Assessment of Marine Shoreline Characteristics

As pertaining to areas seaward of land parcels:

235 Quarry Drive PID 009-555-706
239 Quarry Drive PID 009-555-731
434 Baker Road PID 009-555-781
431 Baker Road PID 000-014-656

SALT SPRING ISLAND

Report for Coastal Erosion Mitigation

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1. Synopsis

This assessment of marine shoreline was conducted using field, analytic and existing data to determine wave and sediment dynamics associated with erosion management of the coastline, as well as transport control of mobile sediments. These determinations are used to inform size distribution for sediment suitable for beach nourishment methods of erosion mitigation and transport control.

There are ~670m of hard armouring, or ~28.5% of the 2,350m shoreline within the drift-cell. Within the study area, there are ~70m of riprap and concreate, creating a ~14% hard-armoured coastline within the Site. This amount is considered to be moderate, where further erosion mitigation hard armouring would be discouraged by regulatory authorities.

There were two zones with distinct sediment size characteristics spread across the Site, for which there were sediment/gravel mixtures identified as being suitable for beach nourishment.

Lastly, the suitability of erosion mitigation and sediment transport control in context of Site factors and dynamics was evaluated. This evaluation encourages both continued monitoring and beach nourishment as suitable activities to pursue as part of erosion mitigation and sediment transport control.

2. Introduction

Landowners of four parcels adjacent to Baker Beach on Salt Spring Island have observed increased occurrence of punctuated erosion (e.g. landslide and landslip/tree-topple) and progressive erosion (e.g. plucking, thermal-jacking, or overland flow sediment mobilization). These landowners requested an assessment of the ~40m x 600m Site (Figure 1 – Appendix A), including existing foreshore and backshore characteristics, which informs sediment and wave dynamics. The assessment of foreshore and backshore dynamics will generate a drift-cell model for the Site. The drift-cell model will be used to evaluate suitability of proposed erosion mitigation measures at the end of this report.

This report is applicable to the foreshore and backshore seaward of the following land parcels:

Common Address	Parcel Identification
235 Quarry Drive	PID 009-555-706
239 Quarry Drive	PID 009-555-731
434 Baker Road	PID 009-555-781
431 Baker Road	PID 000-014-656

This report was written using existing and field-based data that provides spatial layout of the Baker Beach foreshore and backshore, generalized coastal zone sediment budget, beach particle size assessment and a drift-cell model summary.

2.1. Author Qualifications

Thomas R Elliot PhD is a Qualified Professional (QP) Geoscientist [# 43570] and Professional Agrologist [# 3045] registered within the Province of British Columbia and in good standing with both professional associations. The QP has 16 years of geohazard, soil science, near surface groundwater and hydrology. In the last 9 years, Thomas R Elliot has primarily worked on Vancouver Island and the Lower Mainland of British Columbia in the practice areas of [Geoscience]: Hydrogeology, Geohazard mitigation assessments, Soils/Groundwater management; and [Agrology] Soil science, Agriculture, and Contaminant detection, mitigation and remediation.

3. Scope, Context & Motivation

The purpose of this assessment is characterization of shoreline that will inform suitable marine coastline erosion mitigation measures which can be pursued on Site.

The motivation for this evaluation is to use sediment analysis and a drift-cell model in conjunction with reporting on ecology and geohazards to guide planning of erosion mitigation measures. The planning will be provided in subsequent reporting.

Additionally, there exists Islands Trust (IT) DPA 3 – Shoreline requirements for non-exempt development activities within 10m landward and 300m seaward of the marine-shoreline natural boundary. Therefore, if erosion mitigation recommendations are to occur within this DPA 3 area, there is a requirement to conduct characterization of existing conditions alongside demonstrably supportable recommendations for erosion mitigation.

The motivation to produce this report is to provide IT record of existing shoreline conditions, in partial or completion of IT DPA – 3 Shoreline requirements.

4. Shoreline Terminology, Site Delineation and Erosion Mechanisms

The shoreline area, as per IT DPA 3 definition, consists of a 300m coastal zone from the coastline, above which it extends into 10m of the uplands.

The Site includes the area of Baker Beach, as bracketed by public access, in addition to self-similar shoreline at both extents for a total ~600m of coastline (Figure 1 – Appendix A).

To best align this document with existing map products of shoreline delineation by IT, such as Saltspring Is. North Map 1 of 3: Distribution of Shoreline Types, Figure 3 was generated with identical classification and colour scheme.

Of the erosion mechanisms identified on Site from previous geohazard assessment, the following are of note:

- Pore pressure/Groundwater Seepage from surficial soils, reducing cohesion and resulting in landward progression of the crest through continuous or punctuated mobilization of sediment.
- Toe-erosion of bedrock, or undercutting of shoreline sediment, which decreases stability of all materials above, often resulting in narrow failures from crest to base of coastal bluff.
- Landslip/Tree-topple is occurring on Site wherein trees near, or overhanging, the coastal bluff mobilize consequent to soil creep, pore pressure or toe-erosion. These failures result in a larger volume of surficial sediment during failure than toe-erosion instability reaching the crest. Depending on root reinforcement or friability of bedrock, landslip may mobilize underlying shale and siltstone.
- Landslide is a moderate to large scale failure event which can mobilize bedrock and overlying surficial sediment. Coastal landslide are often consequent to a history of toe-erosion, bedrock fracture and an increase in pore pressure (i.e. saturated soils during a storm event) which has destabilized the coastal bluff in that area.

5. Shoreline Characteristics and Dynamics

This section presents details on the existing composition and quantifiable characteristics of the assessed marine shoreline. The following is a summary table of global characteristics, acquired from previous geohazard reporting[1], while details of each area are reviewed in subsequent relevant sections. Field assessment methods provided in Appendix A of this report.

TABLE 1. GENERAL SHORELINE CHARACTERISTICS FROM PREVIOUS REPORTING

Geology & Geomorphology	
Geology	Siltstone to mudstone in upland, sandstone within coastal zone, of the Nanaimo group – which is an elevation-banded sedimentary and metamorphic rock assemblage.
Surficial Sediment	Well to rapidly drained sandy loam to loam belonging to the Galiano soil association is present at the coastline.
Landslide/Landslip activity frequency	Concentrated within areas of accelerated erosion, with a Site wide occurrence of 1 per ~40m of coastline.
Shore & beach type and beach features	*Shore type:* Rocky coastline bluff with variable elevation bedrock resulting in low rock/boulders, boulder/cobble and sea cliff natural coastline. There are structurally altered (i.e. hard armour) coastline up-drift, within and downdrift of the assessment area.

[1] Geohazard assessment for each land parcel, completed by TRE Environmental Services under separate cover. For reference and details, please refer to those reports.

	Beach type: The presence of bedrock within the coastal bluff and foreshore results in the Site being typified as a high tide reflective beach face fronted by intertidal rock flats (i.e. bedrock low-tide terrace). *Features:* There exist two bedrock outcropping, nearly 40 – 50m from coastline at seaward extent of the low-tide terrace, which are in line with two ridges descending from uplands and consistent with the benching morphology of this shoreline geology.
Ground and Surface Water	
Watershed conditions	Single benching slope above the assessment area results in small-scale flow accumulations. There are no identified streams, albeit there was some evidence of overland flow associated with high volume precipitation events.
Groundwater	Limited infiltration to bedrock results in perched water table within the veneer to mantle of surficial materials. Perched water table causes increase pore water pressure at soil interface with air, decreasing soil stability.

5.1. Hard Armouring

At respective distances of 115m and 490m northwest of Site, there are ~200m of groyne and ~300m of coastline-riprap hard armouring installations. Of these anthropogenic foreshore modifications, the groynes may be encouraging some sediment accumulation along the beach face by diffracting wave energy, albeit that poor installation has resulted in low sediment retention; while the riprap has reduced kinetic wave action on the shale and siltstone coastline, reducing supply from upland to the local coastal zone sediment system.

Down-drift from Site is ~80m of coastline-riprap on a sediment bar at the mouth of Booth Inlet. This hard-armouring restricts both progressive and punctuated sediment mobilization from the area by constricting flow to a narrowed channel, thus reducing fine-sediment supply to local shoreline.

There are three additional sections of hard armouring within Site: coastline-riprap placed at the northwest (10m) and southeast (30m) CRD access points, as well as along the coastline of 241 Quarry Rd (30m) – creating a ~14% hard-armoured coastline within the Site.

In total, the ~2,350m long drift-cell (see Section 6) – extending from Vesuvius Bay to the mouth of Booth Inlet – has ~670m of hard armouring, or ~28.5% of the local area shoreline.

5.2. Backshore

Indicators of a backshore are the presence of accumulated fine sediment and clasts, large littoral debris, sparse vegetation, and an area that is dry under normal conditions but exposed to wave action during storm events coinciding with high-tide. With this criterion, the backshore on Site was determined to have limited extent, often less than 1m in width and non-existent in some areas where there is continuous bedrock outcrop to the coastal bluff.

The backshore does not have sufficient width to create dunes or other geomorphic sediment accumulations. However, there exists minor clastic terrace deposits above the wrack line in sections of backshore that were contiguous with the beach face. There is sparse littoral and flotsam debris accumulated within the backshore, which is in contrast with the common to frequent presence of accumulated debris along up-drift sections of shoreline which have been historically armoured by rock groynes.

Sediment supply from uplands is principally delivered to the backshore as progressive erosion of coastline bedrock bluff. Sediment deposits from punctuated toe-erosion, landslip and landslide failures were also present in the backshore – some of which hosted perennial salt-tolerant vegetation, suggesting a multi-year existence. The persistence of these deposits through prior year storm-season (i.e. high wave energy and storm events) is a component of continuous sediment supply to Baker Beach.

5.3. Foreshore

The bedrock transition from shorerise to a ~3^o gradient low-tide terrace is notably marked by the presence of two bedrock rises which present as 'barrier islands' for a portion of Baker Beach (see Figure 1). Under high tide conditions, these outcrops are fully submerged. The low-tide terrace is a wave-cut rock platform in siltstone and shale bedrock. The wave-cut platform has been created over the most recent eustatic sea level, in existence since the end of the last ice age ~8,000ybp.

Within the low-tide terrace there is a mixture of sediment and bedrock coverage, as shown in Figures 3 & 4 – Appendix A. The accumulation of sediment is facilitated by undulating bedrock surface, with depressions readily infilled. The infill presented cobbles and gravel surface armouring, with fine sediments captured and retained underneath. There is a typical progressive reduction in the amount of mobile gravel toward the seaward extent of low-tide terrace.

The 10 – 25m width of ~5^o gradient continuous beach face across the Site is demarcated by a grading of accumulated sediment, from sparse cobbles and coarse gravel atop sand at the low-tide terrace interface, to fine gravel and sand at the backshore interface. Generally, there is a surface layer of mobile gravel which accumulates to greater depths toward the backshore interface. There is a wrack layer at the upper extent of the beach face, with accumulation of littoral debris by normal wave and tide-action.

The beach sediment is a broad mixture of boulder erratics emerging from sedimentary bedrock or upland surficial material through weathering, to gravel, coarse sand and limited fines. Further information on beach sediment is found in the Section 5.5 – Beach sediment analysis.

5.4. Wave dynamics

Wind-driven wave generation is largest in the west to northwest direction, creating acute incidence of approach. However, windrose diagrams (Figure 4) demonstrate a predominantly southwest to southeast winds that reach moderate velocity (≥6.0m/s). These predominant winds would form waves over a maximum 4.6km fetch. There are rarely occurring strong northerly to northwesterly winds recorded for the autumn period which would incur the maximum possible 13.5km fetch for the Site. The reference marine shoreline development guidelines recommend differentiating between Low, Moderate and High energy waves when fetch exceeds 1.6km & 8.0km (respectively) – therefore wind-driven wave energy on Site is determined to be Moderate.

Vessel-wake wave energy is predominantly from the most transited paths through the Sansum Narrows, and the regular Vesuvius-Crofton ferry. While there is large cargo vessel traffic to the nearby Crofton Mill, the lower frequency and low-speed manoeuvring does not contribute significantly to wave-energy delivered to Baker Beach. Due to the predominant angle of incidence, the vessel-wake do contribute to alongshore drift, moving fine sediment within the Drift cell.

Using equation 3 from Appendix B, typical wave velocity at high-tide across the rising low-tide terrace is determined to be 1.98m/s (7.12 km/h) resulting in a surging breaker classification. Surging breaker waves involve a progressive transfer of potential to kinetic energy across the coastal zone of Site.

Under storm event conditions where wind energy increases wave speed, wave type shifts to plunging breakers at steep shorerise, with the resulting whitewater traveling across the low-tide terrace and beach face as turbulent motion.

Based on sediment deposition patterns and distance from deep water, tidal currents do not have an apparent influence on wave dynamics at Site. Further, Booth Inlet – immediately east of the Site – is an ebb-tide delta with observable fine sediment accumulation. There is little evidence of increased fine sediment accumulation from the ebb-tide delta within the Site, demonstrated through beach sediment analysis, reinforcing that the drift-cell transports alongshore from northwest to southeast.

5.5. Beach sediment analysis and Beach Nourishment Sizing

Sediment analysis of the coastal zone samples were evaluated for mineral type and size fraction (See Appendix C). Sediment analysis provides distribution across distinct size ranges for samples from the following delineated coastal zones: Coastline, Backshore terrace, Backshore face/wrack, Foreshore beach, and Nearshore crest.

Within the study area, the most consistent sediment size-composition (Graph C1) was found across the well sorted foreshore beach face (Figure 2). After which, the backshore face and backshore terrace demonstrate good size consistency (Graph C2, C3) across the Site. There is a clustered distribution of sediment composition for the nearshore samples (Graph C4), which demonstrate a zonation along the drift cell.

To better understand the zonation, sediment size was charted for each property (Graph C5 – C9) to determine if there are alongshore affects to be accounted for in beach nourishment sizing. This identified grouping of sediment sizes between property 1 and 5, as well as 3 and 6; suggesting similar wave action and resulting sediment transport processes in these areas.

Generalized Sediment Budget

The Site is of limited spatial area, and therefore can only receive sediment from a limited section of the coastline and intertidal terrace erosion. While there is some alongshore sediment transport within the drift-cell, the mobile size fraction – being fine sand to silts – was most prevalent in the nearshore adjacent land parcels further along in the drift-cell. This distribution indicates a fine sediment deposition zone in the eastern portion of the Site, which agrees well with geomorphic factors – such as the nearby confluence of Booth Inlet.

Coarse sand to stones are most readily supplied to Site by erosion of surficial materials in the coastline and uplands, accomplished through overland transport or failure of the coastal bluff. These sediment sources are limited in volume prior to when their transport to beach would encroach on built structure geohazard setbacks. As such, we can state that there will be a decrease in sediment supply from uplands, trending to zero in the long term, should safe use of the built structures be prioritized.

Sparse gravel coverage along the low tide terrace and beach face demonstrates a low supply and low loss environment. The deposits present were found to be armoured at surface with large clasts, finding sand and silt content further within the sediment profile. This suggests there is reworking of sediment within the drift-cell, but there does not appear to be sufficient force to transport the larger size range of sediment present out of the drift-cell.

In context, the drift-cell generalized sediment budget is low input/output, with primary loss – being fine sands to silts – through evacuation to off-shore. There is reworking of gravel present, although observed armouring and stratification of beach sediment profile indicates a heavily conserved higher clastic fragment size range.

From this generalized sediment budget, beach nourishment planning can be better focused on the larger sediment size ranges to ensure conservation of materials while including coarse sand to help stratification and armouring processes occurring on the beach face.

Beach Nourishment Sizing

Determining sediment size suitable for beach nourishment within the Site becomes more complex in context of a drift cell, where materials deposited to a portion of the Coastal Zone (Figure 2.) will disperse to adjacent zones and alongshore within the drift cell. This is a factor in determining both target-zone, and size range for beach nourishment. One suitable approach is to determine sediment size composition for beach nourishment through averaging of existing sediment within zones that will ultimately receive the material, weighted for the target deposition area.

Based on Client motivation, the target deposition area within Site would be the backshore face, where it is anticipated that there will be transport to backshore terrace and foreshore beach face. Additionally, there is no intention of placing easily transportable material – meaning that there will be no purposeful addition of silt to the beach nourishment, and coarse sand will be the smallest size fraction identified for placement.

Due to the previously identified zonation, there are two size ranges suitable for beach nourishment at the backshore face – as follows:

Zone 1: Property 1 & 5

Percent Composition	Size Range	Common Name
60%	4.8mm+	(30%) 20mm washed drain rock, (40%) 40mm washed crushed rock, (25%) 60mm washed crushed rock, (5%) 10 - 20cm round cobbles
20%	1.8mm to 4.7mm	10mm washed rounded gravel
20%	1.7mm-	Fine to coarse sand

Zone 2: Property 3 & 6

Percent Composition	Size Range	Common Name
45%	4.8mm+	(30%) 20mm washed drain rock, (40%) 40mm washed crushed rock, (25%) 60mm washed crushed rock, (5%) 10 - 20cm round cobbles
20%	1.8mm to 4.7mm	10mm washed rounded gravel
35%	1.7mm-	Fine to coarse sand

6. Drift Cell Model - Interpretation and Summary of Marine Shoreline Dynamics

The drift-cell of Baker Beach extends 2,350m from the rocky outcrops at south Vesuvius Bay to the mouth of Booth Inlet. This drift-cell is designated based on a common alongshore drift-current that transport sediments and has been generated by consistent waves approaching at oblique angles to the shoreline.

Baker Beach is currently supply limited, resulting in discontinuous sections of beach face, with long-term coastline retreat driven by wave, water and weathering erosion mechanisms. The beach features a bedrock intertidal terrace, over which a moderate alongshore drift-cell current provides low-volume sediment transport.

Consequently, the primary source of sediment for Baker Beach are sections of the adjacent upland coastal bluff, which contribute silt, sand and gravel. The delivery of sediment is through progressive erosion mechanisms and punctuated erosion mechanisms. Bedrock erosion produces angular to sub-angular coarse to fine gravel which is highly susceptible to further breakdown due to the fissility of shale – the predominant bedrock type. A variable mantle of ~0.5 – 3m of surficial material contributes sandy to silty loams, with clastic fragment (e.g. gravel, cobbles, stones) content up to 20% by volume. There are sparse stones to boulders on the beach which have weathered out of bedrock during formation of the low-tide terrace, or through erosion of the surficial uplands sediment mantle.

Sediment discharge from the drift-cell includes evacuation of mobilized sediment to off-shore depths, and limited wind-driven loss of fine sediment fraction from the backshore and uplands.

Due to the low-tide terrace having a gentle slope and predominantly bedrock surface, alongshore sediment movement is facilitated when this area is submerged. Outside of these times, alongshore sediment movement is very limited due to lack of supply and the steep shorerise which has the low tide terrace above sea level for much of the inter-tidal period.

7. Suitability of Erosion Mitigation and Sediment Transport Management Recommendations

Previous reporting on geohazards[2] identified erosion mechanisms and developed recommendations for mitigation. This report has assessed shoreline and sediment processes, culminating in a drift-cell model which differentiates between prevalent kinetic forces (i.e. wave, wind, current & weathering) and results in a generalized sediment budget for Baker Beach.

In this section, the recommended erosion mitigation options are evaluated for suitability in context of existing conditions and drift-cell model. Suitability is a high, moderate and low ranking based on evidence gathered through this and preceding reporting.

The following table is evaluation of activity suitability for mitigation of erosion and management of sediment transport in the Site foreshore.

TABLE 2. SUITABILITY OF EROSION MITIGATION AND SEDIMENT TRANSPORT RECOMMENDATIONS MADE UNDER PREVIOUS GEOHAZARD REPORTING.

	Suitability			
Mitigation or Management Activity	**Foreshore**	**Backshore**	**Wave Dynamics**	**Sediment Supply**
Monitoring rate of erosion	High Monitoring captures multi-seasonal natural cycles.	High Monitoring captures multi-seasonal natural cycles.	High Direct capture of data.	High Capture seasonal fluctuation in sediment transport.
Bioengineering and selective planting	Low Very challenging establishment conditions.	Moderate Shelter and stabilization of sloughed surficial material and bedrock. Challenging establishment conditions.	Moderate Bioengineered and root reinforcement of sedimentary coastline. Overhanging vegetation would shelter bedrock from weathering.	Low Mitigation activity would reduce primary sediment supply to beach.
Wave deflection	Moderate Reduces incident wave energy reaching backshore. Close placement to be uniformly effective.	Low Would constitute hard armouring in coverage required to be effective.	Moderate Moderate energy wave conditions and presence of discontinuous backshore de-prioritizes this option.	Moderate Reduces incident wave energy reaching backshore. Reduces amount of sediment supplied to beach.
Beach Nourishment	High Post-placement in the backshore, natural transport of sediment would supply the foreshore.	High Placement in the backshore would reduce wave energy reaching coastline.	Moderate Moderate wave energy would evacuate some of placed sediment.	Moderate Subsidize existing natural supply, reduces natural sediment supply. Would need re-supply in future.

The interaction with Site ecology, efficacy and ease of implementation and maintenance of these recommended mitigation options should be carefully considered in context of Marine Shoreline Design Guidelines.

8. Summary

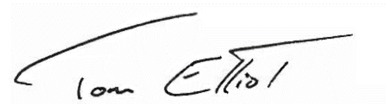
This assessment of Baker Beach and surrounding area marine shoreline has characterized shoreline, wave dynamics, erosion and sediment supply of the area which constitutes a drift-cell. Within Site, detailed foreshore and backshore characteristics were established from field and existing data.

Analysis of beach sediments has identified a zonated drift-cell with deposition of fine sediments in the eastern portion of the Site. The drift-cell generalized sediment budget is low input/output, with primary loss – being fine sands to silts – through evacuation to off-shore. There were two distinct sediment-size distributions identified that would be suitable for beach nourishment activities.

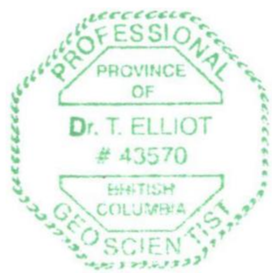
A drift-cell model was developed for the Site, which establishes sediment supply and transport mechanisms present. Using the drift-cell model, a suitability evaluation of erosion mitigation and transport management activities was undertaken for the Site with explanatory rationale demonstrating whether particular recommendations would be viable in context.

Despite moderate energy wave conditions on Site, a limited sediment supply exists due to the low amount of global sediment movement brought about by tidal currents and lack of up-drift sediment sources.

A comparison of activity suitability from this assessment with a similar suitability evaluation based on geohazards and ecology would be instrumental when applying the reference Marine Shoreline Development Guidelines.

Qualified Professional of Record	THOMAS R. ELLIOT PhD P.Geo, P.Ag Name	 Sign

Thomas R Elliot PhD P.Geo. P.Ag.



Date: December 1, 2023

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Closure and Limitations

The QP signatory to this assessment and report assures accuracy of existing and field observation, and evaluation of technical geohazard according to best practices of the Engineers and Geoscientists of BC. The content of this report are applicable to the subject land parcels, and specifically the Site as defined in this report. Any extension of the evaluation to areas outside of the defined area assessed are not valid.

The report has been conducted according to guidelines and reporting standards of similarly qualified professionals, given similar time and budget. At time of writing, the report meets due diligence and investigatory reporting requirements to provide QP recommendations with declared competency in the subject areas. Therefore, the author of this report does not maintain liability insurance for actions taken based on the reporting, and only accepts error and omission liability up to the value of this report. The receipt, utilization and any planning, further studies or development actions undertaken by the recipient of this report are based on their acceptance of their own liability therein.

Appendix A

Maps and Figures

Figure 1. Assessment area

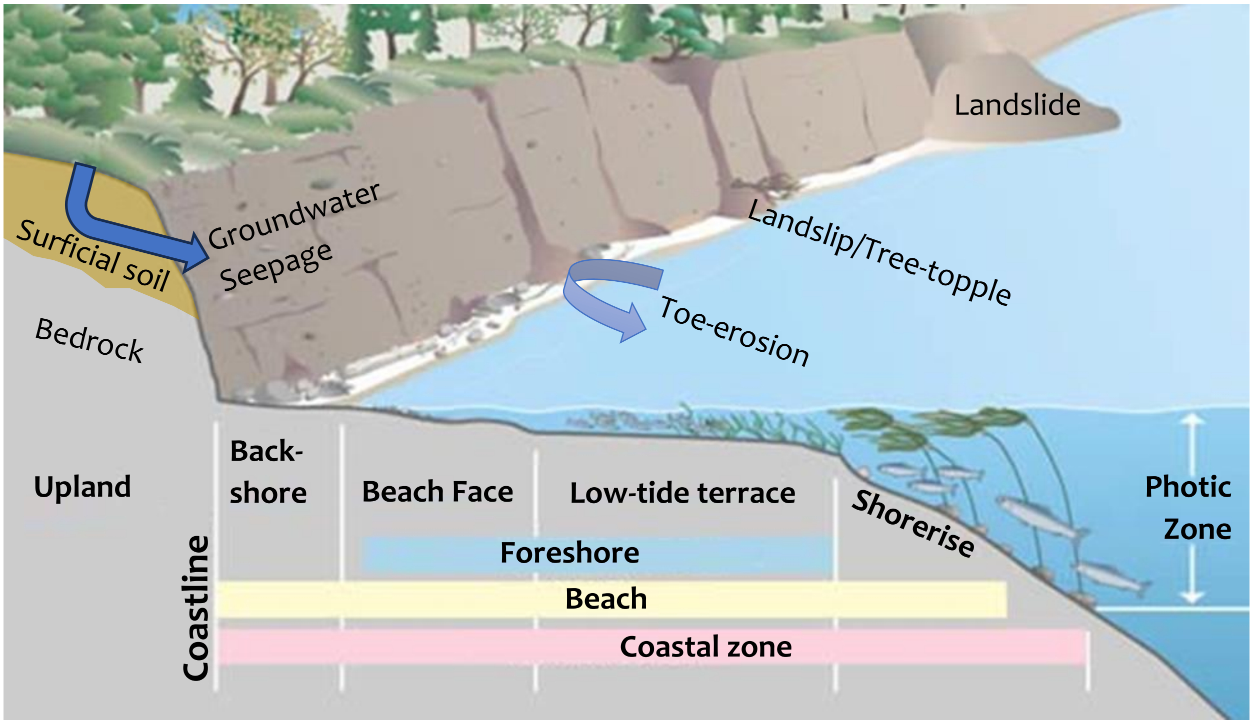
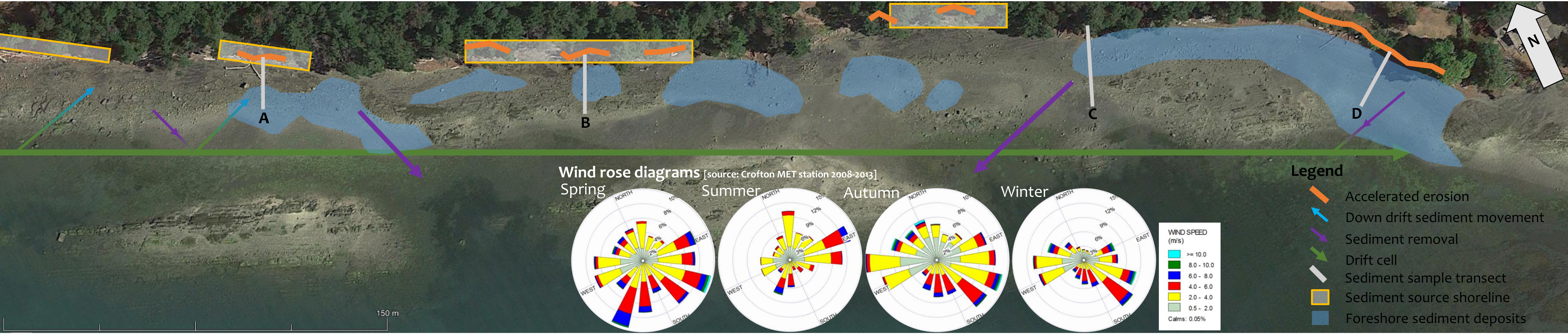


FIGURE 2. CONTEXTUAL DELINEATION OF THE SITE WITH RELEVANT TERMINOLOGY TO ASSIST WITH READING OF THIS REPORT. THE COMPONENTS OF THE COASTAL ZONE AND UPLANDS ARE INDICATED ALONG WITH ACTIVE EROSION MECHANISMS. ADAPTED FROM: KING COUNTY NEARSHORE ENVIRONMENTS, CENTRAL PUGET SOUND, WASHINGTON STATE.

Figure 3. Shoreline types, sediment transects and bedrock outcroppings

Figure 4. Sediment dynamics, drift-cell current, and windrose diagrams



Appendix B

Methods and Rationale

Field and Analytic Methods

Field Methods

Two field days were used to characterize the Site.

Day One: Characterization of geology, geomorphology, wave dynamics, sediment dynamics, and documentation of soil and bedrock erosion/evidence of groundwater.

Day Two: foreshore delineation and beach sediment sampling along Transects A – D, as shown in Figure 3 & 4.

Beach sediment sampling

Sediment samples were collected using appropriate tools, ensuring they represent the area of interest accurately.

A 250mL silicon container was used to collect uniform volume of trowel-excavated (to a depth of 10cm where existent) grab samples from beach sediments at specific locations, as follows: backshore, beach face, low-tide terrace, and shorerise.

The distance from coastline to each sample location was measured alongside multiple GPS enabled photographs which are used to document the precise location.

Each sample was codified, and placed in a sample bag.

The samples were retained in a cool environment until analytic testing (see below).

Analytic Methods

The process of drying and fractioning sediment typically involves the following standard methods:

Drying: The collected sediment samples are spread out in thin layers and set to air dry at a low temperature (usually around 105°C). This process removes moisture from the samples without significantly altering the composition.

Sieving: Dried sediment is sieved through various mesh sizes to fractionate the particles based on their size. This can range from very fine sieves for clay particles to coarser sieves for sand and gravel fractions.

Particle Size Analysis: After sieving, the fractions are weighed and analyzed to determine the percentage of different particle sizes in each fraction. This analysis may involve techniques such as sedimentation, laser diffraction, or microscopic examination to precisely determine particle size distribution.

Organic Matter and Mineral Content Analysis: Sediment fractions were not evaluated for organic content. Mineral composition was determined by hand-lens heuristic assessment to general rock type.

Data Interpretation: The results obtained from these analyses are used to characterize the sediment, understand its properties, and make inferences about its origin, quality, and potential uses or impacts in various contexts.

Rationale

Wave Dynamics

Wave generation proximal to Site is by two mechanisms: wind and vessel-wake. Wind-generated waves are formed off-shore, above deeper water, oriented in the predominant wind direction of the area, which is shown for Site in Figure 4 seasonal windrose diagrams[2].

Vessel-wake waves are generated by marine traffic, forming short-period, steep sided wave-trains with moderate height that move quickly across open waters. Larger vessels initiate wave-trains that compound to amplify height, which can exceed wind-generated waves in areas with short-fetch.

Waves generated by wind above deep water are typically short-period, with steep sides, with relatively tall height that move slower during wind-driven generation. Transition to swell waves occurs as the proto-waves concatenate in the orientation of predominant wind as modified by any coastal-reflection. Swell waves are longer, faster and uniformly spaced as they approach coastal environments, whereupon contact with the rising bedrock causes them to shoal and break. The contact with bedrock in shallow waters also starts to re-orients the incoming swell waves to be more perpendicular to the coastline due to refractive waves.

The potential energy contained within swell waves are released as kinetic energy through this shoal and break mechanism. Typically, the wave height (H, trough to crest), period (T, time for crest to crest to pass), length (L), and velocity (C) are related to each other through the following equations:

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g[2] It should be noted that the weather-station which acquired wind data for the windrose diagrams shown in Figure 4 is situated at the coastline of Crofton, on the west side of Sansum Narrows – opposite to Site at a distance of 3.8km, and as such the weather-station location will be subject to a wind regime modified by local topography that over-represents winds coming from off-shore – although general trends in wind direction would be consistent for both the meteorological station and Baker Beach.

Eq. 1	$L = 1.56\ T$	wave length
Eq. 2	$C = 1.56\ T^2$	off-shore wave velocity
Eq. 3	$C = \text{sq.rt.}(g*d)$	near-shore wave velocity, where g is gravitational constant, d is depth of water

wherefrom velocity can be used as general proxy for mechanical energy conveyed by waves.

Transferral of wave potential energy to kinetic energy at the foreshore and coastline is, in part, dependent on the angle of incidence (α), as the measurement of wave alignment to perpendicular from coastline. When waves enter the break and swash zone at oblique angles, the momentum gradient in the alongshore direction produces an alongshore current typically known as a drift current. This current advects sediment mobilized by a combination of wave motion and turbulent motion in the alongshore direction. The alongshore current forms the fundamental component of a Drift Cell, which is a representation of wave, current, tidal and transport processes – ultimately determining distribution of sediment within the Site.

Tides influence waves and kinetic energy delivered to coastlines by altering the shoal and break mechanism through adjustment of the water depth in the foreshore (i.e. high vs. low tide). Exceptionally high tides, typically corresponding to full or new moons, are contributory to backshore composition and configuration due to this increased depth and concurrent wave activity which can reach the backshore.

Tidal currents are critical to supply of fine sediment for drift cells, and within regional proximity to Site there are Department of Fisheries and Oceans current predictions[3] which indicate a low to moderate tidal effect throughout the Gulf Islands on the east coast of Vancouver Island. Due to Site being off-set from a main tidal channel, the influence on sediment budget is anticipated to have a lesser effect than a similar site more exposed to tidal current.

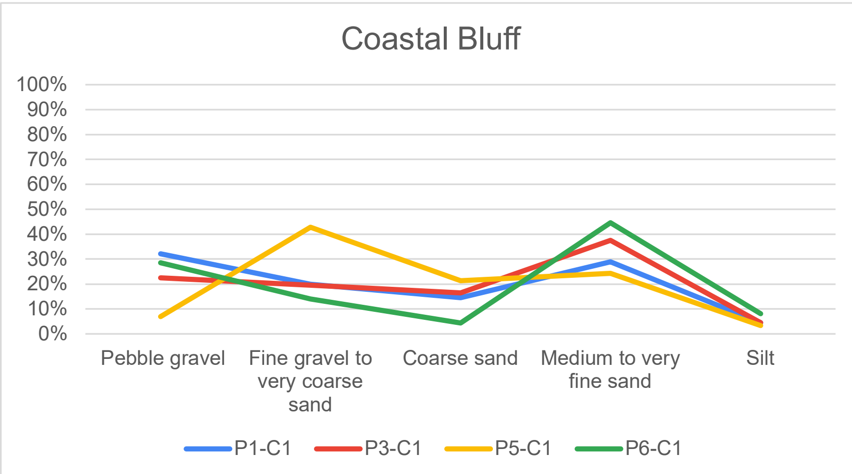
The angle of waves incidental to Site is such that a considerable amount of wave-energy is reflected, or disrupted, from Baker Beach during high tide – resulting in a reduction to incoming moderate wave energy and therefore less kinetic erosion on bedrock and sediment coastline, as well as lower energy evacuation of water from the shoreline. During low-tide conditions, the shoreline bedrock terrace is above sea level, restricting the amount of kinetic energy transferred to the bedrock and sediment coastline.

[3] Canada Department of Fisheries and Oceans. Current Predictions by Station: https://tides.gc.ca/en/current-predictions-station utilizing Gabriola Passage [43km distant], Porlier Pass [17km distant] as indicators. Accessed October 2023.

Appendix C

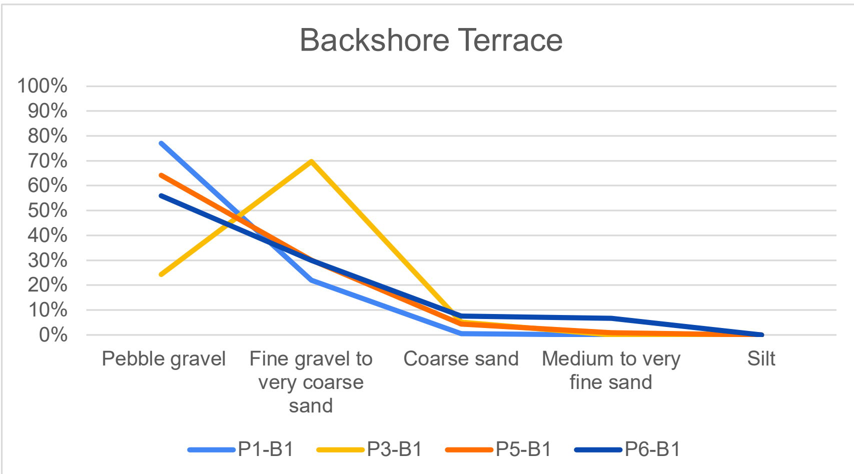
Sediment Analysis

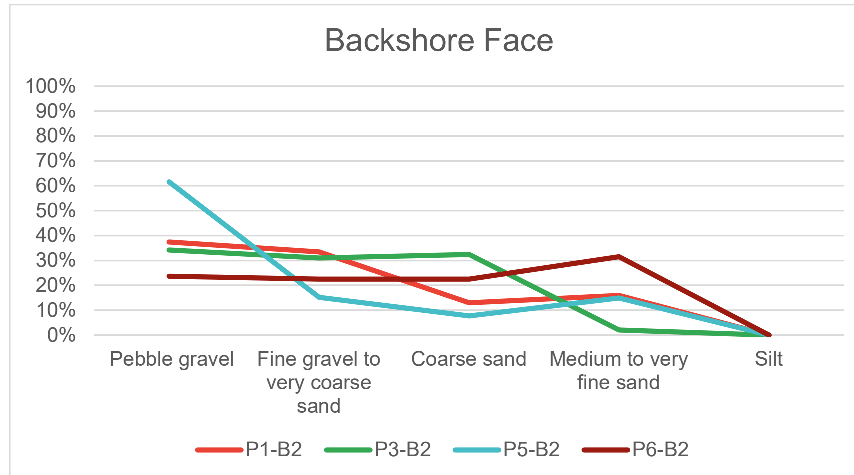
Date	Sector	m	Wet Weigl	Dry Weigh	XL(g)	Pebble gr	L (g)	Fine grave	M(g)	Coarse sa	S(g)	Medium tc	XS(g)	Silt	Notes
	P1-C1	n/a	221	221	71	32%	44	20%	32	14%	64	29%	10	5%	
	P3-C1	n/a	204	200	45	23%	39	20%	33	17%	75	38%	9	5%	
	P5-C1	n/a	280	271	19	7%	116	43%	58	21%	66	24%	9	3%	
	P6-C1	n/a	193	186	53	28%	26	14%	8	4%	83	45%	15	8%	



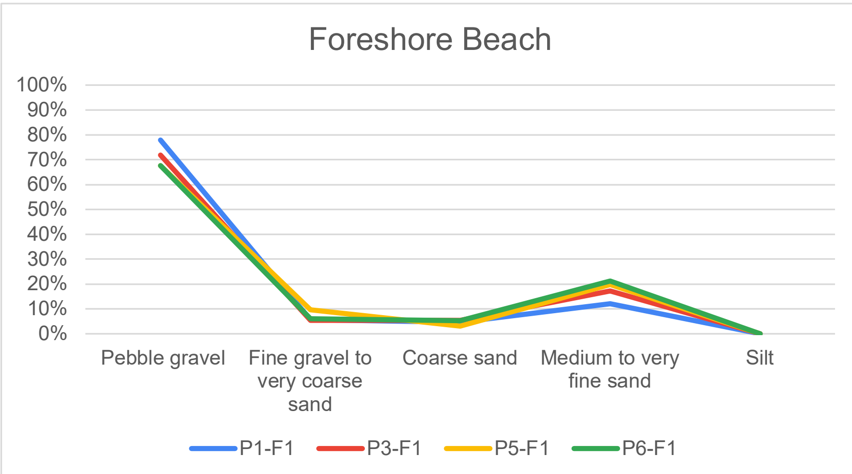
	Size Range (mm)		Wentworth Classification
XL		4.7498	Pebble Gravel
L	4.7497	1.8288	Granule Gravel to Very Coarse Sand
M	1.8287	0.762	Coarse Sand
S	0.7619	0.0737	Medium sand to very fine sand
XS	0.0736		Silt

Date	Sector	m	Wet Weigh	Dry Weigh	XL(g)	Pebble gra	L (g)	Fine gravel	M(g)	Coarse sar	S(g)	Medium to	XS(g)	Silt	Notes
	P1-B1	0.65	322	322	248	77%	71	22%	2	1%	0	0%	0	0%	
	P1-B2	2.9	352	337	126	37%	113	34%	44	13%	54	16%	0	0%	
	P3-B1	2.26	367	367	89	24%	256	70%	19	5%	0	0%	0	0%	
	P3-B2	5.09	346	333	114	34%	103	31%	108	32%	7	2%	0	0%	
	P5-B1	1.71	316	316	203	64%	95	30%	14	4%	3	1%	0	0%	
	P5-B2	4.54	375	375	231	62%	57	15%	29	8%	56	15%	0	0%	
	P6-B1	1.71	355	343	192	56%	103	30%	26	8%	23	7%	0	0%	
	P6-B2	4.66	332	317	75	24%	71	22%	71	22%	100	32%	0	0%	

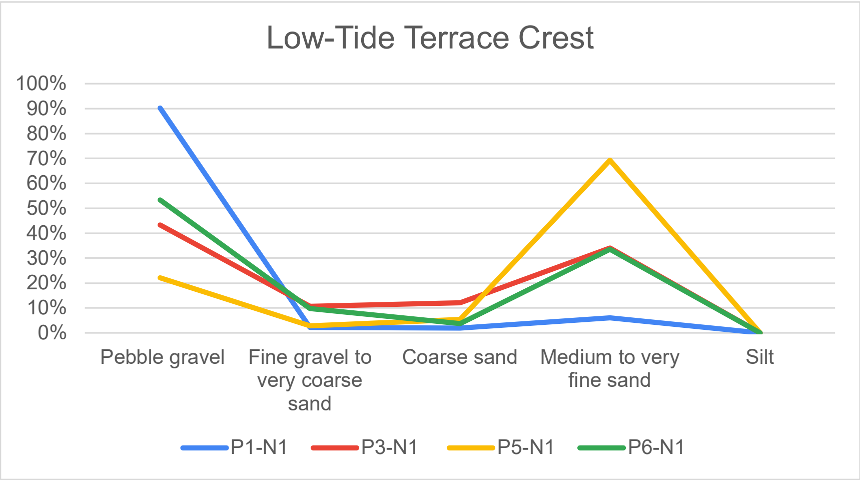




Date	Sector	m	Wet Weigh	Dry Weight	XL(g)	Pebble gra	L (g)	Fine gravel	M(g)	Coarse sar	S(g)	Medium to	XS(g)	Silt	Notes
	P1-F1	9.63	424	404	315	78%	23	6%	19	5%	49	12%	0	0%	
	P3-F1	8.64	462	442	318	72%	24	5%	24	5%	76	17%	0	0%	
	P5-F1	10.95	408	390	264	68%	38	10%	12	3%	77	20%	0	0%	
	P6-F1	10.88	482	457	309	68%	28	6%	24	5%	97	21%	0	0%	



Date	Sector	m	Wet Weigh	Dry Weight	XL(g)	Pebble gra	L (g)	Fine gravel	M(g)	Coarse sar	S(g)	Medium to	XS(g)	Silt	Notes
	P1-N1	15.7	569	556	502	90%	12	2%	11	2%	33	6%	0	0%	
	P3-N1	17.98	465	422	183	43%	45	11%	51	12%	144	34%	0	0%	
	P5-N1	15.18	353	284	63	22%	8	3%	15	5%	197	69%	0	0%	
	P6-N1	18.87	466	439	234	53%	43	10%	16	4%	147	33%	0	0%	



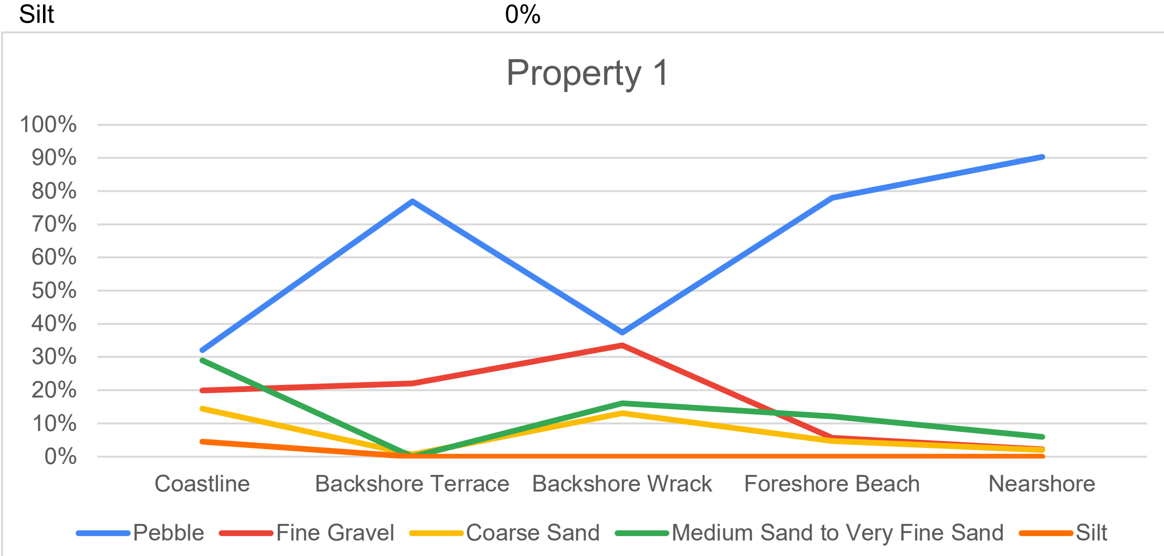
Deposit Area Weighting Scheme:	Weight	Areas impacted by deposit
	10	Backshore Terrace
	60	Backshore Face
	30	Foreshore Beach Face

Aggregate Mix #1 (Property 1 & 5)		
59%	4.8mm+	Drain
20%	1.8 to 4.7mm	pea
22%	fine to coarse sand	fine to coarse sand

Property 1

	Coastline	Backshore	Backshore	Foreshore	Nearshore
Pebble	32%	77%	37%	78%	90%
Fine Gravel	20%	22%	34%	6%	2%
Coarse Sand	14%	1%	13%	5%	2%
Medium Sand to Very Fine Sand	29%	0%	16%	12%	6%
Silt	5%	0%	0%	0%	0%

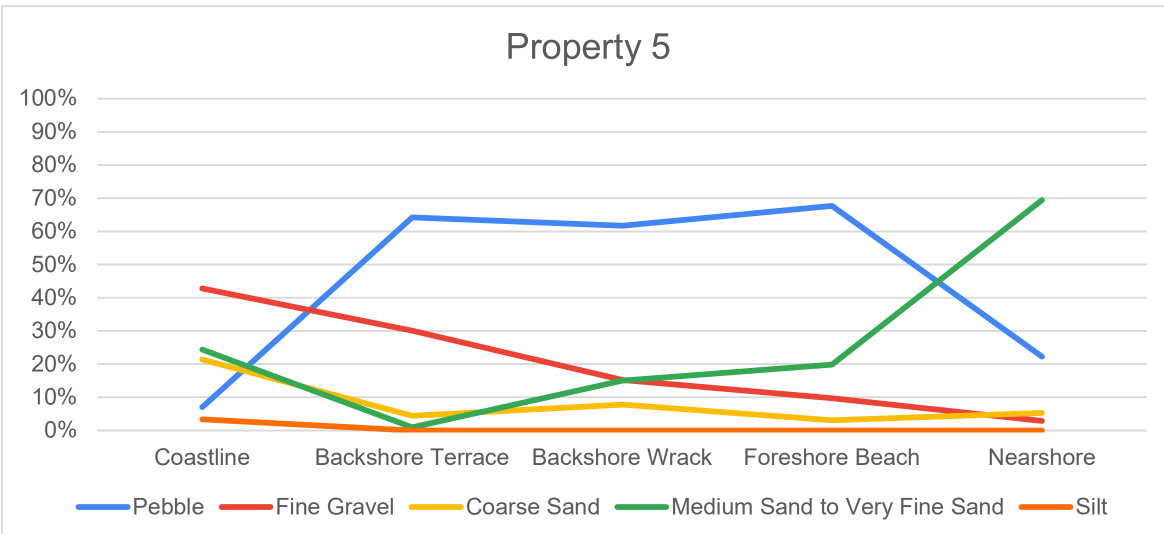
Recommended Composition	
Pebble	54%
Fine Gravel	24%
Coarse Sand	9%
Medium Sand to Very Fine Sand	13%
Silt	0%



Property 5

	Coastline	Backshore	Backshore	Foreshore	Nearshore
Pebble	7%	64%	62%	68%	22%
Fine Gravel	43%	30%	15%	10%	3%
Coarse Sand	21%	4%	8%	3%	5%
Medium Sand to Very Fine Sand	24%	1%	15%	20%	69%
Silt	3%	0%	0%	0%	0%

Recommended Composition	
Pebble	64%
Fine Gravel	15%
Coarse Sand	6%
Medium Sand to Very Fine Sand	15%
Silt	0%



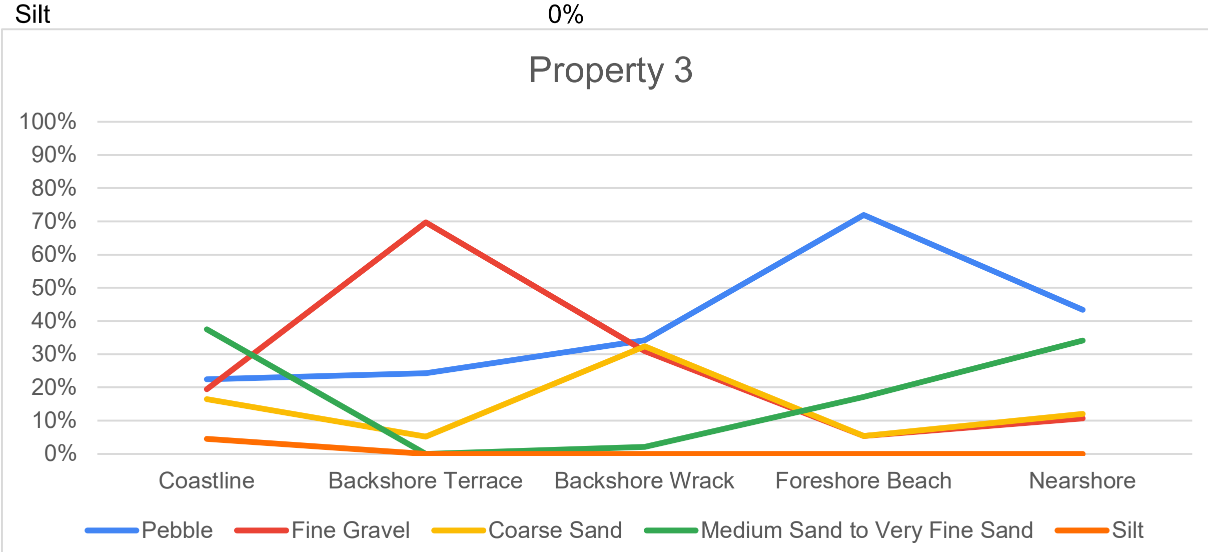
Sediment Size Range (mm)		Wentworth Classification
+	4.7498	Pebble Gravel
4.7497	1.8288	Granule Gravel to Very Coarse Sand
1.8287	0.762	Coarse Sand
0.7619	0.0737	Medium sand to very fine sand
0.0736	-	Silt

Aggregate Mix #2 (Property 3 & 6)		
42%	4.8mm+	Drain
23%	1.8 to 4.7mm	pea
35%	fine to coarse sand	fine to coarse sand

Property 3

	Coastline	Backshore	Backshore	Foreshore	Nearshore
Pebble	23%	24%	34%	72%	43%
Fine Gravel	20%	70%	31%	5%	11%
Coarse Sand	17%	5%	32%	5%	12%
Medium Sand to Very Fine Sand	38%	0%	2%	17%	34%
Silt	5%	0%	0%	0%	0%

Recommended Composition	
Pebble	45%
Fine Gravel	27%
Coarse Sand	22%
Medium Sand to Very Fine Sand	6%
Silt	0%



Property 6

	Coastline	Backshore	Backshore	Foreshore	Nearshore
Pebble	28%	56%	24%	68%	53%
Fine Gravel	14%	30%	22%	6%	10%
Coarse Sand	4%	8%	22%	5%	4%
Medium Sand to Very Fine Sand	45%	7%	32%	21%	33%
Silt	8%	0%	0%	0%	0%

Recommended Composition	
Pebble	40%
Fine Gravel	18%
Coarse Sand	16%
Medium Sand to Very Fine Sand	26%
Silt	0%