7	37.1

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
TH-8-5	0.0	23.5	0.0	17.2	4.5	54.9
TH-8-6	0.0	0.0	0.0	0.0	0.0	100.0
TH-8-7	0.0	0.0	0.0	5.5	0.0	94.5
TH-8-8	0.0	0.0	0.0	0.0	0.0	100.0
TH-8-9	0.0	0.0	0.0	0.0	0.0	100.0
TH-9-10	0.0	50.6	0.0	39.2	8.4	1.7
TH-9-11	0.0	0.0	0.0	75.3	24.7	0.0
TH-9-12	0.0	56.4	0.0	20.2	11.1	12.3
TH-9-2	0.0	46.0	0.0	3.2	0.9	50.0
TH-9-3	0.0	0.0	0.0	21.1	15.6	63.3
TH-9-4	0.0	13.9	0.0	39.6	8.4	38.1
TH-9-5	0.0	0.0	0.0	32.5	43.8	23.7
TH-9-6	0.0	33.4	0.0	66.6	0.0	0.0
TH-9-7	0.0	4.5	0.0	77.6	2.3	15.6
TH-9-8	0.0	31.3	0.0	42.5	0.0	26.2
TH-9-9	0.0	13.0	0.0	36.0	2.8	48.2
Grand Total	**0.1**	**25.0**	**1.0**	**18.3**	5.3	**51.3**

Table E-42. NAD type breakdown for Thurston County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
PI-5-1/TH-1-1	0.0	0.0	0.3	0.0	0.3
TH-10-11/TH-10-12	0.0	0.0	0.0	0.5	0.5
TH-10-1-NAD	0.0	0.0	0.0	0.1	0.1
TH-10-2/TH-10-3	0.0	0.0	0.0	0.4	0.4
TH-10-3/TH-10-4	0.0	0.0	0.0	0.1	0.1
TH-10-7/TH-10-8	0.0	0.0	0.0	1.4	1.4
TH-11-1/TH-11-2	0.0	0.0	0.0	0.2	0.2
TH-11-2/TH-11/3	0.0	0.0	0.0	0.1	0.1
TH-11-2/TH-11-3	0.8	0.0	0.0	10.6	11.4
TH-11-3-NAD	0.0	0.0	0.0	0.1	0.1

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
TH-12-3/TH-12-2	0.0	0.0	0.0	0.1	0.1
TH-2-1/TH-2-2	0.0	0.0	0.0	0.3	0.3
TH-2-2-NAD	0.0	0.0	0.0	0.7	0.7
TH-2-3/TH-2-4	0.0	0.0	0.0	0.4	0.4
TH-3-1/TH-3-2	0.0	0.0	0.0	0.7	0.7
TH-3-1-NAD	0.0	0.0	0.0	0.1	0.1
TH-3-3/TH-3-4	0.0	0.0	0.0	0.8	0.8
TH-3-3-NAD	0.0	0.0	0.0	0.1	0.1
TH-3-5-NAD	0.0	0.0	0.0	0.1	0.1
TH-3-7/TH-4-9	0.1	0.0	0.0	3.0	3.0
TH-4-2/TH-4-3	0.0	0.0	0.0	0.4	0.4
TH-4-5/TH-4-4	0.0	0.0	0.0	0.1	0.1
TH-4-5-NAD	0.0	0.0	0.0	0.2	0.2
TH-4-6/TH-4-7	0.2	0.0	0.0	10.1	10.4
TH-5-1/TH-3-9	0.0	0.0	0.0	0.1	0.1
TH-5-2/TH-5-3	0.0	0.0	0.0	1.8	1.8
TH-5-3-NAD	0.0	0.0	0.0	0.4	0.4
TH-5-5/TH-5-4	0.0	0.0	0.0	0.4	0.4
TH-5-6/TH-5-7	0.0	0.0	0.0	0.1	0.1
TH-6-1-NAD	0.0	0.0	0.0	0.0	0.0
TH-6-2/TH-6-3	0.0	0.0	0.0	1.8	1.8
TH-7-2/TH-7-3	0.0	0.0	0.0	0.5	0.5
TH-7-4/TH-7-5	6.0	0.0	0.0	0.0	6.0
TH-8-1/TH-7-6-NAD	0.0	0.0	0.0	0.1	0.1
TH-8-3/TH-8-4	0.0	0.0	0.0	0.9	0.9
TH-9-11/TH-9-12	0.0	0.0	0.0	0.5	0.5
TH-9-12-NAD	0.0	0.0	0.0	0.1	0.1
TH-9-2-NAD	0.0	0.0	0.0	0.2	0.2
TH-9-3/TH-9-4	0.0	0.0	0.0	0.2	0.2
TH-9-7/TH-9-8	0.0	0.0	0.0	0.8	0.8
Grand Total	7.1	0.0	0.3	38.5	45.9

Table E-43. Summary statistics of the percent of each shoretype found across all Thurston County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	0.1	19.5	0.0	23.5	8.6	48.3
Median	0.0	13.6	0.0	13.2	4.5	49.5
Std Dev	0.9	22.2	0.0	27.5	14.3	33.3

Table E-44. Modified shores that were likely historic feeder bluffs throughout Thurston County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	8.8	26.8
MOD without Historic FB	6.5	19.9
MOD marked Unknown	17.5	53.3
Total MODs	**32.8**	**100**

Whatcom County

Table E-45. Summary of shoretypes across Whatcom County. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
WH-1-1	13.1	14.9	0	14.6	49.9	7.6
WH-1-2	17.2	21.2	0	0	61.7	0
WH-2-2	0	0	0	0	0	100
WH-2-3	0	56.4	0	0	41.8	1.7
WH-2-4	0	42.7	0	11.9	37.2	8.2
WH-2-5	0	86.2	0	0	5.3	8.5
WH-2-6	0	0	0	0	93.9	6.1
WH-2-7	2	14.2	0	6.7	73.1	4
WH-3-10-1	0	62	0	3.4	34.6	0
WH-3-10-2	0	39.7	0	32.1	28.2	0
WH-3-8	2.9	35.4	0	14.8	40.4	6.4
WH-3-8/WH-3-9	0	0	0	0	100	0
WH-3-9	0	0	0	0	71.3	28.7

Drift Cell	CGS Shoretypes (%)					
	FBE	FB	FB-T	TZ	AS	MOD
WH-4-11	0	6.7	0	34.1	47.7	11.4
WH-4-12	11.2	40	0	0	25.1	23.7
WH-4-13	0	36.4	0	12.3	29.6	21.7
WH-4-14	9.1	24.4	0	13.7	52.7	0
WH-4-15	9.6	53.8	0	1	35.6	0
WH-4-16	0	1.1	0	2.7	96.2	0
WH-4-17	0	61.1	0	18.1	20.8	0
WH-4-19	0	0	0	0	43.9	56.1
WH-4-21	0	4.9	0	8.7	12.8	73.5
WH-4-23	0	23.5	0	21.8	54.7	0
WH-4-24.1	0	11.7	0	0.7	80.9	6.7
WH-4-24.2	0	21.6	0	65.1	13.3	0
WH-4-25	0	71	0	25.6	3.5	0
WH-4-26	0	35.7	0	30.6	5.9	27.8
WH-4-29	0	17	0	35.7	44.9	2.5
WH-4-32	0	21.4	23	34.8	13.9	6.9
WH-4-33	0	24.2	0	54.5	18.7	2.6
WH-5-22	0	39	0	4.9	33.4	22.7
Grand Total	**2.8**	**28.4**	**2.1**	**14.8**	**38.2**	**13.7**

Table E-46. NAD type breakdown for Whatcom County (in miles).

Name	NAD-AR	NAD-B	NAD-D	NAD-LE	Total
VIT-1	0.0	0.4	0.0	0.0	0.4
WH-1-1	1.2	0.0	0.0	0.0	1.2
WH-2-1/WH-2-2	3.8	0.0	0.0	0.0	3.8
WH-2-2/WH-2-3	0.0	0.0	0.0	9.7	9.7
WH-2-3-NAD	0.3	0.0	0.0	0.0	0.3
WH-2-5/WH-2-6	0.9	0.0	0.0	0.0	0.9
WH-2-6/WH-2-7	0.0	0.0	0.0	0.1	0.1
WH-3-10/WH-4-11	6.3	0.0	4.2	0.0	10.5
WH-3-8/WH-3-9	3.2	0.0	0.0	0.0	3.2

WH-4-21/WH-5-22	0.0	0.0	9.1	0.0	9.1
WH-4-22/SK-1	2.9	10.1	0.0	2.1	15.1
WH-4-23/WH-4-24	0.0	0.2	0.0	0.0	0.2
WH-4-23/WH-4-25	0.0	0.7	0.0	0.0	0.7
WH-4-26/WH-4-32	0.0	8.2	0.0	0.0	8.2
WH-4-29/WH-4-33	0.0	1.0	0.0	0.0	1.0
WH-4-32-NAD	0.0	1.0	0.0	0.0	1.0
WH-4-33-NAD	0.0	0.1	0.0	0.0	0.1
WH-5-22/SK-1	8.5	0.7	0.0	0.0	9.2
Grand Total	**27.1**	**22.5**	**13.3**	**11.9**	**74.7**

Table E-47. Summary statistics of the percent of each shoretype found across all Whatcom County net shore-drift cells. FBE = Feeder bluff exceptional, FB = Feeder bluff, FB-T = Feeder bluff – talus, TZ = Transport zone, AS = Accretion shoreform, MOD = Modified.

Statistic	FBE	FB	FB-T	TZ	AS	MOD
Average	2.1	27.9	0.7	14.4	41.0	13.8
Median	0.0	23.5	0.0	8.7	37.2	6.1
Std Dev	4.6	23.3	4.1	17.2	27.8	23.3

Table E-48. Modified shores that were likely historic feeder bluffs throughout Whatcom County.

MOD Type	Total (mi)	Percentage
MOD with Historic FB	3.5	35.5
MOD without Historic FB	2.8	28.2
MOD marked Unknown	3.5	36.3
Total MODs	**9.8**	**100**

Map Folio