Urban Estuaries of the Capital Regional District

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Introduction

This report presents maps and inventories of the high estuarine ecosystem in the urban Greater Victoria region. The study area is divided into Esquimalt Lagoon, Esquimalt Harbour, Portage Inlet, Gorge Waterway, and Victoria Harbour physiographic regions (Figure 1). This project was undertaken to fill the information gap on the distribution and extent of high estuarine ecosystems in the Victoria metropolitan area. Parallel studies were conducted on Coburg Peninsula, sites in Portage Inlet, and in the Gorge Waterway where observations were made of elevation and substrate. Results for those studies are presented by Pearce (2005, in preparation) and Bein (2005, in preparation).

Estuarine ecosystems have many functions and values that benefit society, biodiversity, and environmental health. Estuarine ecosystems are impacted by land use and occur in areas of high population. Well-informed decisions need to be made when loss, degradation, or protection of estuaries is at stake. Mapping and inventorying estuaries can help decisions and planning.

Estuaries are important for biodiversity. Even though a given site may be considered species poor in itself, species occurring in the estuary do not occur in other habitats. The limited range of conditions these species occur in contributes to regional diversity. Estuaries also provide crucial environments for animals, including fish and birds that use the estuarine zone in their life cycle.

Research on reference sites informs urban development, engineering, and restoration projects that affects the estuarine ecosystem. The role of the estuary in performing ecosystem services such as pollution trapping, erosion control, and water retention is often overlooked. Monitoring estuarine environment provides a baseline for assessing ecosystem change due to cumulative impacts from affects like climate and urbanization.

The *Harbours Atlas* contains information on the intertidal and near shore ecosystem of Esquimalt Lagoon, Esquimalt Harbour, Portage Inlet, and Victoria Harbour. General information exists on the location, extent and quality of existing tidal marshes, meadows, and related habitats. Additional mapping in the intertidal zone will complete gaps in the information already recorded, detailing and expanding existing shore-unit and intertidal information. The results of this study, along with additional coastal information of the *Harbours Atlas*, will help inform planning, locate reference sites, identify habitats at-risk, and provide baseline data to assess environmental change in the future.

For this study, tidal marsh and meadow estuarine ecosystem components were distinguished according to plant composition and other physical properties. Orthophoto interpretation, site visits, and Differential Geographic Position System were used to map these units. Ecosystem maps were prepared to depict associations. The plant composition and surface substrate of selected ecosystem units were also inventoried to verify species assemblages and describe the high estuarine flora of the area. Data was entered into a Geographic Information System so that it may be included in the *Harbours Atlas* and shared with public, planners, and decision makers.

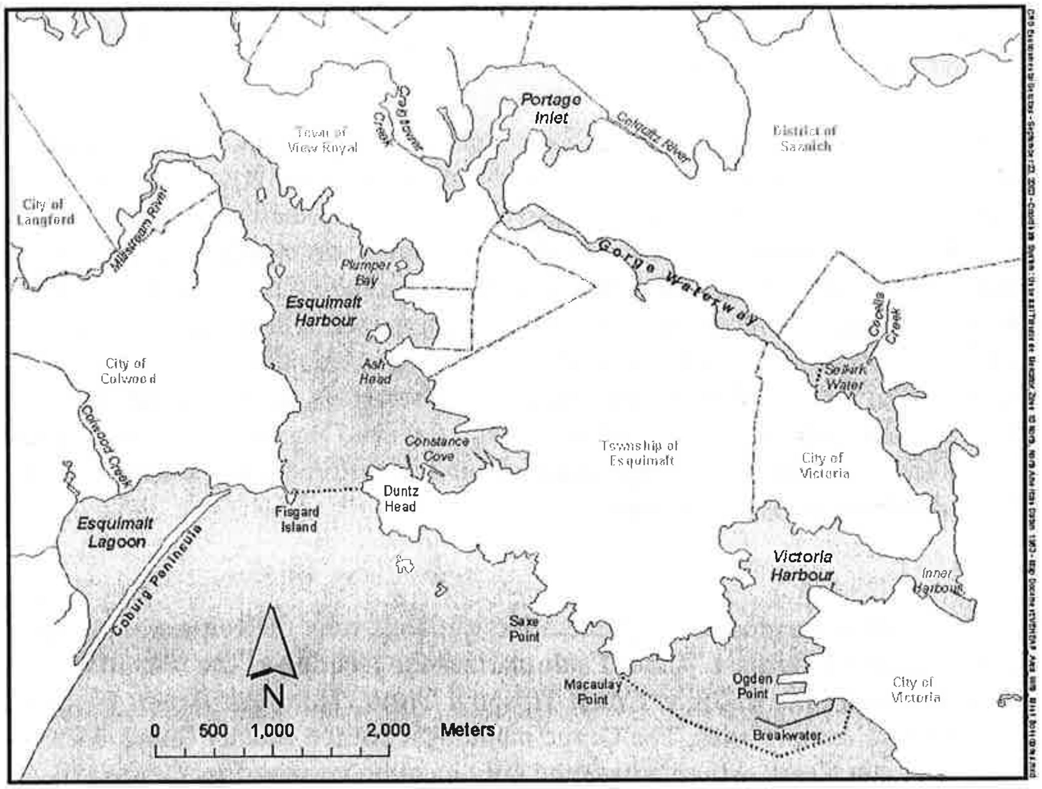


Figure 1: The study area.

Estuarine Ecosystems and the Study Area

Collectively, an estuary and lagoon are treated as estuarine ecosystems. An estuary is "…an intertidal community, occurring at the confluence of a freshwater source and the marine environment, and is regularly flooded by brackish waters" (Mackenzie and Moran 2004). In terms of physical structure, an estuary may be considered a "semi-enclosed body of sea water where salinity is measurably diluted by fresh water" (Howes et al. 1999). By this definition, a lagoon is related to an estuary. A coastal lagoon is defined as "…an area of salt or brackish water separated from the adjacent sea by a low-lying sand or shingle barrier…" (Barnes 1980). Lagoons and estuaries overlap, and biologically, are systems on a continuum of saltwater wetlands, called estuarine ecosystems. The estuarine ecosystem is characterized by shallow sub tidal areas, tidal flats and channels in lower tide zones, and vascular plants and stream reaches in higher tide zones.

In the higher tidal zone of the estuarine ecosystem, tidal marshes, meadows, and even swamps form on level or very slightly inclined platforms above tidal flats and on benches of stream channels. In the lower reaches of streams, seawater mixes with draining outflow, and water level changes with the tide. The platforms or benches are a result of fine mineral particles, suspended by tidal and fluvial floodwater, being trapped by the growth of plants over the long-term.

In the *Harbours Atlas*, tidal marsh (indicated by *Salicornia*) and tidal meadow (indicated by presence of estuarine graminoids) types are identified in the shore units. These occurrences show Esquimalt Lagoon has a high occurrence of marshes around the whole shoreline. Upper

Esquimalt Harbour and Portage Inlet have occurrences of both types. The rest of the study area had lower frequency and cover of these types.

Mapping of intertidal flats and the sub tidal zone of Esquimalt Lagoon, Portage Inlet, the Gorge, and Victoria Harbour is shown on the *Harbours Atlas*. In the study area, shallow sub tidal areas in Portage Inlet, Esquimalt Lagoon, and the Gorge Waterway have significant area. Sub tidal areas are covered by brackish or marine water. The waters are usually quite different from the incoming marine waters due to restricted tidal currents and mixing. Tidal flats in these sites and in Upper Esquimalt Harbour are also prominent. Tidal flats are exposed at low tide are gently inclined or level extents of soft sediments. In the study area they are generally non-vegetated. Invertebrates, including crabs and shellfish, macro-algae, fish, shorebirds, and microbes form complex communities in these habitats. By way of biota, tidal flats and lagoons or sub tidal areas of estuarine ecosystems are responsible for a significant amount of the biological activity in sub tidal basins and tidal flats of estuarine ecosystems.

Study Sites

In this study, sites with a high occurrence of high estuarine wetlands were differentiated from the general physiographic regions of Figure 1. Table 1 summarizes the location of the sites in the study area. Portage Inlet includes the Colquitz Creek, Hospital Creek, Tidewater Creek, Elfgate Creek, and Craigflower Creek estuary sites. The Gorge includes Kinsmen estuary found at the Esquimalt-Gorge Park. Cecelia Creek estuary site is the only location surveyed in Victoria Harbour. Esquimalt Harbour contains the Millstream and Upper Harbour estuary sites. Esquimalt Lagoon includes Coburg Peninsula and the Colwood Creek estuary sites.

Table 1: Summary of the sites within the study area.

Site Name	Description
Portage Inlet	The shoreline and mudflat areas outside of the estuaries in Portage Inlet to the base of Christie Point.
Colquitz Creek estuary	Estuary of the Colquitz Creek to where it flows into Portage Inlet. The immediate widening of the stream mouth and the small delta are considered part of the site.
Hospital Creek estuary	Estuary of Hospital Creek to opening into Portage Inlet. This site includes the mudflat below its mouth.
Tidewater estuary	Estuary near Tidewater road including the shallow channel. Former creeks do not have a name.
Elfgate estuary	Estuary at next to Sunnyside school. The former creek does not have a name.
Craigflower Creek estuary	Estuary of Craigflower Creek, above and below Helmken Bridge.
Gorge Waterway	Shoreline and mudflat areas between Portage Inlet and Victoria Harbour; includes Cecelia and Kinsmen estuary.
Kinsmen estuary	The highly modified inlet at Esquimalt-Gorge Park.
Victoria Harbour	
Cecelia Creek estuary	Estuary of Cecelia creek to opening into the Selkirk Waters.
Esquimalt Lagoon	Shore excluding, Colwood estuary and Coburg Peninsula
Coburg Peninsula	The barrier spit of Esquimalt Lagoon, including both the lagoon and Juan de Fuca straight sides
Colwood Creek estuary	Estuary at the outlet of Colwood Creek.
Esquimalt Harbour	Shoreline and mudflat areas, including islets.
Millstream Creek estuary	Estuary occurring in the lower reaches of the stream, above its mouth.
Upper Esquimalt Harbour	The estuarine sites by the Millstream mudflat, occurring above Coal Island.

Ecosystem Classification

Pojar, Meidinger, and Klinka (1991) provide an overview of the British Columbia Ecosystem Classification methodology used for ecosystem inventory, description, monitoring, and research. In order to map an ecosystem over a landscape, it must be classified into component parts. Each part must be a relatively uniform physical and biological unit of the landscape. Because plants and soil integrate most ecosystem components and are easy to observe, they are useful in determining a unit of an ecosystem. An ecosystem unit is characterized by a vegetation pattern and substrate within a defined area. The boundaries of the unit may be gradual or abrupt. The unit is classified into an association depending on the physical and biological features observed at the site. An association is defined by diagnostic species that occur in specific combinations or compositions in certain physical conditions. The association is named after indicator plant species, not necessarily only dominant ones.

Within the estuarine ecosystem, several types of tidal marshes, meadows, and swamps may be distinguished. MacKenzie and Moran (2004) provide extensive definitions and descriptions of tidal marsh and tidal meadow characteristics, including vegetation and physical details of associations. Tidal swamps are defined by Warner and Rubec (1998), with specific examples described as flood associations by MacKenzie and Moran (2004).

Classification of estuarine marsh or meadow is based on degree of tidal flooding, (height above mean tide), degree of freshwater influence, and plants tolerant of wet brackish soils (MacKenzie and Moran 2004). The degree of freshwater influence is represented by a salinity gradient: fresh is below 0.5 ppt salts; low is weakly brackish, 0.5 to 5 ppt salts; medium is moderately brackish, 5-18 ppt salts; high, 18 to 30 ppt salts; normal sea water, 30-40 ppt salts; and hyper salinity, above 40 ppt salts. Degree of tidal flooding is proportional to height above zero tide, and is represented by low, middle, and upper thirds of the tidal range in a given region.

MacKenzie and Moran (2004) define the tidal marsh as exposed diurnally to tide. They define several tidal marsh associations:

- *Salicornia virginica – Glaux maritima* occurs in middle tidal zone where water is highly saline. It is also found in protected bays.
- *Distichlis spicata* is on poorly drained sites in the mid tidal zone with strongly to hyper saline flood waters. *Salicornia virginica* is usually co-dominant. *Atriplex patula* is common.
- *Carex lyngbyei* is usually the lowest vegetated association along river channels, on sites with chronic water logging. It occurs in middle tidal zone with moderately to highly saline floodwaters. *Potentilla egidii* and *Eleocharis palustris* may also occur.
- *Spergularia canadensis* is a sparsely vegetated association that occurs on sites protected from waves and strong currents in muddy waterlogged depressions.
- *Schoenoplectus americanus* forms monotypic stands below *Carex lyngbyei* associations. This species is at-risk (B.C. Conservation Data Centre 2005).

Tidal meadows occur above marshes and have less frequent, shorter duration tidal flooding. Recognized tidal meadow associations include (MacKenzie and Moran 2004):

- *Deschampsia cespitosa – Hordeum brachyantherum* is found on steep shores, as a narrow fringe, as well as on fans and creek side areas. It occurs in the upper tidal zone, where daily flooding is brief and moderately to strongly saline. *Potentilla egedii,* and *Carex lyngbyei* can also be prominent species. In disturbed sites of the Georgia Depression, *Agrostis stolonifera* may be dominant. *Triglochin maritima* is common.

- *Deschampsia cespitosa – Aster subspicatus* occupies platforms that have infrequent weakly to strongly saline flooding in the upper-most tidal zone. *Achillea millefolium, Carex lyngbyei, Hordeum brachyantherum, and Potentilla egedii* may be abundant. *Agrostis exarata* and *Triglochin maritima* are common.
- *Juncus arcticus – Plantago macrocarpa* appears in protected sites saturated with low salinity water such as tidal reaches of streams in the upper tidal zone. *Aster subspicatus* and *Potentilla egedii* may also be dominant species. *Triglochin maritima* is common.
- *Agrostis stolonifera* is an introduced species invading upper estuarine meadows in the Georgia Depression, creating monotypic patches.
- *Leymus mollis – Conioselinum gmelinii*: Found on beach ridges and berms where salt spray and tidal flooding is infrequent.

Freshwater marsh associations may occur with estuarine classes when floodwaters near the estuarine ecosystem are fresh. The following associations are of interest to estuarine ecosystems (MacKenzie and Moran 2004):

- *Phalaris arundinacea* establishes on flood-benches of low-gradient streams. In Capital Regional District, the species was often seeded for agriculture (Pers. Obs.).
- *Typha latifolia* occurs in protected sites with soil-water saturation during the growing season and high nutrient levels, including sites with excess salt accumulation.
- *Eleocharis palustris* occurs on shallowly flooded brackish sites, protected inlets, and weakly brackish tidal fluvial reaches. *Carex lyngbyei, Deschampsia cespitosa, Triglochin maritima,* and *Potentilla egedii* are typical associates.

Tidal swamps are areas of woody vegetation that experience occasional flooding of brackish water (Warner and Rubec 1998). The resulting substrate is slightly saline which is water logged from soil-water irrigation. *Salix sitchensis, S. hookeriana,* and *Malus fusca* are examples of small trees and shrubs that may be found at the edges of lagoons, brackish river channels, and estuaries (Douglas et al. 1998; MacKenzie and Moran 2004). Flood associations, even though not identified for this region, may be represent tidal swamps (MacKenzie and Moran 2004):

- *Malus fusca – Maianthemum dilatatum* occurs in the upper limit of tidal influence, experiencing salt spray and/or saline irrigation. It occurs in the outer coasts of BC and is not identified in the Georgia Depression.
- *Salix sitchensis – Maianthemum dilatatum* is uncommon in the Coast, found in transition from freshwater to brackish conditions in lower reaches of fluvial systems. Not identified in the Georgia Depression.

Methods

Methods were based on the BC Ecological Classification methodology (Pojar, Meidinger, and Klinka 1991) and related procedures (Hunter et al. 1983; Meidinger et al. 1998; Howes et al. 1999; MacKenzie and Moran 2004). Orthophotos, Geographic Positioning System (GPS), and site visits were used to map high estuarine ecosystem. For selected sites, additional observations were made of vegetation and substrate. Finally, a Geographic Information System database was produced to accommodate the map and inventory results. The methods implemented were a compromise between practicability, technology, time constraints, and level of detail.

Ecosystem Mapping

Maps were developed in the field with the use of orthophotos, GPS, and description. High-resolution orthophotos were used to identify potential estuarine ecosystem units (Table 2). In cases where the location of ecosystem units on the orthophotos was apparent, units were mapped directly on the orthophoto. This was reliable for the lower edges of marshes and the contrast between vegetation types.

Table 2: Orthophoto tiles of the study area.
V. = City of Victoria, S. = District of Saanich, V.R. = Township of View Royal, and C. = Colwood

Tile No.	Source	Year	Tile No.	Source	Year
Gorge Waterway			Esquimalt Lagoon		
92b.044.1.1.3	V.	2001	92b.043.2.1.4	C.	2003
92b.044.1.1.4	V.	2001	92b.043.2.3.1	C.	2003
92b.044.1.3.1	V.	2001	92b.043.2.3.2	C.	2003
92b.044.1.3.2	V.	2001			
92b.044.1.3.3	V.	2001	Esquimalt Harbour		
			92b.043.2.3.3	C.	2003
Portage Inlet			92b.043.2.3.4	C.	2003
92b.043.4.2.2	S.	2003	92b.043.2.4.1	C.	2003
92b.043.4.2.3	S.	2003	92b.043.2.4.3	C.	2003
92b.043.4.2.4	S.	2003	92b.043.4.1.2	C.	2003
92b.043.2.4.4	S.	2003	92b.043.4.2.1	V.R.	2003
92b.043.4.2.1	V.R.	2003			

Differential GPS with real time corrections aided mapping (Table 3). Better than 1 m precision was achieved in the open, a frequent characteristic of field sites. Error of the position increased adjacent to woods, these positions were used as general references in mapping. In some cases readings were taken from canoe and despite high precision, had low accuracy because the point was offset up to 5 m from the actual location of the mapped feature. The direction of this offset was towards the shoreline.

Ecosystem units were finalized on the ground. The final polygon representing a unit was overlain over the orthophotos and aligned with differential GPS markers, when available. Because of the small scale of mapping and the high resolution of orthophotos, accuracy could match the GPS in open, un-shaded areas. The accuracy, source of information, and date of collection were documented when the map unit was established.

Table 3: Differential GPS specifications.

GPS Model: Trimble ProXR
Target Precision: 1 m (95%)
Logging intervals: 1 s
Configuration / GPS Rover Options / Position filters:
• Position mode: over determined 3D
• Elevation mask: 15.0 degrees
• SNR Mask: 6.0
• DOP Type: HDOP
• HDOP mask: 2
Differential GPS corrections type: Real-time

Description of map units

In addition to ecosystem units, anthropogenic units and satellite units were distinguished. Ecosystem units are areas of relatively uniform physical environment and vegetation. A unit may contain variation, depending on nature of boundary and patterns of vegetation or form. Anthropogenic units are areas directly modified and changed by people. These include fill sites, ditches and drainage channels, shore stabilization, and constructed wetlands. Satellite units are small patches of estuarine vegetation that occur within another kind of ecosystem. These units are generally less than 5 m^2.

For each ecosystem or anthropogenic unit, the type, ecosystem class, geomorphic form, community dominants, and association was recorded. Up to three main species were recorded as community dominants for a unit. The BC Ecosystem Classification for wetlands was a guide for classifying ecosystem units into classes and associations (MacKenzie and Moran 2004). The main classes of concern were tidal flats, marshes, and meadows. Certain freshwater marsh and flood classes were also used. A best-fit association was determined for the unit according to the published procedures. Sites that did not fit into the classification scheme were noted for later review and detailed vegetation inventory.

Geomorphic form was recorded descriptively using British Columbia Terrain Classification system categories and definitions (Meidinger et al. 1998; Appendix 3).

For satellite units, ecosystem class and geomorphic form were not applicable, because the unit occurred within a larger ecosystem unit that was not the subject of the study. Since satellite units were very small, the area of the patch was recorded and located as a point.

Inventory of selected sites and classes

Inventories were also completed to describe local examples of the marsh and meadow classes. This was critical for sites that did not easily match the published associations. When an ecosystem unit was atypical, containing species that could not be represented by the classification system, or it was not obvious which association to classify a unit under, detailed inventory was completed. Similar vegetation patterns that recurred in a site would be identified once, inventoried across these sites to describe the local pattern. Sometimes this would result in a multi-part ecosystem unit, that shared the same inventory and classification records.

To record the plant composition of a unit, a complete species list was drawn. *The Flora of British Columbia* (Douglas et al. 1998) was used to aid in identifications and naming. For each species, percent cover was visually assessed with the aid of the cover charts (Appendix 4). Distribution of the species in unit was recorded according the several categories (Appendix 4). Relevant notes, such as habitat preference, were also taken.

Surface substrate was identified and ranked in abundance as surface cover. Substrate type was adapted from the *Field Manual for Describing Terrestrial Ecosystems* (Appendix 5). Ranking substrate type and texture was recorded from most to least abundant.

Geographic Information System and Data Processing

A digital geodatabase was designed with ArcGIS software to store field records and maps. The spatial components were the map units and they linked to species and substrate records. Several reference tables translated coded data into readable terms.

Map units were drawn in the geodatabase based on field visits and notes, GPS information, and orthophoto interpretations. Field records pertaining to a map unit were entered into tables associated with the map unit. Every map unit was assigned:

- PolygonID – A unique identifier for the unit, composed of unit type, site, and map label.
- SiteName – One of the sites from Table 1.
- UnitType – Ecosystem, anthropogenic, or satellite.
- EcosystemClass – Tidal marsh, tidal meadow, etc.
- CommDomm1 – Species name of the most abundant plant in the unit.
- CommDomm2
- CommDomm3
- Association – Name of association.
- GeomorphicForm – Description of geomorphic form of site
- DataProject – Name of GPS filename of polygon.
- DataDate – Date polygon was created.
- DataSource –
- DataAccuracy – Error in metres.

Species information, if collected for an ecosystem unit, was entered into the species table. Every record was a separate species observation. Every record included:

- PolygonID – the unit the species was found
- Species – name of species, using a six letter code, the first three were the genus and the last three the species. These codes with full names are one of the tables in the geodatabase.
- Abundance – abundance of less than 1% was recorded as 0; species that did not occur were not recorded.
- Distribution
- Comments

Substrate data, if collected, included:

- PolygonID – the unit the substrate was observed
- SubstrateType
- Rank

Results

Units were mapped in Portage Inlet, Gorge Waterway, Esquimalt Harbour, Esquimalt Lagoon, and Victoria Harbour (Table 4). These include ecosystem, satellite, and anthropogenic units. Maps of the estuarine ecosystem units are depicted at 1:10,000 and sites with significant estuarine units presented at a smaller scale (Appendix 6). The majority of the area were ecosystem units, with highest occurrences in Esquimalt Lagoon followed by Portage Inlet and Upper Esquimalt Harbour. Much less area is in Gorge, Victoria Harbour, and Esquimalt Harbour, where there are sporadic occurrences of estuarine vegetation.

Anthropogenic units were a minor component of overall vegetation (Table 4). The largest occurrences were in Esquimalt Lagoon, an un-vegetated restoration site, and Kinsmen estuary in the Gorge, in a modified tidal inlet used for recreation and now undergoing restoration (Table 1). Esquimalt Harbour also had some occurrences of restoration sites. The rest of the GOR and Portage Inlet had natural regeneration on artificial shorelines.

Table 4: Number and area (m^2) of units mapped in study sites.

	Eco. Units		Anthro. Units		Satellite Units		Total Units	
	No.	Area (m^2)	No.	Area (m^2)	No.	Area (m^2)	No.	Area (m^2)
Portage Inlet								
Colquitz Creek estuary	19	5,261	0	0	4	13	23	5,274
Hospital Creek estuary	10	1,706	1	31	2	8	13	1,745
Tidewater estuary	11	4,023	0	0	0	0	11	4,023
Elfgate estuary	8	821	1	37	0	0	9	858
Craigflower Creek estuary	24	3,958	2	100	1	3	27	4,061
Other	12	427	3	23	54	146	69	596
Total	**84**	**16,196**	**7**	**191**	**61**	**170**	**152**	**16,557**
Gorge Waterway								
Kinsmen estuary	0	0	6	762	0	0	6	762
Other	9	571	2	19	54	195	65	785
Total	**9**	**571**	**8**	**781**	**54**	**195**	**71**	**1,547**
Victoria Harbour								
Cecelia Creek estuary	**4**	**818**	**0**	**0**	**0**	**0**	**4**	**818**
Esquimalt Harbour								
Millstream Creek estuary	9	3,251	0	0	0	0	9	3,251
Upper Esquimalt Harbour	19	4,766	0	0	3	12	22	4,778
Other	21	1,283	2	222	6	15	29	1,520
Total	**49**	**9,300**	**2**	**222**	**9**	**27**	**60**	**9,549**
Esquimalt Lagoon								
Coburg Peninsula	24	12,128	1	485	0	0	25	12,563
Colwood Creek estuary	11	4,506	0	0	0	0	11	4,506
Other	75	18,667	2	1,345	30	49	107	20,012
Total	**110**	**35,301**	**3**	**1,830**	**30**	**49**	**143**	**37,081**
Grand Total	**256**	**62,186**	**20**	**3,024**	**154**	**441**	**430**	**65,651**

In Portage Inlet, satellite units were found and were mainly composed of *Salicornia virginica* (75%) and in some cases, *Carex lyngbyei* (22%). In the Gorge Waterway, estuarine vegetation was fragmented along the channel shore. Several units occupied 590 m^2 (Table 4). The other occurrences were satellite and covered 195 m^2. The main species of these patches were

Salicornia virginica, *Carex lyngbyei*, and *Distichlis spicata*. Few satellite units occurred in ESH and they were sparsely covered by mainly *Salicornia virginica* (31%). In ESL, most satellite units occurred in the northeastern shore, the composition was: *Salicornia virginica* (23%), *Distichlis spicata* (14%), *Leymus mollis* (12%), *Carex lyngbyei* (4%), and *Atriplex patula* (4%).

The distribution of tidal marshes and the related associations accounted for the majority of the total area (Table 5). *Salicornia virginica*, *Carex lyngbyei*, and *Distichlis spicata* were the most widespread associations with some minor variants. *Spergularia canadensis* and *Schoenoplectus americanus* were also represented. Other associations included salt pond with algae and *Agrostis* sp. marsh.

Table 5: Area (m^2) of tidal marshes associations.

Site	*Distichlis spicata*	*Salicornia virginica*	*Spergularia canadensis*	*Carex lyngbyei*	*Schoenoplectus americanus*	*Other*	Total
Portage Inlet							
Colquitz Creek estuary	22	0	0	3,251	34	0	3,307
Hospital Creek estuary	254	509	149	96[c]	0	0	1,008
Tidewater estuary	2,046	0	0	0	22	98[d]	2,166
Elfgate estuary	118	37	0	275	0	0	430
Craigflower Creek estuary	469	46	0	1,685	0	0	2,200
Other	143	0	0	285	0	11[e]	439
Total	**3,052**	**592**	**149**	**5,592**	**56**	**109**	**9,550**
Gorge Waterway							
Kinsmen estuary	467	296	0	0	0	0	763
Other	0	8	0	582	0	0	590
Total	**467**	**304**	**0**	**582**	**0**	**0**	**1,353**
Victoria Harbour							
Cecelia Creek estuary	**0**	**152**	**0**	**156**	**0**	**0**	**308**
Esquimalt Harbour							
Millstream Creek estuary	155	28	0	2,636	0	0	2,819
Upper Esquimalt Harbour	1,762	31	0	338	31	1,593[f]	3,755
Other	31	446[a]	0	206	15	0	221
Total	**1,948**	**505**	**0**	**3,180**	**46**	**1,593**	**7,272**
Esquimalt Lagoon							
Coburg Peninsula	872	7,773	127	0	0	0	8,772
Colwood Creek estuary	0	379	0	1,705	0	0	2,084
Other	4,353	2,396	223[b]	333	319	575[g]	8,199
Total	**5,225**	**10,548**	**350**	**2,038**	**319**	**575**	**19,055**
Grand Total	**10,692**	**12,054**	**499**	**11,549**	**421**	**2,277**	**37,492**

[a] *Salicornia virginica* – *Juncus arcticus* hybrid occurred in 20 m^2 in Esquimalt Harbour.
[b] *Spergularia canadensis* – *Potentilla egidii* association occurred in 223 m^2 in Esquimalt Lagoon.
[c] *Triglochin maritima* occurred in 27 m^2 in Hospital Creek.

[d] Salt ponds of algae occurred in 98 m^2 at Tidewater Estuary.
[e] An unclassified tidal marsh occupied 11 m^2 in Portage Inlet.
[f] *Agrostis* sp. (diminutive form) association occupied 1,593 m^2 in Upper Esquimalt Harbour.
[g] A 575 m^2 restoration site was unvegetated in Esquimalt Lagoon.

Tidal meadows were also widespread but had less area than tidal marshes (Table 6). *Juncus arcticus* was the most abundant association. It exhibited a hybrid association with *Distichlis spicata* in Esquimalt Lagoon and Craigflower creek estuary. *Leymus mollis* had erratic occurrence in Portage Inlet and Esquimalt Harbour. In Esquimalt Lagoon it was mainly represented by variants represented by *Festuca rubra* and *Ambrosia chamissonis* associations. *Agrostis* sp. and *Elymus repens* formed the next most abundant tidal meadow associations. *Agrostis* sp. and *Elymus repens* occurred in Elfgate, Craigflower, Cecelia, and Esquimalt Lagoon. Other associations included *Aster subspicatus* and *Grindelia integrifolia*.

Table 6: Area (m^2) of tidal meadow associations.

Site	*Leymus mollis*[a,b,c]	*Elymus repens*	*Agrostis* sp.[d]	*Juncus arcticus*[e]	Other[f,g]	Total
Portage Inlet						
Colquitz Creek estuary	0	0	710	992	0	1702
Hospital Creek estuary	95	0	0	634	0	729
Tidewater estuary	0	0	501	1,355	0	1,856
Elfgate estuary	0	127	0	300	0	427
Craigflower Creek estuary	229	468	267[d]	893[e]	0	0
Total	**324**	**595**	**1478**	**4,174**	**0**	**5,678**
Victoria Harbour						
Cecelia Creek estuary	**0**	**64**	**0**	**446**	**0**	**510**
Esquimalt Harbour						
Other	302[a]	0	216	288	0	504
Millstream Creek estuary	0	0	258	0	0	258
Upper Esquimalt Harbour	228	0	358	0	0	586
Total	**530**	**0**	**832**	**288**	**0**	**1650**
Esquimalt Lagoon						
Colwood Creek estuary	139	181	1,291	355	182[f]	2,148
Coburg Peninsula	3,288[a,b]	0	0	0	69[g]	69
Other	1,535[b,c]	1,658	487	5,579[e]	0	0
Total	**4,962**	**1,839**	**1,778**	**5,934**	**0**	**14,513**
Grand total	**5,816**	**2,498**	**4,088**	**10,842**	**251**	**23,495**

[a] *Ambrosia chamissonis* occurred in Esquimalt Harbour (302 m^2) and Coburg peninsula (376 m^2).
[b] *Festuca rubra* occurs in 2,889 m^2 on Coburg Peninsula and 44 m^2 in Esquimalt Lagoon.
[c] *Leymus mollis* - *Ambrosia chamissonis* variant occurs in 247 m^2 in Esquimalt Lagoon.
[d] A combined *Elymus repens – Agrostis* sp. association occurs at Craigflower Creek estuary (276 m^2).
[e] *Juncus arcticus–Distichlis spicata* occurs at Craigflower (211 m^2) and Esquimalt Lagoon (2,738 m^2).
[f] In Colwood Creek estuary, *Aster subspicatus* association occurs in 182 m^2.
[g] On Coburg Peninsula, *Grindelia integrifolia* association occurs in 69 m^2.

Tidal swamps and marshes had a limited extent (Table 7). Esquimalt Lagoon had the most tidal swamps, with some occurrence in Millstream Creek estuary. Marshes occurred in small patches in Colquitz Creek estuary, Upper Esquimalt Harbour, and Colwood Creek estuary.

Table 7: Area (m^2) tidal swamp and marsh associations adjacent to tidal units.

	Tidal Swamp		Marsh			
Site	*Malus fusca* or *Rosa nutkana*	*Salix* sp.	*Phalaris arundinacea*	*Typha latifolia* or *Agrostis* sp.	*Eleocharis* sp.	Total
Portage Inlet						
Colquitz Creek estuary	0	0	254	0	0	254
Other	0	0	11	0	0	11
Esquimalt Harbour						
Millstream Creek estuary	0	173	0	0	0	173
Upper Esquimalt Harbour	0	0	0	218	206	424
Esquimalt Lagoon						
Colwood Creek estuary	0	0	0	274	0	274
Other	583	1,878	94	485[a]	0	2,555
Total	**583**	**2,051**	**359**	**977**	**206**	**4,176**

[a] This is an *Oenanthe sarmentosa* dominant unit occurring in an anthropogenic unit near CBG and ESL

Tidal Marshes

The tidal marshes were found on narrow platforms, the low bench of estuarine stream reaches, and channel banks. The typical substrate was mud for sites by stream channels and organic soil for units established on stream benches. Sometimes coarser particles like sand, pebble, shell, cobble, and even rip rap occurred.

The average tidal marsh species composition was determined from 90 out of 153 ecosystem units, spanning 29,195 m^2. Typically, a tidal marsh community had a total plant cover of 100% (Table 8). The most abundant species were *Salicornia virginica*, *Carex lyngbyei*, and *Distichlis spicata*. They formed patches with abrupt edges. *Salicornia virginica* and *Distichlis spicata* mixed with relatively equal abundance on some sites. There was moderate overlap and strong segregation among the dominant species, resulting in patchy distribution in the marsh mosaic.

Table 8: Frequency (%) and cover (%) of species composing tidal marshes.

Species	Frequency (%)	Cover (%)
Salicornia virginica	66	36%
Carex lyngbyei	52	24%
Distichlis spicata	53	13%
Atriplex patula	59	9%
Potentilla egidii	24	4%
Agrostis sp.	13	3%

Juncus arcticus	22	2%
Grindelia integrifolia	33	2%
Schoenoplectus americanus	10	1%
Plantago maritima	27	1%
Deschampsia cespitosa	22	1%
Other tidal herbs		2%
Other herbs		2%
	Total	**100%**

Several species were also present, although not dominant. *Atriplex patula* was widespread and associated with *Salicornia virginica* and *Distichlis spicata*. *Potentilla egidii*, *Juncus arcticus*, *Grindelia integrifolia*, *Plantago maritima*, and *Deschampsia cespitosa* were fairly frequent. *Agrostis* sp. was a small diminutive type, distinct from the *Agrostis* sp. found in tidal meadows. *Schoenoplectus americanus* was uncommon as well. Other tidal herbs had a cover of less than 1% each, and included *Triglochin maritima* at 28% frequency, *Hordeum brachyantherum* at 23%, *Spergularia canadensis* at 14, *Aster subspicatus* at 4%, and *Festuca rubra* 8% frequency. *Eleocharis* sp., *Cuscuta salina*, *Leymus mollis*, and *Ruppia maritima* only had a frequency of 1% and less than 0.1% cover. There were many other herbaceous plants occurring at the edges of marsh, all had a cover less than 1% each. *Elymus repens* was 19% frequent and *Rumex crispus* was 4% frequent, and the rest of the species had frequencies of less than 2%.

Tidal Meadows

Tidal meadows occurred above tidal marshes, usually adjacent to wooded riparian zones or sloped shores, on low bench of creeks, and between the tree-line and marshes. Substrates were organic soils with coarse mineral particles. 90 units, covering 21,260 m^2, were sampled out of 107 tidal meadow units. The total average cover of the tidal meadow in the study is 95% (Table 9). *Juncus arcticus* was the most abundant with *Potentilla egidii*, *Elymus repens*, *Agrostis* sp. providing a relatively even contribution to cover. *Atriplex patula*, followed by *Elymus repens*, and *Grindelia integrifolia* were the most frequent. *Festuca rubra*, *Grindelia integrifolia*, *Leymus mollis*, *Ambrosia chamissonis*, *Phalaris arundinacea*, *Triglochin maritima*, *Salicornia virginica*, and *Aster subspicatus* had a abundance less than 5%. Other tidal herbs each had cover less than 1%. *Carex lyngbyei* and *Hordeum brachyantherum* had frequencies from 22-28%. *Plantago maritima*, *Achillea millefolium*, *Deschampsia cespitosa*, *Spergularia canadensis* and had frequencies of 4-10%. *Polygonum fowleri* and *Maianthemum dilatum* had only a 1% frequency. For the other herbs and woody species, no one species had a cover greater than 1%. *Rosa nutkana*, *Rumex crispus*, and annual grasses had the highest frequencies at around 10%.

Table 9: Frequency (%) and cover (%) of species composing tidal meadows.

Species	Frequency (%)	Cover (%)
Juncus arcticus	39	24%
Potentilla egidii	44	12%
Agrostis sp.	44	10%
Elymus repens	56	9%
Distichlis spicata	39	9%
Atriplex patula	71	7%
Grindelia integrifolia	51	4%
Leymus mollis	20	3%

Salicornia virginica	32	3%
Festuca rubra	12	3%
Triglochin maritima	38	2%
Ambrosia chamissonis	16	2%
Aster subspicatus	19	1%
Other tidal herbs		2%
Other herbs		3%
Woody		1%
Total		**95%**

Tidal Swamps and Mineral Marshes

Tidal swamp and marsh units occurred next to tidal marshes and meadows. The average composition of tidal swamps was determined from a sample of 5 out of 7 units, with an area of 2,342 m^2 of 2,636 m^2. Tidal swamps had a cover of 144% from the overlap of small trees and shrubs (Table 10). *Salix* sp. was the most abundant plant. *Rosa nutkana* was the next most abundant. *Malus fusca* occurred in small patches. Other woody species had 2-3% cover each and included *Rubus discolor*, *Alnus rubra*, *Symphoricarpos albus*, *Daphne laureola*, *Hedera helix*, *Crataegus douglasii*, and *Ilex aquifolium*. *Atriplex patula*, *Carex* spp., and *Agrostis* sp. were the main understory species. *Elymus repens* was an abundant component of the open edges of the thickets. Other tidal herbs occurred in openings between shrub thickets sporadically. Species included *Salicornia virginica*, *Leymus mollis*, *Juncus arcticus*, *Spergularia canadensis*, and *Potentilla egidii*.

Table 10: Frequency (%) and cover (%) of species composing tidal swamps.

Species	Frequency (%)	Cover (%)
Salix sp.	80	67%
Rosa nutkana	60	26%
Elymus repens	80	17%
Atriplex patula	86	14%
Malus fusca	40	13%
Carex lyngbyei	60	6%
Carex sp.	20	5%
Agrostis sp.	60	4%
Other herbs		4%
Other woody		12%
	Total	**166%**

Marshes occurred adjacent to tidal units, 6 out the 9 units were sampled for average composition (Table 11). This represents an area of 1,030 out of 1,542 m^2. *Agrostis* sp. was the most abundant followed by *Typha latifolia*, *Phalaris arundinacea*, and *Potentilla egidii*. *Eleocharis* sp., *Juncus arcticus*, *Carex lyngbyei* were also present in some units. *Eleocharis* sp., *Veronica* sp., *Oenanthe sarmentosa*, *Ranunculus* sp., and *Iris pseudacorus* were relatively infrequent compared to the other species.

Table 11: Frequency (%) and cover (%) of species composing marshes adjacent to tidal units.

Species	Frequency (%)	Cover (%)
Agrostis sp.	83	52%

Typha latifolia	60	27%
Phalaris arundinacea	33	21%
Potentilla egidii	50	20%
Eleocharis sp.	17	5%
Juncus arcticus	17	5%
Carex lyngbyei	33	2%
Elymus repens	50	2%
Veronica sp.	17	1%
Oenanthe sarmentosa	17	1%
Ranunculus sp.	17	1%
Iris pseudacorus	17	1%
Other herbs		3%
Other woody		3%
	Total	**144%**

Discussion

Extent, Distribution, and Composition of Ecosystem Units

High estuarine classes and associations occupy 6.49 ha. This is a small area compared to the area of tidal flats, which cover 78.7 ha. The extent of high estuarine types are very small proportion of the total estuarine ecosystem, including tidal flats and sub tidal lagoons.

Esquimalt Lagoon is the largest estuarine ecosystem with the least disturbance and has the most tidal marshes meadows and swamps with the most diversified associations. Portage Inlet is also a large estuarine ecosystem. Tidal marshes and meadows are concentrated around incoming creeks, which drain into large tidal flats, and are composed of commonly occurring associations, such as *Carex lyngbyei* and *Juncus arcticus*. Upper Esquimalt Harbour has a large tidal flat but limited, although rare, tidal marsh and meadow associations. Overall, tidal marshes and meadows are found in the following landscape patterns:

- Fluvial channels; bends and inlets of stream or creek channels. Examples: Hospital Creek estuary, Colquitz Creek estuary, Craigflower Creek estuary, Millstream Creek estuary
- Wide platforms near large mudflats at the freshwater-marine confluence. Examples: Elfgate estuary, Tidewater estuary, Cecelia Creek estuary, Upper Esquimalt Harbour, Craigflower Creek estuary
- Platform fringing lagoons. Examples: Esquimalt Lagoon, Portage Inlet
- Satellites and strands along channel and shore margins. Examples: Gorge Waterway, lower reach of Colquitz Creek estuary and Craigflower Creek estuary
- Highly disturbed regeneration on filled shorelines including riprap and pebbles. Examples: Kinsmen estuary, Esquimalt Harbour
- Below fresh water marshes. Examples: Colwood Creek estuary, Upper Esquimalt Harbour

Rare species include *Schoenoplectus americanus* and *Eleocharis* sp., they both have a low frequency and cover. *Schoenoplectus americanus* had a relatively low frequency, occurring at many sites but not more than once per site and a low cover. *Schoenoplectus americanus* is red-listed and about half are in precarious locations at the edges of property lines where filling or dumping could eliminate a sub-population. Some species of *Eleocharis* sp. are also listed, regardless of the which species the *Eleocharis* sp. are, they are rare in the study area. A diminutive *Eleocharis* sp. was found only in two units at the same site. The population of the small *Eleocharis* sp. is uncertain as it also occurs on the border of private property that may be buried.

Other species of note occurred in estuarine meadows. *Maianthemum dilatum* had a low frequency and cover and is associated with fresh water swamps. *Hordeum brachyantherum* had a fair frequency but low cover, it is also a terrestrial wet meadow species. *Polygonum fowleri*, an estuarine species was observed in one ecosystem unit.

Tidal swamps are uncommon, occurring only in Esquimalt Lagoon and Millstream Creek estuary. The tidal swamps form in depressions that open to estuarine benches, allowing flows of high-tide water. Saline soil-water probably influences the substrate.

Tidal meadows have a high level of exotic plant invasion. These exotics are diverse, with at least 19 species, dominated by *Elymus repens*, *Atriplex patula*, probably *Agrostis stolonifera*, *Phalaris arundinacea*, and *Arrhenatherum elatius*. The collection of these exotics is typical for the region and occur in old-fields and other disturbed sites. Additional exotic annual and perennial grass and forb species occurred with a cover of less than 1% each. Some of these pervasive species include *Bromus* spp. (annual species), *Sonchus arvensis*, *Cirsium vulgare*, *Plantago lanceolata*, *Daucus carota*, *Rumex* spp. (*R. crispus* and *R. acetosella*).

Swards of *Agrostis* spp. were infrequent. Possible species include *Agrostis exarata* and *A. stolonifera*. The presence of invasive, non-native species was not confirmed because of the difficulty in identifying individuals and lack (and similarity) of inflorescences.

Some of the species like *Elymus repens* and *Rosa nutkana* are salt tolerant or opportunistic colonizers that may invade during annual breaks in tide height.

The *Salix* sp. was not identified to species there were no catkins present at the time of survey. At least half of the *Carex* sp. observed was *Carex lyngbyei*, the other half may be *Carex obnupta*, in these latter cases flowers were not present to confirm identification. *Agrostis* sp. and possibly the *Carex* sp. probably occurred in freshwater line.

Tentative associations: Disturbed, Successional, Possible variants or regional site series

Impacts

Few wetlands are undisturbed. Extant patches occur at the edge of human impact. Impacts include:

- Exotic species invasion; leaving exotics species like *Crataegus monogyna*, *Rubus discolor*, and *Elymus repens* to naturalize in Parks
- Petrochemicals in storm water runoff Unprocessed septic effluent (e.g. Hospital Creek estuary) and possibly combined storm-sewer drainage during storm events (e.g. Elfgate estuary)
- Land-filling (everywhere)
- Absent buffer zones and degraded riparian areas
- The soft sediment marshes are sensitive to compaction, even from walking

Some landowners adjacent to parks and green-spaces are possessive over the intertidal area by their land. While the property and resident may limit access to a site, reducing visitor impact, the places often become an extension to backyards. Trails, refuse piles, and vegetation removal and replacement complete the connection between private and public land. Decks, patios, and docks interject into intertidal zone. Reacting to fear of erosion, many fill in estuaries that are degrading, instead of correcting the underlying causes, such as construction, compaction, or defoliation in the intertidal or riparian zone by residents. In extreme cases, this has manifested in livestock erosion, mowing the lawn well into tidal wetlands, and retaining walls in the tidal zone, which extend area of private property.

Protection and restoration of shoreline is problematic for areas that have been filled. Is the zone of tidal influence based on historic extent of shore or on filled land? Who is liable for these actions and were they justified, given the sheltered nature of the shorelines in the study area.

To grapple these issues and conserve estuary and lagoonal systems, especially the tidal meadows and marshes, ecological planning and ecological land-use must be adopted. Some suggested principles include:

- No more loss policy
- Maintain a long-term perspective and accept long-term recovery time; 10 to 100 years.
- Going beyond private beach mentality, shorelines are commons and adjacent properties and land-uses impact these ecosystems negatively
- Sites with a geomorphic form that is still intact are candidates of restoration
- Mitigation and remediation projects should be viewed as gaining poor quality habitat and not interpreted as restoration of high quality habitat

Finally, stronger permitting and commitment to the shoreline as public property is recommended in the form of:

- Coastal riparian area special management zone; a Development Permit Area that holds landowners and developers accountable and liable for interfering with coastal ecosystem functions.
- Invasive species strategy to deal with invasive estuarine plants.
- Protection as the most effective means of restoration
- Apply mitigation in highly disturbed sites, where significant area can be prepared for natural regeneration.

References

Barnes, R. S. K..1980. Coastal Lagoons: The Natural History of a Neglected Habitat. Cambridge University Press. New York, New York.

B.C. Conservation Data Centre. 2005. BC Species and Ecosystems Explorer. B.C. Ministry of Environment. Victoria, BC. Available: http://srmapps.gov.bc.ca/apps/eswp/ (accessed Oct.1, 2005).

Douglas, G.W., G.B. Straley, D.V. Meidinger, and J. Pojar (Eds.). 1998. Illustrated Flora of British Columbia: Volumes 1 to 8. Ministry of Environment, Lands, and Parks and Ministry of Forests, Province of British Columbia. Victoria, British Columbia.

Howes, D. E., M. Morris, and M. Zacharias. 1999. British Columbia Estuary Mapping System, Version 1.0. Coastal Task Force, Resources Inventory Committee, Province of British Columbia. Victoria, British Columbia.

Hunter, R. A., L. E. Jones, M. M. Wayne, and B. A. Pendergast. 1983. Estuarine Habitat Mapping and Classification System Manual, MOE Manual 3. Surveys and Resource Mapping Branch, Ministry of Environment, Province of British Columbia. Victoria, British Columbia.

MacKenzie, W. H. and J. R. Moran. 2004. Wetlands of British Columbia: A Guide to Identification, Land Management Handbook No. 52. Research Branch, Ministry of Forests, Province of British Columbia. Victoria, British Columbia.

Meidinger, D., R. Trowbridge, A. Macadam, and C. Tolkamp (Eds.). 1998. Field Manual for Describing Terrestrial Ecosystems, Land Management Handbook No. 25. Resources Inventory Branch, Ministry of Environment, Lands, and Parks and Research Branch, Ministry of Forests, Province of British Columbia. Victoria, British Columbia.

Pojar, J. D. Meidinger, and K. Klinka. 1991. Chapter 2 Concepts *In:* Ecosystems of British Columbia, Special Report Series No. 6 by D. Meidinger and J. Pojar (Eds.). Research Branch, Ministry of Forests, Province of British Columbia. Victoria, British Columbia.

Warner, B. G. and C. D. A. Rubec (Eds.). 1998. The Canadian Wetland Classification System, Second Edition. National Wetlands Working Group, Wetlands Research Centre, University of Waterloo. Waterloo, Ontario. Accessed on ---- at http://www.uwwrc.net/web/wetlandsrc/cat/books/books-1053313151236

Appendix 1: Botanical and Common Names

Species Name	Common Name
Acer	maple
Achillea millefolium	Yarrow
Agrostis	Bentgrass
Aira praecox	
Allium cernuum	nodding onion
Alnus rubra	red alder
Ambrosia chamissonis	silver burweed
Amelanchier alnifolia	Saskatoon or service berry
Anaphalis margaritacea	pearly everlasting
Anthemis	chamomile
Anthoxanthum odoratum	sweet vernal grass
	bur chervil
Arbutus menziesii	arbutus
Arrhenatherum elatius	false oat grass
Asparagus officinalis	garden asparagus
Aster subspicatus	Douglas' aster
Atriplex patula	Orache
Bromus sp.	Brome grass
Bromus hordeaceus	soft brome
Bromus sterilis	barren brome
Cakile edentula	Northern sea rocket
Carex sp.	sedge
Carex lyngbyei	Lyngbye's sedge
Carex macrocephala	dune sedge
Carex obnupta	slough sedge
Chenopodium	lamb's quarters
Cichorium intybus	chicory
Cirsium	thistle
Convolulus sepium	wild morning-glory
Conioselinum gmelinii	Pacific hemlock-parsley
Cornus stolonifera	red osier dogwood
Crataegus douglasii	black hawthorn
Crataegus monogyna	English hawthorn
Crataegus spp.	hawthorn species
Cuscuta salina	salt marsh dodder
Cynosurus echinatus	hedge hog dogtail
Cytisus scoparius	Scot's broom
Dactylis glomerata	orchard grass
Daphne laureola	laurel leaved Daphne
Daucus carota	Wild carot
Deschampsia cespitosa	
Distichlis spicata	seashore saltgrass
Eleocharis palustris	creeping spike-rush
Elymus repens	quackgrass
Equisetum	Horsetail
Festuca sp.	fescue
Festuca rubra	red fescue
Glaux maritima	
Grindelia integrifolia	entire leaved gumweed
Gualtheria shallon	salal
Hedera helix	English ivy
Holodiscus discolor	ocean spray
Holcus lanatus	Yorkshire fog
Hordeum	
Hordeum brachyanthum	
Hypochaeris radicata	hairy cat's ear
Ilex aquifolium	English holly
Iris psuedo	yellow iris
Juncus sp.	rush
Juncus arcticus	Arctic rush
Lathyrus japonica	beach pea
Leymus mollis	dunegrass
Lolium	perennial rye grass
Lomatium nudicaule	yampah
Lonicera ciliosa	orange trumpet honeysuckle
Lonicera involucrata	black twinberry
Lotus	
Lupinus bicolor	two coloured lupin
	skunk cabbage
Mahonia aquifolium	tall Oregon grape
Maianthemum dilatatum	false lily of the valley
Malus pumila	domestic apple
Malus fusca	Pacific crab apple
Malva parviflora	cheeseweed mallow
Melilotus alba	white
Mentha sp.	mint
Oemleria cerasiformis	Indian plum
Oenanth sarmentosa	Pacific water-parsley
Orobanche californica	California broom rape
Phalaris arundinacea	reed canary grass
Plantago lanceolata	Lance leaved plantain
Plantago macrocarpa	
Plantago maritima	Seaside plantain
Poa pratensis	Kentucky blue grass
Polygonum sp.	knotweed
Polygonum fowleri	Fowler's knotweed
Polypodium glycyrrhiza	licorice fern
Polystichum munitum	sword fern
Populus tremuloides	trembling aspen
Potentilla egidii	
Prunus sp.	cherry
Psuedotsuga menziesii	Douglas-fir
Pteridium aquilinum	bracken fern
Quercus garyana	Gary oak
Ranunculus sp.	buttercup
Rosa eglanteria	Sweetbrier
Rosa nutkana	Nootka rose
Rosa sp.	Rose species
Rubus discolor	Himalayan blackberry
Rubus ursinus	trailing blackberry
Rumex acetosella	sheep sorrel
Rumex crispus	curley dock

Ruppia maritima	widgeon grass
Salix sp.	willow
Salicornia virginica	pickleweed or glasswort
Sambucus racemosa	elderberry
Schoenoplectus americanus	Olney's bulrush
Sedum lanceolatum	lance-leaved stonecrop
Sedum spathulifolium	broad-leaved stonecrop
Sedum album	white stonecrop
Sisymbrium officinale	hedge mustard
Solanum dulcamara	European bittersweet
Solidago canadensis	Canada goldenrod
Sonchus sp.	milk thistle
Sorbus sp.	mountain ash
Spergularia canadensis	Canadian sand spurry
Spergularia rubra	
Symphoricarpos albus	Snowberry
Triglochin maritima	Seaside arrow grass
Typha latifolia	common cattail
Veronica sp.	speedwell
Vinca major	large periwinkle
Vulpia sp.	

Appendix 2: Field Forms

Site Name ______________________ **Location** ______________________
Field workers ______________________________________ Date ____________
Weather ______________________ **Time In** ________ **Time out** ________
GPS Filename ______________________
Disturbances ____
____
____
Wildlife ____
____
____
Notes ____
____
____

Map Unit (repeat for every polygon or unit mapped at site)

Shape type[1] (point, line, area)__________ Notes:
Unit type ____________________
Ecosystem class[2] ______________
Map label ____________________
Community Dominants[3] ______________________________________

Species Composition[4]

Name / Cover (%)/ Pattern	Name / Cover / Pattern	Name / Cover / Pattern

Substrate[5] ____

Additional information

---

[1] For points specify area of feature; for lines specify average width. Line thickness should be noted with diagrams and measurements at several points.
[2] Ecosystem class: Shrub, Dune, Tidal meadow, Tidal marsh, Tidal flat, Rock outcrop, etc. If it is a satellite unit specify what ecosystem class it occurs in.
[3] Name up to three of the most abundant species from most to least.
[4] Visually estimate species occurring in unit. Use code of scientific name. Take specimen for unrecognized organisms and use Unid# until identity is confirmed. See Appendix 4 for cover and distribution types.
[5] Specify types in order of most to least abundant. Surface substrate types include Mineral soil (specify texture), Organic matter (specify fabric), Decaying wood, Bedrock, Stones/cobbles, Water, Other (specify) -- see Appendix 5.

Map Unit

Shape type (point, line, area)__________ Notes:

Unit type ______________________

Ecosystem class ________________

Map label ______________________

Community Dominants ____

Species Composition

Name / Cover (%)/ Pattern	Name / Cover / Pattern	Name / Cover / Pattern

Substrate *(in order of most to least abundant)*

____

____

Additional information

Map Unit

Shape type (point, line, area)__________ Notes: __________

Unit type ______________________

Ecosystem class ________________

Map label ______________________

Community Dominants ____

Species Composition

Name / Cover (%)/ Pattern	Name / Cover / Pattern	Name / Cover / Pattern

Substrate *(in order of most to least abundant)*

____

____

Additional information

Appendix 3: Geomorphic Terms

TABLE 2.5. Surficial (genetic) material codes

Code	Name	(Assumed status)	Description
A	Anthropogenic	(A)	Artificial or human-modified material
C	Colluvium	(A)	Products of mass wastage
D	Weathered bedrock	(A)	*In situ*, decomposed bedrock
E	Eolian	(I)	Materials deposited by wind action
F	Fluvial	(I)	River deposits
FG	Glaciofluvial	(I)	Ice contact fluvial material
I	Ice	(A)	Permanent snow, glaciers, and icefields
L	Lacustrine	(I)	Lake sediments; includes wave deposits
LG	Glaciolacustrine	(I)	Ice contact lacustrine material
M	Morainal	(I)	Material deposited directly by glaciers
O	Organic	(A)	Accumulation/decay of vegetative matter
R	Bedrock	(-)	Outcrops/rocks covered by less than 10 cm of soil
U	Undifferentiated	(-)	Layered sequence; three materials or more
V	Volcanic	(I)	Unconsolidated pyroclastic sediments
W	Marine	(I)	Marine sediments; includes wave deposits
WG	Glaciomarine	(I)	Ice contact marine sediments

TABLE 2.7. Geomorphological process codes

Code	Name	(Assumed status)	Description
A	Avalanches	(A)	Terrain modified by snow avalanches
B	Braiding	(A)	Diverging/converging channels; unvegetated bars
C	Cryoturbation	(A)	Materials modified by frost heaving and churning
D	Deflation	(A)	Removal of sand and silt by wind action
E	Channeled	(I)	Channel formation by meltwater
F	Slow mass	(A)	Slow downslope movement of masses of cohesive or non-cohesive material
H	Kettle	(I)	Depressions in surficial material resulting from the melting of buried or partially buried glacier ice
I	Irregular channel	(A)	A single, clearly defined main channel displaying irregular turns and bends
J	Anastomosing channel	(A)	A channel zone where channels diverge and converge around many vegetated islands
K	Karst	(A)	Processes associated with the solution of carbonates
L	Surface seepage	(A)	Zones of active seepage often found along the base of slope positions
M	Meandering channels	(A)	Channels characterized by a regular pattern of bends with uniformed amplitude and wave length
N	Nivation	(A)	Erosion beneath and along the margin of snow patches
P	Piping	(A)	Subterranean erosion by flowing water
R	Rapid mass movement	(A)	Rapid downslope movement of dry, moist, or saturated debris
S	Solifluction	(A)	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate
U	Inundation	(A)	Seasonally under water because of high water table
V	Gully erosion	(A)	Parallel/subparallel ravines caused by running water
W	Washing	(A)	Modification by wave action
X	Permafrost	(A)	Processes controlled by the presence of permafrost
Z	Periglacial processes	(A)	Solifluction, cryoturbation, and nivation processes occurring within a single unit

TABLE 2.6. Surface expression codes

Code	Name	Description
a	Moderate slope	Unidirectional surface; > 15° to < 26°
b	Blanket	A mantle of unconsolidated materials; > 1 m thick
c	Cone(s)	A cone or segment of a cone; > 15°
d	Depression(s)	A lower area surrounded by a higher terrain
f	Fan(s)	A segment of a cone; up to 15°
h	Hummock(s)	Hillocks and hollows, irregular in plan; 15–35°
j	Gentle slope	Unidirectional surface; > 3° and ≤ 15°
k	Moderately steep slope	Unidirectional surface; > 26° and < 35
m	Rolling	Elongate hillocks; 3–15°; parallel forms in plan view
p	Plain	Unidirectional surface; up to 3°
r	Ridge(s)	Elongate hillocks; 15–35°; parallel forms in plan view
s	Steep slope	Steep slopes; > 35°
t	Terrace(s)	Step-like topography
u	Undulating	Hillocks and hollows; up to < 15°; irregular in plan view
v	Veneer	Mantle of unconsolidated material; 0.1 to 1.0 m thick
w	Mantle of variable thickness	A layer or discontinuous layer of surficial materials of variable thickness that fills or partially fills depressions in an irregular substrate. The thickness ranges from 0 to 3 m.
x	Thin veneer	A dominance of very thin surficial materials about 2–20 cm thick

Appendix 4: Vegetation cover and distribution

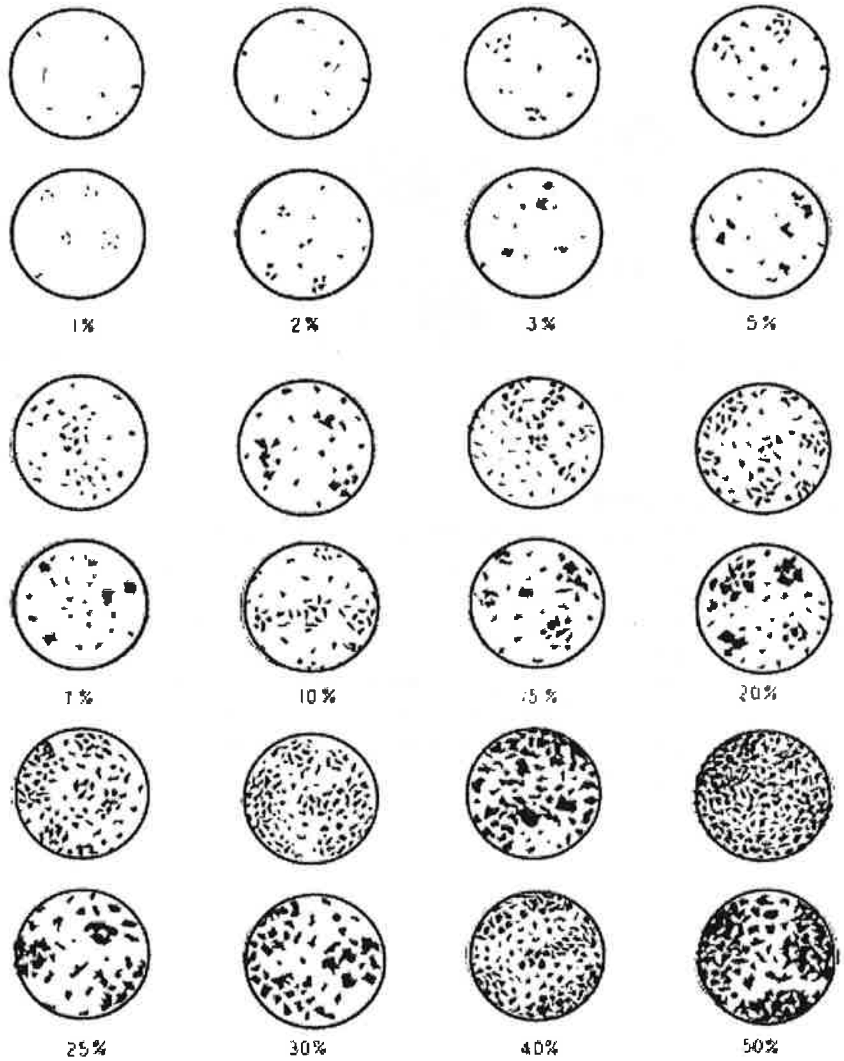


FIGURE 3.2. Comparison charts for visual estimation of foliage cover.

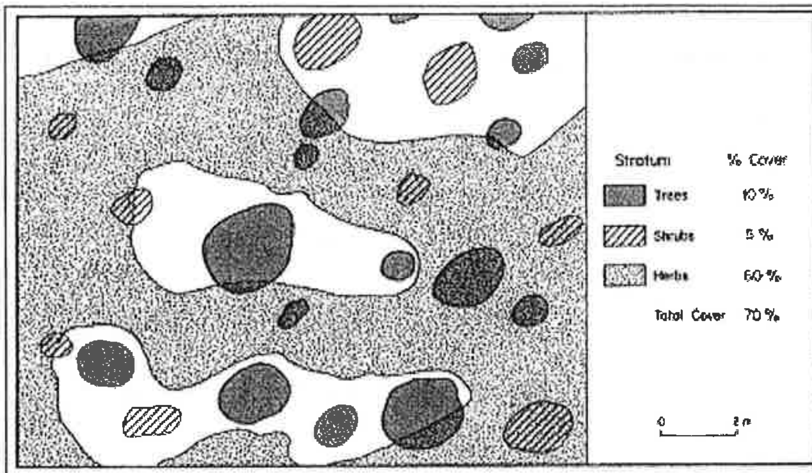


FIGURE 3.3. An example of percent coverages in a plot, viewed from above.

Distribution Categories

Code	Distribution	Description
R	Rare	rare abundance, limited to a few individuals
E	Erratic	sparse abundance, too few individuals to make discrete patches
C	Clump	One patch of species within site with sparse to mod abundance.
P	Patchy	More than one clump, low to dense abundance.
G	Gappy	Widespread but with gaps.
W	continuous	Widespread occurrence of species, could have low to dense abundance.

Appendix 5: Substrate types and descriptions

Code	Name	Size (mm)	Description
Bedrock:			
BR	bedrock	n/a	exposed solid rock
Clastic:		*see range below*	*materials made up of fragments of rock*
BL	blocks	>256	angular particles
BO	boulders	>256	rounded and subrounded particles
CO	cobble	64-256	rounded and subrounded particles
PE	pebbles	4-64	rounded and subrounded particles
GN	granules	2-4	
SA	Sand	0.062-2.000	
SI	Silt	0.002-0.062	
CL	Clay	< 0.002	
MF	Mixed fragments	>2	mix of rounded and angular particles
GV	gravel	>2	mix of boulders, cobbles, and pebbles
AG	angular	>2	mix of blocks and rubble
RU	rubble	2-256	angular particles
MU	Mud	< 0.062	fines; a mix of clay and silt
Biogenic:		*range, see below*	*materials originating directly from organisms, excluding humans*
SH	Shells	range	shells or shell fragments
FI	Fibric		well-preserved fibre; (40%) identified after rubbing; includes plant litter
ME	Mesic		intermediate composition between fibric and humic
HU	Humic	<1	decomposed organic material; (10%) identified after rubbing
OR	organic soil		mix of humic, mesic, and fibric materials
LW	large woody debris	< 75 (diameter)	
SW	small woody debris	> 75	less than 75 mm in diameter, length greater than 75 mm
Anthropogenic:		*variable*	*materials arising from human activities*
AGV	gravel		
ARR	Riprap		
ACR	concrete/cement rubble		

Appendix 6: Map Folio

November 23, 2005 - Technologist: SR - Map Document: Est_Fringe_Gorge_Waters.mxd

CRD CAPITAL REGIONAL DISTRICT
Environmental Services

ESTUARY AND FRINGE MARSH

GORGE WATERS

DRAFT

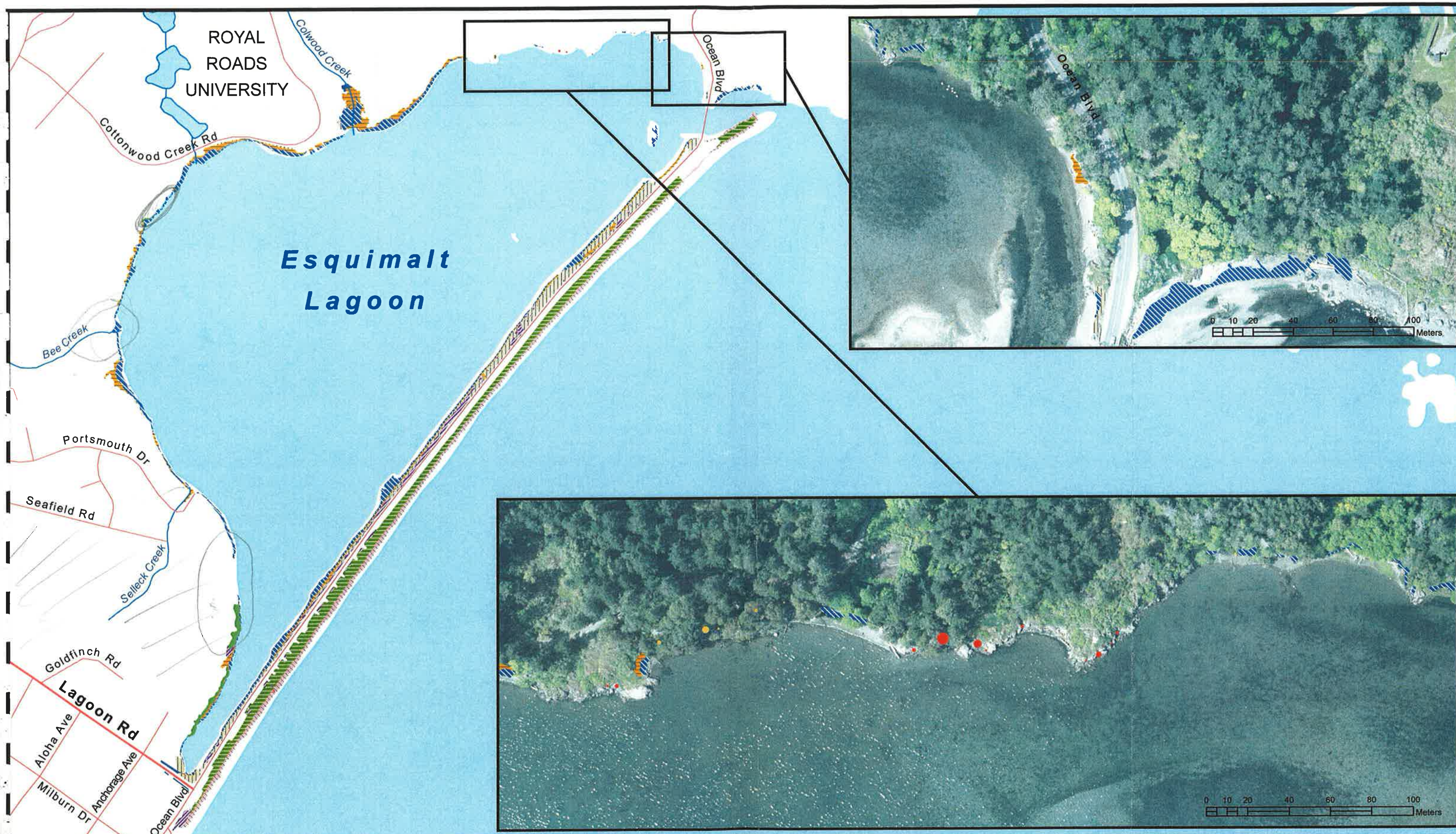
0 100 200 300 400 Meters

Projection: Universal Transverse Mercator - Zone 10 North
North American Datum 1983

Ecosystem Class

- Meadow
- Shrub
- Tidal flat
- Tidal marsh
- Tidal meadow
- Unknown

N



November 22, 2005 - Technologist: SR - Map Document: Est_Fringe_Esq_Lagoon.mxd

CRD CAPITAL REGIONAL DISTRICT
Environmental Services

ESTUARY AND FRINGE MARSH

ESQUIMALT LAGOON

DRAFT

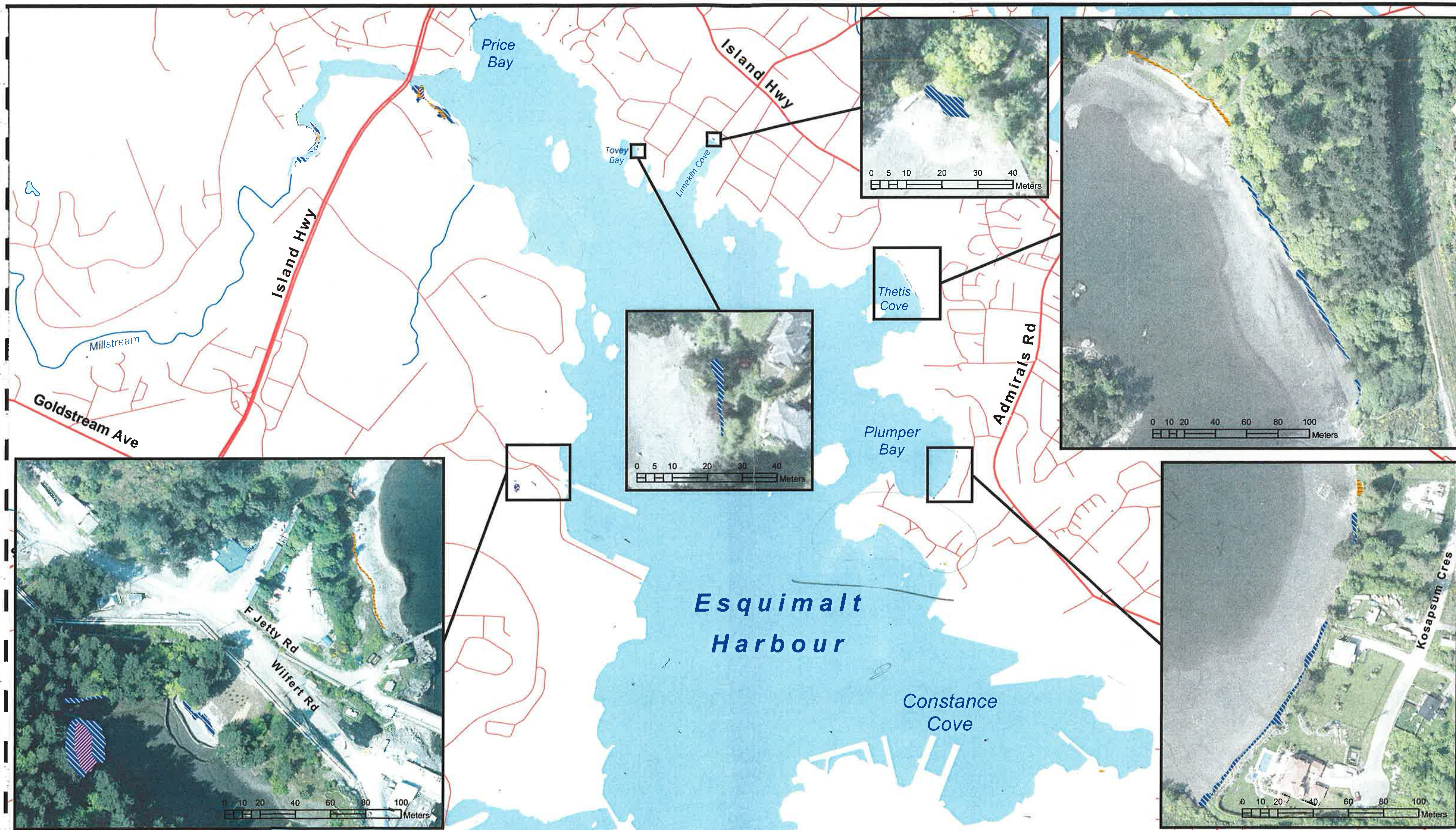
0 50 100 150 200 Meters

Projection: Universal Transverse Mercator - Zone 10 North
North American Datum 1983

Ecosystem Class

- Beach face
- Beach ridge
- Dune
- Marsh
- Meadow
- Shrub
- Tidal flat
- Tidal marsh
- Tidal meadow
- Tidal outcrop
- Tidal swamp
- Unknown

N



November 23, 2005 - Technologist: SR - Map Document: Est_Fringe_Esq_Harbour.mxd

CRD CAPITAL REGIONAL DISTRICT
Environmental Services

ESTUARY AND FRINGE MARSH

ESQUIMALT HARBOUR

DRAFT

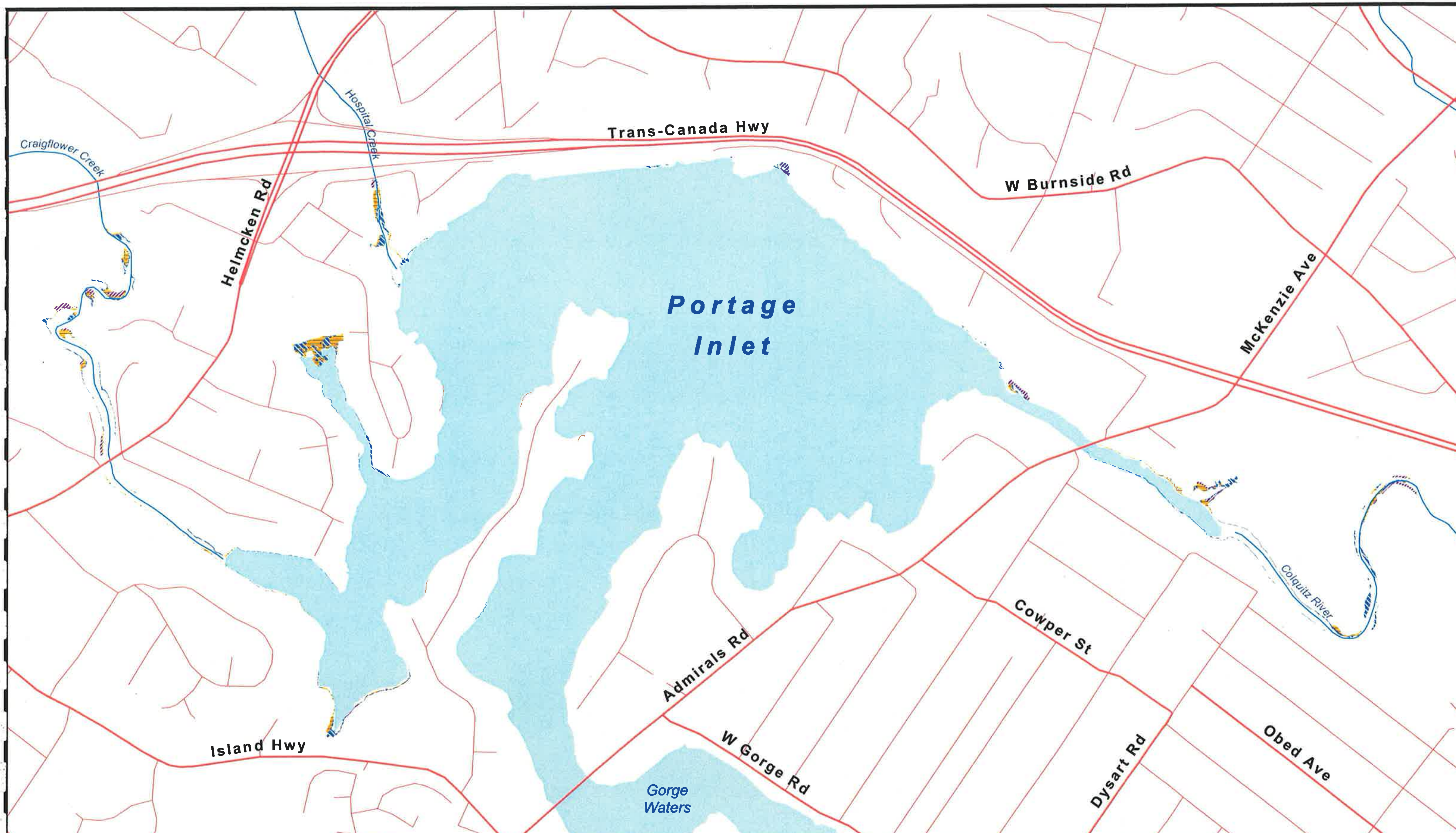
0 100 200 300 400 500 Meters

Projection: Universal Transverse Mercator - Zone 10 North
North American Datum 1983

Ecosystem Class

- Beach ridge
- Cliff
- Dune
- Marsh
- Meadow
- Shrub
- Tidal marsh
- Tidal meadow
- Tidal outcrop
- Tidal swamp
- Unknown

N



November 23, 2005 - Technologist: SR - Map Document: Est_Fringe_Portage_Inlet.mxd

CRD CAPITAL REGIONAL DISTRICT
Environmental Services

ESTUARY AND FRINGE MARSH

PORTAGE INLET

DRAFT

0 50 100 150 200 Meters

Projection: Universal Transverse Mercator - Zone 10 North
North American Datum 1983

Ecosystem Class

- Channel
- Meadow
- Salt pan
- Shrub
- Tidal marsh
- Tidal meadow
- Tidal outcrop
- Unknown
- Woodland

N