City of Campbell River
Marine Foreshore Habitat Assessment and Restoration Plan

FINAL REPORT

Prepared by:

Northwest Hydraulic Consultants Ltd.
Current Environmental
Murdoch de Greeff Inc.

December, 2011

CITY OF CAMPBELL RIVER
MARINE FORESHORE HABITAT ASSESSMENT AND RESTORATION PLAN
FINAL REPORT

Prepared for:

City of Campbell River
301 St. Ann's Road
Campbell River, BC V9W 4C7

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December 4, 2011

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nhc
northwest hydraulic consultants

December 4, 2011

City of Campbell River
Supply Management Department
2nd Floor – 301 St. Ann's Road
Campbell River, BC V9W 4C7

Attention: Terri Martin, Environmental Coordinator

Dear Ms Martin,

Northwest Hydraulic Consultants, in association with Current Environmental Services and Murdoch de Greeff Inc., is proud to present the attached report entitled *City of Campbell River Marine Foreshore Habitat Assessment and Restoration Plan.*

We understand that City Council voted on 18 October 2011 to approve and endorse this assessment and plan and we are pleased to provide you with this final document.

It has been a pleasure working with you and the rest of the City team. Please do not hesitate to contact the undersigned at your convenience.

Regards,

northwest hydraulic consultants

David G McLean

Derek Ray, P.Geo
Fluvial Geomorphologist – Associate

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Principal

EXECUTIVE SUMMARY

Northwest Hydraulic Consultants Ltd. (NHC), in association with Current Environmental Services (Current) and Murdoch de Greeff Inc. (MDI) have been retained by the City of Campbell River (CoCR) to complete a *Marine Foreshore Habitat Assessment* and prepare a *Restoration Plan* for the portion of the shoreline extending from Orange Point Road in the north to Ocean Grove Road at the south end of the study area. This project will provide the City with a comprehensive approach to shoreline management that incorporates a real understanding and sensitivity to natural processes and ecosystems. From this approach a set of tools will be developed that will assist the City to develop a proactive, pragmatic model of foreshore management that incorporates Green Shores methodology. These tools will include:

1. A detailed investigation describing the physical system of the shoreline;
2. A detailed marine shore habitat assessment;
3. A set of restoration planning and design guidelines; and
4. A prioritised action plan and budget.

The approach taken by the team treated the physical, biological, and human aspects of the study as integral components of the shoreline system. The level of investigation varied and depended on the priority of the site. City-owned properties, including parks, were investigated in more detail while the study area as a whole was investigated at an overview-level, relying primarily on existing reports, airphotos, maps, and interview with selected agencies. The linear extents of the study area are outlined above. The lateral extents include the intertidal zone shoreward to the backshore zone.

The study area was divided into distinct reaches for the purposes of directing the analysis and tying into the development guidelines. A brief description of the seven physical reaches is outlined in the table below and shown on Map 2. These reaches were used in both the Physical and Ecological Existing Conditions Assessments.

Reach No.	Geomorphic Reach Name	Description
1	Southern Beaches	From Ocean Grove Road north to Ken Forde Boat Ramp
2	Willow Point	From the south side of Willow Point (Ken Forde Boat Ramp) to the north side of Willow Point near Frank James Park
3	Middle Beaches	From Frank James Park north to Hidden Harbour Park South
4	Southern Bluffs	From Hidden Harbour Park South to the Maritime Heritage Center
5	Industrial	From the Maritime Heritage Center to north of the Discovery Harbour Marina
6	Estuary	From the north side of the Discovery Harbour Marina to the intertidal bar
7	Northern Bluffs	From the intertidal bar north to the rock outcrop at the end of Orange Point Road

Twelve Management Reaches were also defined for inclusion in the Development Guidelines. These reaches are summarised in the table below and shown on **Map 2**.

Management Reach No.	Management Reach Extents
1	Ocean Grove Road to Oregon Road
2	Oregon Road to Ken Forde Boat Ramp
3	Ken Forde Boat Ramp to Adams Road
4	Adams Road to Frank James Park
5	Frank James Park to Big Rock Park North
6	Big Rock Park North to Rotary Beach Park North
7	Rotary Beach Park North to Pinecrest Road
8	Pinecrest Road to Maritime Heritage Centre
9	Maritime Heritage Centre to Industrial Shipping Terminal
10	Industrial Shipping Terminal to Tyee Spit (north)
11	Tyee Spit (north) to McDonald Road
12	McDonald Road to Orange Point Road

The results of the Physical Existing Conditions Assessment show that the shoreline within the study area has been heavily modified by human development, which has had a profound effect on the natural geomorphic processes. Installation of rip rap and seawalls to protect against erosion, and the construction of various groynes, piers and breakwaters are the primary impacts on the supply of sediment as well as the way it is transported and deposited along the beach. Bank armouring creates a steeper beach front that reflects more wave energy than a gentler, natural beach slope, which tends to dissipate the wave. The result is that sediment is pushed seaward and the beach becomes lower and coarser. Groynes and jetties interrupt the longshore transport, starving the down-drift sections.

In addition to the existing physical conditions, ongoing physical processes affecting the Campbell River shoreline were investigated and are included in more detail in **Appendix A**. These processes include tides, wind-generated waves, and the effects of future sea level rise. The southern portion of the study area is exposed to the largest waves coming from the southeast and the area immediately south of Willow Point is exposed to the largest waves. The northern portion of the study area is largely protected from the southeast waves but is exposed to occasional storms from the northwest, which generate smaller waves but appear to result in significant erosion along selected sections of shore. The BC Ministry of Environment has published guidelines for coastal flood hazard management (BC MOE, 2011) which adopt a median estimate of 0.8 m sea level rise by 2100 and a "high" estimate of 1.2 m. The BC MOE (2011) report incorporates these sea level rise projections into new guidelines that are intended to replace the existing land use management guidelines that were introduced in 2004. The guidelines will pose a considerable planning challenge to the City while the potential sea level rise will undoubtedly result in an acceleration of shoreline damage and erosion with the possibility of serious flooding.

The Ecological Existing Conditions Assessment focuses on four key habitat types: 1) Forage Fish Habitat; 2) Backshore Habitat; 3) Juvenile Salmonid Rearing Habitat and Estuaries; and 4) Low Intertidal and Shallow Subtidal Vegetation Communities. Each reach within the study area was assessed based on the quality of these four key habitat types. Habitat condition for most ecological reaches was ranked as 'poor' or 'non-existent' with some key habitats ranked as high as 'poor to moderate'. The exception is in the estuary reach, which received a ranking of 'moderate to good' for juvenile salmonid and estuary habitat and either 'poor to moderate' or 'moderate' for the other habitat types. The only reach that received a 'good' ranking was the Northern Bluffs reach, which received a 'good' ranking for low intertidal to subtidal vegetation. Opportunities for restoration of shoreline function are presented in the summary section of the assessment.

Development guidelines rationale is proposed for the Campbell River shoreline that consider the following values:

- Recreation and Leisure Activities
- Public Access
- Beach Views and Coastal Aesthetics
- Shoreline Properties
- Tourism Potential
- Commercial Potential
- Ecological Values
- Shoreline aesthetic
- Archaeological Values
- Option and Bequest Values

These values were used to assess the shoreline within each of the management reaches using a SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis. Based on the SWOT analysis, a set of ten development principles are presented that would address the Weaknesses and Threats while preserving the Strengths and capitalising on the Opportunities. Sample language that could be used to convert these principles into a regulations document, such as the SOCP, is included as an appendix.

The Action Plan focuses on the following components, which are also shown on **Map 5**:

- Priority Sites for Shoreline Protection
- Priority Sites for Habitat Restoration
- Priority Sites for Beach Nourishment
- Shoreline Protection Options
- Shoreline Vegetation Maintenance Plan

- Boat Launch Maintenance Plan

This plan provides the basis from which the City can adopt a proactive approach to shoreline management. It is dependent on the City coming to an agreement with the relevant government agencies that recognises that the long-term value of the plan will outweigh the short-term negative impacts of sediment management. A cornerstone of the plan is the Rapid Biological Assessment, which provides assurance that sediment management and shoreline protection activities will not impact on recent forage fish spawning – a relatively poorly understood ecological function.

The list of priority sites for shoreline protection will need to be updated on an ongoing basis as conditions change and protection projects are completed. The effects of beach nourishment should be monitored as per the recommendations to determine the locations where placing sediment will have the most benefit. Although this plan has been developed with parks and City-owned lands in mind, it is possible to apply the same principles to privately-owned lands but would require some effort towards educating the public.

One of the most potentially controversial aspects of the plan will be the future management of the boat launches. In particular, we have recommended a seasonal or permanent closure of the Ken Forde boat launch with a consideration towards a seasonal closure of the Big Rock boat launch. A better alternative location for the Ken Forde launch is Adams Park, which is currently under-developed as a park and would provide a less exposed site. Political and budgetary considerations will most likely play a large role in the ultimate decision.

CREDITS AND ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to the City of Campbell River for providing them with the opportunity to participate in this fascinating investigation of the physical processes, ecology, and human development of the Campbell River shoreline. In particular we would like to thank the members of the Project Review Committee for providing contract oversight and critical review. The committee members representing the City of Campbell River include:

- Terri Martin, Environmental Coordinator, Sustainability Department
- Ross Milinthorp, General Manager, Parks, Recreation & Culture
- Grant Parker, Parks Supervisor, Parks, Recreation & Culture
- Jennifer Peters, Utility Manager
- Nina Baksh, Senior GIS Analyst
- Neil Borecky, Senior GIS Analyst
- Trina Soltys, Clerk Technician
- Members of the following Council Committees: Development,Community and Environment

In addition, we would like to acknowledge the efforts of Neil Borecky in providing GIS support to the project by collecting and collating the Shorezone data for mapping. Additional project support from the City of Campbell River was provided by:

- Julie Douglas, Communications Advisor
- Ian Buck, Planner
- Bronwyn Sawyer, Planning Technician
- Amber Zirnhelt, Sustainability Manager
- Ross Blackwell, Land Use Manager
- Lynn Wark, Parks Project Supervisor

The authors also wish to extend their gratitude to the following persons who provided invaluable input through informal interviews, technical advice, and methodology review:

- Cynthia Durance, Precision Identification Consultants, Vancouver, BC
- Patrick Harrison, JPH Consultants, Nanaimo, BC
- Shannon Anderson, Biologist, Fisheries and Oceans Canada
- Barry Peters, Community Advisor, Fisheries and Oceans Canada
- Steven Colwell, Biologist, Marine and Foreshore Oceans, Fisheries and Oceans Canada
- Chuck DeSorcy, Willow Creek Watershed Society
- Tom Easton, Simms Creek Stewardship Society
- Gord McLaughlin, Local resident

Special mention goes to Ramona de Graaf, Biologist with Emerald Sea Biological for her invaluable input into the investigations of forage fish habitat within the study area.

General review was provided by members of the Senior Advisory Committee at the City of Campbell River.

The project team consisted of the following firms and professionals:

Northwest Hydraulic Consultants:

- Derek Ray, P.Geo. – Geomorphologist – Project Manager
- Dr. David McLean, P.Eng. – Coastal Analysis – Senior Technical Review
- Sarah North, GISP – GIS Specialist
- Daniel Arnold, EIT – Project Engineer

Current Environmental:

- Warren Fleenor, R.P.Bio – Marine and Terrestrial Biology
- Rupert Wong, R.P.Bio – Biological Review:

Murdoch de Greeff:

- Paul de Greeff, RLA – Development Design Guidelines

Raincoast Applied Ecology:

- Nick Page, R.P.Bio. – Backshore Habitat Management

Funding for this effort was provided by the Gas Tax Fund, a tripartite agreement between the Province of British Columbia, the Union of British Columbia Municipalities, and the Government of Canada.

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1 INTRODUCTION

Northwest Hydraulic Consultants Ltd. (NHC), in association with Current Environmental Services (Current) and Murdoch de Greeff Inc. (MDI) have been retained by the City of Campbell River (CoCR) to complete a *Marine Foreshore Habitat Assessment* and prepare a *Restoration Plan* for the portion of the shoreline extending from Orange Point Road in the north to Ocean Grove Road at the south end of the study area. This project will provide the City with a comprehensive approach to shoreline management that incorporates a real understanding and sensitivity to natural processes and ecosystems. From this approach a set of tools will be developed that will assist the City to develop a proactive, pragmatic model of foreshore management that incorporates Green Shores methodology. These tools will include:

5. A detailed investigation describing the physical system of the shoreline;
6. A detailed marine shore habitat assessment;
7. A set of restoration planning and design guidelines; and
8. A prioritised action plan and budget.

The study area includes over 16 km of shoreline, and encompasses a variety of physical settings, habitat types and land uses. Given the large scale of this investigation – both geographically as well as in terms of focus – it is not possible to provide a high level of detail in all areas of the foreshore. Instead we have adopted a variable scale of investigation with an emphasis on City-owned lands. We have relied on existing information and avoided the collection of field data except in those areas where the City can implement the action plan directly.

1.1 RATIONALE

The marine shoreline represents one of the most valued and heavily populated environments on the globe. Hundreds of cities are located on the coast; partly for the advantages this location provides with respect to international trade and the movement of commercial products, and partly because people tend to be drawn to the beauty and recreational opportunities that shorelines provide. Coastal regions typically have moderated climates, provide ready access to seafood, are frequently proximal to agricultural lowlands, and offer a range of recreational amenities. The marine shoreline is a truly valued natural resource. However, as is often the case with valuable natural resources, tremendous pressure has been placed on coastal regions with increasing populations and development. With the constant growth of coastal settlements, there is an increasing need for active and thoughtful management of shoreline environments to retain and balance values in the face of intensifying use.

The Campbell River area has experienced consistent growth over the last century. Campbell River was first settled by Salish-speaking peoples, and then came under control of the Lekwiltok people (originally from the Johnstone Straight area) by the mid-1800's. These First Nations groups settled the area to take advantage of this strategic hunting, fishing and trading location. The latter half of the 19th century saw logging camps starting to establish in the area. Shortly thereafter, settlers established farms and recreational fishermen, lured by the tales of excellent trout and salmon fishing in the surrounding creeks streams and straits, began to populate what is now the City of Campbell River. More diversified industry growth (ie: tourism, pulp and paper, commercial fishing, etc) in ensuing years saw Campbell River evolve into a significant Vancouver Island town (adapted from Museum at Campbell River website, 2008).

Proximity to abundant food and natural resources, access to the ocean, and the beauty of the location clearly underpin the value of Campbell River as a settlement location. But, as is characteristic of other coastal locations, settlement of Campbell River has also placed a tremendous amount of pressure on the marine shoreline - people want to live, recreate, and build close to the shoreline to take advantage of the values it offers.

> *Natural resource*: 'Actual and potential forms of wealth [value] supplied by nature' (Dictionary of Business Terms, 2000).

With increasing pressure on the Campbell River shoreline, and a growing need for informed management, there are a set of questions that ought to be explored:

- What is the current condition of the marine shoreline in Campbell River? Is it degraded with respect to certain values, or is it healthy and stable? Does the condition vary from location to location?
- Is it possible that some shoreline values are being exploited to the detriment of other values in some locations?
- What can be done, if anything, to preserve or restore shoreline values?

These are some of the questions that this report will attempt to address. As a start, clarification of the values that the marine shoreline offers will be presented as the basis for further discussion.

1.2 METHODOLOGY – PHYSICAL ASSESSMENT

The physical assessment of the shoreline employed three main investigative techniques:

1. Analysis and review of existing reports;
2. Geomorphic interpretation of landforms; and
3. Numerical analysis and computation.

Due to the limitations imposed by the available budget, the project scope of work was not able to accommodate a significant field investigation component. Instead, the study relied on focused field investigations for the high priority areas within City-owned lands. Other areas were treated to an overview-level assessment, which is in keeping with the variable scale of investigation that was initially proposed. The following is a summary of tasks that were completed as part of the physical assessment.

- Review of previous reports and studies investigating various aspects of the physical conditions within the study area;
- Review of comments and photos provided by City staff and residents of Campbell River;
- Examination of aerial and ortho-photographs for the purposes of interpreting the processes shaping the coastline at Campbell River;
- Analysis of available wind and wave data with computation of the expected wave conditions at specific locations within the study area;
- Overview-level field investigations to verify the interpretation of coastal processes made from aerial photos;
- Overflight of the study area using a fixed-wing aircraft at low altitude;
- Detailed field investigations at selected sites to characterise the processes governing shoreline erosion; and
- Collection of limited topographic data at selected sites using RTK GPS to confirm the elevation of projected coastal flood levels.

Field visits took place on 30 November 2010 and on 17 and 18 January 2011. Very low tides typically occur at night during the winter months so the majority of the field investigations occurred at medium to higher tide levels.

An exhaustive search of available airphotos was outside the scope of this investigation. Rather, airphotos from the City of Campbell River files were reviewed. These include photos from the early 1980s, the mid-1990s and orthophotos from 2005 and 2007.

1.3 METHODOLOGY – BIOLOGICAL ASSESSMENT

Methods employed to complete the biological assessment for this study include a mix of overview-level office-based work, and direct field observations. Office-based inventory work was completed to identify and assimilate relevant, existing information and to help set the scope and direction for project field work. Office-based tasks completed include the following:

1. Informational Interviews. Informational interviews were conducted with various government agency staff, non-governmental organisations (NGOs), and environmental professionals to benefit from local and specialist knowledge about environmental resource issues and to solicit feedback on community objectives specific to the marine shoreline. **Table 1**provides a summary of the various Interviews that were conducted.

Table 1. Summary of groups and people that were interviewed as part of the biological assessment.

Government Agency	NGO	Environmental Professionals
City of Campbell River staff[1] Fisheries and Oceans Canada staff[2]	Local Streamkeeper Groups[3]	R. C. de Graaf of Emerald Sea Research and Consulting provided a great deal of information on forage fish habitat and survey techniques Cynthia Durance (eelgrass specialist) provided spatial information on known locations of eelgrass beds in the Campbell River estuary

2. Review of Online and Digital Information. The following resources were consulted prior to field work to identify known Valued Ecosystem Components (VEC's) and to direct field assessment activities:
   a. Species at Risk. Known and potential occurrences of Species at Risk were identified using the BC Conservation Data Center (CDC) Species and Ecosystem Explorer[4] and the SARA and COSEWIC (Committee on the Status on Endangered Wildlife in Canada) online databases;
   b. GIS Data. GIS-based informational sources specific to shoreline-dependant wildlife and vegetation were queried using the GeoBC Geographic Data Discovery Service[5]. This information included information from the Coastal Resource Information Management System (CRIMS) and the Shorezone dataset. Relevant data that was received from these sources include known locations with infrequent information on relative importance and abundance. Specific datasets reviewed include: known bird colonies; distribution of Black Oystercatcher, Cormorant, Gull, Great Blue Heron, unspecified pelagic and shore birds; clam beds; recreational and commercial crab fisheries; distribution of eelgrass and kelp; herring spawning sites; and Sensitive Ecosystem Inventory (SEI) polygons.
   c. Additional GIS files held by the City of Campbell River provided information on known locations of Bald Eagle nest trees.

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[1] Grant Parker – Parks Supervisor and Terri Martin – Environmental Coordinator

[2] Steven Colwell – Senior Habitat Management Biologist, Marine and Foreshore Oceans; Barry Peters – Community Advisor; Shannon Anderson – Biologist – Oceans, Habitat & Enhancement

[3] Chuck DeSorcy – Willow Creek Watershed Society; Tom Easton – Simms Creek Stewardship Society; Gord McLaughlin – local resident.

[4] www.env.gov.bc.ca/cdc

[5] http://geobc.gov.bc.ca/

3. Fish Presence (freshwater). Office-based resources to determine fish presence and habitat suitability of identified watercourses and estuaries included information researched on the Fisheries Information Summary System (FISS) database, DFO Mapster 2.26 , and the BC Fish Wizard[7] online resources; and
4. Airphotos. Historic airphotos of the study area from various years were provided by the City of Campbell River and were used to identify broad-level characteristics and to set field assessment priorities.
5. Existing Technical Reports. A number of existing environmental studies related to the project area were used to supplement this work and to help prioritize proposed assessment needs for this project. These reports were provided by the City of Campbell River; key information sources used for the ecological inventory include:
    a. Anonymous. 2006. *Campbell River Foreshore Atlas.* 14 pp. City of Campbell River. 69 pp.
    b. Anonymous. 2003. *Campbell River Seawalk Shoreline Restoration Project*. Greenways Land Trust. 9pp.
    c. Penfold, G. 2002. *Campbell River Estuary Management Plan Update*. The District of Campbell River. 73pp.
    d. Komori Wong Environmental. 2005. *Campbell River Integrated Stormwater Management Plan - Biophysical Foreshore Assessment of Representative Stormwater Outfalls and Opportunities for Stormwater Treatment/Habitat Enhancement Sites.* Urban Systems. 30 pp.

Field studies were conducted between December 21st and March 4th by an experienced professional biologist. Generally, field assessments were timed to coincide with lower tide levels; however, the seasonal timing of the assessment limited opportunities to view the intertidal system at low-low tides[8]. Information collected during field assessments typically included the following:

1. Nearshore substrate/sediment classification. This included characterizing sediments on the upper, mid and lower beach face and in the low tide bench to subtidal habitats where possible.
2. Backshore and supralittoral vegetation (predominant species, age, width, linkage to shoreline processes);
3. Presence and frequency of large woody debris (LWD) - particularly LWD that is integrated into high and supralittoral substrates;
4. Evidence of sediment accretion, transport, or erosion;

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[6] http://www.canbcdw.pac.dfo-mpo.gc.ca/ows/imf.jsp?site=mapster
[7] http://webmaps.gov.bc.ca/imf5/imf.jsp?site=awiz
[8] During the winter season, low-low tides occur during the night.

5. Presence of shoreline modifications – ie. rip rap, groynes, roads, walkways, houses, etc., and the integrity of drift cell processes;
6. Presence of invasive species;
7. Incidental observances of wildlife - no direct sampling of wildlife to establish presence/absence was conducted as part of this assessment;
8. Freshwater inputs (streams/estuaries, seeps, outfalls, etc.); and
9. Opportunities for shoreline habitat improvements.

Despite the importance of forage fish to the overall aquatic ecosystem health (see **Section 2.5**), there is currently no existing information on forage fish habitat in the Campbell River area. Therefore, all information was required to be collected in the field. As a start, shoreline habitats within the study area were assessed to determine: a) the existence of suitable substrates that could be used by forage fish for spawning; b) the existence of wide supralittoral areas with integrated LWD; c) functional backshore vegetation – particularly overhanging vegetation; c) sediment sources and the apparent stability of existing finer substrates; d) potential effort to restore or enhance the habitat for forage fish spawning; and, e) to identify candidate beaches for future monitoring to establish or confirm forage fish spawning.

Methods to determine potential forage fish spawning habitat entailed surveying substrates between the mean tide level to mean higher high water substrates to identify areas with appropriate substrate depth (minimum 3 cm depth) and composition (fine gravels - pea to coarse pebbles with a sand base) to support forage fish spawning. Specific criteria used to classify forage fish spawning habitat are presented in **Table 2**. It is important to note that a high substrate suitability score does not necessarily correlate to use of the habitat by forage fish. As little is known about these fish, there is a wide variety of factors that may influence use of beaches by these fish; therefore, direct sampling of beach substrates for eggs is the only way to determine use of beach areas by forage fish. The value of classifying the suitability of forage fish potential is to identify beaches with a higher probability of use by Surf Smelt and Sand Lance, identify candidate beaches for monitoring, and to ascribe restoration effort required to enhance or maintain the habitat. Ramona de Graaf (Emerald Sea Research and Consulting) provided a great deal of assistance with this particular aspect of the assessment.

Criteria used to classify backshore vegetation condition are presented in **Table 3**. Classification data for both forage fish spawning suitability and backshore vegetation are presented geospatially in the **Map 3** sheet series.

Table 2. Forage fish spawning habitat potential classification criteria.

Value	Substrate Suitability *	Effort to Improve or Maintain	Foreshore Characteristics	Riparian/Backshore Characteristics
1	None	Not feasible	-sediment and geomorphic character inappropriate to support forage fish spawning habitat; -sediments too coarse and/or shallow; -often no sloped beach 'face'; -encroachment	-often lack intact storm berm or functional backshore: -no log-integrated berm in supralittoral; -could benefit from riparian enhancement; -usually intrusion into upper intertidal; -usually seawall or riprap modified; -riparian enhancement for food production for juvenile salmon
2	Low	High	-<0.5m wide band of suitable substrates (sand & pea pebbles); -usually cobble dominated substrates on beach face; -discontinuous patches (<30m) of sand/pebble substrates; -need nourishment - generally 'starved' of fines; -accretion control measures would improve spawning habitat; -usually seawall/riprap modified	-often lack intact storm berm or functional backshore: -no log-integrated berm in supralittoral; -could benefit from riparian enhancement; -usually seawall/riprap modified; -complete riparian enhancement for food production for juvenile salmon
3	Moderate	Moderate	- >0.5 m wide band of suitable substrates (sand and pea pebbles); -discontinuous patches (>30 m) of sand/pebble substrates; -need nourishment: -generally 'starved' of fines (low relative proportion of sand and pebbles); -consider accretion/retention control structures to improve continuity of forage fish spawning habitat	-often lack intact storm berm or functional backshore: -may have log-integrated berm in supralittoral; -could benefit from riparian enhancement; -often seawall/riprap modified; -complete riparian enhancement for shade for summer smelt and food production for juvenile salmon
4	Moderate - High	Low-Moderate	- >0.5m wide band of suitable substrates (sand and pea pebbles); -continuous reaches >100m of sand/pebble substrates; -usually have intact storm berm or functional supralittoral zone with LWD integrated into substrates; -often could benefit from riparian enhancement	-intact storm berm/functional supralittoral zone with LWD integrated into substrates; -could benefit from riparian enhancement; -may have minor seawall/riprap modifications
5	High	None - Protect and Preserve	-wide, continuous reaches >100m of sand/pebble substrates; -no modifications to shoreline; -wide, gentle slope beach face; -intact/functional riparian habitat at least 30 m in width	-intact storm berm/functional supralittoral zone with LWD integrated into substrates; -intact/functional riparian habitat at least 30m in width; -no modifications to shoreline

Table 3. Backshore habitat classification criteria.

Low	Very low incidence of natural vegetation in supra-littoral Lack of overhanging tree and shrub vegetation along shoreline Constructed elements (road, pathway, houses, etc) within 10 m of HHWL. Vegetation usually dominated by invasive species and residential lawn Riprap armouring prevalent
Low-Moderate	Scattered mature trees within 15 m of HHWL. Invasive vegetation species present but not dominant Constructed elements (road, pathway, houses, etc) within 20 m of HHWL. Riprap common but discontinuous and lower profile Can have integrated LWD in spray zone/supra-littoral
Moderate	Presence of clusters or stands (>10 trees) of mature trees (>35 years old) - particularly conifer species Minimum distance of 15 m of native vegetation Constructed elements (road, pathway, houses, etc) within 20 m of HHWL are infrequent Usually have integrated LWD in spray zone/supra-littoral Riprap infrequent/patchy and low profile

2 BACKGROUND

2.1 STUDY EXTENTS

The coastline examined in this reports extends longitudinally from Ocean Grove Road in the south to Orange Point Road in the north, corresponding to the present-day city limits with a shoreline length of approximately 16 km. **Map 1** shows the geographic extents of the study area and illustrates the wide diversity of shoreline types that are present. The active foreshore zone extends laterally from the upland backshore environment seaward beyond the intertidal zone (**Figure 1**). The limits of this zone do not necessarily correspond to the administrative limits of the City of Campbell River; however, they provide a convenient natural boundary to the study.

The study extents become ambiguous in the vicinity of the Campbell River Estuary, where, by definition, marine shoreline processes intermingle with upland fluvial processes. In this study we have focused on the outer edge of the estuary as the defined shoreline. This approach seems appropriate given that much work has been done previously by the City, and others, in the estuary.

2.2 PHYSICAL SETTING – THE BIG PICTURE

The City of Campbell River is located on the east coast of Vancouver Island at the northern limit of the Strait of Georgia (Salish Sea). The shoreline faces northeast into Discovery Passage, which is bounded by Vancouver Island to the west and Quadra Island to the east. The City occupies a portion of the Nanaimo Lowland within the Georgia Depression, a low-relief area at the margin of the Vancouver Island Ranges. The Nanaimo Lowland is underlain by various Upper Cretaceous sedimentary rocks and overlain by a thick mantle of glacial and fluvio-glacial materials (Holland, 1964).

The upland areas within the City of Campbell River slope gently down towards the shoreline, typically ending in steeply sloping bluffs with an elevation of approximately 20 m to 25 m. In the southern part of the study area between Ocean Grove Road and the Hidden Harbour Marina, a narrow low-relief zone extends along the shore between the base of the bluffs and the ocean, with an elevation of up to 8 m. This zone is largely absent to the north of Hidden Harbour Marina except where the Campbell River valley has dissected the coastline and formed the Campbell River delta and estuary. Much of the downtown area is located within these low-lying deltaic sediments (McCammon, 1977). To the north of the estuary the land rises away from the shoreline to form the northern section of bluffs along Orange Point.

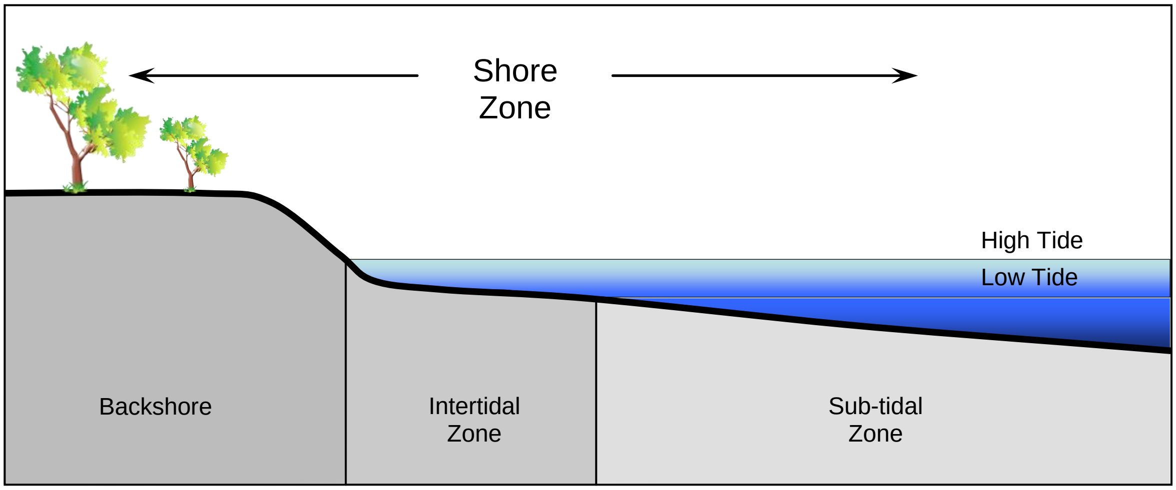

Figure 1. **Cross section of the shoreline delineating the various shore zones.**

2.3 OCEANOGRAPHIC CONDITIONS

Tide levels in the Strait of Georgia are mixed, mainly semi-diurnal – meaning that there are two high, and two low tides each day of unequal height (**Figure 2**). Tide levels are typically described in terms of Chart Datum but for the purposes of this report, all elevations have been converted to Geodetic Datum (GSC). **Table 6** summarises the tidal statistics for the Campbell River gauge (Station 8074). Extreme high tides are caused by a number of factors including:

- Periodic large astronomical tides (Spring tides – also referred to as King Tides).
- Storm surges due to large-scale wind patterns which cause super-elevation of the ocean.
- Wave set-up due to combined waves and tidal currents.
- El Ninõ events which can raise average ocean levels for extended periods of time.

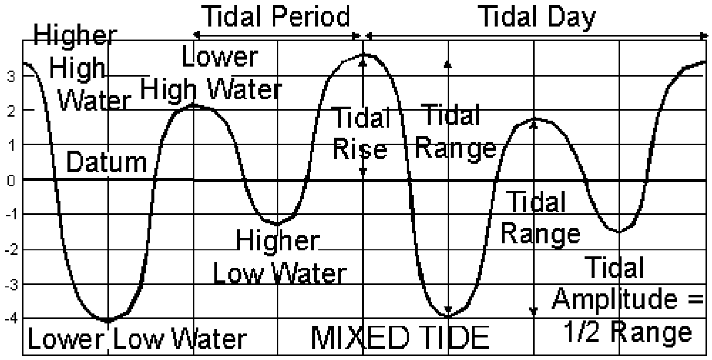

Figure 2. **Mixed semi-diurnal tidal pattern (from Our Restless Tides, NOAA, 1998).**

Table 4. Summary of Tide Levels at Campbell River.

Tide Condition	Abbreviation		
		Chart Datum	Geodetic
Maximum Observed		5.3	2.4
Higher High Water Large Tide	HHW LT	4.8	1.9
Higher High Water Mean Tide	HHW MT	4.0	1.1
Mean Sea Level	MSL	2.9	0.0
Lower Low Water Mean Tide	LLW MT	1.2	-1.7
Lower Low Water Large Tide	LLW LT	0.2	-2.7

Wind generated waves are the primary agent of geomorphic change along most of the shoreline within the study area. Wave heights are dependent on wind speed, wind duration, and fetch (the distance over which the wind can act). Quadra Island, which forms the eastern boundary of Discovery Passage limits fetch length for all but the southern portion of the study area.

Very strong currents develop off Campbell River during large tidal swings. Currents can reach up to 9 knots during flood tides and up to 7 knots during ebbing tides. Nearshore currents would be expected to be much lower and generally would not be sufficient to transport sediment directly, but the tidal current has been observed to alter the wave climate.

A more detailed investigation of oceanographic conditions is included in **Appendix A**, which describes the wind, wave, tidal, and current climate affecting the shoreline at Campbell River. In addition, the issue of climate change and future sea level rise is treated in detail, both in **Appendix A** and **Section 3.2**. **Section 3.2** provides analysis on the wind and wave climate for various locations within the study area.

2.4 SHORELINE PROCESSES

The dominant direction of sediment transport along the southern portion of the shoreline at Campbell River is from south to north, which is a result of the longer fetch length and more frequent high wind events from that direction. Longshore transport occurs as a result of waves arriving at an angle to the shoreline, which moves sediment particles at an angle to the shore on the incoming wave (swash) but perpendicular to the shore as the wave recedes (backwash) (**Figure 3**). Sediment would be expected to move from north to south when waves are generated by northerly winds but the net sediment transport is defined by wind-generated waves from the south.

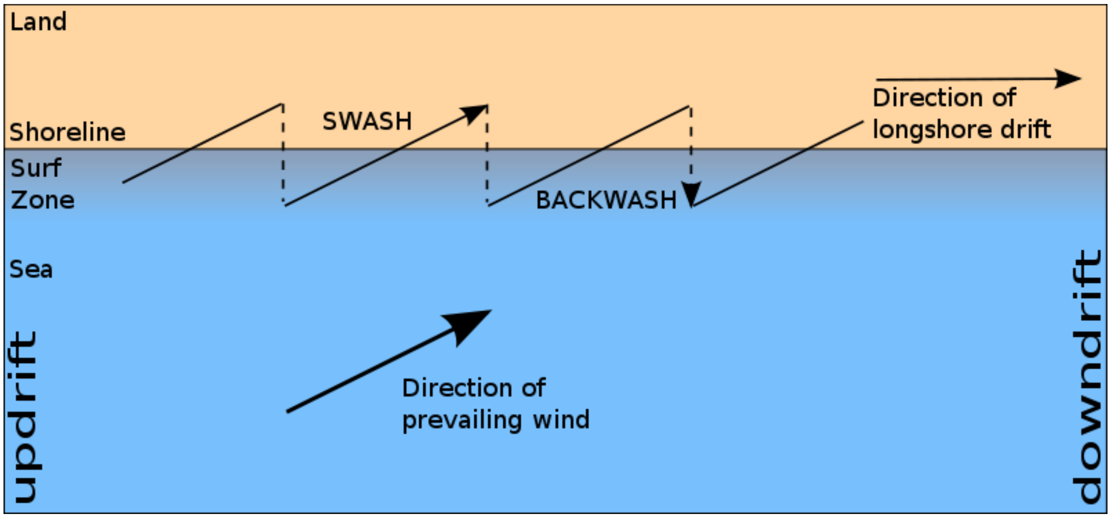

Figure 3. **Schematic diagram illustrating the process of longshore transport of sediment along a coastline.**

Sediment also moves inshore and offshore, between the upper part of the shoreline and the higher sub-tidal areas, in response to changes in the seasonal wave climate. Natural structures, such as rocky headlands, and built structures, such as marina breakwaters, interrupt the longshore transport of sediments, temporarily pushing them offshore into deeper waters. Steep shoreline protection structures also act to reflect wave energy rather than dissipating it as breaking waves, leading to offshore migration of sediments. Sediments temporarily stored in deeper waters can be remobilised during high wind events at lower tide stages or they may remain in place as long-term storage.

The sediments moving along the shoreline system come from various sources. Much of the sediment enters the study area from downdrift sources within the along-shore transport system. Campbell River and the larger creeks draining to the coast deliver sediment in the form of cobble, gravel, and finer sediments, which enter the shoreline system. The input of sediment from erosion of the shoreline is dependent on the rate of shoreline retreat as well as the height of the shoreline.

2.5 THE BIOLOGICAL SYSTEM

Properly functioning shorelines are complex systems that mark the transition from the marine to terrestrial domains. As such, they are characterized as having specific biophysical conditions that support a wide variety of interconnected natural processes that sustain the rich biodiversity that is often found in these areas. As the Campbell River shoreline provides habitat for fish, marine mammals, shellfish, waterfowl, and invertebrates, it is a critical component of the ecological health of the region.

For the purposes of this report, particular focus has been placed on four primary habitat “types” that are not only ecologically critical to proper ecosystem function of the shoreline, but that also provide the added value of setting an effective management framework for restoration and management initiatives of this important area. The four habitat types include: 1) Forage Fish Spawning Habitat, 2) Backshore Vegetation, 3) Juvenile Salmonid/Estuary Habitat, and 4) Low Intertidal/Subtidal Vegetation. An additional element that is discussed throughout the report is surface runoff and stormwater systems as these are known to impact shoreline processes in a variety of ways. Additional comments are provided on known occurrences and incidental observations of wildlife and valued resources.

Of these four habitat types, particular emphasis has been placed on forage fish spawning habitat, as these fish are increasingly becoming recognized as keystone species for the role they play in food web interactions (and by extension, the human economy). They are also recognized as very important indicators of shoreline ecosystem health in the temperate shorelines of the Pacific Northwest. Finally, managing the shoreline for forage fish spawning habitat has the added benefit of creating ancillary benefits for a wide variety of wildlife.

2.6 HUMAN INTERACTIONS

There is a long history of human interaction within the study area. Industrial, urban and agricultural development has transformed not only the shoreline but land-use patterns behind the shoreline as well as processes extending the intertidal zone. **Section 4.1** provides a detailed summary of the existing human modifications to the shoreline. **Chapter 6** includes the Development Guidelines, which provide a blueprint for future direction that development can take in order to minimise the effects on the natural system.

3 COASTAL PROCESSES

3.1 COASTAL GEOMORPHOLOGY ANALYSIS

As part of the Coastal Geomorphology Analysis the study area was divided into seven geomorphic reaches, each representing a relatively homogenous zone of coastal processes or physical environment. The reaches have been defined purposefully to simplify interpretation of the shoreline, drawing out the similarities rather than focusing on short sections within the reach that may not fit the overall trend. The **Map 2** four sheet series shows the delineation of the reaches. The reach boundaries are purposely mapped with 'fuzzy' boundaries to indicate the gradual transition from one shoreline unit to the next. The extent of the reaches is summarised in **Table 5**.

Reach No.	Geomorphic Reach Name	Description
1	Southern Beaches	From Ocean Grove Road north to Ken Forde Boat Ramp
2	Willow Point	From the south side of Willow Point (Ken Forde Boat Ramp) to the north side of Willow Point near Frank James Park
3	Middle Beaches	From Frank James Park north to Hidden Harbour Park South
4	Southern Bluffs	From Hidden Harbour Park South to the Maritime Heritage Center
5	Industrial	From the Maritime Heritage Center to north of the Discovery Harbour Marina
6	Estuary	From the north side of the Discovery Harbour Marina to the intertidal bar
7	Northern Bluffs	From the intertidal bar north to the rock outcrop at the end of Orange Point Road

Table 5. Summary of geomorphic reaches.

3.1.1 *REACH 1 – SOUTHERN BEACHES*

The Reach 1 boundaries are defined by the southern limit of the study at Ocean Grove Road and to the north by the Ken Forde boat launch. The reach is comprised of a nearly continuous gravel beach of varying width. The height of the immediate backshore area varies from between 2 m and 4 m above normal high tide with short sections that extend to 6 m above high tide. The southern portion of the reach is characterised by residential development on fairly large lots, which terminates approximately at the end of Oregon Road. North of the residential development, the shoreline is bounded on the landward side by Highway 19A and the Seawalk with a narrow strip of backshore vegetation.

3.1.2 REACH 2 – WILLOW POINT

Reach 2 encompasses Willow Point, which is associated with a rocky reef extending offshore. The Willow Point reach extends from the Ken Forde Boat Ramp in the south to Frank James Park in the north. The height of the immediate backshore area varies from between approximately 2 m and 3 m above normal high tide. Much of the shoreline is heavily modified by concrete retaining walls and steep rock rip rap. The shoreline protection works have been installed in an *ad hoc* fashion with little apparent consultation or cooperation between adjacent property owners. Most of the shoreline is in private ownership, with development extending to within 30 m of the edge of the shoreline in many locations, with some lots held as public park land.

3.1.3 REACH 3 – MIDDLE BEACHES

Reach 3 extends from the north side of Willow Point to Hidden Harbour Park (South). The reach is essentially one straight section of shoreline with a nearly continuous gravel beach. The immediate backshore area varies from approximately 2 m and 3 m above normal high tide. Shoreline protection is intermittent along this reach, with approximately 60% to 70% of the length protected by rip rap in varying states of repair and the remaining sections left undefended. Active erosion and damage to the shoreline is common. Highway 19A and the Seawalk are routed immediately adjacent to the shore for most of the reach but a short section between Big Rock and Rotary Beach Park has residential development along the shore.

3.1.4 REACH 4 – SOUTHERN BLUFFS

Beginning at Hidden Harbour Park and extending north to approximately the Maritime Heritage Museum, the land level rises steeply from the shoreline to form a bluff that is up to 20 m above normal high tide. The Hidden Harbour Marina, which is located near the southern reach boundary, represents the largest modification to the shoreline processes. The remaining development along the reach, including Highway 19A, is concentrated along the top of the bluff with some properties using the base of the bluffs for parking.

3.1.5 REACH 5 – INDUSTRIAL

Reach 5 extends from the Maritime Heritage Museum north to the north side of the Discovery Harbour Marina. This reach is characterised by nearly continuous rip rap along the shoreline and frequent breakwaters extending out into the shallow and middle sub-tidal zones.

3.1.6 REACH 6 – ESTUARY

The Campbell River Estuary reach includes Tyee Spit as well as the intertidal bar on the north side of the estuary. The southern reach break is defined by the end of industrial use on the spit while the northern boundary is more vaguely defined. Wave energy exposure increases on the north side of the intertidal bar as the lateral extend of the bar decreases and the character of the shoreline transitions to the Northern Bluffs. The shoreline along this reach is generally devoid of artificial protection works.

3.1.7 REACH 7 – NORTHERN BLUFFS

Reach 7 extends north from the Campbell River Estuary to the end of Orange Point Road, the northern limit of the study area. This reach is characterised by steep bluffs extending to over 14 m above normal high tide level. Development generally occurs only on the top of the bluffs and is comprised of private residential development on larger lots. However, some development in the southern portion of the reach, including Painters Lodge, extends down to the shoreline. Shoreline protection works are an *ad hoc* assortment of boulder placements, concrete armouring, and logs that have been installed in an attempt to protect the toe of the bluffs. Poor management of runoff on the top of the bluffs that has resulted in slump failures and shallow gullying appears to be the main issue.

3.2 WIND AND WAVE ANALYSIS

Waves are the primary agent of geomorphic change within the study area and are entirely dependent on large wind events and the limitations of fetch length. Prevailing winds in the study area are predominantly from the northwest in the summer and from the southeast in winter. The strongest winds come from the ESE and SE, with a significant number of high winds coming also from N to NW. Because of the sheltering effect of Quadra Island, only the southern portion of the study area is directly exposed to large waves from the SE. Thus there is a declining wave-energy gradient from south to north.

The deep water wave conditions in the Strait of Georgia are governed by (1) the wind speed, (2) fetch length (distance the winds can blow over), and (3) the storm duration. Deep water wave conditions are commonly described in terms of the significant wave

(H_s) and wave period (T). The significant wave height is a statistical measure of the irregular wave field and is often associated with the average of the highest one-third of the waves during a storm event. The wave period represents the average time between successive wave crests.

Wave hindcasting techniques were used to calculate the maximum wave heights for various locations within the study area. These computations were based on methods contained in the Coastal Engineering Manual (USACE, 2008). The data at Sentry Shoal were used to verify wave hindcasting equations that have been developed to estimate wind-generated waves and to then calculate the wave conditions for Campbell River.

A more accurate method of wave hindcasting involves using a numerical model that represents the time varying wind field over the Strait of Georgia and estimates wave generation as well as the effects of sheltering, wave breaking and wave decay over the storm event. The program SWAN Version 40.81 (2010) was selected for the analysis (DELFT 2010). The model used a nested grid with 1000 m spacing in the southern end of the Strait of Georgia and 200 m spacing north of Sentry Shoal, Oyster River, including the main study area around Campbell River. Figure 4 shows a graph in the variation of deep water versus near shore wave heights for various locations along the Campbell River shoreline during the recent 23 December 2010 storm event.

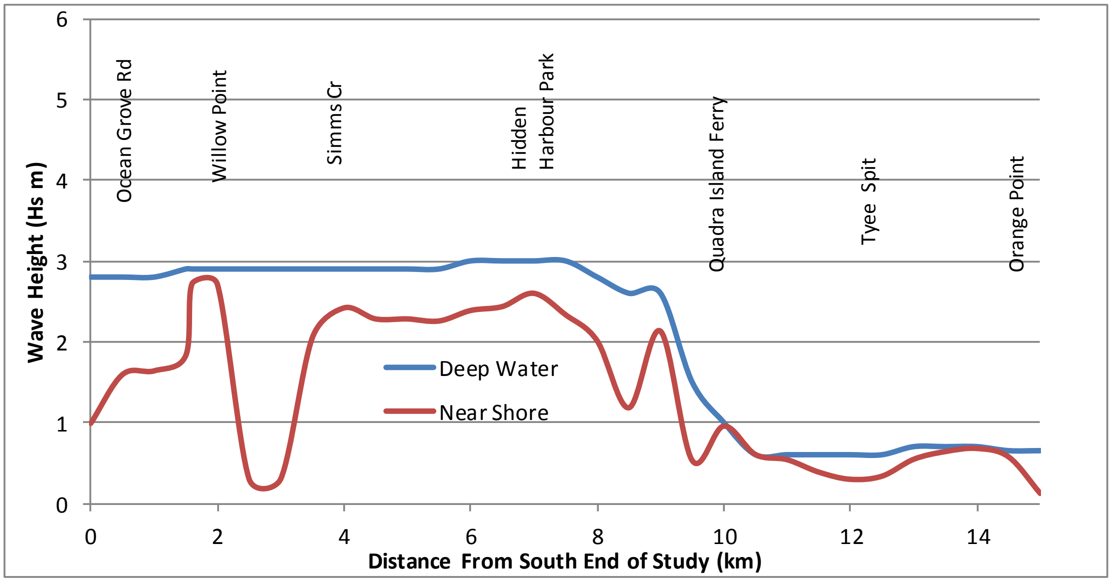

Figure 4. Variation in wave height along the shoreline at Campbell River – December 23, 2010 storm event.

3.3 COASTAL FLOOD LEVELS AND CLIMATE CHANGE

Appendix A of this report provides an in-depth technical treatment of the scientific and engineering rationale for calculating and establishing flood levels in coastal BC. The following is a summary of this material.

The Coastal Flood Level is used for setting the safe elevations and set-backs of buildings and other infrastructure constructed in coastal British Columbia. The BC Ministry of Environment's published coastal flood level for Campbell River is elevation 3.5 m Geodetic (freeboard included). This level was established by Klohn Crippen Consultants in 1989 (BC MOE, 1989) as follows:

- The "Natural Boundary" along sections of the shoreline was estimated by visual site inspections and then determined by surveying to be el. 2.0 m Geodetic;
- A freeboard allowance of 1.5 m was added to the elevation of the Natural Boundary.

This approach was commonly used in the past, although it does not explicitly account for the statistical distribution of extreme tides, storm surges and wave runup.

Wave runup was calculated for the recent December 2010 storm and high water levels were surveyed as a check. These exceeded BC MOE's published Coastal Flood Level at several locations, including near Ocean Grove Road, Ken Forde Boat Ramp, and near Hidden Harbour condominiums (see **Appendix A** for details). The published Coastal Flood Level may be appropriate for conditions in the river estuary and in the very sheltered northern part of the study area, but is not appropriate for the more exposed locations along the southern half of the study area.

It is now generally accepted that global climate change is occurring and that this change is responsible for the observed ongoing rise in global sea level. The BC Ministry of Environment has published guidelines for coastal flood hazard management (BC MOE, 2011), adopting a median estimate of 0.8 m sea level rise by 2100 and a "high" estimate of 1.2 m. The BC MOE (2011) report incorporates these sea level rise projections into new guidelines that are intended to replace the existing land use management guidelines that were introduced in 2004. The 2010 draft guidelines include the following statement:

> *The FCL shall be a minimum elevation for habitable floor level or underside of wooden construction and shall be based on and include allowances for Year 2100 sea level rise and High Tide Levels associated storm surge and wave effects for the designated storm and freeboard.*

The revised Flood Construction Level is elevation 5.3 m Geodetic (freeboard included) for the east coast of Vancouver Island. This level includes a wave runup allowance of 0.65 m, which is representative of relatively sheltered natural gravel beaches, not exposed sites or steeply sloping riprapped revetments where wave runup could be considerably higher. It also includes consideration of local relative sea level change such as tectonics and isostacy (eg. 'glacial rebound').

Therefore, the proposed coastal flood level is applicable only to the sheltered north half of the study area in Campbell River (north of Km 10). Even so, the new level is 1.8 m higher than the present FCL that was established in 1989. This change will have a major effect on the floodplain extent and depth of flooding in the downtown portion of Campbell River. **Figure 5** shows the present floodplain boundary in the main portion of the town with the new FCL that will potentially result. Increasing the coastal FCL from el. 3.5 to el. 5.3 m will extend the southern floodplain boundary inland by up to 400 m in some portions of the town (note that these elevations are based on the *draft* Provincial guidelines). An updated floodplain map should be prepared to show the revised extent. The updated mapping should extend south to the southern limit of this study. This will require acquiring additional topographic information using LIDAR mapping techniques.

Shoreline cross sections surveyed in January 2011 illustrate the effect of the increased coastal flood level at various locations in the southern portion of the study area. **Figure 6** and **Figure 7** show the sections, along with the present coastal FCL for Discovery Passage and the proposed coastal FCL including climate change (June 2010 Draft). BC MOE's proposed updated FCL is higher than many sections of the existing highway and will designate many presently developed areas as floodplain. For example, see **Figure 8**, photos of a surveyor indicating the elevation of the proposed sea level rise at locations within the study area. It should be noted that the coastal FCL in the southern portion of the study area will be somewhat higher than the 5.3 m value, since this section is more exposed and is subject to greater wave runup. Therefore, the flood levels shown in **Figure 6** and **Figure 7** are intended solely to show the effect of sea level rise on the flood extent and are not intended for regulatory purposes. Nor do these cross sections show the building setbacks that are proposed in these studies (see **Appendix A**). This revised setback definition could affect future land use over a large portion of the study area.

Figure 5. Floodplain extents based on existing mapping (Campbell and Quinsam Rivers, BC MOE, 1989) and on projected future sea level rise scenario.

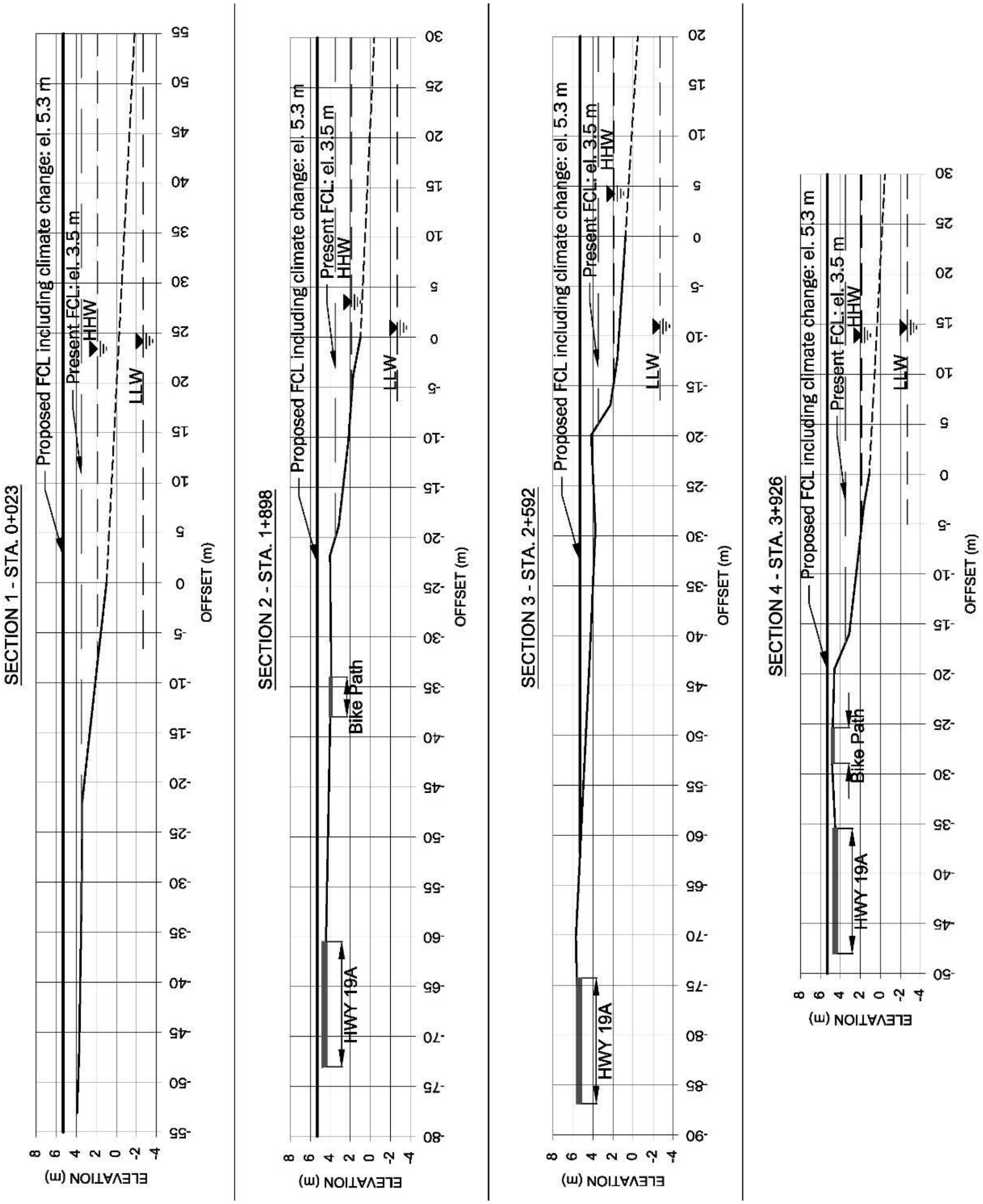

Figure 6. **Shoreline profiles –sections 1 to 4, showing BC MOE's present and proposed coastal FCL.**

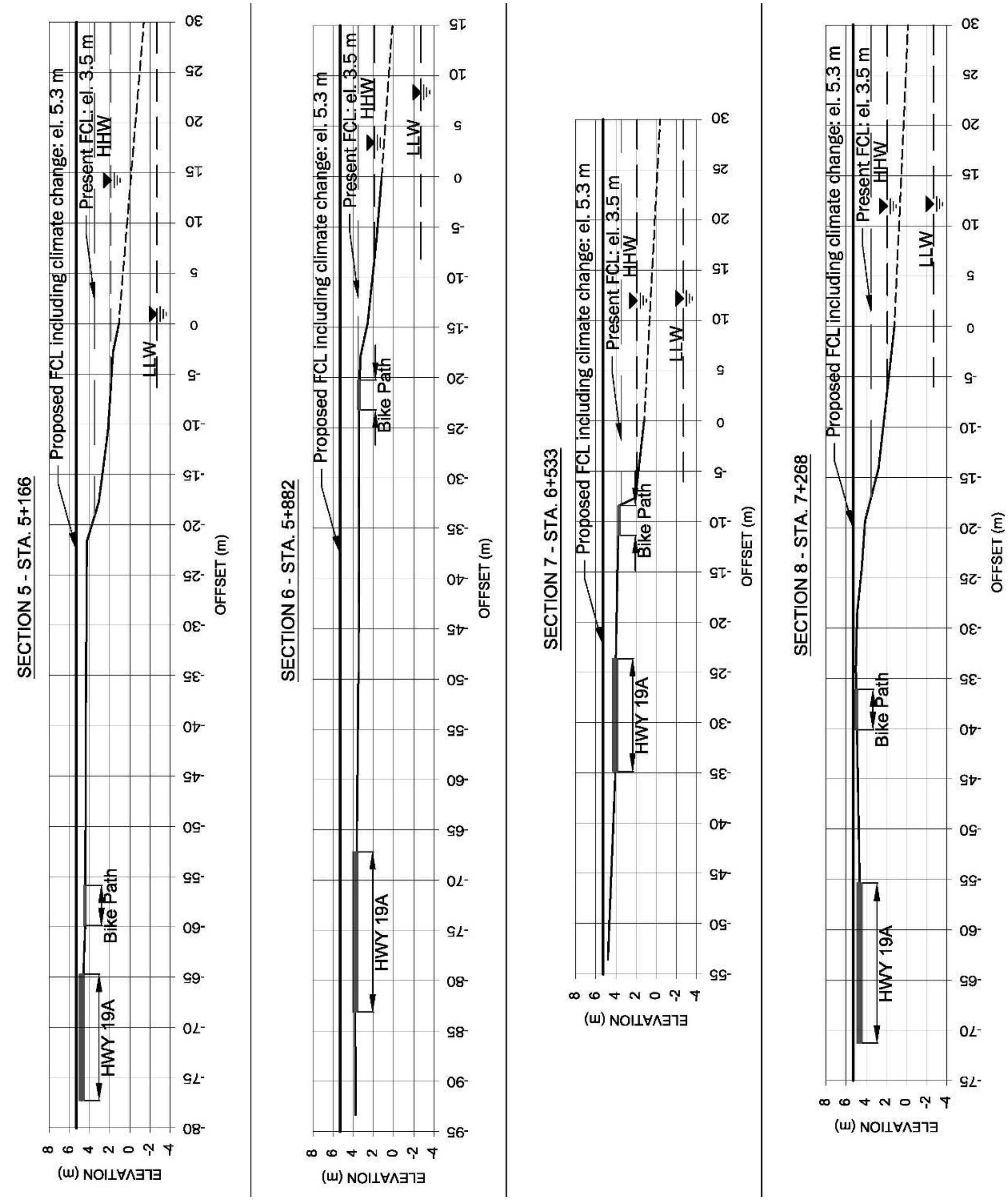

Figure 7. **Shoreline profiles-sections 5 to 8 showing BC MOE's present and proposed FCL.**

Figure 8. Surveyor indicating the elevation of the draft BC Flood Construction Level (with proposed sea level rise included at a) Ocean Grove, and b) near Rotary Beach Park (photos taken 17 January 2011).

4 EXISTING CONDITIONS ASSESSMENT – PHYSICAL

The purpose of the existing conditions assessment (ECA) is to provide a comprehensive description of the physical and biological conditions along the shoreline within the study area. Conditions are expected to change with the ongoing evolution of the shoreline but this assessment will provide a valuable database of the information compiled to date. This chapter (**Chapter 3**) describes the physical conditions within the study area. The existing biological conditions are described in **Chapter 0**. The methodology used to complete the Physical ECA is outlined in **Section 1.2**.

4.1 EXISTING INFRASTRUCTURE

The shoreline within the study area has been significantly modified by human development, starting in the latter half of the 19th century when industrial resource extraction first began. The present-day shoreline has discrete semi-natural sections but for much of its length it is heavily armoured or modified and the reach as a whole is impacted.

4.1.1 BANK ARMOURING

A large portion of the shoreline in the study area has been armoured. Bank armouring is a typical strategy used to offset bank shoreline erosion and retreat. The two most common methods that are used almost universally along the BC coastline are 1) construction of a concrete retaining wall that may also include rock armour at the base of the wall, and 2) installation of large rock riprap along the upper portion of the shoreline. **Figure 9** shows examples of these types of armouring within the study area in various states of repair. The vertical wall shown in **Figure 9a** is functioning without toe protection because it is partially protected by the projection of rock at the mouth of Willow Creek and receives sediment from that drainage, while the toe protection for the wall in **Figure 9b** is necessary because of the higher level of exposure. The failing rock riprap shown in **Figure 9c** is an example of the type of *ad hoc* shoreline protection most commonly found in the study area while the engineered rock berm in **Figure 9d** is the predominant shoreline type within the industrialised reach of downtown Campbell River.

In contrast to the sections of armoured shoreline, the more natural shoreline shown in **Photo 1** has a shallow-angle beach profile that more effectively retains logs and sediment. Vegetation growing at the top of the beach indicates that a minimum level of stability has been achieved. The low-angle beach profile effectively dissipates wave energy while the installation of walls and rock riprap tend to reflect wave energy, resulting in erosion and a lowering of the beach profile.

A comprehensive survey of the shoreline is outside the scope of this study. Instead the shoreline reaches outlined in **Section 3.1** have been characterised in terms of the amount and type of shoreline armouring that has been installed (**Table 6**). Reach 5 –

Industrial – is the most heavily armoured reach with almost 100% of the shoreline protected by rock berms or breakwaters. Reaches 1 and 6 – Southern Beaches and Estuary respectively – encompass the largest sections of relatively natural shoreline. Reaches 2 and 3 – Willow Point and Middle Beaches – contain large sections of armoured shoreline but provide opportunities to restore many sections to a more natural beach profile. Access to the Southern Bluffs reach was limited by the occurrence of high tides so information on this reach is less reliable.

Figure 9. Typical bank armouring along the CoCR foreshore; a) vertical concrete wall at Willow Creek, b) loc-bloc and rock wall protection along new Island Highway South at Simms Creek, c) steep failing riprap near the end of Dahl Road, and d) rock riprap lined shoreline at Frank James Park (all photos 17 January 2011).

Photo 1. **Semi-natural beach south of Willow Point. Note the relatively gentle beach profile and retention of logs (photo 17 January 2010).**

Table 6. **Summary of shoreline armouring by reach.**

Reach No.	Reach Name	Shoreline Armouring
1	Southern Beaches	*Ad hoc* armouring installed along individual properties in Ocean Grove area; discontinuous rock installed at various locations north of Ocean Grove, including concrete retaining wall at the base of the Sea Walk; semi-natural section south of Ken Forde.
2	Willow Point	Majority of reach is armoured by *ad hoc* installation of riprap; concrete retaining wall at south end of reach; some low-lying properties using rock berm to prevent ingress of storm waves; north end has short sections of unprotected shoreline near Adams Road.
3	Middle Beaches	Between 50% to 70% of the shoreline length is armoured with rock that is in various stages of repair. There is no significant development seaward of the road in this reach.
4	Southern Bluffs	Access limited by high tides; extensive shoreline protection is apparent, particularly in the southern portion.
5	Industrial	Virtually 100% of the shoreline in this reach is armoured with riprap or is behind rock breakwaters that protect the various marine facilities such as marinas and ferry docks.
6	Estuary	The spit portion of the Estuary reach is largely natural except at the very southern portion where the shore is armoured for industrial use; the mainland shoreline in the northern portion of the reach is naturally protected by the spit.
7	Northern Bluffs	The base of the bluffs have undergone significant modification; engineered riprap is absent because of difficult access; manipulation of existing boulders and *ad hoc* armouring is present along most of the shoreline; shoreline erosion appears to be a minor issue relative to slope failures caused by drainage issues on the slopes above.

4.1.2 JETTIES AND BREAKWATERS

Jetties and breakwaters have been installed as part of the industrialisation of the shoreline as well as to provide protection at specific locations. These structures project from the shoreline and extend out into deep water in order to deflect incoming waves. They are typically constructed to a height that avoids overtopping so result in a complete interruption of the along-shore transport of sediment. Photo 2 shows an aerial view of a portion of the Industrial reach with jetties and breakwaters constructed to protect the BC Ferries terminal and the Discovery Harbour Marina. These structures have resulted in a significant modification of the original shoreline.

Photo 2. Oblique aerial photo of the breakwaters and jetties installed at the BC Ferries terminal and the Discovery Harbour Marina (photo 18 January 2010).

Pile-supported structures, such as the Discovery Fishing Pier have the potential to modify the shoreline but not to the same extent as the structures built of rock. In addition to the potential shading effect that can modify the local habitat, minor deflection and refraction of waves would be expected but generally sediment should be free to pass through the structure. Lower profile rock structures, such as the rock berms constructed at Big Rock boat launch (Photo 3) temporarily interrupt sediment movement and result in deflection to deeper water. Sediment will eventually build up on the updrift side and pass over the structure.

The various structures are shown on the Map 2 sheet series.

Photo 3. View looking south at breakwater opposite the Big Rock boat launch (photo 17 January 2010).

4.2 FUTURE INFRASTRUCTURE

Future infrastructure projects have the potential to have a profound effect on the outcome of shoreline development in Campbell River. New infrastructure, as well as upgrades to existing transportation and utilities, can either displace or reclaim shoreline habitat, depending on design and associated habitat projects. As awareness of, and sensitivity towards issues related to this ecosystem increase, planning for projects will naturally put greater emphasis on incorporating the natural processes and ecological function of the shoreline environment, and this emphasis will have greater support from the public. Although the City is exempt from the formal Development Permit process, the science presented in this report offers sound guidance that should be adhered to wherever possible. This includes consideration of emerging issues such as future sea level rise, which has been adopted by the Province but has not been officially adopted by the City.

Upgrades to Highway 19A are currently ongoing. CoCR has adopted a phased approach to these upgrades, replacing the existing simple two-lane road with an updated design that incorporates a number of design elements to improve conditions for non-automobile traffic as well as enhancing the visual appeal of the corridor (Lanarc, *et al*., 2005). Upgrades to Highway 19A for the section through Willow Point were completed in the mid-2000s, while upgrades to the section north of Willow Point were under way at the time of report writing. These upgrades follow a phased approach based on ‘Management Areas’ that identifies the highest priority sections for upgrades.

The City is also considering upgrades to the existing waterfront sewer system, which has extensive sections running within the intertidal beach zones between Hidden Harbour and the Maritime Heritage Center. Options have been proposed that combine public access as part of the project and with the sewer system routed either along the existing alignment, along the highway, or a combination of the two (Campbell River walkway brochure). Works within the active shoreline zone will potentially be at higher risk from ongoing coastal processes and sea level change than options that are routed inland.

5 EXISTING CONDITIONS ASSESSMENT – ECOLOGICAL INVENTORY

The purpose of the existing conditions assessment (ECA) is to provide a comprehensive description of the physical and biological conditions along the shoreline within the study area. The physical conditions are described in **Chapter 3**, and form the organisational basis (eg. Identification of geomorphic reach breaks) for the description of the existing biological conditions as described in this chapter (**Chapter 0**). The methodology used to complete this assessment is outlined in **Section 1.3**. The focus of the assessment is on four key habitat features of the study area:

1. Forage Fish Habitat;
2. Backshore Habitat;
3. Juvenile Salmonid Rearing Habitat and Estuaries; and
4. Low Intertidal and Shallow Subtidal Vegetation Communities.

The locations and general conditions of these various habitat types are shown on the **Map 3** series of sheets. Following a general description of each habitat type and discussion of the ecological significance to the Campbell River shoreline, the specific habitat conditions within each geomorphic reach are examined in detail.

5.1 KEY HABITAT TYPES OF THE CAMPBELL RIVER SHORELINE

5.1.1 FORAGE FISH HABITAT (SPAWNING)

Forage fish are small, schooling fish that are ubiquitous along the temperate coastlines of the Atlantic and Pacific oceans. In the context of this report, the term "forage fish" is specific to three main species: Pacific Sand Lance (*Ammodytes* hexapterus), Surf Smelt (*Hypomesus pretiosus*), and Pacific Herring (*Clupea pallasi*). All are planktivorous[9] fish that form a significant portion of the prey base of marine fish (including salmon), seabirds, and marine mammals. They are considered a critical link in the marine food chain. As an example, "thirty five percent of the diet of juvenile salmon and 60% of the diet of Chinook are comprised of Pacific sand lance while Surf smelt (*Hypomesus pretiosus*) make up an important part of the diet of our provincially listed coastal cutthroat trout" (de Graaf, 2007). As such these fish are an important indicator of ecosystem health (Puget Sound Partnership, 2009). Note that most of the information presented in this section is derived from work completed in the Puget Sound area in Washington State.

The life history of each of these fish species is closely linked to natural systems processes in the marine nearshore system in several ways: all three species spend a

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[9] Feed on marine plankton

portion of their life cycle feeding and rearing in shallower waters and as such are subject to impacts related to food production, pollution, and geomorphic processes that determine the distribution of substrates and wood. These issues are addressed in subsequent sections of this report. However, a primary focus of this assessment is the spawning habitat required by these species. These habitats are all highly sensitive to shoreline land uses and modification activities and are described in some detail here.

SURF SMELT AND THEIR SPAWNING HABITAT

Despite the critical importance of these fish to the productivity of our marine systems (especially salmon), the life cycle of this species is surprisingly poorly understood. They are known to inhabit shallow waters along the coast of Vancouver Island throughout the year. Surf Smelt require sand-gravel substrates in continuous or patchy distribution in the upper one-third of the intertidal zone for spawning (**Figure 10**; Penttila, 2005). The specific substrate composition preferred by Surf Smelt is a mix of coarse sand and pea pebble with the bulk of material in the 1-7mm diameter range and a component of finer sands to help retain moisture (**Photo 4**). Smelt eggs typically anchor to coarser sediments that both protect them and help weigh them down in order to sink into substrates during mechanical movement by waves (Penttila, 2005).

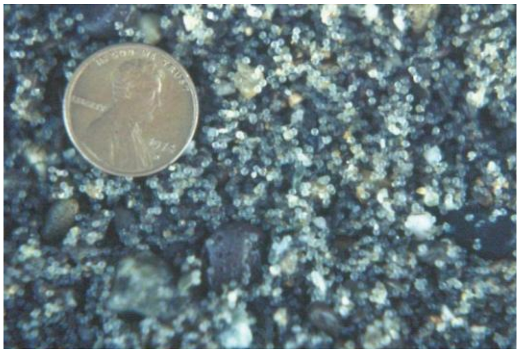

Photo 4. Surf smelt eggs. Photo Dan Penttila, Washington Department of Fish and Wildlife. 2005.

In BC, Surf Smelt can spawn year-round, but spawning is concentrated from November through January, and from May through August[10] (Penttila, 2000). For summer smelt spawning, backshore vegetation plays an important role in maintaining egg viability by reducing desiccation and heat stress through shading of shore substrates. For this same reason, freshwater seepage areas are believed to be a preferred spawning habitat of summer spawning Smelt due to lower fluctuations in gravel moisture and temperature. Spawning occurs during extreme high tide events (Penttila, 2005).

Surf Smelt eggs typically require 4–8 weeks incubation in winter and approximately two weeks for summer smelt (Penttila, 2007). Smelts are believed to be unique from the other forage fish species in that they are obligate in their requirement for fine gravel substrates in the marine intertidal zone (Penttila, 2007; Rice, 2006).

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[10] Ramona de Graaf, Emerald Sea Biological, Pers. Comm., 2011.

PACIFIC SAND LANCE AND THEIR SPAWNING HABITAT

Like Surf Smelt, the life history of Pacific Sand Lance is poorly understood despite their critical importance to the nearshore ecological system. They are known to be common and widespread along the coastal shores of BC as juveniles and are believed to burrow into soft substrates at night to escape predation from larger fish as juveniles (Brennan, 2009).

Pacific Sand Lance spawning occurs on sand to pea-size pebble beaches at tidal elevations between Mean tide to Mean High High Tide (upper one-third of the intertidal zone) of sand-pebble beaches (Penttila, 2007). They will spawn on a broader range of substrates than Surf Smelt, including pure, fine sands to coarse pebble gravels. As such their spawning habitat often overlaps spawning habitats of Surf Smelt (Figure 2). Pacific Sand Lance deposit their eggs in scattered, shallow pits excavated by spawning fish during high tide events between November and February[11]. The deposited eggs typically acquire a coat of sand to protect the egg from mechanical destruction and to help retain moisture against exposure during lower tide events. Incubation is typically four weeks (Penttila, 2007; Rice, 2006).

PACIFIC HERRING AND THEIR SPAWNING HABITAT

Pacific Herring spawn almost exclusively on low intertidal to shallow subtidal marine vegetation that includes eelgrass and seaweed between January to June, with the peak spawning activity occurring in February and March. Eelgrass and kelp provide various other functions in the nearshore system and are discussed in more detail below.

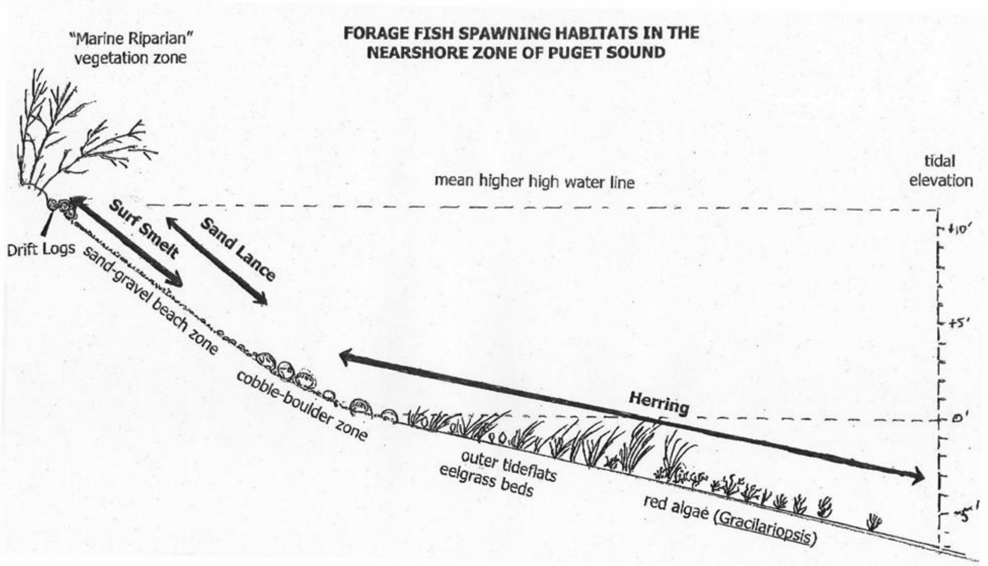

Figure 10. Forage fish spawning habitats in the nearshore system (from Penttila, 2005).

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[11] Ramona de Graaf, pers. comm., 2011.

FUNCTIONAL SIGNIFICANCE IN NEARSHORE ECOSYSTEMS

Forage fish constitute a significant portion of the diets of a wide variety of marine wildlife that include salmon, cod, rockfish, and seabirds. Since forage fish themselves consume zooplankton, they constitute a critical food web link between these smaller organisms and a larger marine wildlife that include several species of commercial and conservation concern (**Figure 11**).

Using salmon as an example, studies of adult chinook salmon in 1989 revealed they fed primarily on sand lance, herring, and smelt (Gearin *et al*., 1994; Prakash, 1962). Juvenile coho salmon consume a wide variety of prey items. Fishes made up 72% of the diet of adult coho salmon; the fish prey was dominated by anchovies, sand lance, and juvenile rock fish. In the Strait of Georgia, fish are an important part of coho salmon diet until summer when herring and sand lance were found to make up 29-35% of the diet of coho salmon (Healey, 1980). Salmon stocks have been in steady decline in the Georgia Basin over the past 40 years (e.g. Simpson, K. 2002) and are at critically low levels (Stouder *et al*, 1997).

Forage fish spawning beaches are protected under Section 35 of the *Fisheries Act* as critical fish habitats.

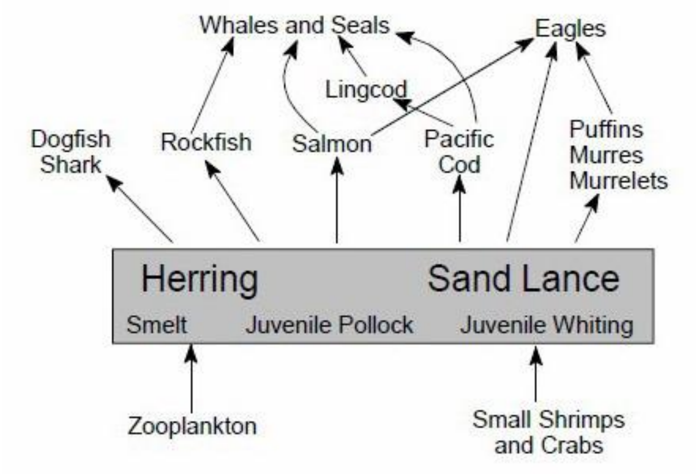

Figure 11. Simplified diagram of food web interactions in the Puget Sound area. (Adapted from Bargmann, 1998).

IMPACTS TO FORAGE FISH HABITAT

Since forage fish spawning habitat is created and maintained by natural geomorphic processes that include erosion, deposition, and littoral transport, shoreline modification is the primary threat to surf smelt and sand lance spawning beaches (Penttila 2005). Protecting forage fish spawning habitat entails maintaining or protecting the physical processes that form and maintain it. Specific impacts include the following:

1. Shoreline armouring and construction. Typical armouring and construction approaches that include rip rap and seawall construction result in an increase in the reflective energy of waves that steepens beach profiles and washes away crucial finer sediments.
2. Interruption of Sediment Supply. Groynes, docks, rip rap, etc, all have the potential to reduce natural erosion and impede littoral drift of sediments to maintain forage fish spawning habitat.
3. Removal of backshore vegetation. The removal of backshore vegetation can result in desiccation and thermal stress of summer smelt eggs, increases in pollution loading, and destabilization of shore profiles.
4. Shoreline Infilling. Lowland areas along shorelines have historically and frequently been infilled to increase developable area. These areas were often highly valuable salt marsh or tidal flat ecosystems. There has been a significant amount of infilling along the Campbell River shoreline over the past 100 years[12].

5.1.2 BACKSHORE VEGETATION

The backshore vegetation zone is delineated by the terrestrial vegetation zone starting with the more salt tolerant species in the supralittoral or splash zone above the high water mark and transitioning to more upland terrestrial plant communities.

IMPORTANCE AND FUNCTIONAL SIGNIFICANCE

Backshore vegetation plays several critical roles in maintaining natural system function along the Campbell River shoreline. These are outlined below.

1. Shade and Microclimate. Backshore vegetation plays an important role in moderating temperatures and maintaining moisture of substrates in the high intertidal zone. This is particularly important for summer Surf Smelt eggs that are subject to heat and moisture stress during periods of stranding at low tides.
2. Food Production. Shoreline vegetation provides habitat for a wide variety of invertebrate species that form a significant portion of the prey base for marine wildlife – particularly forage fish and salmonids (e.g. Healey, 1980).
3. Shoreline stabilization. Vegetation stabilizes and traps shoreline substrates and helps dissipate wave energy to maintain proper natural process functions along marine shorelines.
4. Pollutant Removal. Backshore vegetation filters pollutants from surface flows originating on terrestrial lands. In the case of the Campbell River shoreline, this is particularly significant due to the ubiquitous proximity of major roadways along the shoreline.

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[12] For example, portions of the Campbell River, Simms Creek and Willow Creek estuaries have been infilled (Shannon Anderson, DFO, Pers. Comm. (2011.)

5. Organic Matter and LWD Recruitment. Properly functioning backshore vegetation provides a continuous supply of organic matter to the shoreline system in the form of logs, smaller wood, and leaf litter. This material drives primary food production, provides microhabitats for numerous invertebrate species, helps maintain and regulate moist microhabitats, and dissipates wave energy (Brennan *et al.*, 2009).
6. Raptor Nest and Perch Sites. Mature trees in the backshore provide important perch sites adjacent to food sources for raptor species such as eagles and osprey.
7. Wildlife Migration. Intact backshore vegetation provides critical lateral migration routes along marine shorelines for a great number of terrestrial species.

IMPACTS TO BACKSHORE VEGETATION

The simplification and pronounced degradation of backshore habitats is ubiquitous along nearly all settled shoreline areas on Vancouver Island. Backshore areas are directly impacted by development and other land uses that result in the removal, topping, or trimming of vegetation. As well, indirect impacts to these areas can occur through the alteration of physical conditions that are required by the plant communities. These impacts include:

1. Shoreline defense structures such as rip rap and seawalls that physically eliminate microsites for vegetation as well as interrupt sediment processes to maintain them.
2. Changes to surface runoff patterns from upslope areas can cause erosion of shorelines and elimination of suitable growing sites.
3. Contaminant loading from roads and parking lots, which is a particularly significant effect along the Campbell River shoreline.
4. Introduction of invasive species (Himalayan blackberry, Japanese knotweed, English ivy, etc) that effectively occlude natural vegetation species and result in simplified habitats.

5.1.3 JUVENILE SALMONID REARING HABITAT AND ESTUARIES

Nearshore habitats utilized by juvenile salmonids species - which include anadromous cutthroat and steelhead trout in the Campbell River area – include nearly all components of the shoreline system. These include river and stream mouths, sand and mudflats, tidal marshes, sand spits, cobble, gravel, and sand intertidal areas, intertidal and subtidal eelgrass or macroalgae beds and kelp forests, and subtidal benthic areas.

IMPORTANCE AND FUNCTIONAL SIGNIFICANCE

Juvenile salmonids are dependant on the more shallow marine habitats of the nearshore system for food, protection from predation, a migration corridor, and a specific salt to freshwater transitional environment as they move from the freshwater to marine stages of their development. Juvenile salmonids benefit from nearly all of the attributes described above due to the fact that they are dependant upon nearly all of the natural systems processes of a properly functioning shoreline system. However, of particular importance are estuary regions with low wave energy, fine grained substrates of wetland and salt marsh areas with eelgrass or macroalgae beds. Juvenile salmonids typically utilize the nearshore zone most intensively between April and October (Groot and Margolis, 1991) Salmon stocks have been in steady decline in the Georgia Basin over the past 40 years (e.g. Simpson, 2002) and are at critically low levels (Stouder *et al.*, 1997).

TYPICAL SHORELINE ACTIVITIES THAT IMPACT JUVENILE SALMONID REARING HABITAT AND ESTUARIES

As juvenile salmonids benefit from nearly all of the habitat features described above, the impacts upon their key habitats have been discussed in the previous sections. In addition to the above-mentioned impacts, estuary areas along the Campbell River shoreline have been frequently infilled to increase useable land area and to minimize conflicts with roadways.

High quality habitat for juvenile salmonids (e.g. functional estuary habitat, mudflats, and eelgrass) results from very specific physiographic conditions and is therefore susceptible to disturbance and at the same time is difficult to replicate. This underscores the importance of preserving and protecting important estuary habitats rather than relying on future restoration efforts.

5.1.4 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION COMMUNITIES

Low intertidal to shallow subtidal vegetation species along the Campbell River shoreline that provide meaningful ecological function include eelgrass and kelp. These two species are important marine vegetation that are dependant upon specific environmental conditions in the nearshore system, including substrate, salinity, ambient light, and water quality. Specifically, eelgrass (*Zostera marina*) requires soft, fine substrates to establish a root system much like common terrestrial plants. Kelp - brown algae – attaches to rocky or other stable substrates in order to grow. Generally, eelgrass grows near the elevation of Mean Lower Low Water (MLLW) to depths of about 9 m below MLLW, while kelp can grow to depths of approximately 20 m.

IMPORTANCE AND FUNCTIONAL SIGNIFICANCE

Eelgrass and kelp provide a variety of important functions in the nearshore system, including:

1. Primary Producers. As these are photosynthetic plants, they are critical primary producers in the nearshore system. They generate nutrients that are important “building blocks” for a variety of invertebrates (e.g. copepods), crustaceans and fish species in the nearshore food web system. The growth of these plants also provides an important “carbon capture” function.

2. Spawning Habitat. Pacific herring and numerous crab species are highly dependant on kelp and eelgrass for the deposition of eggs during spawning activities. Newly hatched larvae are also dependant on these areas for rearing and protection from predators.
3. Refuge and Forage Habitat. These vegetation communities provide important refuge for numerous species including commercially valued juvenile salmonids and crustaceans.
4. Wave energy dissipation. Kelp forests and eelgrass beds dissipate wave energy that is otherwise transmitted to the shoreline, resulting in erosion of the nearshore system.

TYPICAL SHORELINE ACTIVITIES THAT IMPACT LOW INTERTIDAL TO SHALLOW SUBTIDAL VEGETATION COMMUNITIES

Shoreline modification activities are detrimental to the establishment and viability of these marine vegetation species. In particular, the following activities are known to impact these important resources:

1. Shoreline armouring – alters wave energy patterns that can affect substrate composition.
2. Stormwater and Septic runoff – marine vegetation is susceptible to impacts related to pollutant levels in stormwater runoff such as heavy metals, hydrocarbons, nutrient levels, and turbidity.
3. Removal of backshore vegetation – can alter temperature regimes and result in increases in turbidity and pollutants.
4. Direct alteration or infilling of substrates in the low intertidal and shallow subtidal zone.

Note that low intertidal shelf habitat is not addressed specifically in this assessment. The low intertidal shelf of the Campbell River shoreline primarily consists of cobble and boulder substrates usually lying on a rock shelf. As such, these habitats, though important, are generally not as susceptible to shoreline modification works as the other habitats discussed above.

5.2 RESULTS

The results of the Ecological ECA are shown on the **Map 3** series of sheets. The nearshore system within the study area is in poor condition in terms of ecological integrity and function. The assessment found the following general impacts that have resulted in a simplified shoreline system with low functional capacity:

- Extended sections of continuous shoreline armouring interspersed with discontinuous shoreline armouring;
- Proximity of major roadways and buildings to the nearshore system within most reaches;

- Elimination of most of the backshore vegetation; and,
- Release of untreated stormwater runoff from urbanized areas.

Due to the fact there are no feeder bluffs in the area, and shoreline armouring has blocked significant sediment sources from low-bank faces, sediment sources are primarily limited to river and stream sources. Furthermore, the existing conditions of the nearshore system limit the opportunities to restore biological function to the area without a significant commitment from the community.

Reach-specific assessment results are presented in the following sections and are based on the key attributes outlined in **Section 5.1** above. A summary table outlining the key assessment points and restoration priorities for each reach is provided at the end of each section. For reasons of consistency, the reach breaks used are consistent with those identified in the geomorphic analysis.

5.3 REACH 1 - SOUTHERN BEACHES – EXISTING ECOLOGICAL CONDITIONS

The Southern Beaches Reach extends from the southern study limit at Ocean Grove Road to the Ken Forde Boat Ramp Park south of the Willow Creek estuary. Moving north from Ocean Grove Road, land use along this reach is oceanfront landscaped residential with some mature conifer trees in the backshore for the first 600 m before transitioning to a long reach in which the shoreline closely parallels the South Island Highway. Throughout this section there are a series of small municipal parks (Seawalk and Ken Forde Boat Ramp Park) and the backshore zone is very thin as a result of the close proximity of the highway and seawalk. **Table 7** provides a summary of habitat condition in the reach.

5.3.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

Generally, substrates in the high intertidal zone along most of the length of this reach are thin and coarse, with a low sand content – likely a result of the rip rap armouring along much of the shore (**Photo 5a**) and lack of sediment sources in the drift cell. Moving north, however, the beach face widens and substrates transition to deeper fine pea gravels with a higher sand content at a point approximately 460 m south of the Ken Forde Boat Ramp (**Photo 5b**; **Map 3 – Sheet 1**).

RESTORATION OPPORTUNITIES

Priority restoration options to improve this habitat include re-establishing a natural beach profile in some areas using a “soft shore” approach, riparian planting with the objective to establish trees and overhanging shrubs along most of the shoreline for shade, and installing pollution control BMP’s for stormwater systems and surface road runoff (see Komori Wong Environmental, 2005).

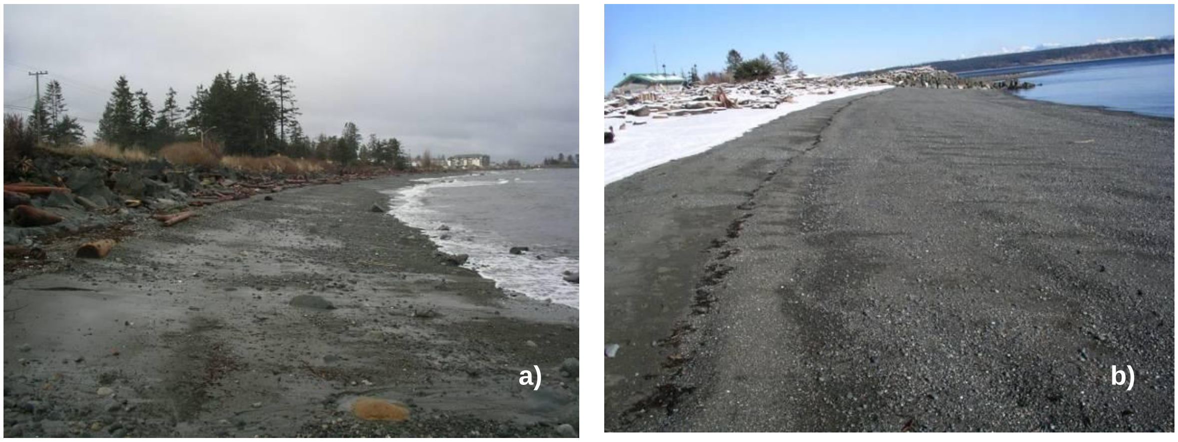

Photo 5. Typical shoreline profile within Reach 1 – Southern Beaches at a) reach midpoint, and b) near Ken Forde Boat Ramp.

5.3.2 BACKSHORE VEGETATION

Backshore vegetation along this section of the study area shoreline is limited by the close proximity of the South Island Highway, Seawalk, and residential buildings. There is a relatively short 200 m section of backshore habitat in the Ocean Grove Road area within which there are mature conifer trees interspersed with residential buildings that are providing shade, litterfall, and insects to the shoreline system (Photo 6). As well, these trees provide good perch sites for raptor birds; Bald Eagles were frequently observed to use these trees during the assessment. Between the southern limit of the seawall and Ken Forde Boat Ramp Park, there is a very narrow (2 m to 10 m) strip of vegetation that is dominated primarily by Nootka Rose and invasive species (Himalayan Blackberry, Scotch broom, orchard grasses), with some isolated and infrequent specimens of young alder, willow, Douglas fir, and hemlock. Vegetation species at the constructed estuary breakwater include a thin fringe of Japanese Rose (*Rosa rugosa,* non-native) and Scotch broom along the top of the riprap structure, with populations of grindelia, sea shore saltgrass, sea plantain, and common threesquare.

Photo 6. Typical shoreline near Ocean Grove Road.

RESTORATION OPPORTUNITIES

The entire section between the start of the Seawalk and the Ken Forde Boat Ramp should be planted with native vegetation species, with a particular emphasis on the establishment of conifer species due to the wide variety of benefits they provide (shade, food production, shore stabilization, LWD recruitment, esthetics). In particular, the wider grassy section at Ken Forde Boat Ramp Park should be planted with native species to improve backshore habitat function along the well-functioning beach at this location.

5.3.3 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION

There were no eelgrass or kelp communities observed or reported in the Coastal Resource Information Management System for this reach.

5.3.4 JUVENILE SALMONID REARING AND ESTUARY HABITAT

Juvenile salmonid rearing habitat within this reach is generally in poor condition and is limited by the near-total lack of functional backshore vegetation that is a result of the close proximity of the highway and seawalk, and the absence of low intertidal vegetation. It is expected that road and parking area runoff also release pollutants into the nearshore system that could possibly affect juvenile salmonids. The Willow Creek estuary has a crescent shaped rip rap breakwater that was apparently constructed to create some estuarine and mudflat habitat and to protect the Willow Creek culverts under the South Island Highway. This area is providing marginal function, but is limited by the small area, poor mixing of salt and freshwater during most tide elevations, and lack of functional backshore vegetation. Local residents report that historically, the Willow Creek estuary consisted of a long, spit that paralleled the shore and extended to Adams Road[13]. Generally, LWD was frequent along this reach, which would help to provide some microhabitats for invertebrate food sources for juvenile salmonids.

5.3.5 INCIDENTAL WILDLIFE OBSERVATIONS

Bald Eagles in perch trees, Great Blue Herons on rocks in low intertidal; Hooded Mergansers, Mallards, Black-bellied Plovers, and Gulls at Willow Creek estuary.

5.3.6 LOW TIDE TERRACE

Boulder and cobble mix on rock shelf.

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[13] Gordon McLaughlin and Chuck deSorcy, pers. comm., 2011.

Table 7. Existing Ecological Conditions Summary – Southern Beaches.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor	Road and seawalk encroachment; armour causing coarsening of substrates, steepening beach face, and backshore vegetation loss.	Good potential spawning substrates and LWD integrated into high beach berm along 460 m section to south of Ken Forde Boat Ramp	Seawalk Park Areas	Restore natural beach profile and increase finer substrate composition.	Good candidate areas for forage fish spawning habitat inventory program.
Backshore to Supratidal Vegetation	Poor to Poor-Moderate	Road and seawalk encroaching on backshore habitat - loss of vegetation and limited potential for restoration.	Some moderate riparian function (mature conifer trees) along residential shoreline near Ocean Grove Road.	Seawalk to Ken Forde Boat Ramp (parks).	Increase native conifer and shrub species; manage invasives.	Ken Ford Boat Ramp Park has large area for plantings.
Juvenile Salmonid and Estuary Habitat	Poor	General shoreline modifications.	Abundance of LWD in supralittoral zone.	-	-	Consider vegetating Willow Creek estuary breakwater and improving fresh/saltwater mixing?
Low Intertidal to Subtidal Vegetation	Poor to non-existent	General shoreline modifications.	-	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking in upland areas	

5.4 REACH 2 – WILLOW POINT – EXISTING ECOLOGICAL CONDITIONS

The Willow Point Reach extends from the Willow Creek estuary to Frank James Park. Land use along this reach is almost exclusively residential with three small municipally-held parks (Adams, Larwood and Jaycee Parks). Table 8 provides a summary of habitat condition within the reach.

5.4.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

Substrates in the high intertidal along this reach are very coarse with a low sand content – likely a result of the continuous and large-scale riprap and seawall shoreline defense structures along the large majority of the shore (Photo 7). There appeared to be a significant amount of riprap encroachment into the high intertidal zone throughout the reach. This has seriously impaired natural processes needed to sustain forage fish spawning habitat in the area; as such there is little to no potential forage fish spawning habitat within this reach. Herring have been reported to spawn on the eelgrass community off of Willow Point (see below). Willow Creek is likely a significant source of sediment for this reach, however there was very little evidence of finer pea gravels and coarse sand in the area.

Photo 7. Typical shoreline armouring in the Willow Point Reach.

RESTORATION OPPORTUNITIES

Restoration options to improve this habitat appear to be relatively limited as a result of the close proximity of houses to the shoreline and the heavy investment into riprap and seawall armouring. There may be opportunities for re-establishing a natural beach profile along residences fronting onto Adams Road.

Other restoration opportunities include backshore planting with the objective to establish trees and overhanging shrubs along the shoreline for shade, and installing pollution control BMP's for stormwater systems and surface road runoff. Backshore plantings should be focused at municipal parks; local residents should be encouraged to do the same on their properties.

5.4.2 BACKSHORE VEGETATION

Backshore vegetation along this section of the study area shoreline is limited by the close proximity of residential buildings along the entire reach. Mature trees and native shrubs are largely absent from the backshore zone; the area is primarily colonized by residential grasses and small ornamental shrubs and trees with patches of invasive species (Himalayan Blackberry and Scotch broom). Vegetation at both Larwood and Jaycee municipal parks is primarily turf grasses with a few 25-30 year old Douglas fir trees at Larwood Park. Adams Park has a number of ornamental shrubs and smaller trees with a very thin fringe of snowberry and dunegrass in the supralittoral zone (**Photo 8**).

Photo 8. Backshore vegetation at Adams Park.

There is a Bald Eagle nest tree reported on the municipal GIS data records located immediately south of "The Village" at Willow Point (**Map 3 – Sheet 1**). Eagle use of this nest tree was not observed during the field assessment.

RESTORATION OPPORTUNITIES

Residential land use severely limits the opportunities to enhance backshore vegetation along this reach. Efforts to increase the amount of native vegetation at the three municipal parks should be completed. Again, a particular emphasis on the establishment of conifer species due to the wide variety of benefits they provide (shade, food production, shore stabilization, LWD recruitment, aesthetics) should occur. In particular, the wider grassy section at Jaycee Park should be planted with native species to improve backshore habitat function at this location.

5.4.3 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION

There is a large kelp community in the high subtidal zone along the length of this reach as reported in the CRIMS GIS dataset. This is confirmed by local resident Gord McLaughlin; he has been completing photopoint monitoring of kelp communities on roughly the same date and tide elevation at seven sites in the southern Campbell River area at low tides since 2003. Mr. McLaughlin graciously shared his photos with the project team. The photo record shows a consistent community of kelp off this reach. It is reported that Pacific Herring have historically used this kelp community to spawn[14].

5.4.4 JUVENILE SALMONID REARING AND ESTUARY HABITAT

Juvenile salmonid rearing habitat within this reach is poor and is limited by the preponderance of riprap and seawall armouring. There is also a near-total lack of functional backshore vegetation that is also a result of the armouring as well as the residential landscaping and buildings. It is reported by local residents that the Willow Creek estuary once consisted of a long spit that paralleled the shore and extended to Adams Road but this has been eliminated[15]. Generally, LWD was lower in frequency along this reach; likely a result of the apparently high wave energies occurring in the area.

5.4.5 OTHER VALUES

A clam bed is reported off of Willow Point on the CRIMS GIS dataset (**Map 3 – Sheet 1**). Comments included with the spatial information indicate that the distribution of clams is patchy and “not a lot” in density.

5.4.6 INCIDENTAL WILDLIFE OBSERVATIONS

Mallards and Gulls at Adams Park; cormorants.

5.4.7 LOW TIDE TERRACE

Cobble dominated with boulders.

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[14] Steven Colwell, DFO Habitat Biologist., and Gord Mclaughlin pers. comm., 2011

[15] Chuck DeSorcy – Willow Creek Watershed Society; Tom Easton – Simms Creek Stewardship Society; Gord McLaughlin – local resident, Pers. Comm., 2010-11.

Table 8. Existing Ecological Conditions Summary – Willow Point.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor	Heavy shoreline armouring causing coarsening of substrates, steepening beach face, and backshore vegetation loss.	Potential Herring spawn on kelp beds.		Restore natural beach profile and increase finer substrate composition.	Adams Road residences interested in pilot project? Herring spawning reported off Willow Point.
Backshore to Supratidal Vegetation	Poor	Heavy shoreline armouring, residential buildings and landscape encroaching on backshore habitat - loss of vegetation and low potential for restoration.	None	Jaycee, Larwood and Adams Parks	Increase native conifer and shrub species; manage invasives.	Encourage landowners to enhance backshore vegetation.
Juvenile Salmonid and Estuary Habitat	Poor	Largescale elimination and modification of estuary habitat (Willow Creek); general shoreline modifications.	Moderate abundance of LWD in supralittoral zone.	-	-	
Low Intertidal to Subtidal Vegetation	Poor	General shoreline modifications.	Kelp communities in low tide/subtidal waters.	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking areas	

5.5 REACH 3 – MIDDLE BEACHES - EXISTING ECOLOGICAL CONDITIONS

Reach 3 is a long section of shoreline that extends from Frank James Park to South Hidden Harbour Park. For nearly the entire length of this reach, the South Island Highway closely parallels the marine shoreline and is usually within 15 meters of the high water mark. As such the backshore zone is very thin throughout this reach and is often less than 10 m wide. Throughout this section there are a series of small municipal parks (Frank James, Lift Station 7, Ellis, and Big Rock North and South, McCallum, Rotary Beach and Hidden Harbour Parks), that are immediately adjacent to the shoreline. There is one stretch of residential lots contiguous with the shoreline for a length of about 950 m between Big Rock Park North and McCallum Park. Table 9 provides a summary of habitat condition within the reach.

5.5.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

Substrates in the high intertidal zone at Frank James Park consist of continuous lengths of sand and pebble substrates greater than 5 m in width that appear to be appropriate for forage fish spawning (Photo 9; Map 3 – Sheet 1). There was also an intact supralittoral zone with integrated LWD that improves the potential for use of the area by forage fish. Moving north, appropriate forage fish spawning substrates and intact supralittoral zones were still observed, however suitable substrates became slightly more patchy, with some sections of coarse or thin substrates interspersed throughout the reach until a point 25 m north of Big Rock Park (north) at which point the substrates transition to cobble dominated areas with too few fines to support successful spawning habitat. The Simms Creek estuary appears to be a significant source of finer sediments for the beach system; these substrates are seeding potential spawning habitat in the local area. It is likely the constructed breakwater at the Simms Creek estuary is functioning to cause accretion of substrates at this location. Between a point 25 m north of Big Rock Park and

Photo 9. Substrates and intact supralittoral berm at Frank James Park.

Hidden Harbour South, substrates are too coarse and thin to provide meaningful potential for forage fish spawning. There is frequent riprap armouring throughout this section, and the supralittoral zone alternates between having intact sections with integrated LWD (**Photo 10a**) to simplified and steepened profiles dominated by riprap.

There is one final stretch of potential Forage Fish spawning habitat approximately 265 m long at Hidden Harbour Park (**Photo 10b**). Substrates at this location are a mix of fine pea gravels and sand, with an intact supralittoral zone that has large volumes of integrated LWD.

Pacific Herring may use the kelp beds in the low intertidal and shallow subtidal zone to spawn (see below).

Photo 10. Typical shoreline habitat conditions within Reach 3 – Middle Beaches: a) intact supralittoral zone near Simms Creek estuary, and b) invasive species and functioning supralittoral berm at Hidden Harbour Park.

RESTORATION OPPORTUNITIES

Priority restoration options to improve this habitat include re-establishing natural beach profiles and functional supralittoral berms along degraded areas of the shoreline using the “soft shore” approach. Several candidate beaches that are currently low in fine gravels were identified for substrate nourishment. Riparian planting along the entire reach with the objective to establish trees and overhanging shrubs along the shoreline for shade is strongly recommended. As well, installing pollution control BMP’s for stormwater systems and surface road runoff is suggested as a worthwhile effort.

5.5.2 BACKSHORE VEGETATION

As with the reaches further south, backshore vegetation along this long section of the study area shoreline is limited by the close proximity of the South Island Highway, seawalk, and to a lesser extent, residential buildings. Mature trees and native shrubs are largely absent from the backshore zone; the area is primarily colonized by residential grasses, invasive species such as Himalayan Blackberry, Scotch broom, and English Ivy (**Photo 11a**). There are sections along the shore (e.g. just south of the Simms Creek estuary) where a single line of 35 to 45 year old conifers have been retained (**Photo 11b**). These trees provide good habitat value and will increase in value as they mature. From an esthetic perspective, the trees look great; this section could be used as an example for future plantings along the Campbell River shoreline. Backshore vegetation at Lift Station No. 7 also includes a stand of mature conifers and some native shrubs; this section of the backshore habitat provides the one area rated as "moderate" value in this entire reach. Most of the shoreline in this reach does not have an intact supralittoral bench with integrated LWD with the exception of Frank James Park and portions close to Simms Creek estuary and Lift Station No 7 (**Photo 10a**).

There are no Bald Eagle nest trees reported within 30 m of the shoreline along this reach. Very few suitable perch trees were observed in the area as well.

Photo 11. Typical backshore habitat conditions within Reach 3 – Middle Beaches: a) invasive species and seawall in supralittoral zone near Big Rock Park, and b) conifer trees along the seawalk near Simms Creek estuary.

RESTORATION OPPORTUNITIES

Vegetation at the all of the municipal parks should be planted with native vegetation species, with a particular emphasis on the establishment of conifer species due to the wide variety of benefits they provide (shade, food production, shore stabilization, LWD recruitment, esthetics). In particular, the wider grassy sections at Frank James, Rotary, Simms, Big Rock, Rotary, and Hidden Harbour Parks should be addressed.

5.5.3 *LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION*

There is a large kelp community in the high subtidal zone along the length of this reach as reported in the CRIMS GIS dataset. This is confirmed by the photopoint monitoring completed by Gord McLaughlin. The photo record shows a consistent community of kelp off the shoreline in this reach.

5.5.4 JUVENILE SALMONID AND ESTUARY HABITAT

Juvenile salmonid rearing habitat within this reach is poor and is limited by the close proximity of the South Island Highway and Seawall, residential buildings and the open, grassy landscaping of the municipal parks. Over most sections, there is a severe lack of functional backshore vegetation that is also a result of the extensive armouring as well as the residential landscaping and buildings. The Simms Creek estuary is highly simplified by the intensive land development in the vicinity of the estuary. As with the Willow Creek estuary, local residents and Streamkeepers report[16] that the Simms Creek estuary once consisted of a long spit parallel to the shore and that extended to Rockland Road but this habitat has been eliminated within the past 70 years. Generally, LWD frequency along this reach was quite high.

The kelp community reported in the Coastal Resource Information Management System and documented by Mr. Mclaughlin provides valuable rearing and foraging habitat for juvenile salmonids in this area. The portion of the Simms Creek estuary that is reported to have been eliminated would likely have supported eelgrass habitat and other aquatic vegetation in this area.

5.5.5 INCIDENTAL WILDLIFE OBSERVATIONS

Great Blue Herons and cormorants on rocks in low intertidal; Mallards, Black-bellied Plovers, and Gulls at Willow Creek estuary.

5.5.6 LOW TIDE TERRACE

Boulder and cobble mix on rock shelf.

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[16] Chuck DeSorcy – Willow Creek Watershed Society; Tom Easton – Simms Creek Stewardship Society; Gord McLaughlin – local resident, Pers. Comm., 2010-11.

Table 9. Existing Ecological Conditions Summary – Middle Beaches.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor - Moderate	Road and seawalk encroachment; shoreline armouring causing coarsening of substrates, steepening beachface, and backshore vegetation loss.	Some sections with appropriate spawning substrates and intact supralittoral berms with integrated LWD (Frank James Park, Big Rock Park). Potential Herring spawn on kelp beds.	Municipal parks (Frank James, Seawalk, Ellis, Big Rock, McCallum, Rotary)	Restore natural beach profile and increase finer substrate composition.	Good candidate park areas for beach nourishment programs and forage fish spawning habitat inventory program.
Backshore to Supratidal Vegetation	Poor	Heavy shoreline armouring and residential buildings and landscape encroaching on backshore habitat - loss of vegetation and low potential for restoration.	-	Municipal parks (Frank James, Seawalk, Ellis, Big Rock, McCallum, Rotary)	Increase native conifer and shrub species; manage invasives.	Encourage landowners to enhance backshore vegetation.
Juvenile Salmonid and Estuary Habitat	Poor	Largescale elimination and modification of estuary habitat (Simms Creek); general shoreline modifications..	Abundance of LWD in supralittoral zone.	-	-	
Low Intertidal to Subtidal Vegetation	Poor - Moderate	General shoreline modifications.	Kelp communities in low tide/subtidal waters.	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking in upland areas	

5.6 REACH 4 – SOUTHERN BLUFFS - EXISTING ECOLOGICAL CONDITIONS

Reach 4 extends from Hidden Harbour Park north to the Maritime Heritage Center in the downtown core of Campbell River. The defining feature of this reach is that the backshore zone is relatively steep and climbs approximately 20 meters to a flat bench upon which residences, large hotels, and commercial buildings are constructed. Municipal parks fronting onto the shoreline include Sequoia and House on the Hill Parks. Due to the relative security and lower municipal control of the shoreline in this reach, field assessment results were deliberately limited to Sequoia Park and the area immediately south of the Maritime Heritage Center Park. There is a large breakwater constructed at Hidden Harbour to protect a marina at the southern limit of this reach. Table 10 provides a summary of habitat condition within the reach.

5.6.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

With the exception of a small beach immediately south of the breakwater at the Maritime Heritage Center, observations of substrates in the high intertidal zone along this reach indicate that there is a total lack of fine substrates that precludes forage fish spawning activity. Field results at Sequoia Park indicate that there is a functional/intact supralittoral zone with integrated LWD, however substrates in this reach are “starved” of fines and are dominated almost exclusively by cobbles (Photo 12a). This may be a result of the large breakwater at Hidden Harbour.

Photo 12. Typical substrate conditions within Reach 4 – Southern Bluffs: a) substrates in the high intertidal zone at Sequoia Park, and b) sediment accretion at the south side of the Marine Heritage Center Park breakwater.

The constructed breakwater at the Marine Heritage Center are causing localized accretion of finer substrates that are appropriate for forage fish spawning activity (Photo 12b).

RESTORATION OPPORTUNITIES

Due to the scarcity of finer substrates in spite of a moderately functioning backshore and poor accessibility to the area, there are no real viable restoration options to improve habitat in this reach. As always though, installing pollution control BMP's for stormwater systems and surface road runoff is suggested as a worthwhile effort.

5.6.2 BACKSHORE VEGETATION

Photo 13. Invasive species dominate the backshore vegetation at Sequoia Park (Aug. 2011).

Backshore vegetation at Sequoia Park consists of a reasonably wide (~25 m) vegetated area that is overwhelmingly dominated by invasive species (Himalayan Blackberry and English Ivy (Photo 13). Other areas show that there are isolated portions of backshore vegetation that contain trees, however these areas were not directly observed.

There are no Bald Eagle nest trees reported within 30 m of the shoreline along this reach. No suitable perch trees were observed in the area.

RESTORATION OPPORTUNITIES

The domination of backshore vegetation at Sequoia Park by invasive species will make it very difficult to establish a functional natural plant community. However, efforts to establish a forested stand along the toe of the slope would provide some benefit in terms of providing habitat for birds and food production for marine life.

5.6.3 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION

There is a large kelp community in the high subtidal zone that extends from Willow Point reported on the CRIMS dataset is indicated to continue along the length of this reach however this was not confirmed visually. Unfortunately, the photopoint monitoring completed by Gord McLaughlin did not cover this area.

5.6.4 JUVENILE SALMONID REARING AND ESTUARY HABITAT

There are no estuary habitats or substantial forested backshore areas in this reach. As such, juvenile salmonid rearing habitat within this reach is poor and is generally limited by the close proximity of the South Island Highway, residential and commercial buildings, and breakwaters. Juvenile salmonids have been reported to use the small beach immediately south of the Maritime Heritage Center for rearing[17]. Generally, LWD frequency along this reach was quite high. As mentioned, the kelp community reported in the Coastal Resource Information Management System provides valuable rearing and foraging habitat for juvenile salmonids in this area.

5.6.5 INCIDENTAL WILDLIFE OBSERVATIONS

Various gull species, cormorants.

5.6.6 LOW TIDE TERRACE

Cobble on rock shelf.

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[17] Shannon Anderson, DFO Biologist, Pers. Comm., 2011.

Table 10. Existing Ecological Conditions Summary – Southern Bluffs.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor	Some shoreline armouring causing coarsening of substrates, steepening beachface, and backshore vegetation loss.	Small accretionary beach immediately south of Marine Heritage Center; potential Herring spawn on kelp.	-	Restore natural beach profile and increase finer substrate composition.	Limited restoration options.
Backshore to Supratidal Vegetation	Poor	Heavy shoreline armouring and residential buildings and landscape encroaching on backshore habitat - loss of vegetation and low potential for restoration.	-	-	Increase native conifer and shrub species; manage invasives.	Encourage landowners to enhance backshore vegetation.
Juvenile Salmonid and Estuary Habitat	Poor	General shoreline modifications.	High abundance of LWD in supralittoral zone.	-	-	
Low Intertidal to Subtidal Vegetation	Poor - Moderate	General shoreline modifications.	Kelp communities in low tide/subtidal waters.	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking in upland areas	

5.7 REACH 5 – INDUSTRIAL – EXISTING ECOLOGICAL CONDITIONS

The Industrial Reach extends from the Marine Heritage Center in the south to the NVI Mining Terminal in the north on Spit Road. Land use along the shoreline is heavily developed and urbanized for commercial and industrial purposes with some public use amenities and parks as well. There are several very large marinas, BC Ferries and cruise ship terminals, and several large shopping center strip malls in the area. There are two municipally-held parks in this reach: Discovery Fishing Pier and Robert Ostler Park. The marine shoreline is highly modified throughout the entire length of this reach. These modifications include nearly one hundred percent coverage of the shoreline with large riprap (**Photo 14a**); near-total loss of backshore vegetation; and the release of pollutants from roads, parking areas, marinas, and industrial sites. Furthermore, there has been large-scale encroachment into nearshore habitats – some of which were once valuable wetland and salt marsh habitats associated with the Campbell River estuary[18] (Penfold, 2002). These include infilling low areas and the construction of numerous large breakwaters throughout the reach. **Table 11** provides a summary of habitat condition within the reach.

5.7.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

The pronounced modification of the shoreline has interrupted the physical processes that would sustain suitable spawning habitat for forage fish along this reach. As such, there is no potential spawning habitat for these fish in this area with one possible exception. This is the small sandy beach 250 m north of the Quadra Island Ferry Terminal; at this location there is an accretion zone created by a very large constructed breakwater; substrates at this location consist of a mix of fine sands and pea gravels that would likely support forage fish spawning activity (**Photo 14b**). Herring may spawn on offshore kelp and eelgrass communities within this reach (see below).

RESTORATION OPPORTUNITIES

Restoration options to increase forage fish spawning opportunities in this reach are very limited by the extensive armouring and nearshore development. Backshore planting along the abovementioned small beach with the objective to establish trees and overhanging shrubs along the shoreline for shade is one enhancement option; however it is limited by riprap placement and road alignments. If future monitoring confirms that this beach is used by forage fish for spawning, efforts to establish vegetation in the riprap zone should be considered. Installing pollution control BMP’s for stormwater

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[18] Shannon Anderson, DFO, Pers. Comm., 2010.

systems and surface road runoff is also recommended. Future opportunities for restoration may arise as lands within the reach are developed or re-developed.

Photo 14. **Typical foreshore and substrate conditions within Reach 5 – Industrial: a) breakwater located at the Government Wharf Marina (Discovery Pier in right side of photo), and b) small sand substrate beach located 250 north of the Ferry Terminal.**

5.7.2 BACKSHORE VEGETATION

Backshore vegetation along this section of the study area shoreline is very limited by the close proximity of roads, parking lots, buildings, and shoreline armouring along the entire reach. As such, trees and native shrubs are largely absent from the backshore zone. Vegetation at Robert Ostler Park consists primarily of turf grasses with a few 25-30 year old Douglas fir trees (Photo 15).

There are no Bald Eagle nest trees reported on the municipal GIS data records. Potential perch trees were also noted to be in very low abundance.

Photo 15. **Backshore vegetation at Robert Ostler Park.**

RESTORATION OPPORTUNITIES

Efforts to increase the amount of native vegetation at Robert Ostler Park should be considered. Again, a particular emphasis on the establishment of conifer species due to the wide variety of benefits they provide (shade, food production, raptor use) should occur.

5.7.3 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION

The large kelp community in the high subtidal zone continues along the length of this reach as reported in the CRIMS GIS dataset. This is also confirmed by local DFO agency staff[19]. While there were no eelgrass beds reported on the CRIMS data, Cynthia Durance, a biologist specializing in eelgrass management and inventory, provided approximated spatial information indicating that there are communities located at the small beach close to the ferry terminal, immediately adjacent to and inside the large breakwaters at the Discovery Harbour Marina, and along the shore between the cruise ship terminal and the southern limit of Dick Murphy Park (**Map 3 – Sheet 3**). These areas provide important rearing habitat for a wide variety of marine life.

5.7.4 JUVENILE SALMONID REARING AND ESTUARY HABITAT

In many ways, juvenile salmonid rearing habitat within this reach is very limited by the preponderance of riprap and seawall armouring, lack of backshore vegetation, and untreated stormwater release. However the existence of eelgrass and kelp communities helps to offset these impacts by providing good quality rearing and foraging habitat. DFO agency staff report that the small beach north of the ferry terminal has been confirmed as a rearing area for juvenile salmonids[20].

5.7.5 INCIDENTAL WILDLIFE OBSERVATIONS

Gulls at Robert Ostler Park.

5.7.6 LOW TIDE TERRACE

Unable to assess due to encroachment into nearshore habitats.

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[19] Shannon Anderson, DFO, Pers. Comm., 2010.
[20] Shannon Anderson, DFO, Pers. Comm., 2011.

Table 11. Existing Ecological Conditions Summary – Industrial.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor	Extensive encroachment; shoreline armouring causing coarsening of substrates, steepening beachface, and backshore vegetation loss.	Potential Herring spawn on kelp beds. Small beach north of ferry terminal has potential spawning habitat.		Restore natural beach profile and increase finer substrate composition.	Very limited restoration opportunities. Small beach near ferry term is a good candidate for forage fish spawn monitoring program.
Backshore to Supratidal Vegetation	Poor	Heavy shoreline armouring and extensive seaside development encroaching on backshore habitat - loss of vegetation and low potential for restoration.	None	Robert Ostler Park	Increase native conifer and shrub species; manage invasives.	High potential for restoration at Ostler Park. Establish vegetation at small accretion beach if forage fish spawning is confirmed.
Juvenile Salmonid and Estuary Habitat	Poor	Largescale elimination and modification of estuary habitat (Campbell River); general shoreline modifications; Low abundance of LWD in supralittoral zone.	Low abundance of LWD in supralittoral zone.	Small beach near ferry terminal.	Establish vegetation in riprap or along top of bank.	
Low Intertidal to Subtidal Vegetation	Poor - Moderate	General shoreline modifications.	Kelp communities in low tide/subtidal waters.	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking areas	

5.8 REACH 6 – ESTUARY - EXISTING ECOLOGICAL CONDITIONS

Reach 6 encompasses the shoreline reach from the NVI Mining Terminal along the shoreline face of Tyee Spit and across the mouth of the Campbell River to Painters Lodge on the north side of the Campbell River estuary. Due to the specific scope of this shoreline study to focus on problematic shoreline issues and the large existing body of inventory work already completed on the estuary, this assessment will focus on the nearshore habitat of Dick Murphy Park and to a lesser extent on the shoreline areas north side of the Campbell River estuary.

Table 12 provides a summary of habitat condition within the reach. However, it is important to note that from a biodiversity and fisheries productivity perspective, the Campbell River is an extremely important ecological area within Campbell River. The estuary provides a unique array of biophysical conditions that supply critical habitats for various wildlife species that include the following key functions:

- Specific fresh and saltwater conditions to help anadromous fishes gradually acclimate to marine or freshwater life history stages;
- Highly productive forage habitat for salmonids and other wildlife;
- Diverse habitats (saltwater marsh, mudflats, eelgrass beds, etc) that support highly diverse biological communities.

Long-term planning and management efforts to protect, enhance, and restore the Campbell River estuary are crucial to the health of natural systems in the Campbell River region.

5.8.1 *FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY*

Upon first inspection, substrates in the high intertidal zone along the northern reach of Dick Murphy Park appear to be well suited for forage fish spawning habitat due to the prevalence of finer pea gravels of a good depth and width along the shore and the existence of a functional supralittoral bench with integrated LWD. However, closer analysis of the substrates indicate there is a low fraction of sand within the substrates that will limit the effectiveness of the spawning habitat due to problems related to desiccation and the inherent preferences displayed by these fish (Photo 16a). Portions of this beach have been recently restored to re-establish a natural beach profile and functional supralittoral bench (Photo 16b); it is expected that the parent material used for this work was originally low in sand and fines and that the disconnected drift cell processes related to the large breakwaters to the south are limiting fine sediment sources to the area.

Photo 16. Typical substrate and foreshore within Reach 6 – Estuary: a) substrates lacking in finer sand component at Dick Murphy Park, and b) shoreline profile at Dick Murphy Park. Note sparse backshore vegetation.

There are numerous eelgrass beds noted in the area that likely provide important spawning habitat for Pacific Herring (more below).

Furthermore, there is a lack of tree species and overhanging shrub vegetation along the Dick Murphy Park shoreline that will limit the viability of summer smelt eggs. The fact that this beach area is northeast facing will help mediate this effect.

RESTORATION OPPORTUNITIES

As there is already a very good structural framework along this reach, measures to increase the fine sand content of substrates along this reach would be a valuable undertaking. Riparian planting along the entire reach with the objective to establish trees and overhanging shrubs along the shoreline for shade is also strongly recommended.

5.8.2 BACKSHORE VEGETATION

Along the southernmost 400 m of this reach, backshore vegetation is somewhat limited by the close proximity of Spit Road. North of this, the amount of available backshore habitat increases significantly. Mature trees and native shrubs are largely absent from the backshore zone throughout this reach; the area is primarily colonized by residential grasses (orchardgrass) with some populations of dunegrass, Nootka rose, Scotch broom, yarrow, moss species, and curly dock (**Photo 17**).

There are no Bald Eagle nest trees reported within 30 m of the shoreline along this reach. Very few suitable perch trees were observed in the area as well. There are several nest trees reported to exist further inside the estuary (**Map 3 – Sheet 3**).

RESTORATION OPPORTUNITIES

It may be argued that spits such as these are not naturally colonized by forest communities; however, the overall scarcity of mature trees along the entire Campbell River shoreline dictates that efforts to establish any trees along the shore would be worthwhile. Vegetation at Dick Murphy Park should be planted with native vegetation species, with a particular emphasis on the establishment of conifer species due to the wide variety of benefits they provide (shade, food production, shore stabilization, LWD recruitment, and aesthetics). There are also isolated specimens of Scotch Broom and Himalayan Blackberry that can be managed without too much effort.

Photo 17. Typical backshore plant community at Dick Murphy Park.

5.8.3 *LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION*

The large kelp community in the high subtidal zone does not extend north to this reach as reported in the CRIMS GIS dataset and by DFO agency staff[21]. Not surprisingly, numerous eelgrass beds are reported to exist in this area on the CRIMS dataset and by spatial information provided by Cynthia Durance (**Map 3 – Sheet 3**). These areas are important rearing and forage habitat for a wide variety of marine life.

5.8.4 *JUVENILE SALMONID REARING AND ESTUARY HABITAT*

This area provides important Juvenile Salmonid Rearing Habitat as it provides the unique salt and freshwater mixing and productive forage and rearing habitat as evidenced by the existence of tidal flats and eelgrass beds. Over most of the reach, there is a lack of functional backshore vegetation (trees and shrubs). Generally, LWD frequency along this reach was moderate.

5.8.5 *INCIDENTAL WILDLIFE OBSERVATIONS*

Abundant shorebirds were noted within the estuary that included: Common Murre’s, Gulls, Northern Shovelers, Scaups, Common Goldeneys, and Buffleheads. Bald Eagles

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[21] Shannon Anderson, DFO, Pers. Comm., 2010.

were also observed in flight and perched in mature trees on the backshore areas of the Campbell River estuary.

Table 12. Existing Ecological Conditions Summary – Estuary.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor - Moderate	Some road and seawalk encroachment; low fine content in substrates limiting potential of habitat.	Good beach face structure and intact supralittoral berms with integrated LWD Potential Herring spawn on eelgrass beds.	Dick Murphy Park	Increase fine sand content in high intertidal substrates.	Possible that parent beach restoration material was originally low in sand/fines? Good candidate areas for forage fish spawning habitat inventory program.
Backshore to Supratidal Vegetation	Poor - Moderate	Sections of road and shoreline armouring encroaching on backshore habitat.	Large areas of grassed backshore habitat, few buildings.	Dick Murphy Park	Increase native conifer and shrub species; manage invasives.	High potential for good value restoration success.
Juvenile Salmonid and Estuary Habitat	Moderate – Good	Elimination and modification of estuary habitat (Campbell River); general shoreline modifications..	Eelgrass beds, mudflats. Marshlands inside estuary; abundance of LWD in supralittoral zone along outside shoreline.	Area inside estuary not addressed	Area inside estuary not addressed	
Low Intertidal to Subtidal Vegetation	Moderate	General shoreline modifications.	Eelgrass communities reported along shoreline.	-	-	Potential for cruise ship traffic to impact?
Stormwater System	Moderate	Some pollutants from untreated storm and road runoff.	Soils are sand and surface runoff should infiltrate well.	-	Pollution control BMP's along roads and parking in upland areas	

5.9 REACH 7 – NORTHERN BLUFFS - EXISTING ECOLOGICAL CONDITIONS

Reach 7 is comprised of the shoreline area extending north from Painters Lodge to the end of Orange Point Road. Land use along this reach is primarily residential with the exception some limited areas of open field near the southernmost 400 m of the reach. This reach is characterized as having a rock shelf intertidal zone with a relatively steep backshore "bluff" varying between approximate height of 4-13 meters and a width of between 3 m to 10 m. Boulder substrates along the intertidal shelf have been extensively removed and arranged into windrows by local residents and shore users to form boat and walking access points to deeper water and possibly in an effort to alleviate shoreline wave energy[22]. **Table 13** provides a summary of habitat condition within the reach.

5.9.1 FORAGE FISH SPAWNING HABITAT AND ENHANCEMENT SUITABILITY

Substrates in the mean to high water zone consisted of mucky fines colonized by Nootka reedgrass over the southernmost 700 m of this reach. Due to the low motility of the sediment, the potential for forage fish spawning is very low. Starting at Painters Lodge, substrates become less fine, with scattered pockets of fine sands and pea pebble substrates that appear to be appropriate for forage fish spawning. The frequent arrangement of intertidal boulders and cobbles into windrows has impacted the longshore drift processes that has resulted in a patchy distribution of finer spawning substrates throughout most of the reach. There are numerous eelgrass beds noted in the area that likely provide important spawning habitat for Pacific Herring (more below).

Generally, backshore vegetation is providing moderate to good shade and cover to shoreline substrates along the northernmost 650 meters of this reach as a result of the treed bluff area. Over the remaining sections, of this reach, shade for summer smelt is poor as a result of the proximity of residential buildlings and landscaped yards.

RESTORATION OPPORTUNITIES

As the Campbell River is likely providing an abundance of finer substrates to nourish beach faces along this reach, a possible option to improve forage fish spawning suitability could involve redistributing the windrowed boulders into a more natural scattered pattern to restore drift cell function in the area.

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[22] Steve Colwell, DFO, Pers. Comm., 2010.

5.9.2 *BACKSHORE VEGETATION*

Photo 18. Backshore habitat along the northern bluffs (background) and foreshore (foreground).

Backshore habitat varied significantly throughout the reach as a result of the proximity of residential buildings and steep bluffs and slopes that limit the ability to build houses close to the shoreline. As such, backshore vegetation is providing moderate to good function along the northern portion of the reach due to the existence of the treed, steep bluff zone. Tree species along this backshore area include Douglas fir, red alder, bigleaf maple, cedar and hemlock trees, with sub-canopy populations of willow and red osier dogwood (**Photo 18**; **Map 3 – Sheet 4**). Invasive species (English Ivy, Himalayan Blackberry, periwinkle) have colonized extensive portions of the backshore vegetation along this reach and threaten many of the mature trees along the bluff (**Photo 19**). Moving southward, backshore vegetation decreases significantly as a result of the closer proximity of residential buildings to the shoreline.

There are no Bald Eagle nest trees reported within 30 m of the shoreline along this reach. Several suitable perch trees were observed in the area – in particular mature conifers along the northern bluffs, and adjacent to the shoreline in the southern portion of the reach.

RESTORATION OPPORTUNITIES

Local residents should be encouraged to increase the number of conifer trees along the shoreline throughout this area.

5.9.3 *LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION*

Again, numerous eelgrass beds are reported to exist in the southern portion of this reach on the CRIMS dataset and by spatial information provided by Cynthia Durance (**Map 3 – Sheet 4**). These areas are important rearing and forage habitat for a wide variety of marine life.

5.9.4 JUVENILE SALMONID AND ESTUARY HABITAT

The southern portions of this reach provide important Juvenile Salmonid Rearing Habitat as it supplies unique salt and freshwater mixing processes and productive forage and rearing habitat as evidenced by the existence of tidal flats and eelgrass beds. Moving northward, the variable backshore vegetation provides patchy functional habitat for fish food production and cover. Generally, LWD frequency along this reach was low.

Photo 19. Invasive species are prevalent in the backshore vegetation throughout most of the Northern Bluffs Reach .

5.9.5 OTHER VALUES

There is a recreational Dungeness Crab fishery reported at the mouth of the Campbell River. Comments provided with the data indicate the fishery is very productive and highly used[23].

5.9.6 INCIDENTAL WILDLIFE OBSERVATIONS

Abundant shorebirds that included Common Murre’s, Gulls, Northern Shovelers, Scaups, Common Goldeneyes, and Buffleheads. Bald Eagles were observed perched atop mature conifers on top of the bluffs near McDonald Road.

5.9.7 LOW TIDE TERRACE

Not observed.

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[23] Information cited in 1993.

Table 13. Existing Ecological Conditions Summary – Northern Bluffs.

Key Attribute	General Condition	Main Impacts	Functional Attributes	Possible Restoration/ Enhancement Sections	Restoration/ Enhancement Objectives	Other Comments
Forage Fish Habitat	Poor - Moderate	Arrangement of boulder/cobble substrates into windrows is impacting littoral drift system.	Patches of good potential spawning substrates and LWD integrated into high beach berm; Herring spawning habitat on eelgrass beds.	Low tide bench from Painters Lodge north.	Take advantage of Campbell River sediment source: restore natural littoral drift system by redistributing boulders and cobbles.	Good candidate areas for forage fish spawning habitat inventory program.
Backshore to Supratidal Vegetation	Poor - Moderate	Residential landscaping - loss of natural forest community vegetation.	Some moderate riparian function (mature conifer trees) along steeper bluff section.	Residential areas.	Increase native conifer and shrub species; manage invasives.	Encourage landowners to enhance backshore vegetation.
Juvenile Salmonid and Estuary Habitat	Moderate – Good	General shoreline modifications (residential landscaping).	Productive mudflats, eelgrass habitat; abundance of LWD in supralittoral zone.	-	-	
Low Intertidal to Subtidal Vegetation	Good		Large eelgrass beds reported.	-	-	
Stormwater System	Poor	Pollutants from untreated storm and road runoff.	-	-	Pollution control BMP's along roads and parking in upland areas	

5.10 SUMMARY OF ECOLOGICAL ASSESSMENT

Within the study bounds, the Campbell River nearshore, including the backshore area, has been extensively modified as a result of a long history of waterfront development. From the perspective of ecological function, the intensive development has resulted in a simplified system characterized by having limited backshore vegetation communities resulting from the proximity of roads and buildings, extensive shoreline armouring (rip rap and concrete seawalls), frequent seaward encroachment into shoreline habitats, problematic erosion, impairment of natural sediment sources and littoral drift processes, elimination and modification of estuarine habitats, and the release of pollutants from stormwater systems.

Fortunately, there are numerous opportunities to restore some of the lost habitat function to along the shoreline. The effort and cost that will be needed to implement restorative measures will vary considerably, and in some cases such as establishing vegetation in residential areas, may require public outreach or incentive programs. Restoration opportunities are presented in Chapter 7.

For this assessment, emphasis has been placed on four main habitat types due to the critical importance of these attributes to maintaining ecological integrity of the shoreline system as well as their utility as components of a management framework for the management of shorelines. The existing condition of these four main habitat types within the study area is summarized below.

5.10.1 FORAGE FISH SPAWNING HABITAT

Shoreline armouring, specifically rip rap, concrete seawalls and breakwater and jetty structures have increased the reflective energy of waves, cut off natural sediment sources, and eliminated supralittoral bench habitats along the majority of the Campbell River shoreline. This has resulted in the coarsening of substrates in the upper intertidal area and decreased or eliminated the suitability of substrates for forage fish spawning. Further impacts to forage fish spawning habitat include pollutant loading to shoreline system from stormwater systems, and the elimination of backshore vegetation that provides shade which is critical to the viability of summer smelt eggs. Overall, these impacts are exacerbated by a general lack of sediment sources in the Campbell River area. Forage fish form the cornerstone of marine food webs due to their pivotal role of transferring secondary production to higher trophic levels.

Currently, in spite of the poor health of the Campbell River shoreline, there are a few areas within the study area that have substrates that appear to be suitable for forage fish spawning. These include the beach immediately south of the Ken Forde Boat Ramp, Frank James Park, a portion of Hidden Harbour Park, and two smaller beaches adjacent to large breakwaters at Heritage Discovery Marina and north of the BC Ferries Terminal

(**Map 3 – Sheet 3**). The area between Frank James and Big Rock Parks also appears to have suitable substrates for forage fish spawning but in a more patchy distribution.

5.10.2 BACKSHORE VEGETATION

Backshore vegetation within the study area has largely been eliminated by the ubiquitous placement of rip rap and the close proximity of the seawall and roads, residential buildings, and commercial or industrial structures in the high intertidal shoreline zone. Where there are strips of vegetation along the shoreline, native vegetation has commonly been displaced by invasive species that include Himalayan blackberry, Scotch broom, and English ivy. As mentioned, the loss of backshore vegetation results in decreased levels of shade which is critical to the viability of summer smelt eggs. The lack of mature conifer species and overhanging shrubs along the study area shoreline have resulted in a degradation of food production for juvenile salmonids and other wildlife, loss of nest and perch sites for raptors, destabilized or erosion-prone shoreline substrates, very poor wildlife migration corridors, and impaired filtration of surface flows from upslope areas.

There are no reaches with “high quality” backshore vegetation within the study area. There were several reaches characterized as having “moderate” habitat value; these are Lift Station 7 Park, a small section near Hidden Harbour, Robert Ostler Park area, and along the bluffs of the northernmost 640 m of the study area.

5.10.3 JUVENILE SALMONID REARING AND ESTUARY HABITAT

The extensive development and modification of the Campbell River nearshore has resulted in the degradation of important habitats for juvenile salmonids. Due to their preference for migrating along and rearing in shallow marine habitats and estuaries during their early life history stages, juvenile salmonids are dependant upon the full spectrum of nearshore habitat types. The most significant impacts to these habitats include the following:

1. Large-scale elimination and simplification of estuary habitats of Willow and Simms Creeks and of extensive salt marsh habitats of the Campbell River estuary has reduced the availability of critical feeding, nursery, and fresh-salt water acclimation areas required by these fish.
2. The elimination of the majority of the backshore vegetation, extensive shore armouring, and loss of functional storm berm, have cut off important food sources for these fish such as insect drop from overhanging vegetation and invertebrate productivity within finer beach substrates.
3. The proximity of busy roads, parking areas, and impervious city landscapes results in the release of untreated stormwater runoff into the nearshore area that degrades salmonid productivity through reducing the quality and quantity of food and rearing and foraging habitat.

5.10.4 LOW INTERTIDAL AND SHALLOW SUBTIDAL VEGETATION

There is a large band of bull kelp that extends from Willow Point to the cruise ship terminal near the Campbell River estuary in the north. This kelp community benefits from the strong currents and rocky substrates in the high subtidal and shallow low intertidal zone, and provides nursery rearing habitat for fish and invertebrate species, and foraging habitat for a wide variety of wildlife. Importantly, Pacific Herring use the bull kelp stands to spawn along the Campbell River shoreline.

Eelgrass communities, on the other hand, are much less frequent than kelp in the area. Land-use practices such as infilling and modifying estuary and salt marsh habitats, shoreline armouring, dredging, and water quality impacts related to stormwater runoff have undoubtedly resulted in a decrease in the abundance and distribution of this critical component of the nearshore system.

As one would expect, there are communities of eelgrass reported within the Campbell River estuary. As well, there are smaller eelgrass beds reported between the cruise ship terminal north to the southern end of Dick Murphy Park, within the breakwaters of Discovery Harbour Marina, and in front of the smaller beach just north of the BC Ferries Terminal (**Map 3 – Sheet 3**). Considering the historical loss and scarcity of eelgrass habitat in the Campbell River area, these areas should be managed for their long-term protection and expansion.

5.10.5 OPPORTUNITIES TO RESTORE SHORELINE FUNCTION

In summary, the nearshore system of the Campbell River area is in a degraded state of functional condition. Thankfully, there a large number of opportunities to restore habitat and natural systems processes within the study area. These opportunities range widely in cost and ease of implementation. Restoration opportunities include the following:

1. Establish Backshore Vegetation. Despite the constraints imposed by the proximity of roads, seawalk, and buildings throughout the study area, there are a great number of opportunities to effectively improve the condition of backshore vegetation. There are frequent sections of existing parkland within which native tree and shrub species can be established with minimal cost. As well, local landowners should be encouraged to improve backshore vegetation on private property, possibly through the implementation of public outreach and incentive campaigns. A potential obstacle to this form of restoration may be the reluctance of landowners living across the South Island Highway from the shoreline due to concerns over impacts to viewscapes. A possible way to alleviate these concerns may be through the use of positive examples of functional backshore areas that also have strong aesthetic values. Candidate areas include Lift Station 7, the roadside area south of the Simms Creek estuary, and the neighbourhood at the end of Ocean Grove Road.

2. Re-establish Natural Shore Profile and Supra Littoral Bench. Despite being known as the "Salmon Capital of the World", the shoreline area has been modified to the point where there is very little functional value to support the productivity of salmonids and the myriad of other wildlife that are dependent upon the shore.
3. Install Stormwater Pollution Control BMPs. Stormwater pollution control is generally lacking along the study reach. The infiltration gallery that has been installed at the end of Ocean Grove Road, which appears to be functioning well, is an exception to this observation. Best Management Practices for the treatment of stormwater are outlined in the Campbell River Integrated Stormwater Management Plan (e.g. Komori Wong Environmental, 2005). There are many ecological benefits, such as mitigation of pollutants and dispersion of freshwater inputs, but there is relatively high cost involved because of the physical infrastructure that is required. Incorporation of pollution control BMPs as part of redevelopment, upgrades, and future projects is recommended rather than a stand-alone program of upgrades.

6 DEVELOPMENT GUIDELINES BACKGROUND AND RATIONALE

6.1 VALUES

In this report, we focus on the marine shoreline as a *natural resource*. Natural resources might be traditionally thought of as components of the landscape that are harvested, such as wildlife, forests, minerals or wild fish stocks. However, a natural resource can also be a scenic landscape that provides value as part of a national parks system, a mountain slope that is transformed into a ski hill, a water body that is highly valued as a boating destination, etc. The marine shoreline can also be classified as a natural resource since, as a distinct landscape unit, it provides a wide range of values to humans.

Indeed, the Campbell River shoreline provides a diverse range of resource values. The following list provides a summary of key values that the Campbell River community derives from its shoreline (adapted from SACPB, 1993):

RECREATION AND LEISURE ACTIVITIES:

i. Active Recreation – Swimming, wind surfing, sailing, boating, jet-skiing, kayaking, fishing, beach games, and general exercise.
   1. In Campbell River, the sea walk benefits from close proximity to the shoreline and the sea walk provides an additional subset of active recreation activities, such as rollerblading, running, cycling and walking.

ii. Passive Recreation – Relaxation on the beach, fishing, beachcombing, walking, dog walking, sunbathing, storm watching, picnicking, casual public gatherings.

PUBLIC ACCESS:

i. Access to the shoreline serves as a defining public amenity for recreation and leisure in Campbell River

ii. The shoreline also serves as a popular venue for small and sometimes large scale public or community events that suit the seaside geography and particular community interests. Some of these events may be in existence already in Campbell River, or may have the potential to exist in the future given a vibrant and publically accessible shoreline (i.e. fishing derby, motorcycle tour route, water races, chainsaw carving event, etc).

BEACH VIEWS AND COASTAL AESTHETICS:

i. Generally, preference exists for natural scenic vistas along shorelines, except for shorelines in urban areas. Urban shorelines are typically places where facilities (such as marinas, boat launches, ferry terminals and waterfront walkways) provide options, energy, excitement and vibrancy, or are just interesting places to watch life go by.

ii. Views of the shoreline are enjoyed in three ways: 1) from a boaters' perspective viewing the shoreline from sea; 2) from a beach users' perspective, viewing along the shoreline; and 3) from land-based activities viewing out to sea – all three 'critical observer viewpoints' provide value to the community, depending on the activity or use of the shoreline.

iii. The shoreline provides Campbell River with a 'sense of place'. It has literally shaped the settlement form of the community, and provides residents with opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience (de Groot, *et. al*, 2002).

SHORELINE PROPERTIES:

i. Real estate along a shoreline is generally valued higher than upland properties.

ii. Properties located close to publically accessible shoreline amenities like parks and waterfront walkways are typically valued higher, even if not located immediately adjacent to the shoreline - a public shoreline can provide incremental tax benefits to communities in this way (Smith, 1993; Quayle & Hamilton, 1999).

iii. Property value is fiercely defended along shorelines – both engineered and *ad hoc* foreshore protection works are common (ie: riprap walls, concrete seawalls, groynes and other erosion prevention devices) and are intended to benefit property values along the shoreline by preventing loss of use or potential damage to buildings and facilities from storm-generated waves.

TOURISM POTENTIAL:

i. A tourism attraction in and of itself, the shoreline in Campbell River provides two important values to the city's key tourism drivers as follows:
    1. The shoreline provides the scenic foreground and recreation amenity to a large number of accommodation/hospitality establishments; and
    2. The shoreline houses important ecological processes that support juvenile salmonid and forage fish populations (which in turn have a direct impact on local salmon, waterfowl and marine mammal populations, and other tourism drivers such as whale watching, birding, fishing, etc).

ii. Striving towards a vibrant, public shoreline with a stronger link to tourism has been a successful and profitable policy in other shoreline communities (BCDC, 2005).

COMMERCIAL POTENTIAL:

i. The Campbell River shoreline houses a diversity of commercial and industrial activities that define the character of portions of the shoreline (ie: marinas, hotels, transportation nodes and industrial sites).
ii. Shoreline properties, at least in part, help fuel the real estate and development sectors of the local economy and provide for a diversity of real estate product.
iii. Tourism has a strong link to the shoreline as noted above.
iv. The shoreline supports juvenile salmonid and forage fish populations that not only affect the sport fishing industry, but also commercial fishing stocks. As such, there is an important link between local commerce and shoreline habitat for feed fish populations.

ECOLOGICAL VALUES:

i. A healthy, natural shoreline typically provides a concentration of ecological services. In the Campbell River area in particular, a natural sediment shore (that would have been characteristic of much of the shoreline pre-development) serves to:
    a. Filter pollutants including sediment;
    b. House photosynthesis/primary productivity/carbon cycling in shallow productive zones;
    c. Support diverse marine shoreline ecologies and has critical links to other community values, including:
        i. Nursery rearing, fish and bird migration, and food production (invertebrate and forage fish);
        ii. Shoreline aesthetic;
        iii. Forage fish spawning along sediment shorelines – forage fish are a critical food source for salmonids, marine mammals, migratory birds, and waterfowl; and
        iv. Eelgrass beds, salt marsh and kelp beds – these are important food production areas (primary producers) and critical habitats for a wide variety of marine species that include forage fish, salmonids and crabs).
ii. Dissipate wave energy, protecting property values – there is a critical shift in thinking that is required around seawall construction and removal of backshore since seawalls cause loss of ecological values and are less effective at dissipating energy than a natural shoreline – this shift in thinking is fully supported by the federal Department of Fisheries and Oceans and provincial Ministry of Environment.

ARCHAEOLOGICAL VALUES:

i. Aboriginal communities frequented the shoreline as is evidenced by numerous midden deposits and other artefacts commonly found along the shoreline on the east coast of Vancouver Island. Portions of the Campbell River shoreline may house archaeologically significant features (note that archaeological explorations are outside of the scope of this report and will only be addressed peripherally).

OPTION AND BEQUEST VALUES:

i. Existence value – the value derived from knowing that a public resource is available and protected for current and future generations;
ii. Option value – the value of something set aside for future use;
iii. Bequest value – the value to the current generation of preserving an amenity for future generations.

All of the listed values above relate to the Campbell River shoreline. As one might imagine, some of the values are not necessarily compatible, depending on how the shoreline is managed. For example, coastal ecologists are increasingly recognizing that placing rip rap along the shore to protect against erosion and protect property values is causing the loss of habitat for salmonids and forage fish spawning (i.e. ecological values). Small fish, like Surf Smelt and Sand Lance, that support salmon populations are lost when sea walls are built, because they spawn along the highest part of the beach - precisely where sea walls are built. Also, the loss of backshore vegetation along seashores results in loss of cover and food production for the nearshore system. The list of values above highlights the importance of the shoreline as a natural resource, but also begins to identify that management of this natural resource is not a simple proposition if maximum *and* diverse values are to be derived. The following comparison matrix (**Table 14**) shows how values derived from a shoreline might conflict.

But where, specifically, along the Campbell River shoreline might current management practices be in need of adjustment to better balance values? Are there locations where specific values are currently favoured and what values, if any, have been lost as a consequence? To address these questions, the current condition of the Campbell River shoreline will be summarized in **Section 6.2** below.

Table 14. **Comparison Matrix: Not all shoreline values are compatible under current management approaches.***

VALUE:	recreation and leisure	public access	views/aesthetics	shoreline properties	tourism	commercial	ecological integrity	archaeological values	option and bequest
recreation and leisure	⬜								
public access	🟩	⬜							
views/aesthetics	🟩	🟩	⬜						
shoreline properties	🟧	🟧	🟧	⬜					
tourism	🟩	🟩	🟩	🟧	⬜				
commercial	🟧	🟧	🟧	🟩	🟩	⬜			
ecological integrity	🟩	🟩	🟩	🟧	🟧	🟧	⬜		
archaeological values	🟩	🟩	🟩	🟧	🟩	🟧	🟩	⬜	
option and bequest	🟩	🟩	🟩	🟧	🟩	🟧	🟩	🟩	⬜

🟩 Compatible
🟧 Potential Conflict

*compatibility may vary depending on assumption of shoreline management approaches used.

6.2 SWOT: STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

Understanding the current condition of the Campbell River shoreline is of critical importance, prior to preparing guidelines for management. In essence, the summary of current conditions that follows fits between values and guidelines in the following manner:

1. Values (presented above) clearly identify how property owners and the community as a whole can benefit from the shoreline in different ways;
2. Exploration of the current conditions (this section) helps identify those areas where an imbalance or loss of values exists; and
3. Guidelines (**Section 6.3** below) suggest general strategies for re-balancing or restoring lost values.

A significant effort has been placed on exploring the current condition of the Campbell River shoreline. This section presents a synthesis of detailed observations for segments or 'reaches' of the Campbell River shoreline as outlined in **Chapter 3**.

The approach used in this section to synthesize observations on current conditions is called a SWOT analysis, which presents Strengths, Weaknesses, Opportunities and Threats to shoreline values for specific sections of the shoreline as follows:

- Strengths – identifies values of a specific shoreline reach that are intact;
- Weaknesses – identifies values that are degraded;
- Opportunities – identifies those degraded values that can be restored through reasonable inputs or interventions; and
- Threats – identifies currently intact values that are at risk of being degraded.

The following sections outline the SWOT analysis completed for each of a series of management reaches as described. Note that the reaches below differ slightly from the geomorphic reaches defined elsewhere in this report because anthropogenic and land-based effects have been included in their definition. A reach comparison map is shown in the **Map 2** sheet series.

6.2.1 Ocean Grove Road to Oregon Road

STRENGTHS:	OPPORTUNITIES:
• Views/aesthetics – moderate vegetation retention and buildings fairly well screened; • Property value – limited shoreline armouring on sections; quaint neighbourhood character; • Ecological integrity – limited shoreline armouring on sections.	• Option and bequest – purchase of waterfront lots for public ownership; • Views/aesthetics – use of natural materials & colours; allow vegetation re-establishment; • Property value – improved screening; • Ecological – restore natural beach slope, control invasive species and limit or remove armouring.
WEAKNESSES:	THREATS:
• Recreation and leisure – limited to below high tide line for public; • Public access – limited to below high tide line with limited entry points; • Tourism – limited access.	• Property value – new seawall construction & sea level rise; • Ecological integrity – risk of increased shoreline armouring and backshore vegetation removal.

6.2.2 OREGON ROAD TO KEN FORDE BOAT RAMP

STRENGTHS:	OPPORTUNITIES:
• Recreation and leisure – seawalk and beach provide amenity; • Public access – proximity to roadway; • Tourism – seawalk and beach access; • Option and bequest – public ownership; • Ecological – sections of intact or moderately functional beach.	• Ecological integrity – restore backshore vegetation, control invasive species & restore natural beach slope; • Public access – restore beach cross section to facilitate easy walking access; • Views/aesthetics – restore beach cross section and backshore vegetation to improve beach aesthetics.
WEAKNESSES:	THREATS:
• Views/aesthetics – limited backshore vegetation; desire to maintain expansive views conflicts with establishment of backshore vegetation; • Property value – shoreline armouring for highway protection.	• Ecological integrity – risk of increased shoreline armouring; • Public access/aesthetics – increased shoreline armouring reduces walking access and aesthetics. • Property value – highway at risk from sea level rise.

6.2.3 KEN FORDE BOAT RAMP TO ADAMS ROAD

STRENGTHS:	OPPORTUNITIES:
• Recreation and leisure – active and passive park amenities; • Public Access – waterfront parks; • Property value – high value private waterfront properties; • Option and bequest – some public ownership;	• Views/aesthetics – apply building aesthetic guidelines; allow vegetation re-establishment; • Property value/ecological – restore natural beach cross section and backshore vegetation and control invasive species.
WEAKNESSES:	THREATS:
• View/aesthetics – most shoreline vegetation removed; • Ecological integrity – significant shoreline armouring and degraded beach cross section; • Property value – costly shoreline armouring.	• Property value – increased armouring causing adjacent increased risk; sea level rise; • Views/aesthetics – unrestricted building massing blocking views and overshadowing beach.

6.2.4 ADAMS ROAD TO FRANK JAMES PARK

STRENGTHS: • Views/aesthetics – moderate vegetation retention; • Property value – waterfront lots.	OPPORTUNITIES: • Property value/ecological – restore natural beach slope (possible candidate reach for restoration pilot project on privately owned shoreline); • Option and bequest – large community-owned undeveloped lot.
WEAKNESSES: • Recreation and leisure – limited to below high tide line for public – poor beach quality; • Ecological integrity – significant shoreline armouring and degraded beach cross section; • Public access/tourism – poor walking access at eroding escarpment.	THREATS: • Property value - private residences at risk from sea level rise; • Ecological value – increased shoreline armouring; invasive species.

6.2.5 FRANK JAMES PARK TO BIG ROCK PARK NORTH

STRENGTHS: • Recreation and leisure – good passive recreation opportunities; • Public access – easy access to beach; • Tourism – seawalk and scenic views.	OPPORTUNITIES: • Ecological value – restore backshore vegetation and natural beach slope; • Property value – enhance protection of highway infrastructure through simultaneous beach restoration & highway upgrade design.
WEAKNESSES: • Views/aesthetics – limited backshore vegetation; poor beach separation from highway; • Property value – shoreline armouring for highway protection.	THREATS: • Ecological integrity – risk of increased shoreline armouring and loss of existing backshore vegetation; • Property value/option & bequest value – pressure to develop large non-park city owned parcels for revenue?

6.2.6 BIG ROCK PARK NORTH TO ROTARY BEACH PARK NORTH

STRENGTHS: • Recreation and leisure – active recreation facility on city owned parcel; • Tourism – popular boat launch facility.	OPPORTUNITIES: • Option and bequest – purchase of waterfront lots for public ownership? • Views/aesthetics – apply building aesthetic guidelines; backshore vegetation re-establishment; • Property value/ecological – restore natural beach slope and backshore vegetation.
WEAKNESSES: • Views/aesthetics – limited backshore vegetation; • Public access – poor public access to beach (significant accumulation of driftwood in some locations).	THREATS: • Property value – structures at risk from sea level rise; • Ecological value – risk of increased shoreline armouring and further degradation of beach cross section.

6.2.7 ROTARY BEACH PARK NORTH TO PINECREST ROAD

STRENGTHS: • Recreation and leisure – seawalk and parks; • Public access – good; • Tourism – seawalk and beach access;	OPPORTUNITIES: • Ecological value – restore backshore vegetation and natural beach slope. • Property value – enhance protection of highway infrastructure through simultaneous beach restoration & highway upgrade design.
WEAKNESSES: • Views/aesthetics – limited backshore vegetation; poor separation from highway for beach users; • Ecological integrity – significant shoreline armouring and degraded beach cross section; • Public access/tourism – poor walking access to beach.	THREATS: • Ecological value – risk of increased shoreline armouring and further degradation of beach cross section; • Property value – facilities (ie: seawalk) at risk from sea level rise;

6.2.8 PINECREST ROAD TO MARITIME HERITAGE CENTRE

STRENGTHS: • Recreation and leisure – parks and hidden harbour; • Tourism – parks, harbour and other tourism commercial integral to shoreline.	OPPORTUNITIES: • Ecological value – restore backshore vegetation; reduce pollution in stormwater runoff through application of source control BMPs; • Views/aesthetics – restore backshore vegetation where it will not conflict with views.
WEAKNESSES: • Views/aesthetics – limited backshore vegetation • Property value – heavy shoreline armouring for commercial properties and harbour breakwater.	THREATS: • Property value – steepening beach cross section; exposure of structures to storm winds on high-bank/bluff should be considered in building design and material selection.

6.2.9 MARITIME HERITAGE CENTRE TO INDUSTRIAL SHIPPING TERMINAL

STRENGTHS: • Recreation and leisure – parks and marinas; • Tourism – heritage centre, wharf and marinas; close to downtown amenities; • Views/aesthetics – urban setting with lively and vibrant shoreline.	OPPORTUNITIES: • Ecological value – localized backshore vegetation restoration; application of source control BMPs for stormwater pollution reduction; • Tourism – interpretation of city shoreline initiatives at public facilities. • Views/aesthetics – break down large spaces and soften viewscapes with shoreline vegetation; planting design should respond to the highly urban context of this reach.
WEAKNESSES: • Ecological value – limited backshore habitat and shoreline encroachment; • Views/aesthetics – large scenes or landscape spaces with limited shoreline vegetation and predominantly hard	THREATS: • Property value – development of public parcels for revenue generation? • Ecological value – pollution of shoreline from spills and stormwater discharge.

landscape features in some areas; - Public access – some significant breaks to continuity of public access (ie: Hwy 19A, shipping & BC Ferries terminals.	

6.2.10 INDUSTRIAL SHIPPING TERMINAL TO TYEE SPIT (NORTH)

STRENGTHS: - Ecological value - Dick Murphy shoreline restoration; - Recreation and leisure – active and passive recreation opportunities; - Public access – beach and seawalk; - Tourism – beach, seawalk and park.	OPPORTUNITIES: - Ecological value – further shoreline restoration works on back (west) side of spit; interpretation of city restoration initiatives; further backshore vegetation enhancement; - Views/aesthetics – break up large landscape spaces on spit with clusters of trees (ie: enhance backshore vegetation).
WEAKNESSES: - Recreation and leisure – limited active recreation amenity (ie: good location for a boat launch or volleyball court?).	THREATS: - Property value – continuation of beach sediment transport processes may necessitate future beach nourishment.

6.2.11 TYEE SPIT (NORTH) TO MCDONALD ROAD

STRENGTHS: - Property value – high bank provides excellent views; - Tourism – tourism commercial property.	OPPORTUNITIES: - Ecological value – good opportunities for backshore vegetation enhancement.
WEAKNESSES: - Public access – limited access points (ie: private property and steep, high bank).	THREATS: - Ecological value – invasive species; clearing of backshore vegetation.

6.2.12 MCDONALD ROAD TO ORANGE POINT ROAD

STRENGTHS:	OPPORTUNITIES:
• Property value – high bank provides excellent views toward ocean; private sandy beach provide amenity value to shoreline properties.	• Property value – manage tree removal/pruning for views; manage property drainage to reduce risk of bank failure; • Ecological value – manage tree removal/pruning for ecological value; manage beach groynes (ie: consider converting groynes to boulder fields); control of invasive vegetation species.
WEAKNESSES:	THREATS:
• Public access – limited access points (ie: private property and steep, high bank); • Ecological value – removal of trees for views; invasive species on bank; • Property value – property drainage poorly managed which could affect slope stability.	• Property value – increased erosion and slope instability caused by failing or poorly installed drainage systems; • Ecological value – suppression of backshore vegetation (ie: sizable trees) which provide roosting/nesting sites and help stabilize slope.

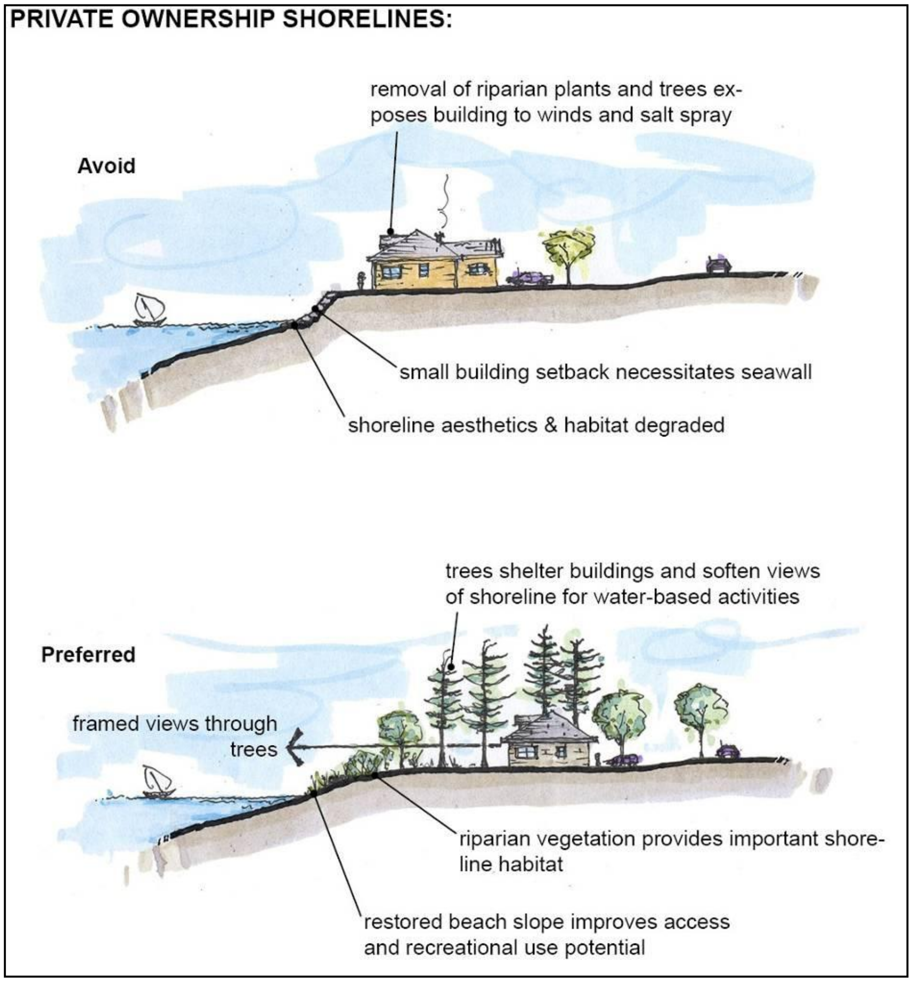
6.3 SHORELINE MANAGEMENT GUIDELINES

Shoreline management guidelines offer clues on how to manage the Campbell River shoreline for enhanced overall value, avoidance of further shoreline degradation, or restoration of lost values. This section will answer the question of what techniques or strategies should be applied to improve shoreline management. The guidelines are intended to be generally applicable to the Campbell River shoreline, and educational in nature and format.

6.3.1 SITING OF PERMANENT STRUCTURES AND FACILITIES:

GUIDELINE I: Ensure adequate setbacks are provided when locating permanent structures and facilities.

Providing setbacks large enough to protect structures naturally is the first step in helping to restore or preserve natural shorelines and shoreline processes. Larger setbacks allow for fluctuations in the beach with the seasons and even minor shoreline erosion, without causing risk to structures and facilities. Even roads and seawalks should be set back from the shoreline appropriately to:



- Facilitate retention or restoration of backshore vegetation;
- Reduce dependency on seawalls;
- Increase the likelihood of functional shoreline habitat;
- Reduce interference with sediment movement systems on the shore; and;
- Improve access and connectivity between upland uses and the shoreline for beach users.

In other local jurisdictions with waterfront properties, setbacks generally range from 7.5 m when a seawall is provided to protect structures, to 15 m or 30 m, depending on the shoreline type (ie: rock shoreline vs. receding bluffs). It is recommended that Campbell River move away from allowing smaller setbacks where seawalls are built, as this approach essentially incentivises the construction of seawalls. Rather, incentives should be considered to promote softer or restorative approaches to shoreline treatment and incorporation of setbacks appropriate to site conditions. Also, the Green Shores CDRS prerequisite #1 sets a standard for setback determination which is recommended. (For more information on structure and facility siting, refer to the Green Shores CDRS, prerequisite #1).

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

6.3.2 CONSERVATION OF CRITICAL OR SENSITIVE HABITATS

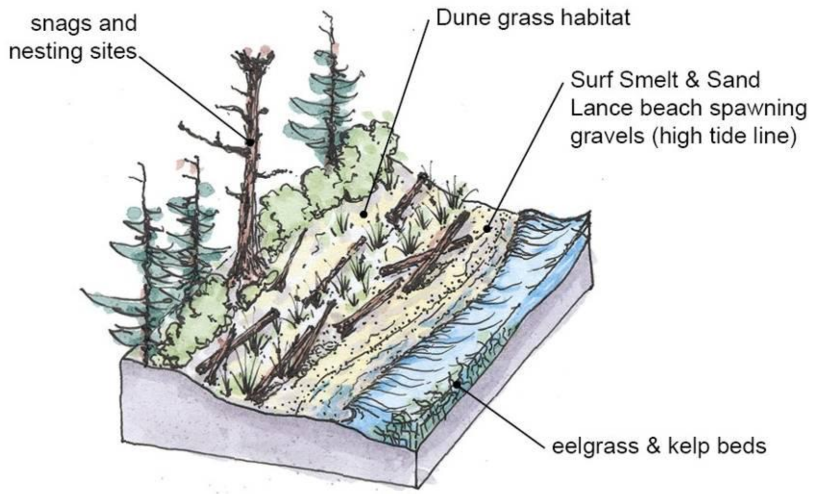
GUIDELINE II: Protect critical or sensitive marine shoreline habitats from development related disturbance.

Shoreline habitats have been severely impacted by development along ocean shorelines. Where habitat features remain intact, every effort should be made by various levels of government and shoreline stakeholders to protect these features. In fact, critical fish and wildlife habitat are generally protected by federal and provincial regulations already. This guideline helps to reinforce the application of these regulations.

(For more information on the protection of critical or sensitive habitats, refer to the Green Shores CDRS, prerequisite #2).

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

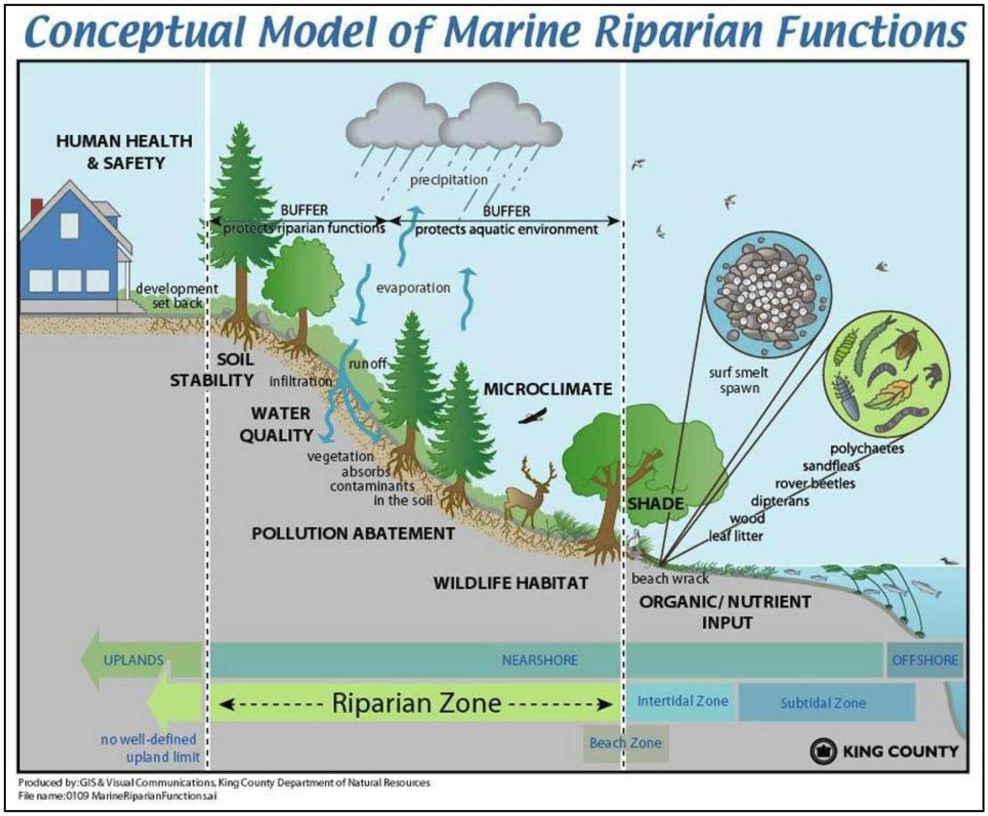
TYPICAL SHORELINE SENSITIVE HABITATS:



6.3.3 BACKSHORE ZONE PROTECTION/RESTORATION:

GUIDELINE III: Conserve or restore native marine backshore vegetation where possible to stabilize the shoreline, buffer from stormwater pollution inputs, improve shoreline aesthetics and restore marine backshore habitat function.

Robust native vegetation along the shoreline is a good indicator of an ecologically healthy backshore zone. Damage to the shoreline typically starts with removal of marine backshore vegetation and follows up with shoreline armouring – retaining backshore vegetation or restoring it in places where it has been removed will help preserve or enhance a wide range of shoreline values. In locations where existing (or introducing new) robust backshore plantings screen views and conflict with other shoreline values, a compromise solution may be necessary, and consideration should also be given to Guidelines I and VII below in these situations.



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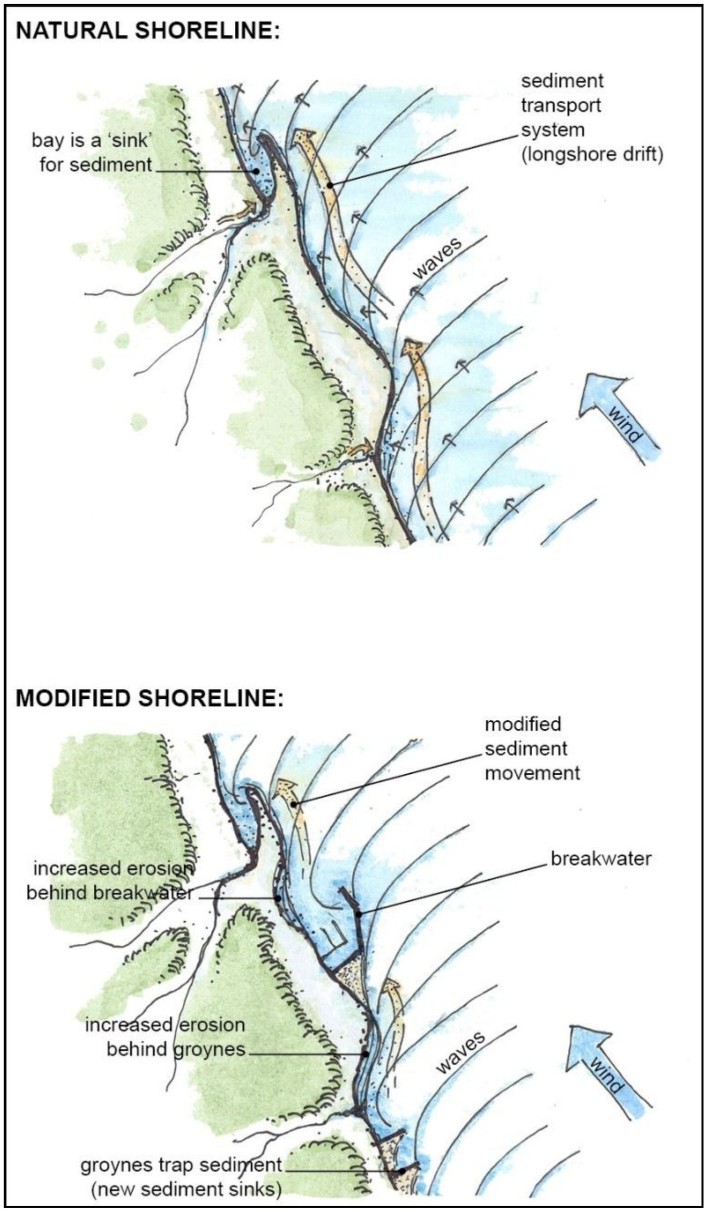
(For more information on marine backshore protection or enhancement, refer to the Green Shores CDRS, prerequisite #3. Note that the GreenShores program uses the term 'riparian' rather than 'backshore'. In the case of this report, the two terms are assumed to be synonymous).

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

6.3.4 COASTAL SEDIMENT PROCESSES

GUIDELINE IVA: Ensure the sediment movement system along the shoreline is not altered as a result of development near the shoreline, and restore modified sediment system function where possible. Beach nourishment may be required.



The movement of sediment along the shoreline in the *longshore drift* system has a profound impact on the character of the beach, the quality of habitat, and beach self-maintenance. Groynes and breakwaters should be avoided to prevent disruption of sediment movement along the shoreline and to prevent possible exacerbation of erosion for adjacent parts of the shoreline. Where groynes and/or breakwaters have been installed for specific management purposes, consideration should be given to Guideline III above, and to targeted prescriptions (Section 5). Also, in situations where sediment supply is starved by 'upstream' alterations or blocks to sediment supply, beach nourishment may be required, especially where a more natural beach cross-section has been restored.

(For more information on the conservation of coastal sediment processes, refer to the Green Shore see CDRS, prerequisite #4).

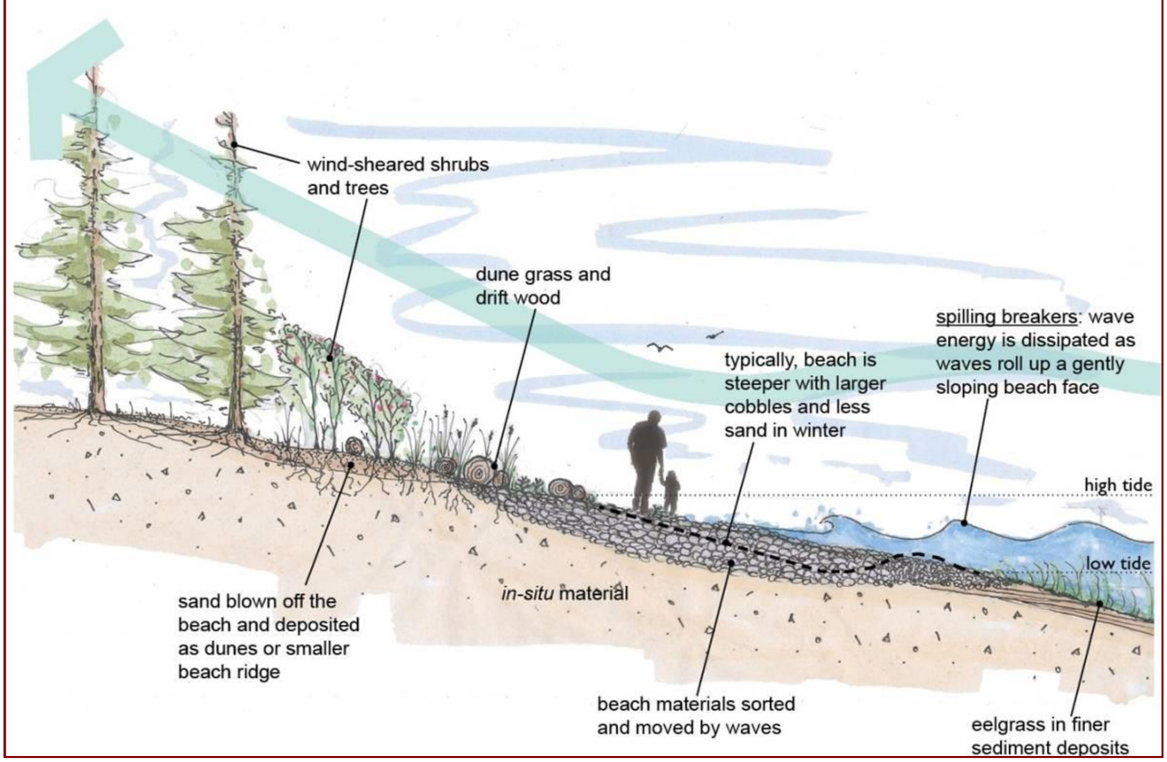
This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

GUIDELINE IVB: Ensure the sediment movement system up and down the beach slope is not altered as a result of development near the shoreline, and restore modified sediment system function where possible. Beach nourishment may be required.

The movement of sediment up and down the beach face (ie: sediment contribution to the shoreline through bank erosion, sorting of sediment on the beach face as a result of wave action, and the resulting morphology of the beach cross section or beach slope, which may vary season to season) has a profound impact on the character of the beach, habitat quality, and beach self-maintenance.

TYPICAL SEDIMENT SHORE:

Under natural conditions, different sections of shorline along the coast may constantly lose sediment (ie: moving to the left; an eroding shoreline), constantly gain sediment (ie: moving to the right; a sediment sink or "accreting" shoreline), or lose some years and gain others (ie: accreting some years and eroding others; a "wobbly" shoreline).

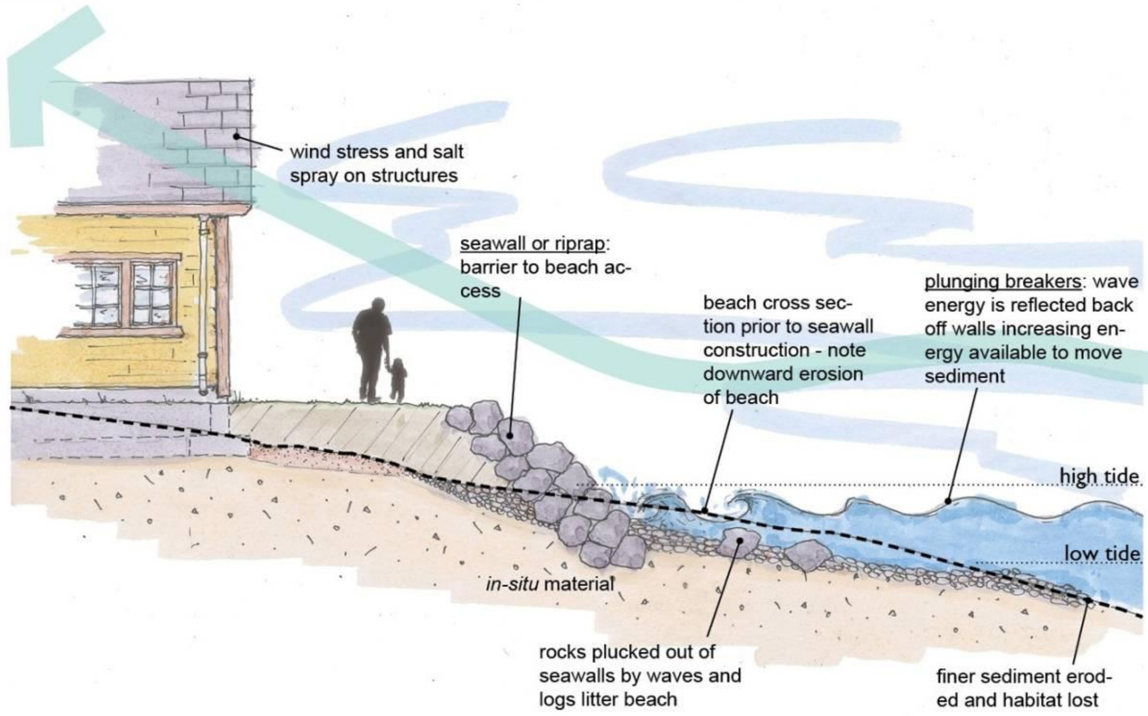


In general, hardening the shoreline through the construction of seawalls is strongly discouraged because seawalls disrupt beach formation and reduce ecological, recreational and aesthetic values. In particular, seawalls generate reflective or plunging waves that dramatically lower the beach cross section below the seawall over time, resulting in the destruction of critical habitat for forage fish spawning (ie: surf smelt and sand lance). Seawalls can also lead to increased rates of erosion for adjacent sections of shoreline.

Where seawalls have been installed to protect property values, consideration should be given to Guideline III and to targeted prescriptions (**Chapter 7**).

MODIFIED (HARDENED) SEDIMENT SHORE:

Shorelines are typically hardened with seawalls or riprap walls to protect property values. However, this is often done with significant loss of other shoreline values. On sediment shorelines, important habitat function is lost, and with typical disruption to beach sediment movement processes, aesthetic value of the beach, public access to the beach, and damage to neighbouring properties can result.



This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

6.3.5 ON-SITE ENVIRONMENTAL MANAGEMENT PLAN

GUIDELINE V: Minimize the impact of construction-related activities on the marine shoreline by developing an environmental management plan for all construction within 30 m of the shoreline.

Construction activities can lead to increased erosion and sediment input to shoreline habitats. Sediment inputs can negatively impact shallow-zone aquatic vegetation (e.g. eelgrass habitats) and disrupt invertebrate and fish life cycle function. Also, increased activity on construction sites can increase the risk of other pollutants entering the marine environment. When engaging in construction activity within 30 m of the shoreline, an environmental management plan is required (before the City of Campbell River will issue a development permit) that clearly articulates the following:

- Site and project description;
- Roles and responsibilities for construction manager and qualified environmental professional;

- Sequence of major construction activities;
- Existing soil and rain water data;
- Scaled site map;
- Description of sediment controls;
- Maintenance and inspection procedures for sediment controls;
- Spill management protocol;
- Waste management protocol; and
- Management protocol for hazardous materials.

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

(For more information relating to on-site environmental management plans, refer to the Green Shores CDRS, prerequisite #5).

6.3.6 BEACH ACCESS

GUIDELINE VI: Restore natural beach cross sections to improve access to shoreline, and anticipate beach trail access locations when restoring backshore vegetation. In situations where seawalls cannot be removed, strategically locate programmed and safe trail access to the beach.

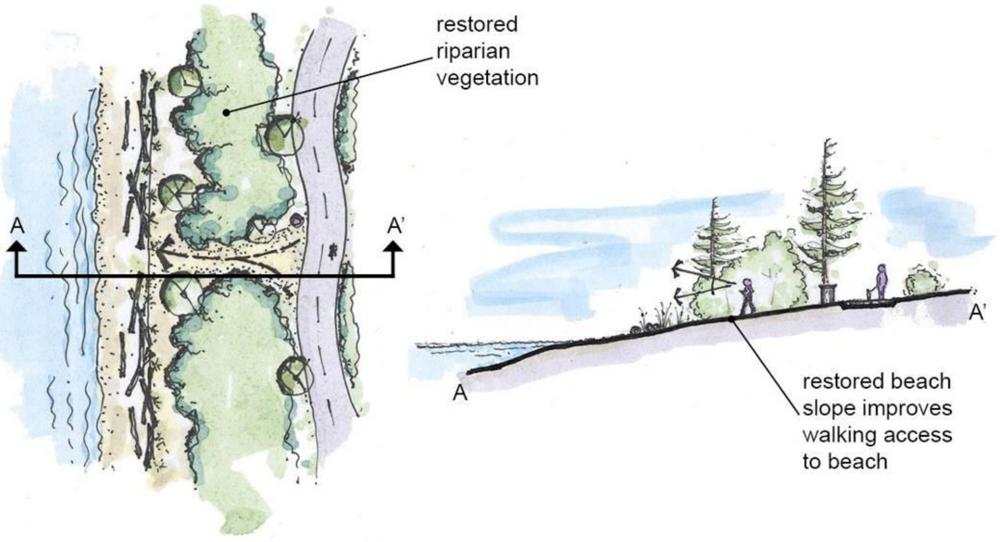
Access to the beach is a significant issue along the Campbell River shoreline. Currently, large angular rock separates parking areas from the beach along much of the publically accessible portions of the shoreline. Seawalls also reflect wave energy and cause finer sediment to be washed off of the beach slope, resulting in beaches with coarser materials that are harder to walk along. Elsewhere, seawalls and breakwaters prevent or reduce the quality of access to the beach.

Where possible, effort should be made to create a more natural transition between the beach and upland development. Restoring a natural beach profile is preferred, with well set-back facilities on the shore, including park facilities, roads and parking areas. This would facilitate the restoration of a gradual and more natural slope down to the beach, with restored backshore vegetation along the shoreline. Programmed pathways leading from parking areas and pedestrian nodes along the seawalk could be routed as breaks in restored backshore vegetation.

This guideline applies to all new beach restoration projects, both private and public.

Refer also to GUIDELINE X: Urban Shorelines.

BEACH ACCESS:

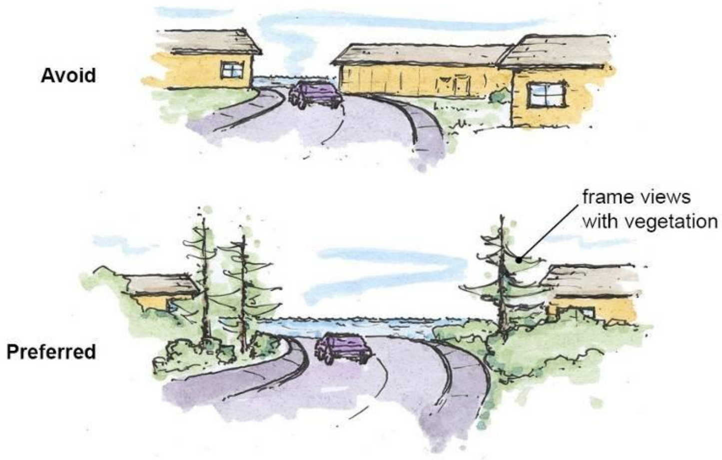


6.3.7 VIEWSCAPE MANAGEMENT

GUIDELINE VII: Manage viewscapes for all three critical observer positions (ie: ocean to shore, along the beach and shore to ocean) through strategic use of vegetation for framing and directing views, and through strategic building scaling, siting and treatment.

Viewscapes are an important consideration along shorelines. In the past, wholesale clearing of vegetation was carried out to open expansive views along the shoreline. Now, it is widely recognized that in addition to having significant environmental benefits, restoring shoreline vegetation strategically can improve shoreline aesthetics by increasing the potential for:

VIEWS - FACILITY PLACEMENT:



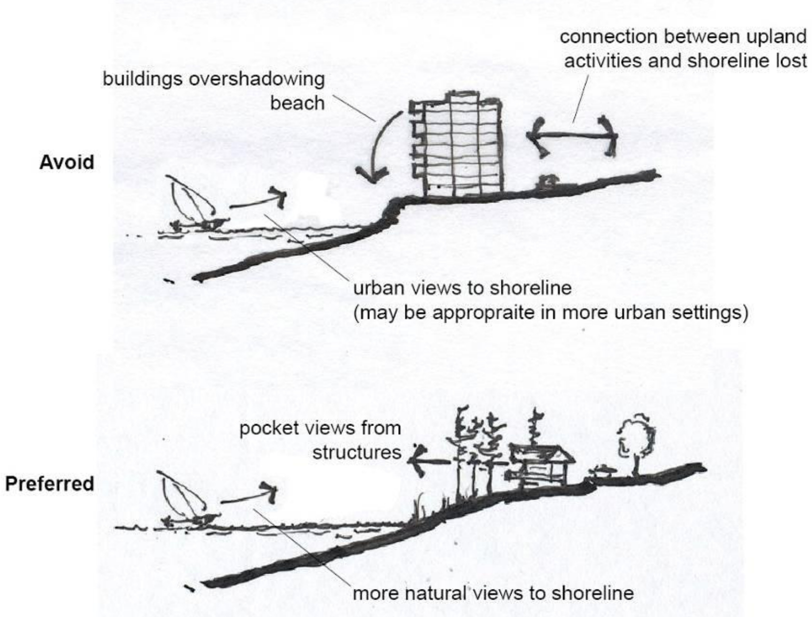
- Privacy and screening between uses;
- Directing views towards desirable landscape features;

- Framing views;
- Softening hard landscape features like parking lots or streetscapes;
- Providing a sense of enclosure;
- Dividing large open landscapes to heighten interest and complexity;
- Defining landmarks and edges;
- Establishing rhythm and pocket views along scenic corridors;
- Surprise and mystery – two key elements that heighten user experience in the landscape. (Kaplan, Kaplan & Ryan, 1998)

There are generally two tools for enhancing viewscapes:

1. Strategic use of vegetation to frame or direct views; and
2. Strategic building and facility placement, scaling and treatment (strategic 'treatment' includes the selection of building colour and materials to suit the landscape context).

VIEWS - FACILITY SCALE & CONTEXT:



Shoreline viewscapes from all three critical observer positions should be managed for greater landscape effect through these methods.

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawalls, etc), both private and public.

6.3.8 SHORELINE RESTORATION TRIGGER

GUIDELINE VIII: Shoreline restoration works should ideally be completed in tandem with new construction or repairs, upgrades, renovations or modifications of private or public buildings, facilities or infrastructure.

When construction projects are proposed for new construction works or for upgrading or repairing infrastructure and buildings along the shoreline, completion of adjacent shoreline restoration works should also be considered, in tandem. There are two reasons why this is important. First, completing shoreline restoration in tandem with adjacent development projects would allow project designers to collaborate with shoreline restoration experts to ensure facilities are appropriately sited and to ensure that shoreline restoration works are designed to complement adjacent facilities and infrastructure. Second, in making restoration of the shoreline part and parcel of infrastructure upgrades, it heightens the importance of shoreline management to a level more consistent with the value the shoreline provides to the community.

In situations where private landowners along the waterfront need to repair or construct seawalls, the city should seek to develop partnerships with landowners for the application of best practices in shoreline management. In particular, restoration of beach slopes and sediment processes are highly desired where seawalls may have been built or repaired in the past to protect property. The probability of success in restoration efforts is likely to be increased where groups of landowners can be brought together to facilitate larger scaled restoration efforts and shared costs. Incentive programs could be used to encourage homeowners to participate in restoration efforts.

This guideline applies to all new construction and renovation of buildings, structures and facilities (ie: homes, roads, sewer lines, seawall construction or repair, etc), both private and public.

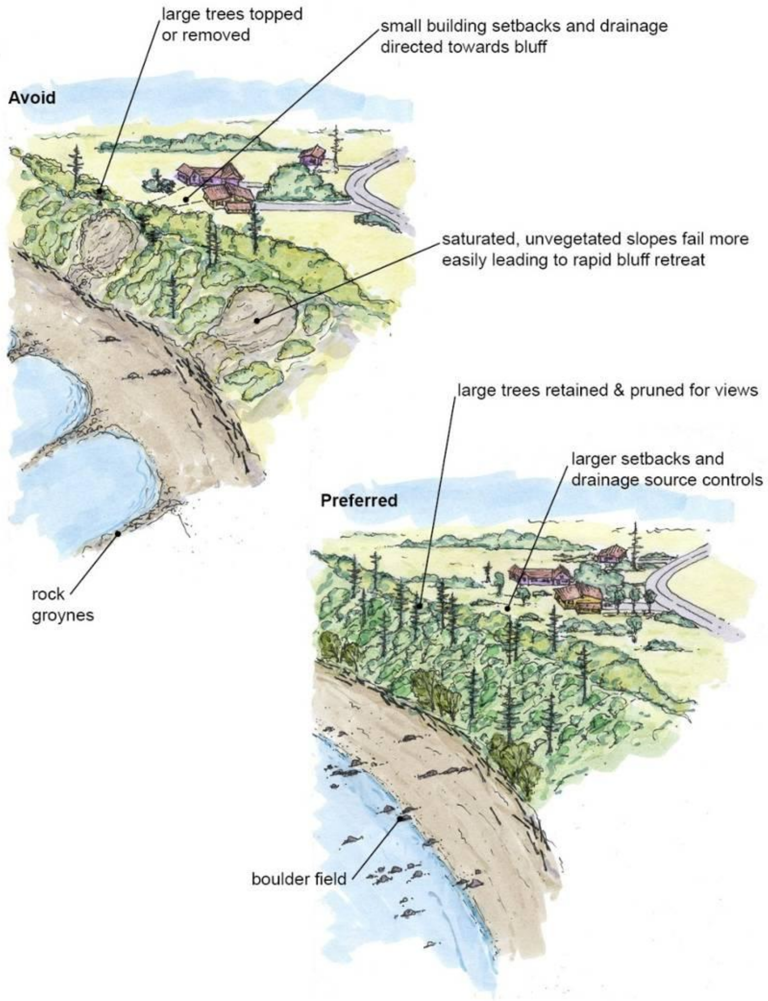
6.3.9 BLUFF SHORELINES

GUIDELINE IX: Bluff shorelines require special attention due to the risk of slope instability, with a focus on preventing saturation of the bluff face, preventing excessive removal of backshore vegetation, preventing construction of excessive beach access structures, and ensuring appropriate setbacks from the top of bank.

The bluff shoreline types found at Orange Point and south of the City centre, require special management due to the risk of slope failure. The bluffs in these areas are comprised of sediment deposits that can be softened with the addition of water. Also vegetation removal on these types of bluffs can exacerbate the risk of slope failure.

Special attention should be given to how storm water, perimeter drain water or septic field drainage is conveyed toward the bank and down to the beach. As well, vegetation should be pruned for views, rather than removed entirely. This will allow rooting structures (especially those of large trees) to continue supporting the bluff face. Where small slope failures do occur, consider the use of soil bioengineering techniques to re-stabilize slopes. Lastly, the construction of elaborate stairways, boardwalks and other means to acquire access down the beach face should be restricted. Installing foundations for these structures and removing vegetation to accommodate them can compound the risk of slope failures.

BLUFF SHORELINES:

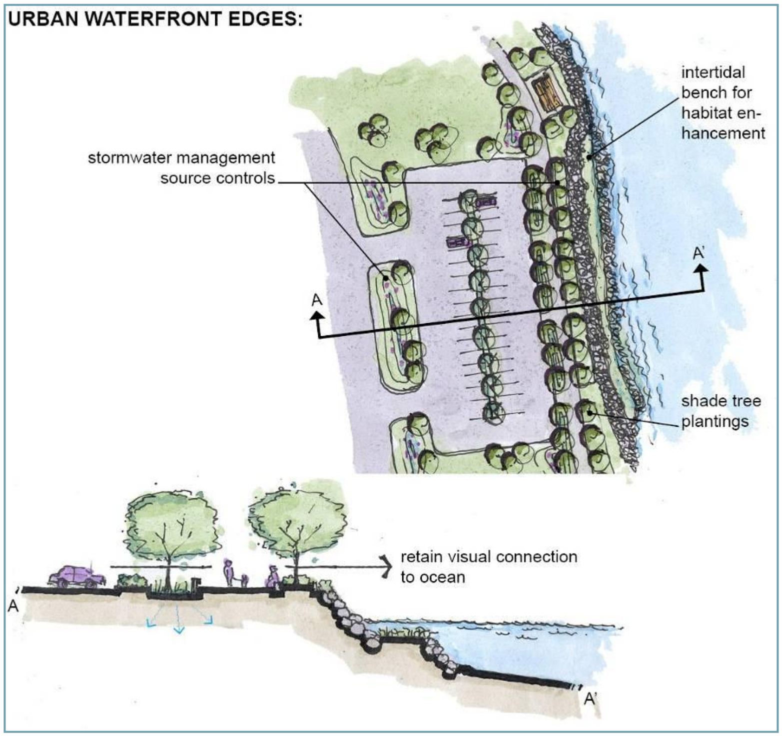


6.3.10 URBAN SHORELINES

GUIDELINE X: In urban situations where the removal of seawalls or breakwaters and restoration of a more natural shoreline is not feasible because of intensive land-based and/or water-based activities, other best management practices can be pursued, including the reduction of pollution in stormwater entering the marine environment, improving public access along the shoreline and programming/designing for a more vibrant and hospitable public realm on the waterfront.

Portions of the urban shoreline in Campbell River are vibrant places with a range of services provided and recreational and commercial oportunities available. Much of the current activity centres on transportation, boating and fishing, but facilities and businesses in the area also support activities such as shopping, eating out and passive recreation.

The urban shoreline is an ideal location for programmed community activities and functions, and for a wide range of recreational activities. As mentioned, some activities and services are already well established, but the city is encouraged to explore programming ideas and design to further enliven the shoreline for people. At the same time, environmental best management practices can be incorporated into designs to reduce pollution entering the marine environment and to improve habitat along the shoreline through construction of features such as intertidal benches. Park facilities that accomodate gatherings of different sizes, softening of shorelines through tree planting, encouraging continuous public access along the shoreline, providing separation between walkers and vehicle traffic and improving the aesthetic appeal of parking lots are all strategies that will help to improve the quality of user experiences along the urban waterfront.



7 ACTION PLAN

The shoreline at Campbell River is experiencing ongoing erosion from wind-generated waves. To date, the *ad hoc* reactive approach that has been taken to address this problem has not provided the needed results to justify the effort, expense, and degradation of the natural systems. Private land owners typically carry the financial burden of protecting discrete sections of shoreline and apply pressure on the City to address individual erosion issues in places where the City owns the shore. In the more industrialised areas of the downtown reach, engineered rip rap has been installed over extensive sections of the shoreline. The result is that long stretches of the shoreline have a high level of erosion protection but at the expense of a heavily degraded foreshore habitat. The remainder of the shoreline is comprised of a patchwork of *ad hoc*, non-standard shoreline protection measures in various stages of disrepair that result in degraded habitat but insufficient erosion protection. In some areas land owners are caught in a cycle of incurring costs to install shoreline protection that must be repaired and upgraded to keep pace with the measures installed by adjacent owners. Other ongoing management activities, such as maintenance of the two City-owned boat ramps and control of vegetation along public pathways, need to be conducted within the context of an environmentally sound approach that incorporates best management practices (BMPs) to avoid undue impacts.

The City could consider adopting an integrated approach to this issue, both as a means of providing support to land owners and as well as to direct their own efforts more efficiently and with a full accounting of the environmental considerations. Adopting this approach will represent a step away from the adversarial environment that has arisen between the City and the various regulatory agencies and a step towards a cooperative climate with greater benefit to residents and the environment.

An action plan has been developed that provides guidance to achieve these goals. The action plan addresses multiples needs from the point of view of management of the shoreline. Many of these elements are heavily inter-related, for example the procedures for boat ramp maintenance are tied to shoreline protection sites and beach nourishment efforts. The Action Plan incorporates the following elements:

- Priority Sites for Shoreline Protection – **Section 7.1**
- Priority Sites for Habitat Restoration – **Section 7.2**
- Priority Sites for Beach Nourishment – **Section 7.3**
- Shoreline Protection Options – **Section 7.4**
- Shoreline Vegetation Maintenance Plan – **Section 7.5**
- Boat Launch Maintenance Plan – **Section 7.6**

The various components of the Action Plan are shown on **Map 5**.

7.1 PRIORITY SITES FOR SHORELINE PROTECTION

The City of Campbell River has requested that a list of priority sites that require protection from erosion be identified. We have assumed that the City can fairly readily plan for and implement works along City-owned lands and rights of way, but is limited in their access to privately owned lands and so direct action at these locations is not likely. In the case of privately owned lands, the City can promote a shift to a sustainable approach to shoreline protection and management by encouraging landowners to work collectively along select sections of the shore.

Priority sites have been identified only within City-owned parcels, including parks, in the three southern reaches: Southern Beaches, Willow Point, and Middle Beaches. Erosion in the other reaches, though an issue, is not of the same level of severity or is affecting privately-owned lands. Table 15 lists all significantly-sized City-owned parcels and waterfront parks within this area, including the approximate size of the park, chainage to the nearest 0.1 km and a reference to the nearest surveyed cross section, if available. There is ongoing erosion of varying severity along the majority of the shoreline within these reaches. Priority sites include sites noted during field investigations as well as sites noted by City staff. Appropriate potential shoreline treatments are outlined in Section 7.4.

Table 15. City-owned lands and waterfront parks within the southern three reaches.

Name	Size (ha)	Chainage (nearest 0.1 km)	Nearest Cross Section
Ken Forde	0.46	2.0	
Jaycee (Lift Stn. 8)	0.17	2.3	
Larwood	0.07	2.6	XS 3
Adams	0.09	2.9	
City-owned lots		3.1	
Frank James	0.19	3.2	
Lift Station #7	0.13	4.2	
Ellis	0.02	4.5	
Big Rock (South/North)	0.83	4.7 / 4.9	
McCallum	0.22	5.2	XS 5
Rotary Beach	0.44	5.9 to 6.3	XS 6
Hidden Harbour South	0.16	7.2	XS 8
Seawalk		0.6 to 7.3	

7.1.1 HIGH PRIORITY SITES

Four high priority sites for shoreline protection have been identified and are summarised in Table 16, and appear in geographical order from south to north. High priority sites are those sites where erosion is particularly severe or where erosion is directly threatening infrastructure, such as pathways, roadways, or buildings. Figure 12 shows the typical conditions at each of the sites. The list of high priority sites is likely to be incomplete because new sites will emerge as conditions change along the shoreline.

Figure 12. **Photos showing conditions at the high priority sites (see Table 16): a) south of Maryland Road, b) south of Twillingate Road, c) Rotary Beach Park, and d) Seaside Estates (photos 17 January, 2011).**

Sites 1 to 3 could be treated using a softer approach instead of installing rip rap or seawall, such as the typical design presented in Section 7.4. Site 4 will require that a 'hard' engineering solution be developed to prevent debris being deposited during wave runup. A more in-depth engineering investigation is required to develop a comprehensive solution. Since this section of shoreline has an existing rip rap bank, placement of large boulders on top of the bank may provide an interim solution.

Table 16. Summary of high-priority erosion protection sites on City-owned land.

Site #	Site Description	Geomorphic Reach	Dimensions (m) Length / Height	Description
		Sub-Unit		
1	S of Maryland Road	1-Southern Beaches	50 / 1.2	Erosion along area that projects slightly from the shoreline. Backshore area used as a popular 'pullout' from the highway. Evidence of firewood cutting. Sections of nearby *ad hoc* rip rap are in poor condition. Continued erosion will eventually threaten the Highway 19A. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**. Address stormwater runoff from above.
		2-Oregon R to Ken Forde		
2	S of Twillingate Road	1-Southern Beaches	60 / 2.0 to 2.5	Dip in seawalk results in uncontrolled stormwater discharge over bank. Ongoing shoreline erosion undermining seawalk. Rip rap within this area is in poor condition. Further erosion will likely result in loss of section of the seawalk. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.
		2-Oregon R to Ken Forde		
3	Rotary Beach Park	3-Middle Beaches	90 / 1.5	Three locations within the park where erosion is eroding the park or threatening the seawalk. Eroding sections occur between sections of non-standard rip rap to form a scalloped shoreline. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.
		6-Big Rock Park N to Rotary Beach Park N / 7-Rotary Beach Park N to Pinecrest Road	40 / 1.5 30 / 1.5	
4	Seaside Estates	3-Middle Beaches	20 / 2.5	Engineered rip rap shore protection provides inadequate height to prevent debris deposition during wave runup. Risk of damage to Seaside Estates building from logs and other debris, which is located with inadequate shoreline setback. Requires an engineered solution to provide adequate protection. **Proposed Action:** a hard engineered solution will be necessary. Consider installing large boulders at the top of the bank to prevent deposition of logs during wave runup as an interim measure.
		8-Pinecrest Rd to Maritime Heritage Centre		

7.1.2 LOWER PRIORITY SITES

Four lower priority sites for shoreline protection have been identified and are summarised in Table 17, and appear in geographical order from south to north. Lower priority sites have been identified at locations where shoreline conditions on City-owned property is in poor condition but is not imminently threatening infrastructure or highly valuable lands. These sites tend to represent areas with poor habitat condition that has been compromised by the installation of poorly functioning rip rap. Figure 13 shows the typical conditions at each of the sites.

The lower priority sites could be treated with a soft approach such as is outlined in Section7.4.

Figure 13. Photos showing conditions at the lower priority sites (see Table 17): a) along shore near Twillingate Road, b) Larwood Park, c) Adams Park, and d) Frank James Park (photos taken 17 January, 2011).

Table 17. Summary of lower priority erosion protection sites on City-owned land.

Site #	Site Description	Geomorphic Reach Sub-Unit	Dimensions (m) Length / Height	Description
5	Twillingate Road	1-Southern Beaches 2-Oregon R to Ken Forde	200 / 2.0 to 2.5	Rip rap along this section is in generally poor condition. Erosion at the rip rap toe has led to over-steepening of the bank. Severe erosion has occurred at select locations (see High Priority Sites in **Table 16** above). Habitat values are compromised. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.
6	Larwood Park	2-Willow Point 3-Ken Forde to Adams Road	25 / 2.0	Steep rip rap in front of park is in poor condition. Overall shoreline condition on adjoining lots is in similar condition. No apparent imminent issues. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.
7	Adams Park	2-Willow Point 4-Adams Rd to Frank James Park	35 / 2.0	Shoreline is in poor condition with apparent 'starving' of smaller gravel sediments. Existing bank protection in the form of small log debris. :Privately owned properties to north and south protected by rip rap. No apparent imminent issues. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.
8	Frank James Park	2-Willow Point 4-Adams Rd to Frank James Park	180 / 2.0	Existing rip rap is in generally poor condition. Shoreline erosion is beginning to threaten the seawalk in some places. **Proposed Action:** install 'soft' engineering bank protection such as presented in **Section 7.4**.

7.2 PRIORITY SITES FOR HABITAT RESTORATION

Priority sites for habitat restoration were identified within the reach by reach analysis of Existing Conditions – Ecological Inventory (**Chapter 0**). The sites and methods outlined in that chapter provide invaluable guidance to those seeking to improve habitat conditions within the study area outside of the sites identified for shoreline protection.

7.3 PRIORITY SITES FOR BEACH NOURISHMENT

Applying sediment to the beach system at key locations will help to offset the sediment deficit that has developed, in part due to the installation of hard shoreline protection measures. Raising the beach profile through addition of sediment will help to dissipate wave energy, and will improve habitat conditions for key forage fish species. The beneficial effects of the nourishment program are not expected to be measureable for the first several seasons.

Ideally, beach nourishment sites would be located at regular intervals along the Campbell River shoreline. However, from a practical point of view, the choice of sites is limited to those areas where City crews can access the shoreline with trucks and machinery. **Table 18** provides a summary of beach nourishment sites and includes guidelines for the volume of sediment that can be deposited at each one. Volumes are based on multiples of truck loads (assumed to be approximately 8 m^3). Beach nourishment sites are indicated on **Map 5** (except boat ramp sites). Each of the two boat ramps is also included in the list of beach nourishment sites. A portion of the sediment should be placed on the north (downdrift) side of the ramp during annual cleaning operations.

The volume of sediment available to the beach nourishment program is dependent on the amount removed from the boat ramps. Similarly, the timing of sediment availability is dependent on the maintenance schedule. As per the findings presented in **Appendix B**, up to 700 m^3 of sediment is removed from the two boat launches per year. Of this, the majority is removed during one large annual maintenance effort at Big Rock. If more regular clearing of the ramps were to occur in future, then up to 150 m^3 of sediment would be available to the beach nourishment program on an ongoing basis throughout the year. A large amount of the sediment would be used as part of the effort to provide shoreline protection at key locations using the 'soft' approach outlined in **Section 7.4**.

Sediment removed from the boat launch sites can be placed directly at any of the beach nourishment sites provided that the protocols for biological assessment included in **Appendix B** (**Section 3.1**) are followed. It is recommended that careful records of beach nourishment activities be kept to assist with later assessment of their effects. Information to be recorded would include: date, location, volume of sediment, source of sediment, photographs of the site before and after application of sediment. The following points provide guidance with respect to the physical operation of the beach nourishment program:

- Sediment is expected to be a mixture of gravel and wood debris but relatively low sand content. Large logs should be sorted from the debris for use in future shoreline protection projects.
- End-dump sediment over higher banks but use a machine to spread the pile at lower bank sites as required. Discrete piles will be reworked by shoreline processes, introducing the sediment to the shoreline system gradually.
- Ensure that at least two thirds of the introduced sediment is distributed by natural processes before applying more sediment to the site. Accretion of the shoreline is expected (and desirable).

Table 18. Recommended beach nourishment sites (see Map 5).

Location	Chainage (nearest 0.1 km)	Volume to be deposited (m^3)	Comment
Maryland Road	0.7	8	Against loc-bloc wall if possible
Twillingate Road	0.9	8	Multiple locations against pullouts
Ken Forde Boat Launch	2.0	16	16 m^3 during annual maintenance + 25% of ongoing maintenance volume. Place material to north.
Jaycee (Lift Stn. 8)	2.3	8	
Larwood	2.6	8	
Adams	2.9	8	Access to shore not confirmed
City-owned lots	3.1	8	Access to shore not confirmed
Frank James	3.2	16 to 24	Various locations against seawalk
Lift Station #7	4.2	8	Immediately north of the park site – access from parking lot
Ellis	4.5	8	South end of the park
Big Rock Launch	5.2	16	16 m^3 during annual maintenance + 25% of ongoing maintenance volume. Place material to north.
Rotary Beach	5.9 to 6.3	16 to 24	Multiple locations along seawalk
Dick Murphy Park	11.9 to 12.4	16 to 32	As required to maintain existing shoreline works

7.4 SHORELINE PROTECTION OPTIONS

A variety of shoreline protection structures have been installed within the study area. These range from heavily engineered rip rap revetments to *ad hoc* placements of rock and logs. In this report we have identified many of the common issues with any approach that introduces bank 'hardening' as part of the shoreline protection approach. These issues include impacts to habitat values on the foreshore, impacts to habitat values on the backshore, lowering of the beach profile, downdrift impacts, and the failure of many of these structures to provide the level of protection that is needed or desired. There has also been a number of projects completed recently that have employed a softer approach to shoreline protection, such as the initiative at Dick Murphy Park.

The City of Campbell River has requested that an alternative approach to the traditional or *ad hoc* reactive approaches to shoreline protection be explored. The shoreline at Kitty Coleman Provincial Park, just north of Comox, represents a similar oceanographic and physical environment to the present study area, including a receding shoreline and wave-cut beach scarp (**Figure 14a**). A recently completed shoreline protection project provides a useful template for application along the Campbell River shoreline.

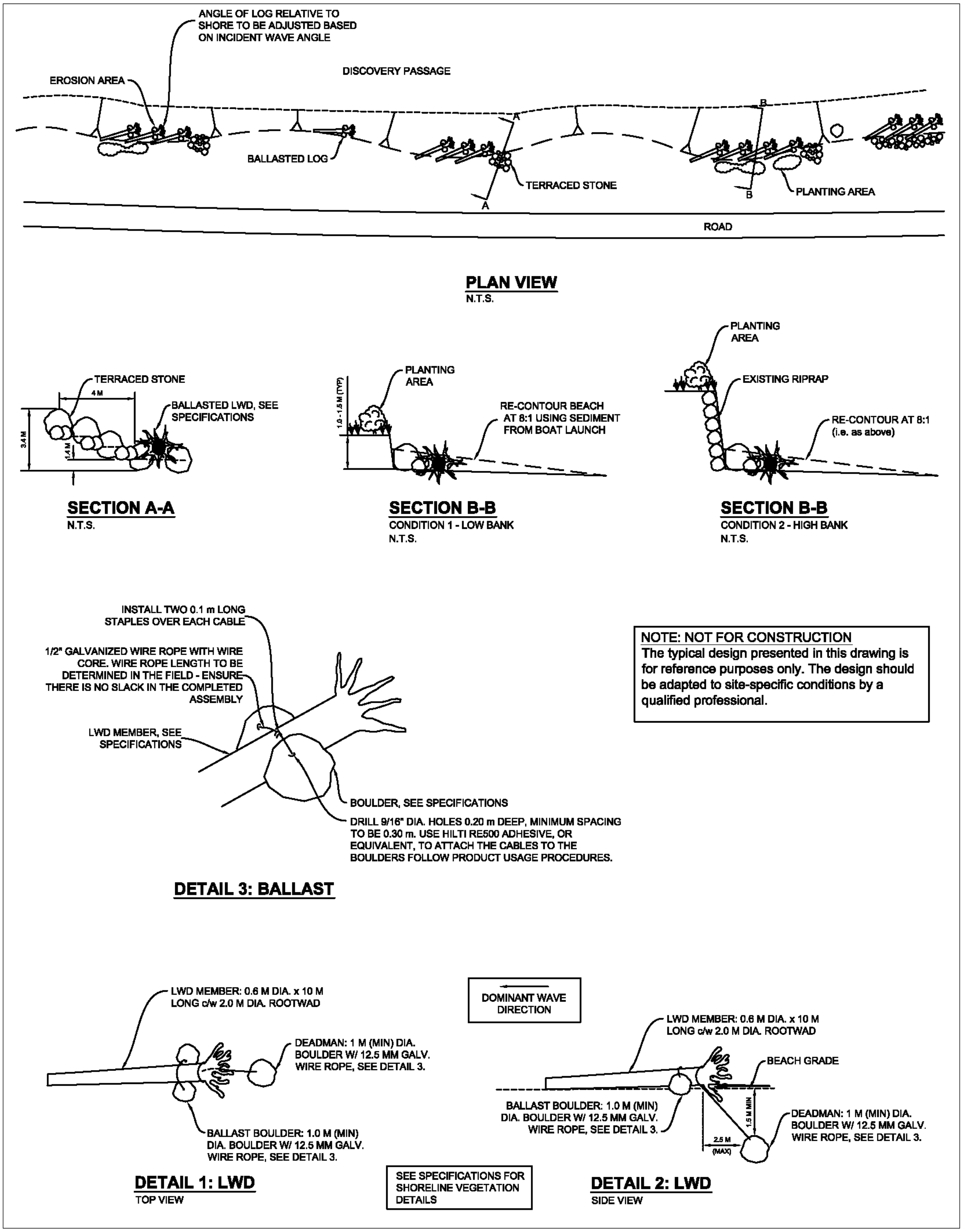
Figure 14. **Views looking south along the shoreline at Kitty Coleman Provincial Park, a) prior to restoration work, and b) after the year-one project completion.**

The typical design shown in **Figure 15** is adapted from that used at Kitty Coleman Park and relies on a combination of ballasted logs and beach slope re-contouring. Logs are ballasted to provide stability using boulders and are attached using steel cables. The boulders are buried or partially buried for added stability and to reduce visual impact. The placement and orientation of the logs are chosen to correspond to the dominant wave direction and would need to be adjusted for each individual site. The design can be installed at sites with a low (1 m to 1.5 m) cut bank or in front of shorelines where rip rap has been installed. Adjustments in the boulder anchor size would be required in areas of higher wave energy at the base of reflective shorelines.

The design is not maintenance free. Depending on the site and on the adjacent shoreline condition, inputs of sediment and occasional repairs to the anchor attachments may be required.

The cost for this type of shoreline protection is dependent on a number of factors, such as length of site, height of the bank at the shoreline, and the cost of materials. The City will have access to the gravel sediment from the boat launch maintenance operations, but may have to purchase logs and boulders. Aside from materials, the typical costs would be associated with machinery (excavator and rock trucks) and crews to complete the work of connecting the logs to the rocks. A typical 50 m long site could likely be completed by a three person crew in 5 days with machinery support.

Variations on this design that rely on burying logs rather than using rock ballast could be considered for areas with a lower risk of project failure. Other options include the installation of submerged breakwaters in offshore intertidal areas, which would help to dissipate wave energy while potentially having a habitat benefit.



NOTE: NOT FOR CONSTRUCTION
The typical design presented in this drawing is for reference purposes only. The design should be adapted to site-specific conditions by a qualified professional.

Figure 15. Typical soft shoreline protection design.

7.5 SHORELINE VEGETATION MAINTENANCE PLAN

7.5.1 *SUMMARY OF VEGETATION MANAGEMENT ISSUES*

As discussed briefly above, shoreline vegetation in the study area is heavily disturbed and fragmented which limits its ecological value and reduces its contribution to shoreline stability. Three broad factors contribute to this condition.

Historic Development and Shoreline Protection. Over 95% of the shoreline within the study area is developed for residential, road, recreation, and infrastructure activities. The South Island Highway closely parallels the shore in many areas, and in areas that it is located further inland, dense residential development, including apartments, townhouses, and hotels, have been constructed. Much of the developed shoreline has been stabilized using riprap, seawalls, or other methods that remove native vegetation or disrupt ecological processes such as sediment movement which sustain shoreline vegetation.

Park Management. A variety of small shoreline parks are located within the study area, including Rotary Beach Park, Frank James Park, Ellis Park, Big Rock Park, and Adams Park. Almost all are intensively developed with pedestrian or multi-use trails, parking areas, mowed grass areas, and isolated tree and shrub patches. Except for the restored shoreline area in Dick Murphy Park, none of the municipal parks are managed primarily for conservation. Natural vegetation, particularly forest, is very limited.

Invasive Plants. Invasive plants are a ubiquitous component of shoreline vegetation in the study area, but current infestations are localized. Non-native Himalayan blackberry and Scotch broom were commonly observed intermixed with native shrubs such as Nootka rose and thimbleberry in narrow shrub thickets. Other invasives such as orchard grass, velvet grass, and other non-native grasses were also common. The timing of the assessment during winter months affected our ability to assess the occurrence of some non-native forbs such as common tansy and St. John's wort that are often found in weedy, shoreline communities.

7.5.2 *RECOMMENDED VEGETATION MANAGEMENT GOAL, OBJECTIVES, AND GUIDELINES*

GOAL

The goal of shoreline vegetation management is to protect existing natural vegetation and restore natural shoreline vegetation communities on public and private lands in the City of Campbell River.

On public lands, the City of Campbell River should strive to increase natural shoreline vegetation to a minimum of 20% of total park area, and 50% of the marine backshore zone (within 15 m of high water mark[24]), by 2025.

Three approaches should be used to meet this goal:

1. Increase emphasis on protecting and restoring ecological value in shoreline parks through park planning (ecological design), recreation management, and changes to maintenance activities;
2. Provide technical assistance (publications, advice, etc.) to private landowners with shoreline properties to protect and restore natural vegetation; and
3. Use the existing Streamside Development Permit Area (encompassing an area 30 m from high water mark) to protect and restore shoreline vegetation during subdivision or development. Emphasize vegetation within 15 m of the high water mark which has the highest ecological value.

VEGETATION MANAGEMENT OBJECTIVES

1 Increase environmental features and functions in shoreline parks and other public lands by increasing native marine backshore and backshore vegetation (typically within 15 m of the high water mark). Focus on three vegetation communities: (a) mixed forest; (b) shrub thicket; and (c) beachgrass meadow. In situations where tree cover is inappropriate because of high recreation use or regular maintenance access, create shrub thickets or beachgrass meadows within 2 m to 5 m of the high water mark.

2 Support improved vegetation management on privately owned shorelines by providing information such as GreenShores publications, providing technical assistance with developing solutions to protect or restore shoreline vegetation, or provide plant materials or other direct support.

3 Use the existing Streamside Development Permit Area to protect and restore foreshore and marine backshore vegetation within 15 m of the high water mark during subdivision or development.

4 Strive to increase natural shoreline vegetation to a minimum of 20% of the total park area, and 50% of the marine backshore zone (within 15 m of the high water mark), by 2025.

5 Reduce maintained vegetation such as turf within 15 m of the high water mark in shoreline parks to reduce maintenance requirements (ie. GreenShores).

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[24] The High Water Mark can also be interpreted as the ‘Natural Boundary’: the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself (BC Land Act).

6 Reconnect the marine backshore (terrestrial) and intertidal zone by avoiding seawalls and riprap shoreline protection, and restoring natural beach profiles.

7 Balance the need to maintain shoreline vegetation to provide recreation opportunities, maintain aesthetics and views, protect public safety, and protect park infrastructure with environmental values (fish and wildlife habitat).

8 Reduce environmental impacts from invasive plants on native backshore by eradicating small infestations, preventing future introductions and spread, and creating competitive invasion resistant plant communities.

VEGETATION MAINTENANCE IN PARKS AND PUBLIC LANDS

Mowing and other vegetation maintenance is required to maintain safe parks, protect park infrastructure, and allow for routine or emergency maintenance access. Regular mowing is undertaken within 30 to 50 cm of the seaward edge of existing paths, and hazard trees are removed as identified.

Guidelines:

1 Mowing and brushcutting of grass, shrub, and tree vegetation is permitted within 30 cm of the seaward edge of trails, parking areas, and other park infrastructure. Exceptions are made for invasive species control or for emergency works that require vegetation removal.

2 No pruning or removal of native trees or shrubs within 15 m of the high water mark should be undertaken to improve views from adjacent private property, or for other aesthetic reasons. Careful pruning is permitted for public safety to a maximum of 5 m above the ground surface.

3 No herbicides, pesticides, fungicides, or chemical fertilizers should be used in shoreline parks to avoid transfer to marine ecosystems. Controlled use for invasive species control is permitted.

4 Reduce mowing or use “no mow” areas to increase vegetation cover and diversity, and reduce maintenance costs. Mowing of tall grasses in these areas should occur during August or September.

5 Dispose of vegetation cuttings, branches, soil, and other materials generated from maintenance activities away from the shoreline (no on-site dumping).

6 Retain a qualified arbourist to identify hazard trees on a regular basis (every 2–5 years). Where possible, hazard trees should be limbed or pruned to reduce risk. If removal is required, larger hazard trees should be topped from 5 to 10 m in height to create artificial snags.

RESTORING BACKSHORE AND MARINE BACKSHORE AREAS

Apart from restored portions of Dick Murphy and Ken Forde Boat Ramp Park (Willow Creek estuary), shoreline parks in the City of Campbell River are managed for recreation use rather than for ecological value. Backshore vegetation is typically confined to a narrow strip between the top of riprap bank protection and trails or maintained vegetation. Most of the marine backshore zone is unforested and disconnected from the adjacent intertidal zone by shoreline armouring. Ecological processes provided by marine backshore forest such as shading and nesting and perching sites for birds are very limited. There may be a need to develop avian perching and nesting tree recruitment guidelines.

Guidelines:

1 Use shoreline protection methods (such as the Green Shores methods used in Dick Murphy Park) that maintain the physical connection (natural beach profile) between marine backshore vegetation and the intertidal zone.

2 Require new park plans and shoreline park development to use designs that incorporate ecological principles.

3 Plant a minimum of one native tree (Sitka spruce, Douglas-fir, western redcedar, big-leaf maple, red alder, or black cottonwood) within the marine backshore zone for every 10 linear metres of shoreline. Minimum stock size is 6 cm caliper.

4 In areas where viewscapes are of high concern, consideration of appropriate horticultural varieties may provide a solution to balancing aesthetic with ecological considerations.

5 Encourage landowners through education and other methods to use trees and other vegetation to frame viewscapes, or use lower shrub or meadow vegetation that doesn’t obstruct viewscapes (see Guideline VII: Manage viewscapes).

6 Use native beachgrass (dune wildrye) or low shrubs such as salal, Oregon-grape, kinnickinnick, and thimbleberry in sites where view lines for public safety are required.

7 Where possible, relocate trails and other park infrastructure at least 15 m away from the high water mark, or limit trail width.

8 Use shoreline construction or maintenance activities (e.g., outfall construction or maintenance) as an opportunity to restore native vegetation within 15 m of the high water mark.

9 Use native trees, shrubs, and forbs for landscape planting within the marine backshore buffer zone. Appropriate horticultural varieties may also be considered.

10 Use bioengineering plantings in concert with other techniques to increase shoreline stability in eroding areas.

11 Top dress existing riprap areas with native gravels and soil to create revegetation opportunities.

12 Where appropriate, incorporate bioengineering plantings (willow and other species) into shoreline stabilization treatments to improve stability and increase ecological value.

7.5.3 CONTROLLING INVASIVE PLANTS

Invasive plants are a widespread but relatively sporadic problem in shoreline parks in the City of Campbell River. Scotch broom and Himalayan blackberry were the most common invasive species identified during the field assessment. Invasive grasses are also common but rarely abundant. Invasive plants are considered to be a secondary issue for shoreline vegetation compared to park management and historic development activities. However, their impact is likely to increase over time.

Guidelines:

1 Multiple vegetation management strategies (active control, promoting invasion resistant communities, limiting dispersal) should be used to control invasive plants in shoreline parks over the long-term.

2 Eradicate or reduce existing infestations of Scotch broom and Himalayan blackberry in Seawalk Park, Ken Forde Boat Ramp Park, shoreline areas south of Dick Murphy Park, and other sites using cutting or pulling (Scotch broom) and cutting and careful glyphosate application (stem injection, wiping). Pulling is the preferred method for smaller plants - when pulling plants, care must be taken to minimize disturbance of soils as this can facilitate re-establishment of invasive species. If larger plants are to be cut flush with the ground, the recommended time of year to do this is when the plants are flowering but before they produce seeds; usually in mid-May to mid-June.

3 Target Himalayan blackberry patches that are a minimum of 50 sq. meters and 50% foliar cover, and all infestations of Scotch broom (from single plants to large patches).

4 Encourage invasive species control projects at priority sites by community and stewardship groups through the provision of training, equipment, and recognition. Identify specific parks or park areas in which stewardship groups can address invasive species over the long-term,

5 Create dense plant communities (large stock size, higher planting densities) to reduce the potential of invasive species colonization of new planting beds.

6 Use green chip mulch (chipped material from tree trimmings) or similar material to top dress (5–10 cm) all new planting beds which may be susceptible to invasive species colonization.

7 Use constructed soils for shoreline projects to reduce the movement of invasive plants. Dispose of soil contaminated with the roots and seeds of invasive plants at an appropriate site.

7.5.4 PRIORITY SITES FOR SHORELINE VEGETATION RESTORATION AND ENHANCEMENT

General priorities for shoreline vegetation restoration and enhancement in the study area are based on the following criteria:

1. Focus restoration activities on parks and public lands.
2. Restore backshore and marine backshore vegetation adjacent to intertidal areas with high ecological value for forage fish or wildlife.
3. Focus on large sites where the massing of shoreline vegetation can provide habitat for wildlife.
4. Use opportunities such as maintenance activities or shoreline protection projects to restore shoreline vegetation (synergies with other project priorities).

Table 19 provides a summary of 14 recommended parks and other public lands for shoreline vegetation restoration and enhancement (from south to north). A general restoration strategy is provided.

SPECIFIC PRIORITY SITES

The top five priority sites are (in order of priority):

1. Big Rock Park and Ellis Park Area (Sites 8 and 9). Revegetation of the backshore area with native tree and shrub species. Consider relocating trail to west to increase width of backshore vegetation.
2. Ken Forde Boat Ramp Park and Estuary (Site 3). Reforestation of the backshore area along Ken Forde Boat Ramp Park and the area surrounding the Willow Creek estuary.
3. Frank James Park (Site 6). Revegetate with isolated native trees (at least one forest patch); shrub thickets (low and high) and/or beachgrass plantings adjacent to trails; maintain some view corridors with low vegetation.
4. Seawalk Park from Twillingate Road to south end of Ken Forde Park (Site 2). Revegetate with isolated native trees (at least one forest patch); shrub thickets (low and high) and/or beachgrass plantings adjacent to trails; maintain some view corridors with low vegetation.
5. Undeveloped / unnamed park 295 m north of McCallum Park/Big Rock Boat Launch (Site 12). Remove Scotch broom and blackberry; reforest marine backshore zone with mixed forest.

Table 19. Recommended sites for shoreline vegetation restoration and enhancement.

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
6 Seawalk Park (south end)] at Maryland Rd outfall.	High	2,160 m^2 / 153 m (all public land)	Shrub and grass; some Scotch broom and blackberry; isolated younger Sitka spruce trees	Address Scotch broom infestation; reforest with Sitka spruce, Douglas-fir, and western red cedar.	
7 Seawalk Park from Twillingate Road to south end of Ken Forde Park parking area.	High	9,800 m^2 / 610 m (note, not all is public land)	Primarily grass and maintained vegetation	Revegetate with isolated native trees (at least one forest patch); shrub thickets (low and high) and/or beachgrass plantings adjacent to trails; maintain some view corridors with low vegetation.	
8 Ken Forde Boat Ramp Park (mouth of Willow Creek)	High	1,260 m^2 / 420 m	Unvegetated riprap; grass; non-native shrubs including some Scotch broom	Plant mixed forest upslope of small estuarine/brackish marsh; top dress riprap with sand gravel and organic-rich soil and revegetation with red alder	

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
9 Jaycee Park	Moderate	735 m^2 / 55 m (note, not all is public land)	Maintained turf and isolated trees and shrubs; narrow band of native beachgrass along margin of riprap shoreline protection	Increase tree cover; use street trees to promote view corridors?; shrub thickets to buffer park from existing private residences	
10 Adams Park	Moderate	825 m^2 / 55 m	Some trees (native and non-native) but primarily maintained turf areas; isolated shrubs; some shrub cover along margin of riprap; benches and other structures	Increase tree cover to restore a native marine backshore zone; maintain viewing areas and benches along shoreline margin.	
11 Frank James Park	High	1,950 m^2 / 335 m	Primarily grass and maintained vegetation; isolated native trees.	Revegetate with isolated native trees (at least one forest patch); shrub thickets (low and high) and/or beachgrass plantings adjacent to trails; maintain some view corridors with low vegetation.	

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
12 Seawalk Park immediately south of Simms Creek estuary.	Moderate	1,240 m^2 / 125 m	Rare unarmoured shoreline area with small patches of Sitka spruce forest or isolated trees; common vinca (non-native) present in understorey; some backshore development	Create continuous band of marine backshore forest (Sitka spruce, Douglas-fir, etc)	
13 Ellis Park	High	4,100m^2/247m	Some trees (native and non-native) but primarily maintained and maintained turf areas; isolated shrubs; some shrub cover along margin of riprap; benches and other structures.	Revegetate with native trees; shrub thickets (low and high) and/or beachgrass plantings. Relocate trail to west to restore backshore vegetation.	
14 Big Rock Park (north and south)	High	2,550 m^2 / 290 m	Minor backshore vegetation (beachgrass); dominated by maintained turf grass	Increase tree and shrub cover; use street trees to promote view corridors; relocate trail to west and restore backshore vegetation.	

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
15 McCallum Park/Big Rock Boat Launch	Moderate	280 m^2 / 20 m	Maintained turf grass; narrow band of beachgrass and isolated native shrubs	Increase tree cover to restore a native marine backshore zone; maintain viewing areas and benches along shoreline margin.	
16 Unnamed park 180 m north of McCallum Park	Moderate	330 m^2 / 32 m	Maintained turf grass; narrow band of beachgrass and isolated native shrubs	Increase tree cover to restore a native marine backshore zone; maintain viewing areas and benches along shoreline margin (viewing platform?)	No photo
17 Undeveloped / unnamed park 295 m north of McCallum Park/Big Rock Boat Launch	High	1,010 m^2 / 65 m	Disturbed parcel with dense Himalayan blackberry and Scotch broom in backshore	Excavate backshore to remove Scotch broom and blackberry; reforest marine backshore zone with mixed forest; provide view corridor at north end of site	

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
Rotary Beach Park North	High	1,245 m^2 / 100 m	Developed park with narrow band of Sitka spruce trees; high recreation value (particularly seasonal use)	Increase width of Sitka spruce forest; shrub and beachgrass plantings not recommended because of recreation use	
Seawalk Park north of Rotary Beach Park	Moderate	1,935 m^2 / 182 m (note, not all is public land)	Narrow band of backshore vegetation; trail through maintained grass; isolate Sitka spruce trees	Increase shrub thicket plantings; increase tree cover; plant beachgrass on both side of trail	
Hidden Harbour Park South	High	930 m^2 / 83 m	Narrow beachgrass-dominated backshore; maintained turf on north portion of site	Revegetate with dense band of Nootka rose, snowberry, oceanspray, and other native shrubs to maintain view; plant isolated trees on north edge of site	

Park / Site	Priority	Area / Length	Current Condition	Restoration Strategy	Representative Photo
Robert Ostler Park	Moderate	3,040 m^2 / 135 m	Maintained turf grass with isolated trees	Create a small forest patch of mixed species adjacent to backshore	
Dick Murphy Park	Moderate	11,000 m^2 / 135 m	Preserved/recovering grass and shrub community. A few isolated trees.	Increase tree cover to address general lack of trees in most of Campbell River backshore.	

7.6 BOAT LAUNCH MAINTENANCE PLAN

The City of Campbell River operates two public boat launches within the study area. Both require ongoing maintenance to clear the ramps and foreshore areas of sediment and debris as well as a significant annual maintenance effort that includes more substantial dredging of the ramp area. Sediment and debris can accumulate very rapidly in the winter months and the boat ramps can require almost continuous maintenance depending on the incidence of weather events. Maintenance activities have had to be curtailed in recent years due to a higher level of awareness of habitat issues and the potential damage to the shoreline environment that can result.

An in-depth investigation of the boat ramps was completed and included in **Appendix B**. The purpose of this investigation is to provide a more in-depth assessment of the natural shoreline processes as they impact boat launch use and maintenance, as well as to provide alternative scenarios for a long-term maintenance solution.

Based on the findings of this investigation, it is concluded that the Ken Forde Boat Ramp is located in a particularly challenging section of the shoreline. It is exposed to waves that are essentially unaltered by transformation from deep water to the near-shore environment, it is located at the end of a long section of active beach, and the physical structures that have been constructed at the ramp and in front of Willow Creek further encourage the deposition of sediment in an area already naturally prone to this process.

The Big Rock boat Ramp is in a somewhat less precarious location. It is located within a relatively straight section of beach and waves generated in open water are reduced in height as they enter the near-shore environment. As a result, sediment blocks the ramp structure less frequently and there is less sediment deposited on the ramp overall, although there is considerably more sediment that deposits further seaward within the two curved groynes.

The previous maintenance approach was not supported by Fisheries and Oceans Canada and members of the public have become frustrated by the limitations on their use of this City-owned facility. The City will need to choose between a number of potential management options to develop an adjusted or new approach. **Table B-2** from **Appendix B** outlines a number of options to modify the existing approach or to develop a new approach and is reproduced below as **Table 20**. If an agreement can be reached with DFO, the Adjusted Current Approach should provide an opportunity for greater flexibility in the maintenance schedule for both ramps but will cost more money to implement than has historically been spent on these facilities. **Appendix B** (**Section 3.1**) provides an outline for the Rapid Biological Assessment that is a key component to this approach. Another key component is the Beach Nourishment Program outlined in **Section 7.3** of this report.

The New Approach includes a number of options for reducing maintenance effort, some of which would require a significant capital investment, such as relocating the Ken Forde ramp to Adams Park or constructing the large groyne outlined in Section 3.2 of Appendix B. Clearly, any decision towards adopting one or more of the options in the New Approach would require further consultation.

Table 20. Summary of approach options for boat ramp management (reproduced from Appendix B).

Adjusted Current Approach	New Approach
• Rapid biological assessment prior to ramp clearing activities • 'Annual' maintenance to occur as before • 'Ongoing' maintenance to occur as needed throughout the year • Adopt a beach sediment nourishment program • Use sediment and debris to construct and maintain 'soft' shore protection sites	• Close Ken Forde permanently and relocate to Adams Park • Close Ken Forde during the winter months • Close both ramps during the winter months • Close both ramps permanently and provide discounted launching at Discovery Marina • Significant capital investment to upgrade Ken Ford

8 RECOMMENDATIONS

The shoreline within the study extents of this investigation has been modified extensively through human habitation and development. Ongoing erosion of the shoreline from wind generated waves has resulted in a management approach that places a lot of emphasis on the protection of property at the expense of the natural environment. While this approach provides temporary protection, it does not represent a long-term solution. The City of Campbell River, which is described as the ‘Salmon Capital of the World’, obviously values the amenities provided by the natural environment. The recommendations outlined in this report provide an alternative approach that incorporates a comprehensive understanding of the natural processes to guide future development, ongoing management, and restoration of the natural resources.

8.1 RECOMMENDATIONS – SHORELINE PROTECTION

Priority sites for shoreline protection have been identified. High priority sites are areas where there is an imminent threat to infrastructure while lower priority sites are areas where shoreline erosion is active but has not yet become serious. The list of sites is current as of the date of this report but will be expected to change as issues emerge with the evolving conditions along the shoreline. With the exception of the issue of debris depositing at Seaside Estates, which requires an engineered solution, these sites can be addressed using a ‘soft’ approach that relies on ballasted logs and beach recontouring as an alternative to rip rap or sea walls. A typical design is included that can be adapted to each site as required.

In addition to bank protection efforts, a beach nourishment program will introduce much-needed sediment to the shoreline system while at the same time providing a location at which to deposit sediment removed from the boat launches during regular maintenance. Eleven sites have been identified based on the need for additional sediment along the shoreline and the ease of access for trucks and machinery. The sites are all within parks or City-owned lands.

8.2 RECOMMENDATIONS – BOAT LAUNCHES

Maintenance of the two City-owned boat launches has been curtailed in recent years in order to bring the City into compliance with environmental regulations. Of the two boat ramps, Ken Forde has historically proven to be the most challenging to keep free of sediment and debris. The analysis shows that this site is almost unique within the Campbell River shoreline, as having the highest waves and being within the area of greatest sediment availability. The Big Rock facility is exposed to smaller waves and is situated within a section of coastline that transports less sediment.

Appendix B provides an in-depth examination of the coastal processes affecting these facilities as well as a number of options for an Adjusted Current Approach or for developing a New Approach. The Adjusted Approach includes actions that can be taken almost immediately to improve public access to the ramps. However, adopting elements of the New Approach will require that decisions are made at the political level as they would involve providing reduced service, an increase in the current level of funding to these facilities, or both.

For immediate action, we recommend that the City engage in discussions with DFO to develop a Memorandum of Understanding (MOU) for a boat launch maintenance program that would include the following elements:

- Adoption of a procedure to perform a Rapid Biological Assessment at least two weeks prior to maintenance activity to determine if the boat ramp sites as well as the beach nourishment sites are free of forage fish eggs;
- Recognition and acceptance of the beach nourishment sites as a repository for the sediment excavated from the ramps; and
- An agreement that the City can perform the required maintenance described under the MOU without formal authorisation from DFO, provided the appropriate best management practices are followed.

8.3 RECOMMENDATIONS – ECOLOGICAL ENHANCEMENT

The Existing Conditions – Ecological Assessment provides a reach-by-reach analysis of the status of the biological system. Conditions are expected to improve as the other recommendaitons in this report are implemented. Specific reach-by-reach recommendations outlined within the Existing Conditions Assessment can be implemented to speed this recovery process as desired.

8.4 RECOMMENDATIONS – VEGETATION MAINTENANCE

Shoreline vegetation plays an important role in the overall health of the shoreline ecosystem. The backshore environment has been heavily impacted by development and the incursions of invasive species, which has an effect on shoreline stability, aesthetics, and ecological function. Because of the importance of the remaining intact backshore vegetation, cutting and mowing along public pathways and rights of way has the potential to cause ecological damage if a consistent approach is not followed.

A vegetation maintenance plan has been presented with specific recommendations and guidelines, both for ongoing maintenance of vegetation within City-owned lands, including the seawalk, as well as for restoring the shoreline vegetation to a more natural state. This plan balances the effort and cost of managing against invasive species against the ecological benefits. We recommend that the City review its current vegetation management approach to ensure that the backshore vegetation communities are protected and enhanced. We further recommend that the City consider developing a comprehensive Bald Eagle perch and nest tree habitat recruitment policy.

There is a very high likelihood that ecological considerations alone cannot guide vegetation management policy without giving rise to conflict with other values, such as sight lines, public safety, and aesthetics. The City may wish to consider a public consultation process to gather input and solicit buy-in to the vegetation management guidelines.

8.5 RECOMMENDATIONS – DEVELOPMENT GUIDELINES

The following recommendations are aimed at helping Campbell River move forward with shoreline management that optimizes shoreline values for the community. This report as a whole provides a large body of information to base shoreline management decisions on, but there are further specific actions that could be pursued to help achieve shoreline management objectives as follows.

Recommendations that fit a regulatory approach or focus include:

- Pursue enhanced Shoreline DP Guidelines in the SOCP. Appendix C includes sample language that has been adapted from the District of Central Saanich guidelines (Central Saanich OCP Bylaw 1600, Section 11.2).
- In addition to SOCP changes, Development/Zoning bylaw amendments could be made to further strengthen regulatory controls on shoreline development.

Further recommendations that fit an education-based approach are as follows:

- Workshops for waterfront owners outlining best practices and current shoreline management issues;
- Guest presentations and expert lectures on shoreline management trends;
- Further interpretive signage for new restoration initiatives;
- Targeted mail outs with information pertinent to specific shoreline neighbourhoods; and
- Promotion of the Green Shores program with shoreline property owners.

Further recommendations that fit an incentives-based approach are as follows:

- Within the next year, it is expected that the Green Shores program will evolve to include a “Green Shores for Homes” program. This program is currently under development through a partnership between the City of Seattle, San Jan County and Green Shores who recently won a US Environmental Protection Agency (EPA) grant to fund development and piloting of the program. Compliance with this program could be included in bylaws to further regulate shoreline development, or the program can be used as an incentive to homeowners who pursue standards of care in development;

- The city might also work with other levels of government and local business or advocacy groups to provide financial or other subsidies for restoration works on private shoreline properties; and,
- Streamlined approvals for innovative development approaches along shorelines can be used as a powerful incentive for shoreline restoration/protection.

8.6 RECOMMENDATIONS – SEA LEVEL RISE

Based on the available science of future sea level rise, large portions of the City of Campbell River will be at risk of flooding and erosion. The Provincial government has recently begun the process of updating the existing guidelines for calculating coastal flood construction levels and appropriate development offsets. This work was at the draft review stage during the time that research for this report was underway and has since been adopted. It will most certainly result in the need for a significant planning effort within the City to manage existing and future developments in light of these new regulations. For example, **Figure 5** shows the potential effect of sea level rise on the downtown area of Campbell River. We recommend that the City engage the appropriate Provincial agencies at the earliest opportunity for assistance with adapting to this newly identified reality.

8.7 RECOMMENDATIONS – FUTURE INVESTIGATIONS

This report was prepared based on an extensive review of available information as well as overview-level field investigations. Follow-on studies would benefit from the inclusion of more in-depth field investigations as part of the scope of work. Field investigations will require a higher level of funding but the resultant information will provide invaluable information to address some of the data gaps that have been identified throughout this report, particularly with respect to forage fish, which is emerging as an important conservation issue.

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APPENDIX A

OCEANOGRAPHIC CONDITIONS

TABLE OF CONTENTS

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1 INTRODUCTION

1.1 PURPOSE

This appendix summarizes information on tides, winds and waves at Campbell River for the *City of Campbell River Marine Foreshore Habitat Assessment and Restoration Plan*, prepared by Northwest Hydraulic Consultants, Current Environmental, and Murdoch de Greeff Inc. The analysis is based on published met-ocean data and bathymetric information, a wave hindcasting analysis using standard coastal engineering methods as well as field inspections and field surveys. The potential impacts of climate-change on coastal flood levels are also described. Information on coastal geomorphology is not discussed in this section, since it is described separately in the main report.

1.2 STUDY EXTENT

Figure A-1 shows the study area in relation to the Strait of Georgia and Discovery Passage. Campbell River is located at the north end of the Strait of Georgia and faces Discovery Passage, which lies between Vancouver Island and Quadra Island. Cape Mudge at the southern end of Quadra Island and Shelter Point on Vancouver Island form the southern entrance to Discovery Passage. Seymour Narrows is located 15 km north of Campbell River and creates a prominent narrowing in Discovery Passage.

Figure A-2 shows the extent of the foreshore study area. The Campbell River foreshore study area extends over a distance of approximately 15 km between Ocean Grove Road at the south end and Orange Point Road to the north. A reference chainage was established along the shoreline, starting at the southern end of the study at Orange Grove Road. These distances (in km) are shown in **Figure A-2. Table A-1** summarizes the reference distances for a number of locations in the study.

1.3 SETTING

The City of Campbell River is located at the north end of the Strait of Georgia and at the southern outlet of Discovery Passage. The town is located on the Nanaimo Lowland and on the delta formed by the Campbell River. **Figure A-3** shows the general bathymetry offshore from Campbell River.

Figure A-4 to **Figure A-8** show the general characteristics of the foreshore in the study area. The southern section is aligned nearly north-south and consists of a relatively steep (1V:10H) gravel beach with a large amount of woody debris and logs near the high tide line (**Figure A-4**). The upper slope is often protected with bank revetments (riprap or concrete structures). The lower beach forms a flat platform near the low tide line and is sandier. The width of this zone varies from 100 to 400 m. This section of beach is exposed to south easterly storms from the Strait of Georgia.

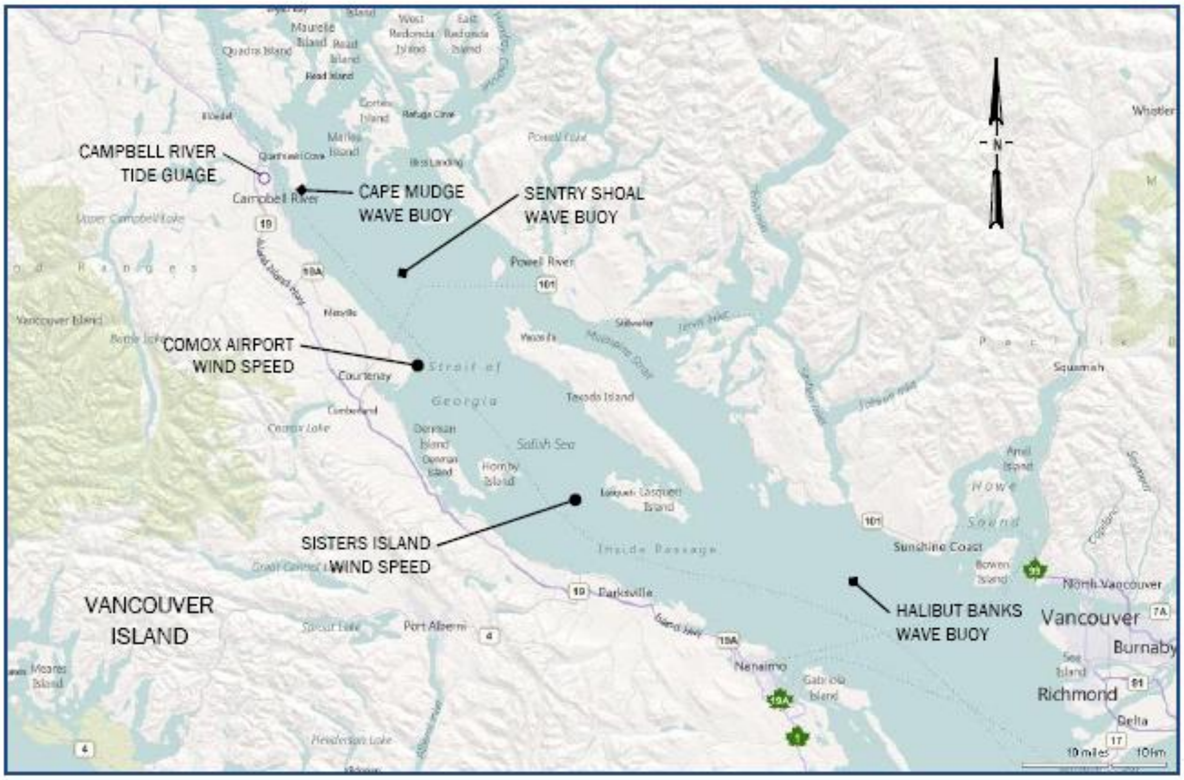


Figure A-1. Strait of Georgia Showing Wave Buoys and Climate Stations.

Willow Point (Figure A-5) is formed by a prominent sandstone ledge that extends out into the Strait. This feature extends offshore for a distance of about 1 km to near Frank James Park.

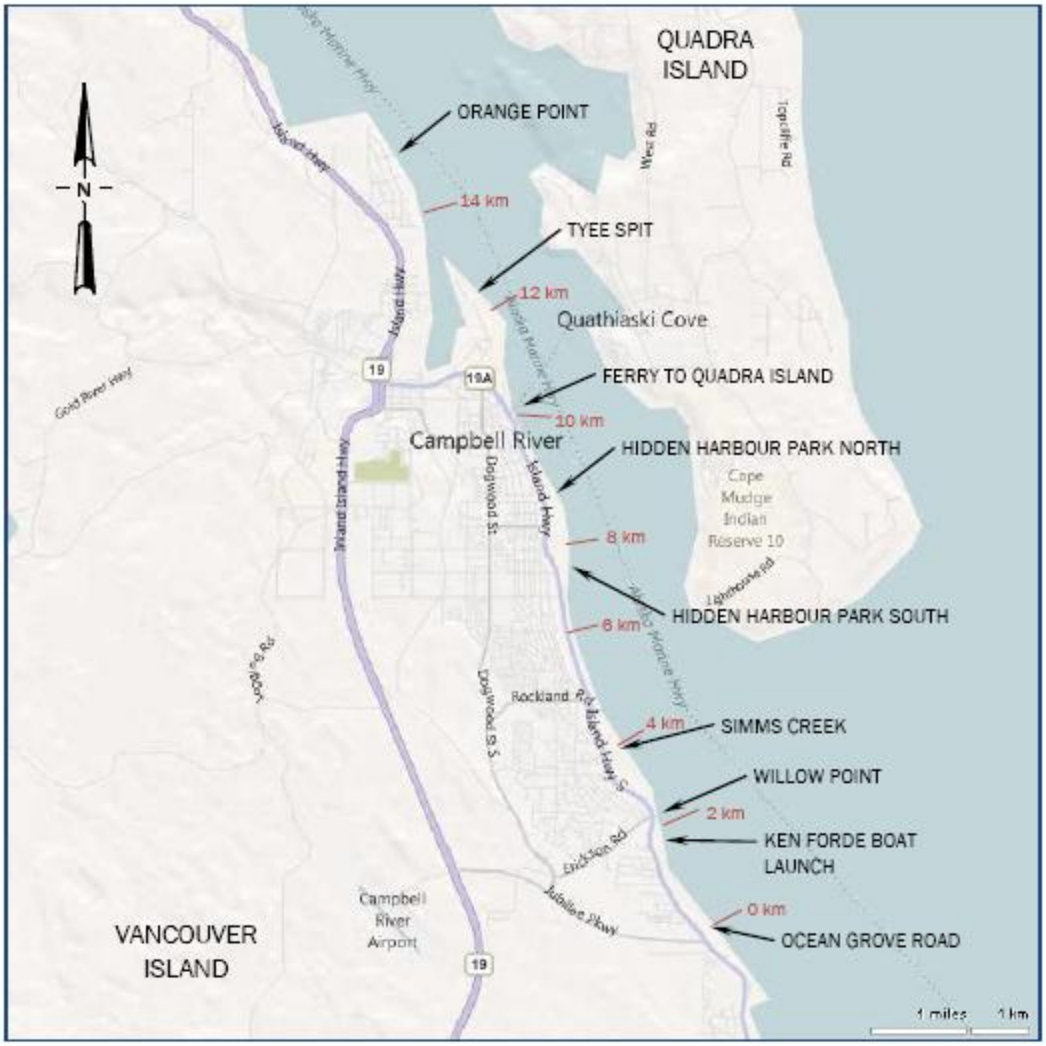


Figure A-2. Extent of Study Area.

North of Simms Creek, the shoreline becomes increasingly sheltered by Quadra Island. The passage between Quadra Island and Campbell River is typically 1.5 to 2 km wide in this section. Closer to the city centre, the shoreline has been altered considerably due to construction of wharves and marinas (Discovery Fishing Pier, Quadra ferry terminal, Discovery Harbour Marina). Near Tyee Spit (Figure A-8), at the mouth of Campbell River, the shoreline turns and is aligned NNE. The north end of the study extends from the mouth of Campbell River to Orange Point. The beach is typically narrow (50 to 100 m) in this section and the contours drop off sharply to depth of 15 to 30 m.

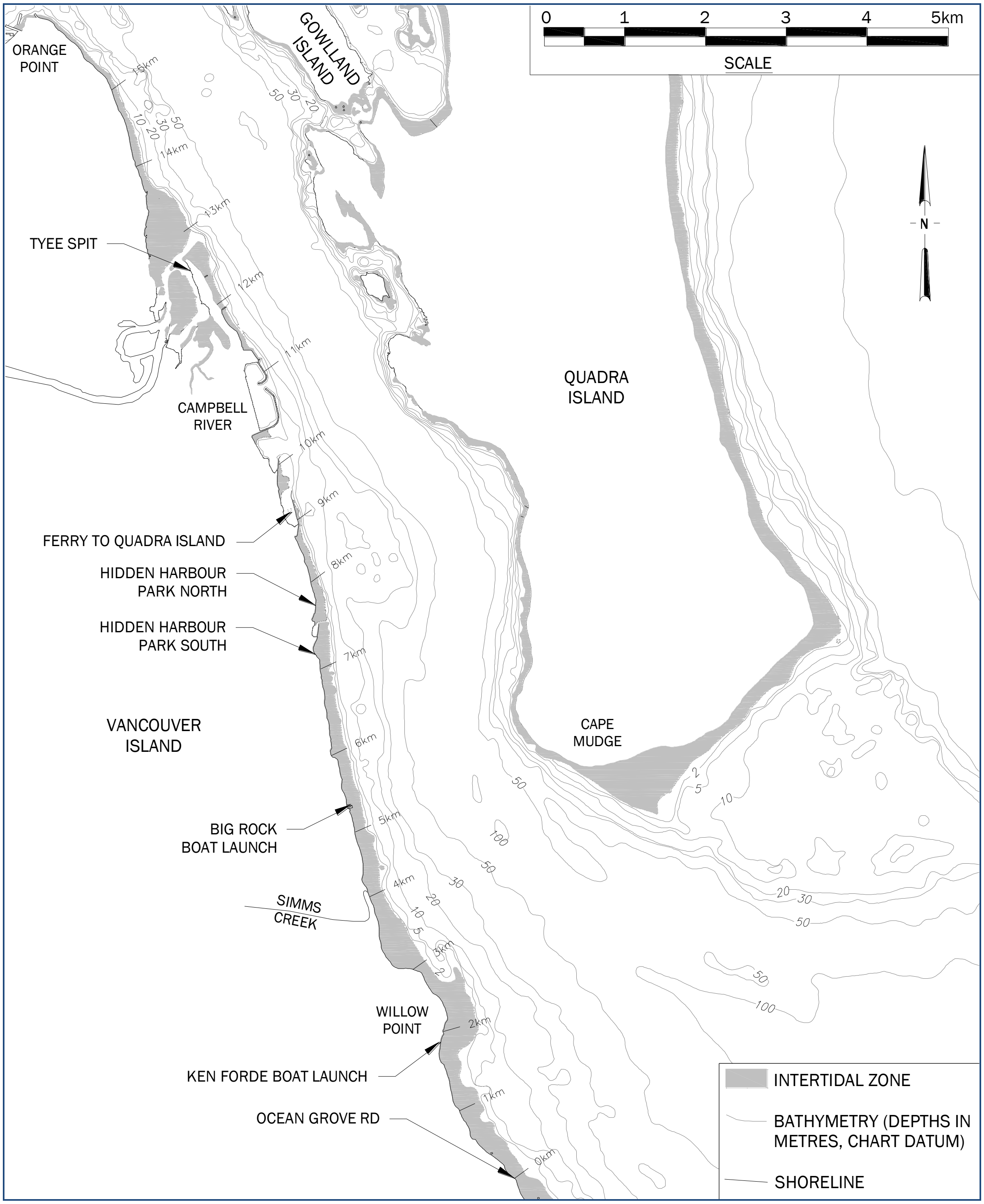


Figure A-3. Bathymetry near Campbell River.

Table A-1. Reference distance at key locations.

Site	Chainage (km)
Ocean Grove Road	0.00
Ken Forde Boat Ramp	1.98
Willow Point	2.10
Jaycee Park	2.25
Adams Park	2.90
Frank James Park	3.10
Simms Creek	4.00
Ellis Park	4.20
Big Rock	4.80
Big Rock Boat Ramp	5.20
Rotary Park Beach	5.90 – 6.10
Hidden Harbour Park South	7.30
Hidden Harbour Park North	8.70
Quadra Island Ferry	10.0
Discovery Harbour Marina	10.3 – 11.2
Dick Murphy Park	12.0
Tyee Spit	12.1 – 12.7
Orange Point	15.0

Figure A-4. **Various photos showing shoreline conditions north of Ocean Grove Road (photos taken 17 January 2011).**

Figure A-5. **Various photos showing shoreline conditions in the Willow Point area (a and b) and Ken Forde Boat Launch (c and d) (photos taken 17 January 2011).**

Figure A-6. **Various photos showing shoreline conditions from McCallum Park to Rotary Park (photos taken 17 January 2011).**

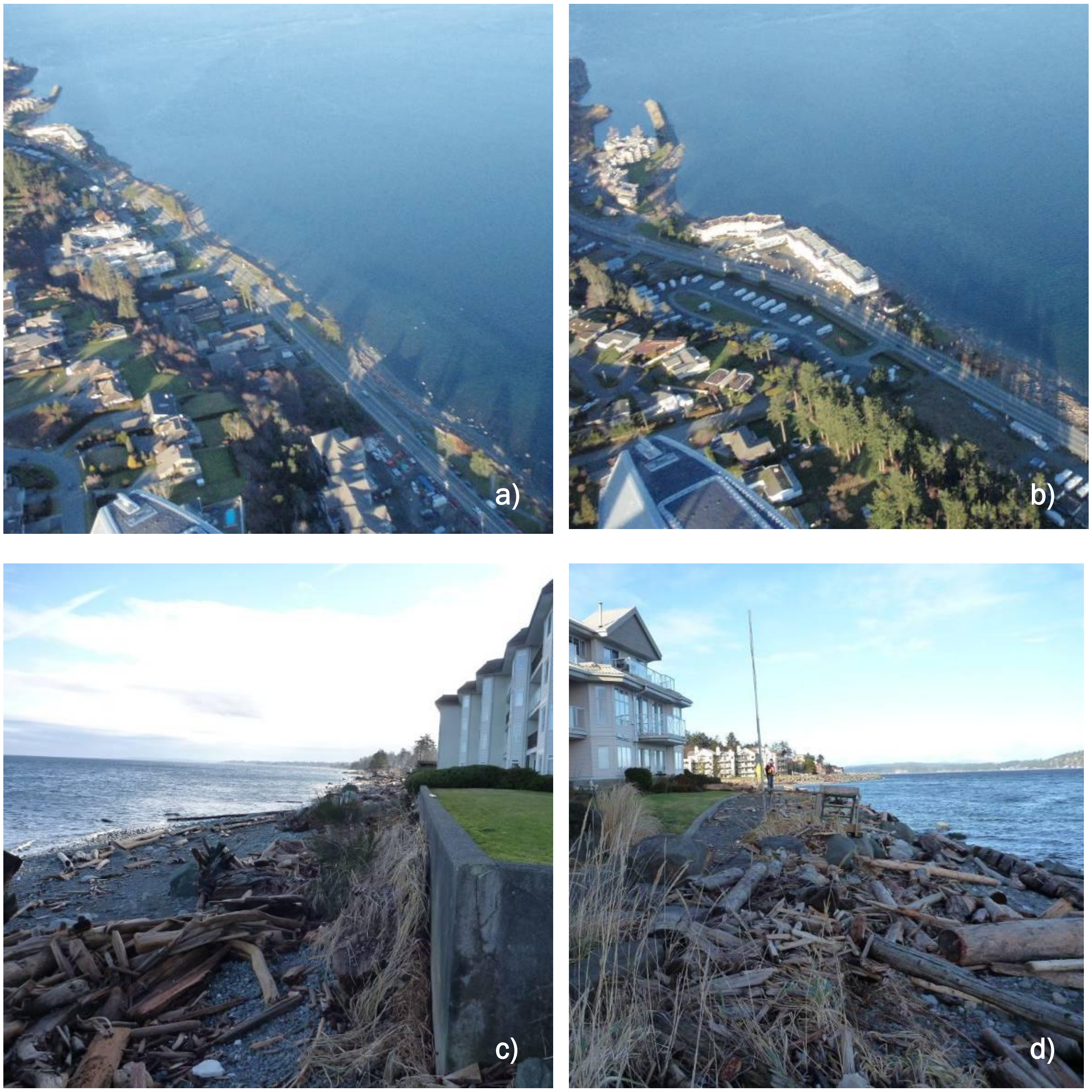


Figure A-7. **Various photos showing shoreline conditions from Rotary Park to Hidden Harbour Park (photos taken 17 January 2011).**

Figure A-8. Various photos showing shoreline conditions from Hidden Harbour Park to Tyee Spit (photos taken 17 January 2011).

1.4 AVAILABLE INFORMATION

Figure A-1 shows the location of the key meteorological stations and wave buoys that were used in the study. Table A-2 summarizes the period of record for each station.

Table A-2. Tide, wave and wind observations near the Study Area.

Instrument Type	Station	Period
Tide Level	Campbell River	1965 – present
Wave Height with Wind Speed and Direction	Sentry Shoal	Oct 1992 – present
	Halibut Bank	Oct 1992 – present
	Cape Mudge	Oct 1997 - Dec 1997
Wind Speed and Direction	Sisters Island	Feb 1995 - present
	Comox Airport	Jan 1953 – present

Hourly predicted and observed tide levels were obtained for Campbell River tide gauge (Station #8074). The difference between the observed and predicted tide levels was taken to represent the storm surge.

Measurements of significant wave height (H_s) and peak wave period (T_p) are available from wave buoy C46131 at Sentry Shoal from October 1992 to the present. This buoy is situated 13 km southeast of the study area, approximately mid-way between Oyster River and the Sunshine Coast at 49^{o}54'N and 124^{o}59'W. The buoy also provides information on hourly wind speed and direction. However, the records are intermittent due to instrument break downs and recording problems. Additional long-term observations are available from buoy C46146 at Halibut Banks, approximately 135 km south east of Campbell River. This buoy also includes measurements of hourly wind speed and direction.

2 TIDES

2.1 TIDE LEVELS

Tides in the Strait of Georgia are mixed, mainly semi-diurnal. Long-term tide level observations are available at only a few locations in British Columbia, including Campbell River (Station 8074). Published tide statistics are summarized in Table A-3 (in both chart datum and geodetic datum). Chart datum is commonly used in oceanographic studies and marine navigation applications and is established on the basis of the observed lowest tides over the year. Geodetic datum is generally used for terrestrial mapping and surveying purposes and is closely related to mean sea level. In British Columbia, geodetic elevations are referenced to the North American Datum of 1927. Throughout this study, all elevations are expressed to geodetic datum unless otherwise noted.

Table A-3. Summary of tide levels at Campbell River.

Tide Condition	Abbreviation	Elevation (m)	
		Chart Datum	Geodetic
Maximum Observed		5.3	2.4
Higher High Water Large Tide	HHW LT	4.8	1.9
Higher High Water Mean Tide	HHW MT	4.0	1.1
Mean Sea Level	MSL	2.9	0.0
Lower Low Water Mean Tide	LLW MT	1.2	-1.7
Lower Low Water Large Tide	LLW LT	0.2	-2.7

The geodetic elevation during the large tide event for High High Water level (HHW) is 1.9 m and -2.7 m for Low Low Water level (LLW). Conversion between geodetic datum and chart datum – the datum used for marine purposes – is approximately 2.9 m.

Extreme high tides are caused by a number of factors including:

- Periodic large astronomical tides (Spring tides).
- Storm surges due to large-scale wind patterns which cause super-elevation of the ocean.
- Wave set-up due to combined waves and tidal currents.
- El Ninõ events which can raise average ocean levels for extended periods of time.

Hourly data from the Campbell River tide gauge is available for the period from 1965 to 2007, with a total of 11 non-consecutive months of data missing. The maximum recorded sea level elevation at Campbell River was 5.27 m (chart datum) or approximately 2.4 m Geodetic, which occurred in 1967. A frequency analysis of annual maximum ocean levels was carried out using the 28 years of observations. Some key statistics from this analysis are summarized below:

- 20-year high tide level: 2.4 m (geodetic)
- 100-year high tide level: 2.5 m (geodetic)
- 200-year high tide level: 2.7 m (geodetic)

These elevations represent the still water levels and do not include wave runup effects.

2.2 CURRENTS

Tidal currents off Campbell River reach up to 9 knots (4.6 m/s) during flood tides and up to 7 knots (3.6 m/s) during ebbing tides. During flooding tides combined with strong southerly winds, a dangerous tidal rip forms off Cape Mudge, often extending across the entrance to Discovery Passage (CHS Chart 3539). The region from Cape Mudge to Willow Point is renowned for some of the most severe rip conditions in the Strait of Georgia due to the relatively long wind fetch and strong tidal stream that surges out of Discovery Passage (Figure A-9). Thompson (1981) described a severe tidal rip during a large flood tide combined with a south-east gale as follows:

> *The currents had literally stopped the waves at the leading edge of the advancing tidal stream. The waves steepened into sharp, white-water peaks over 5 m high, churning and foaming in the effort to propagate against the flow.*

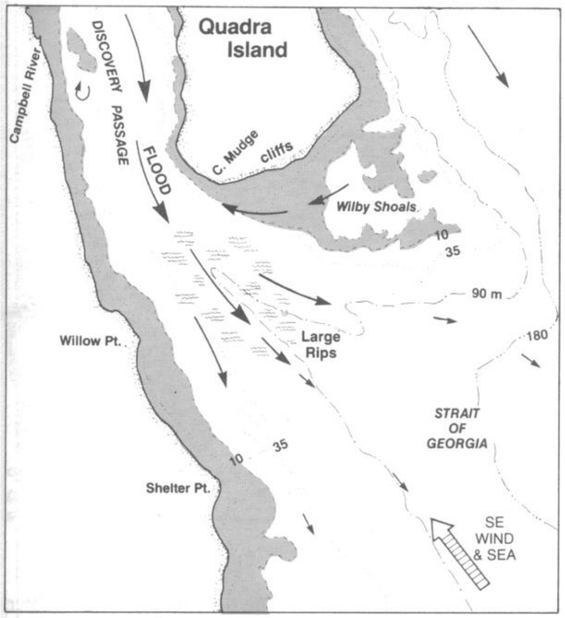


Figure A-9. Rip currents at southern end of Discovery Passage (from Thompson, 1981).

3 WINDS AND WAVES

3.1 WINDS

The prevailing winds are predominantly from the northwest in the summer and from the south east in winter in Georgia Strait. The north westerlies are associated with the clockwise motion of air around the North pacific High pressure system. The south easterlies are associated with the strong anti-clockwise flow of air around the Aleutian Low, which develops just south of Alaska in the winter.

Table A-4 summarizes the variation in wind speed and direction at Sentry Shoal wave buoy, located 13 km ESE from the southern end of the study area. The statistics are based on hourly observations between 1992 and 2007 and are expressed as hours per year in order to assist in interpreting the results. The measurements show strong winds are predominantly from the SE- ESE and NW-NNW directions. For example, winds of 15-18 m/s (29 - 35 Knots) blow from the SE on average 37.7 hours/year and exceed 18 m/s (35 Knots) on average 2.6 hours/year.

A comparison of wind data in the region showed the wind speeds at Sentry Shoal were generally higher than measurements at Campbell River Airport and at Halibut Banks and were similar to values reported at Comox Airport. However, the reported maximum wind speeds were generally lower than values reported at Sisters Island, located 76 km southeast of Campbell River (**Figure A-1**). For example, the data from Sisters Island indicates winds exceeded 18 m/s (35 Knots) on average 44.5 hours/year from the SE direction over the period of observations. Since wave heights were recorded simultaneously with the wind speeds at Sentry Shoal, we have generally made use of the wind data at this site in the subsequent wave hindcasting analysis.

A frequency analysis of annual maximum hourly wind speeds was carried out using the records at Sentry Shoal (and Halibut Banks for comparison). Results of this analysis are shown in **Figure A-10** and **Table A-5**.

Table A-4. Analysis of wind speed and direction at Sentry Shoal Wave Buoy.

Wind Speed and Direction, Expressed as Hours per Year

Direction		1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	>18 m/s	Total (hr)
ENE		92.0	22.8	0.9	0.0	0.0	0.0	0.0	115.7
NE		80.6	21.0	0.9	0.0	0.0	0.0	0.0	102.6
NNE		92.0	28.1	1.8	0.0	0.0	0.0	0.0	121.8
N		155.2	100.8	41.2	12.3	0.0	0.0	0.0	309.4
NNW		260.4	433.0	348.9	78.0	3.5	0.0	0.0	1123.8
NW		333.1	629.4	287.5	43.8	4.4	0.0	0.0	1298.2
WNW		323.5	316.5	68.4	7.9	0.0	0.0	0.0	716.2
W		235.8	71.0	3.5	0.0	0.0	0.0	0.0	310.3
WSW		135.9	20.2	0.9	0.0	0.0	0.0	0.0	156.9
SW		96.4	11.4	0.0	0.0	0.0	0.0	0.0	107.8
SSW		92.9	27.2	4.4	0.0	0.0	0.0	0.0	124.5
S		128.0	86.8	32.4	6.1	0.0	0.0	0.0	253.3
SSE		149.0	250.7	159.5	66.6	11.4	0.0	0.0	637.3
SE		189.3	380.4	427.8	337.5	169.2	37.7	2.6	1544.6
ESE		158.7	218.3	232.3	184.1	67.5	5.3	0.9	867.0
E		121.0	58.7	19.3	2.6	0.0	0.0	0.0	201.6
CALM	769.7	0	0	0	0	0	0	0	769.7
TOTAL	769.7	2643.8	2676.3	1629.6	739.0	256.0	43.0	3.5	8760.7

Table A-5. Frequency analysis of wind speed at Sentry Shoal.

Return Period (Years)	Wind Speed (m/s)	Wind Speed (km/hr)
2	19.2	69.1
5	21.1	76.0
10	22.1	79.6
20	23.1	83.2
50	24.1	86.8

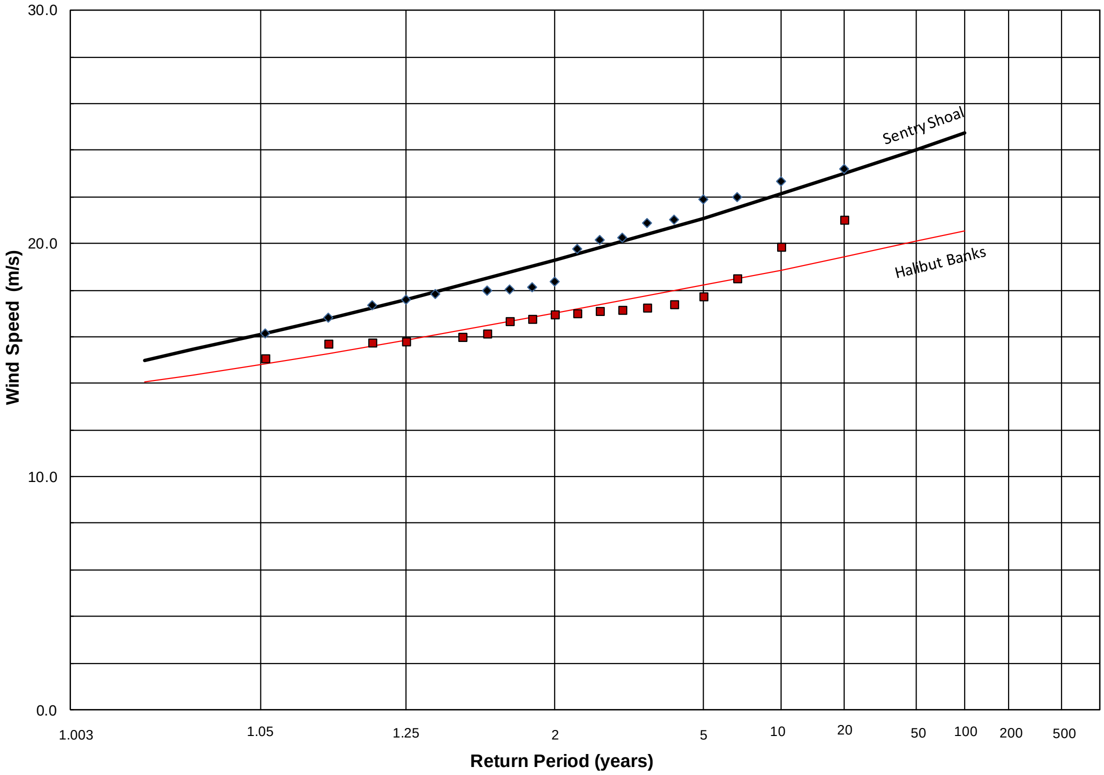


Figure A-10. Frequency of hourly maximum wind speeds.

3.2 WAVE MEASUREMENTS

The deep water wave conditions in the Strait of Georgia are governed by (1) the wind speed, (2) fetch length (distance the winds can blow over), and (3) the storm duration. Deep water wave conditions are commonly described in terms of the significant wave (H_S) and wave period (T). The significant wave height is a statistical measure of the irregular wave field and is often associated with the average of the highest one-third of the waves during a storm event. The wave period represents the average time between successive wave crests.

Wave heights and wave periods have been recorded intermittently at Sentry Shoal wave buoy (**Figure A-1**) since 1992. The buoy is exposed to waves generated from south easterly winds in the Strait of Georgia. The maximum fetch at the buoy is approximately 62 km, from the southeast. **Figure A-11** shows the relation between significant wave height and wind speed for SE storms during 2010.

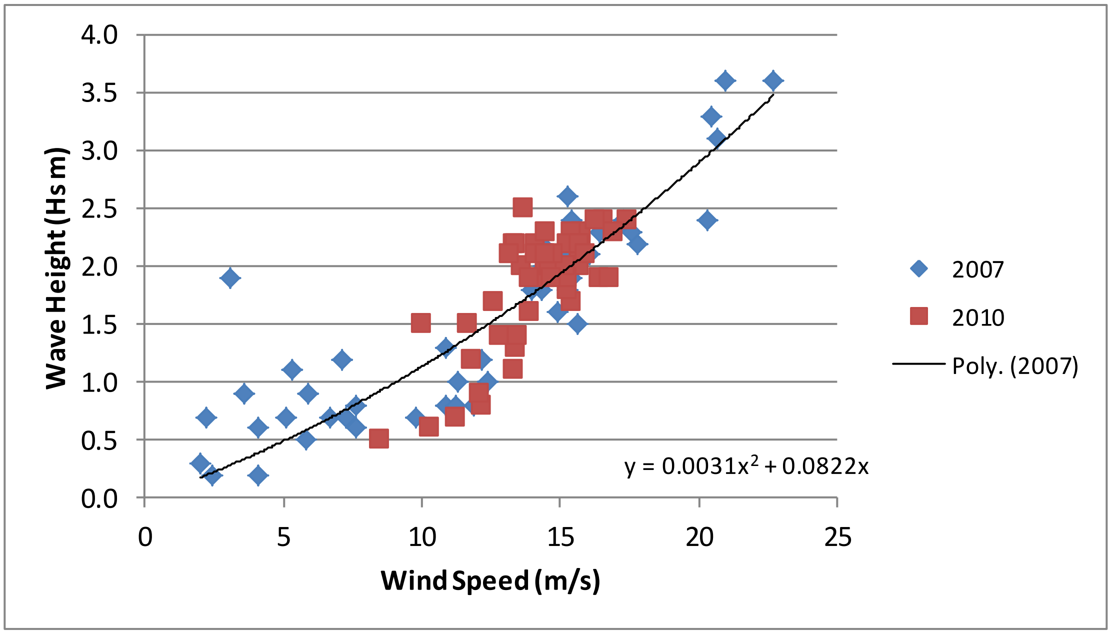


Figure A-11. Observed wave height at Sentry Shoal versus wind speed (SE Storms).

A power law regression indicated the following relation at the wave buoy for SE storms:

H_s=0.0031U^2 + 0.0822U R^2 = 0.80 where

H_s is the significant wave height in meters

U is the wind speed (in m/s) during the storm event (3 hour average)

Table A-6 summarizes some representative deep water wave heights at Sentry Shoal for various wind speeds.

Table A-6. Relation between wind speed and wave heights at Sentry Shoal (SE Storms).

U (m/s)	U (knots)	U (km/hr)	Hours/Year Exceeded	H_s (m) Best Fit	H_s (m) Upper Bound
10	19.6	36	420	1.1	1.8
12	23.5	43.2	200	1.4	2.0
14	27.5	50.4	80	1.8	2.5
16	31.4	57.6	10	2.1	2.8
18	35.3	64.8	2.6	2.5	3.0
20	39.2	72.0		2.9	3.5
25	50.0	90.0		4.0	4.6

A frequency analysis of annual maximum (1-hour) wave heights was made using the 19 years of observations (1992-2010) at Sentry Shoal and Halibut Banks. **Figure A-12** shows the results.

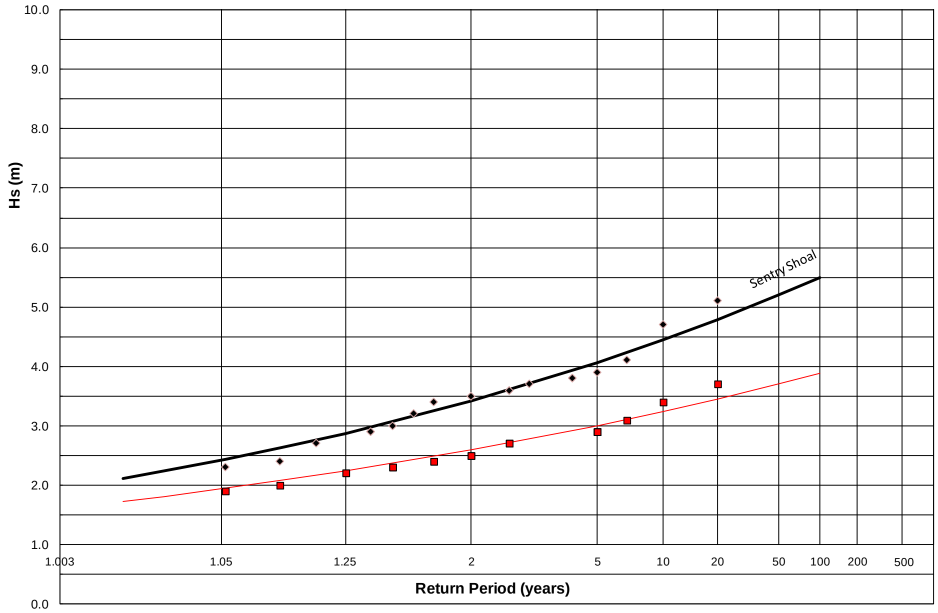


Figure A-12. Frequency analysis of observed deep water wave heights at wave buoys in the Strait of Georgia.

The analysis involved compiling the maximum reported wave height (Hs) in each year, then fitting the data to a log Pearson III probability distribution. The data were screened to eliminate questionable measurements on the basis of the quality coding provided with the raw data. **Table A-7** summarizes the results for return periods of between 2 and 50 years (there are insufficient records for providing reliable estimates of more extreme events).

Table A-7. Summary of wave height frequency analysis at wave buoys in the Strait of Georgia.

Annual Probability of Exceedence (%)	Return Period (Years)	Wave Height Hs (m)	
		Sentry Shoal	Halibut Banks
50	2	3.4	2.6
20	5	4.1	3.0
10	10	4.4	3.3
5	20	4.7	3.5
2	50	5.1	3.7

Note: Log-Pearson III distribution

3.3 WAVE HINDCASTING ANALYSIS AT SENTRY SHOAL

3.3.1 *SIMPLIFIED ANALYSIS*

Hindcasting refers to the process of back-calculating wind-generated wave conditions from measured wind data. The data at Sentry Shoal were used to verify wave hindcasting equations that are summarized in the Coastal Engineering Manual (USACE, 2008) and are recommended for predicting wave heights in relatively confined bodies of water such as the Strait of Georgia. In these areas, the wave height is governed by the wind speed, fetch length the winds can blow over and the wind duration. Fetch distances at Sentry Shoal were determined in GIS using digital mapping from the Canadian Hydrographic Service. Wind data were used from Sentry Shoal, Sisters Island and Comox Airport. The simplified wave hindcasting equations are summarized in Table A-8.

The observed wave heights at Sentry Shoal closely matched (+/- 0.5 m) wave predictions using wind data recorded simultaneously at Sentry Shoal (Figure A-13). Wave predictions based on the wind data recorded at Sisters Island and Comox Airport meteorological stations were of lower accuracy. Therefore, all of the following calculations and discussion are based on the Sentry Shoal data.

Table A-8. Simplified Wave Hindcasting Equations (USACE, 2008).

EM 1110-2-1100 (Part II)
August-2008 (Change 2)

$t_{x,u} = 77.23 \cdot \frac{X^{0.67}}{u^{0.34} \cdot g^{0.33}}$	$Where$: $X = Distance\ (m)$ $u = Wind\ Velocity\ ({}^{m}/_{s})$ $g = Gravity\ \left({}^{m^2}/_{s}\right)$
$C_d = 0.001 \cdot (1.1 + 0.035 \cdot U_{10})$	$Where$: $C_d = Drag\ Coefficient$ $U_{10} = Wind\ Speed\ at\ 10\ m\ Elev.$
$C_d = \frac{u_*^2}{U_{10}^2}$	$Where:\ u_* = Friction\ Velocity\ ({}^{m}/_{s})$
$\frac{g \cdot H_{m_0}}{u_*^2} = (4.13 \times 10^{-2}) \cdot \left(\frac{g \cdot X}{u_*^2}\right)^{1/2}$	$Where: H_{m_0} = Energy - based\ Significant\ Wave\ Height\ (m)$
$\frac{g \cdot T_p}{u_*} = 0.751 \cdot \left(\frac{g \cdot X}{u_*^2}\right)^{1/3}$	$Where: T_p = Wave\ Period\ (s)$

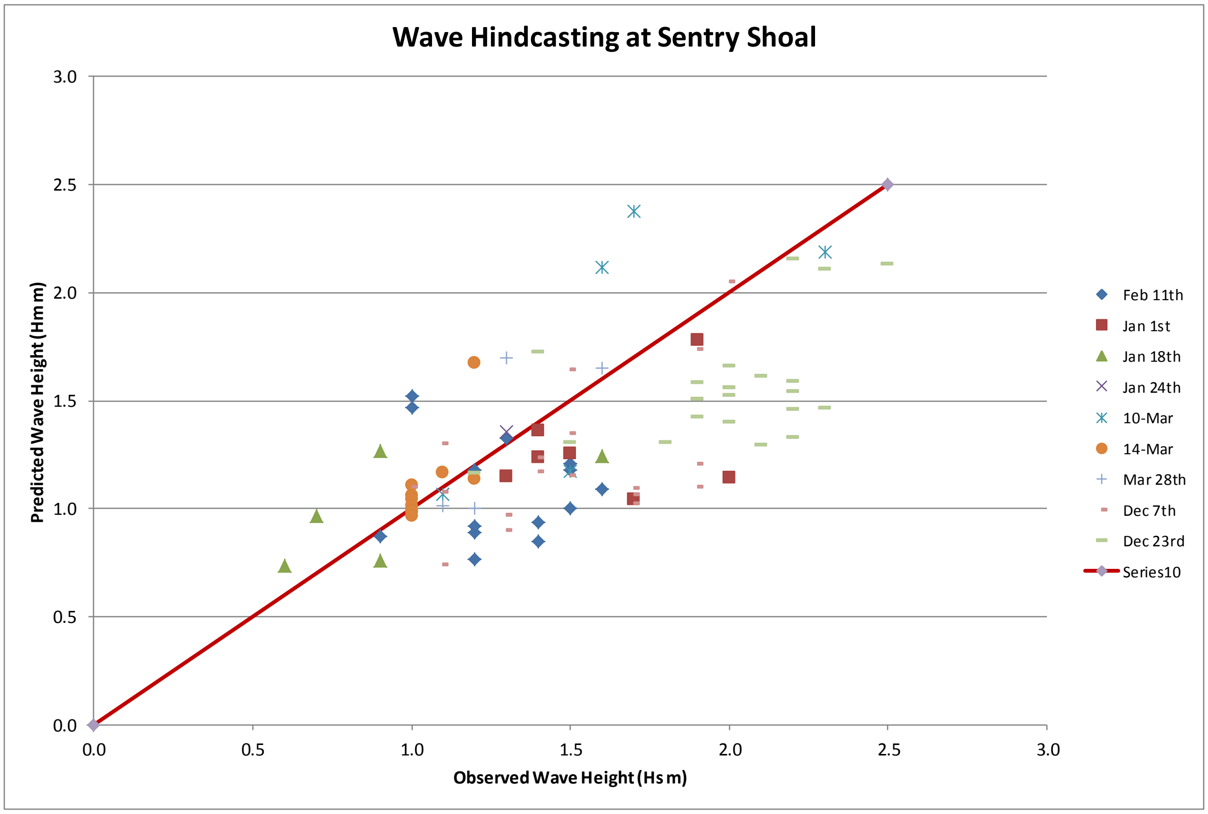


Figure A-13. Predicted versus observed wave heights at Sentry Shoal.

3.3.2 NUMERICAL MODELLING

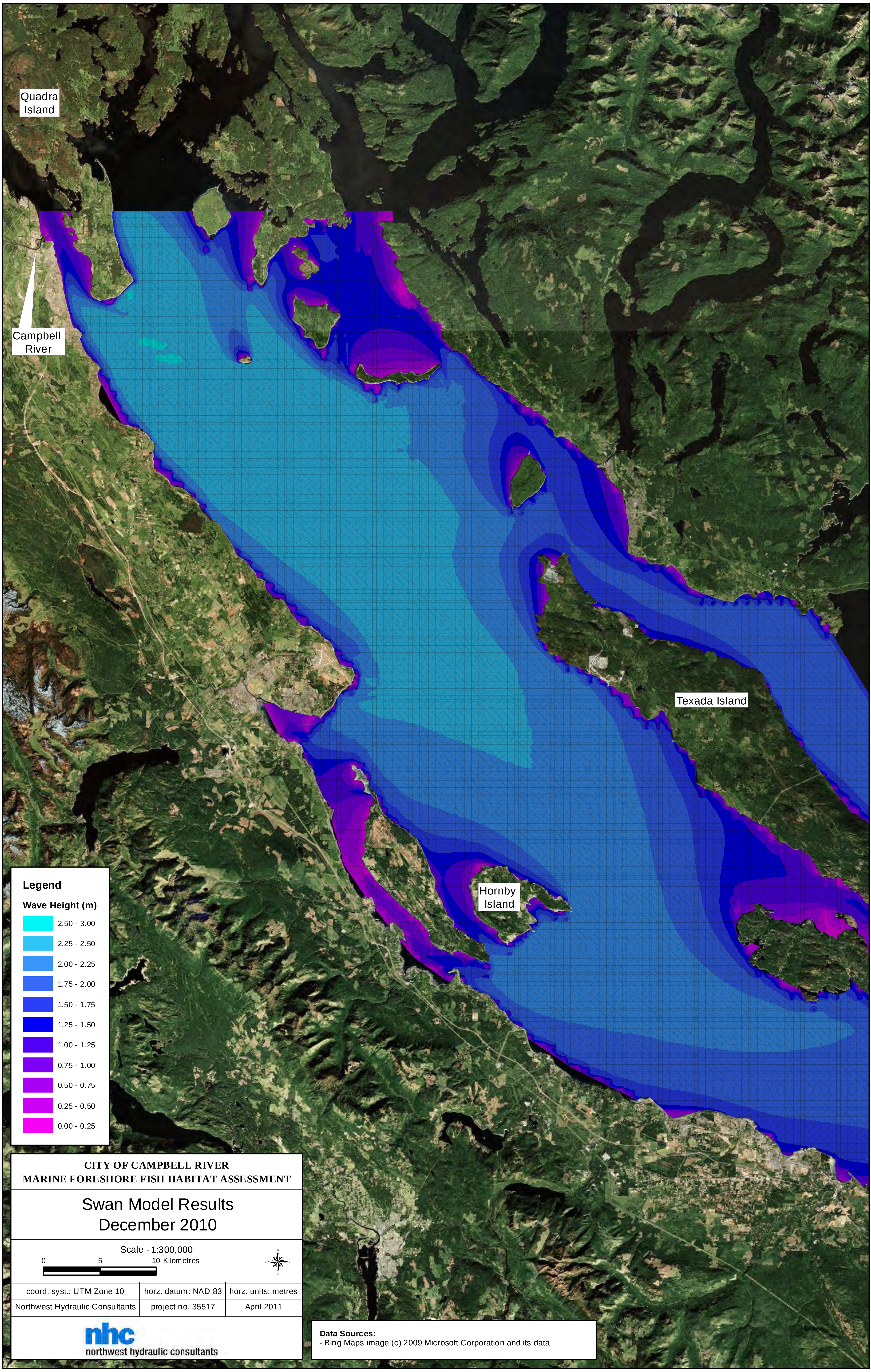
A more accurate method of wave hindcasting involves using a numerical model that represents the time varying wind field over the Strait of Georgia and estimates wave generation as well as the effects of sheltering, wave breaking and wave decay over the storm event. The program SWAN Version 40.81 (2010) was selected for the analysis (DELFT 2010). The model used a nested grid with 1000 m spacing in the southern end of the Strait of Georgia and 200 m spacing north of Sentry Shoal, Oyster River, including the main study area around Campbell River. Bathymetric data was obtained from the following Canadian Hydrographic Service (CHS) charts:

- CHS 3512 Strait of Georgia Central Portion
- CHS 3539 Discovery Passage
- CHS 3513 Strait of Georgia Northern Portion

Wind data was based on the measurements at Sentry Shoal. The model was run for the storm events of December 2010 and November 2007, as a check on the reasonableness of the predictions. The maximum wave height (H_S) predicted from the

SWAN model near the Sentry Shoal buoy was 2.44 m in 2010 and 3.58 m in 2007. The maximum wave height reported by the wave buoy during the same events was 2.48 m in December 2010 and 3.54 m in November 2007. The agreement between the model predictions and the measurements is very good.

Figure A-14 and **Figure A-15** show the variation in maximum significant wave height during the 2010 storm and 2007 storm. The wave height is greatest just south of Cape Mudge, then decreases northward in the confined partially sheltered region between Campbell River and Quadra Island. A run was also made using a 50-year southeast storm, based on the wind analysis at Sentry Shoal. The storm event was modelled on the November 2007 storm, with the maximum hourly wind speed set to 24.1 m/s. The wind direction was maintained constant at 135 degrees (southeast) for a period of 8 hours. The predicted maximum wave height reached 4.4 m near the wave buoy. This value was adopted for the subsequent conceptual design studies.



Legend

Wave Height (m)

- 🟦 2.50 - 3.00
- 🟦 2.25 - 2.50
- 🟦 2.00 - 2.25
- 🟦 1.75 - 2.00
- 🟦 1.50 - 1.75
- 🟦 1.25 - 1.50
- 🟪 1.00 - 1.25
- 🟪 0.75 - 1.00
- 🟪 0.50 - 0.75
- 🟪 0.25 - 0.50
- 🟪 0.00 - 0.25

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Swan Model Results
December 2010

Scale - 1:300,000

0 5 10 Kilometres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	April 2011

nhc northwest hydraulic consultants

Data Sources:
- Bing Maps image (c) 2009 Microsoft Corporation and its data

Figure A-14

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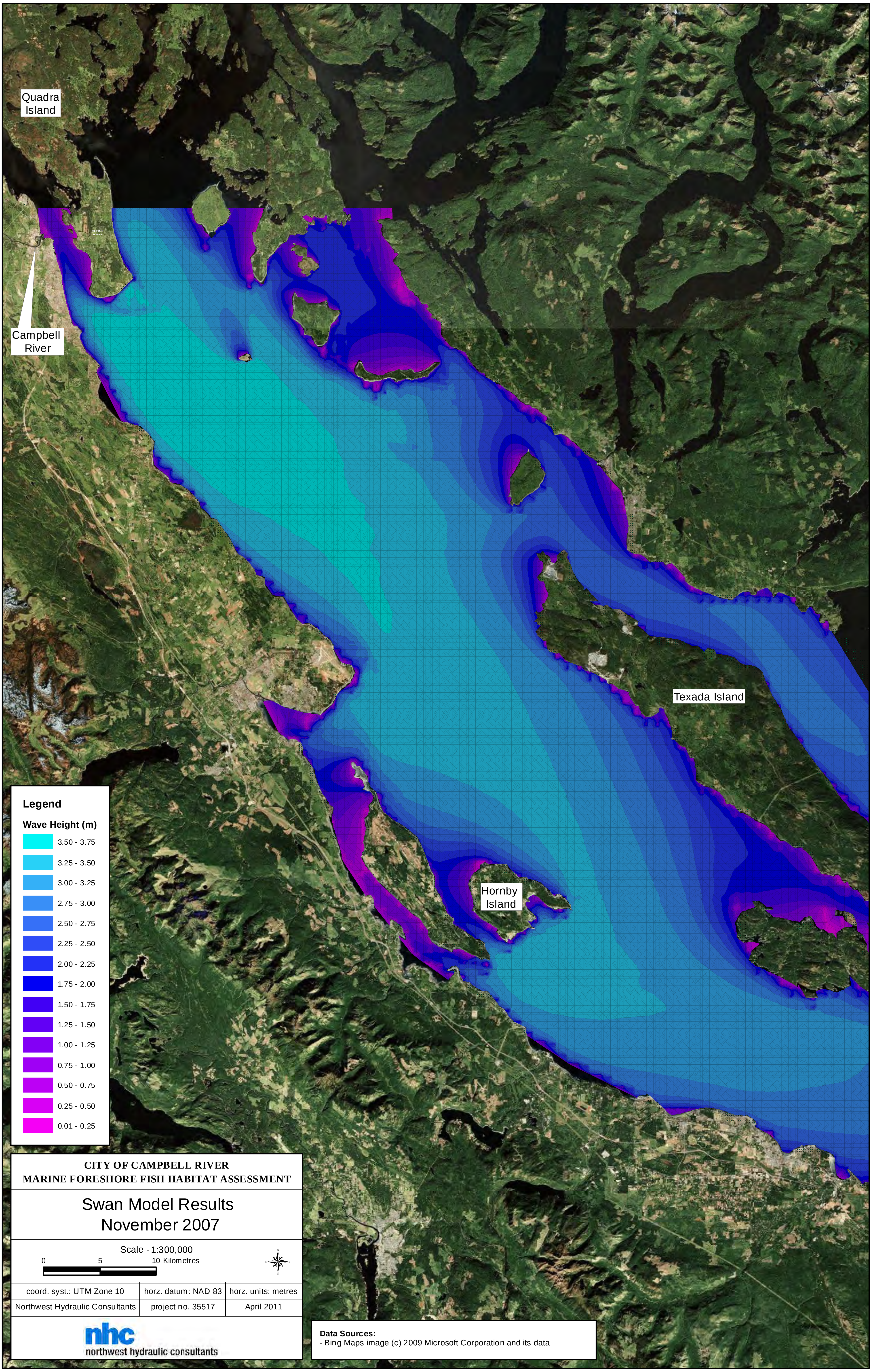

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Swan Model Results
November 2007

Scale - 1:300,000

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	April 2011

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northwest hydraulic consultants

Data Sources:
- Bing Maps image (c) 2009 Microsoft Corporation and its data

Figure A-15

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3.4 WAVE CONDITIONS AT CAMPBELL RIVER

3.4.1 EXPOSURE TO WAVES

The southern end of Quadra Island shelters a large portion of the Campbell River foreshore area from south easterly storms (**Figure A-1**). The variation in the exposed fetch distance along the shoreline is illustrated in **Figure A-16**. **Figure A-2** and **Table A-1** show reference distances for key features along the shoreline.

The maximum fetch distance from the southeast direction ranges from between 115 km and 120 km over the southern 7 km of the foreshore (from Ocean Grove Road to Hidden Harbour Park South). Further north, the shoreline is sheltered from SE generated waves and the greatest fetch distance is from the north (typically around 10 km).

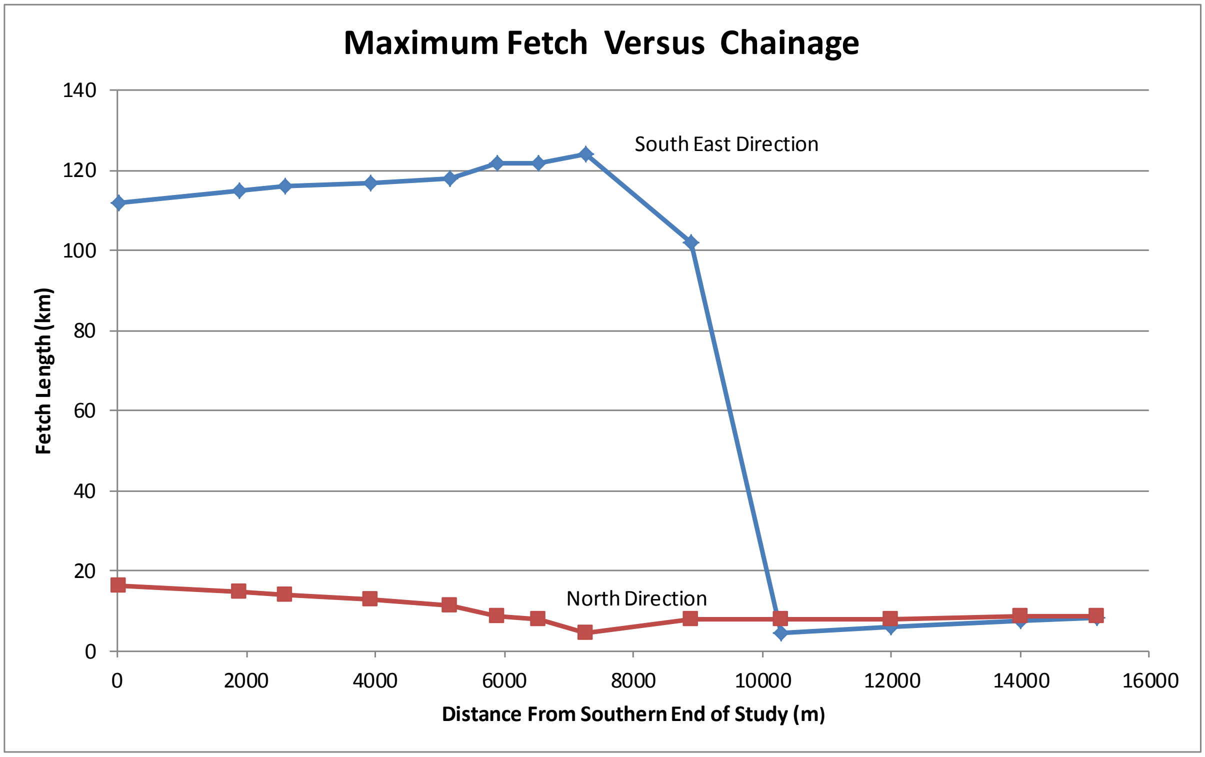


Figure A-16. Variation in fetch length along the shoreline in the Study Area.

3.4.2 RECENT STORM EVENTS

The conditions for two storms were analysed using hindcasting techniques: a) the recent large windstorm of late December 2010, and b) the storm of record that occurred on November 11-12, 2007.

December 23-24th, 2010

The storm of December 23-24, 2010 was generated by a low pressure cell passing across Vancouver Island, inducing south easterly gale force winds in the Strait of Georgia. The maximum wind speed at the meteorological stations in the region was as follows:

- 82 km/hr (Dec 23, 17:00 hr) at Sisters Island
- 67 km/hr (Dec 23, 21:00 hr) at Comox Airport
- 63 km/hr (Dec 23, 17:30 hr) at Sentry Shoal

At Sentry Shoal, the wind speeds averaged 57 km/hour over a 3-hour duration with a wind direction of 127° +/- 10° (south easterly) for 25 hours (**Figure A-17**). The maximum wave height (H_S) at Sentry Shoal was 2.4 m. Based on the frequency analysis of wave heights at Sentry Shoal, the storm had a return period of 1.5 years.

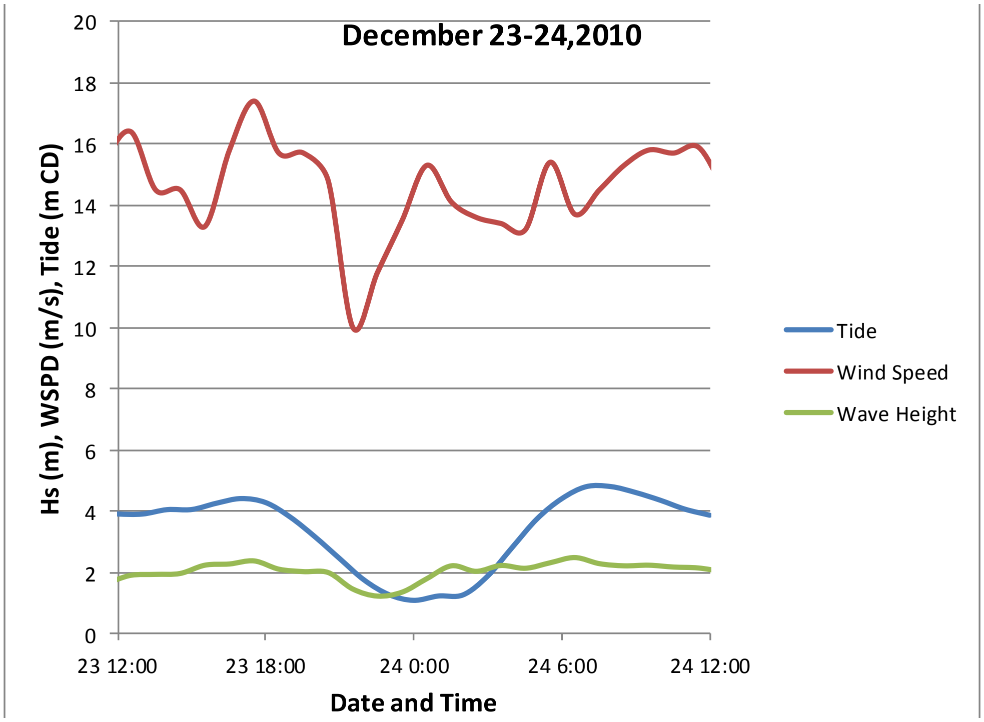


Figure A-17. December 23-24 2010 storm near Campbell River.

On December 23, the highest tide level reached el. 4.7 m Chart Datum (1.8 m Geodetic) at 07:30 and was at el. 4.3 m Chart Datum (1.4 m Geodetic) at 18:00 hr, near the time of the greatest storm intensity. Therefore, the ocean level was close to a HHW Mean Tide condition during the time of the highest waves.

The largest hindcast deep water waves were estimated to reach 3 m as shown in **Figure A-18**. The wave height decreased to 0.6 m in the northern sheltered portion of the study area (north of Sta. 10,000 near the Quadra Island ferry terminal).

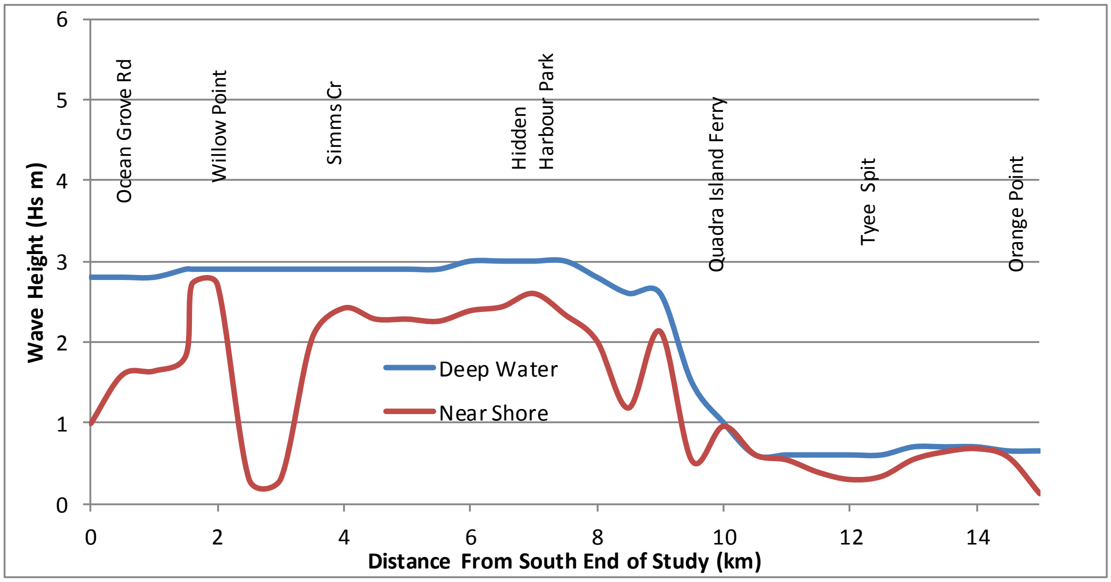


Figure A-18. Variation in wave height along the shoreline at Campbell River – December 23, 2010 storm event.

An estimate of the near shore conditions was made by computing the effects of shoaling and refraction as the waves approach the shoreline. The red line in **Figure A-18** shows the wave height at a water depth of 4 m, near the point of breaking. Since south east waves approach nearly parallel to the coastline in most areas, the wave height is significantly reduced as the waves bend towards the shoreline. Willow Point has a significant impact on the near-shore wave conditions, since it projects out into the Strait. On the south side of Willow Point, near the Ken Forde boat ramp, the shoreline faces the south east and wave refraction/attenuation is relatively minor. In this location, the near shore wave height is similar to the incident deep water wave height. Willow Point sheltered the shoreline on the north side of the point, greatly reducing the waves in this area. North of Simms Creek, the near shore wave height remained relatively constant at about 2.3 m, until near Hidden Harbour, where it increased locally to 2.6 m. Further, north, the wave height decreased rapidly, to approximately 0.5 m near Tyee Spit.

It should be noted that these estimates of wave height do not account for the interaction of waves and tidal currents. As mentioned in **Section 2.2**, portions of Discovery Passage are subject to strong tidal rips, which can produce severe, short-crested waves particularly during strong winds. These waves are generally located offshore, where currents are greatest, rather than along the shoreline.

A field investigation was carried out on January 17th, 2011 to document the December 23-24, 2010 storm in terms of the highest wave runup. This involved surveying a series of beach and shoreline cross sections to determine the beach slope and determining the highest elevation of debris and other high water marks along the shoreline. All elevations were determined using a Real Time Kinematic (RTK) GPS survey system. In some locations, discussions with local residents elicited additional comments and commentary on the December 2010 storm. Results of the high water mark measurements are summarized in **Table A-9**. The highest debris was found on steep riprap slopes that are exposed to south easterly storms such as the Hidden Harbour condominiums (el. 7.9 m Chart Datum or 5.0 m Geodetic). **Figure A-19** shows examples of the effects of debris deposition during wave runup.

Table A-9. Summary of Observed Highwater Mark Elevations in January 2011.

Station (Km)	Surveyed High Water Mark		Beach Slope (%)	Location
	(m Chart Datum)	(m Geodetic)		
0.23	6.9	4.0	11	Near Ocean Grove Road
1.89	6.9	4.0	11	South of Ken Forde boat ramp
2.59	7.1	4.2	67	South of Ken Forde boat ramp
3.93	7.5	4.6	12	Outlet of Simms Creek
5.88	6.2	3.3	11	Rotary Park
6.53	6.6	3.7	67	
7.30	7.9	5.0	100	Near Hidden Harbour condominiums

Wave runup is governed by the incident wave height, the wave steepness, beach slope and roughness of the surface on which the wave is breaking. The estimated wave runup values in **Table A-9** are between 1.9 to 3.6 m higher than the high tide level at the time of the December 23-24 storm event. Equations to predict wave runup on revetments are summarized in USACE (2008). For riprapped slopes (1V:2H), the wave runup (R_{us}) in the December 2010 storm was estimated to be approximately 1.4 times the wave height (H_S) at the base of the structure. Given the near shore wave conditions in **Figure A-18**, the computed wave runup was estimated to be 3.5 m near the Hidden Harbour condominiums, which agrees well with the survey measurements.

Figure A-19. Photos showing debris from recent wave runup (photos taken 17 January 2011).

November 11-12th, 2007

One of the largest recent south-easterly storms in the region occurred on November 11-12, 2007 during the passage of a major low pressure system. The storm affected most of the east Coast of Vancouver Island and damaged sections of Highway 19A between Parksville and Campbell River (**Figure A-20**).

Figure A-20. Photos showing damage to Highway 19A during 2007 storm.

Winds veered from predominantly west during the morning of November 11th to southeast throughout the period of the greatest storm intensity, then veered rapidly back to the west after the passage of the system. The maximum wind speed at Sentry Shoal reached 82 km/hr (21.7 m/s) at 14:30 on November 12th and averaged more than 70 km/hr for five hours (**Figure A-21**). The maximum wind speed recorded at Comox Airport was 83 km/hr (23 m/s). The return period for this storm event was estimated to be approximately 20 years (based on the maximum wind speed at Sentry Shoal and Comox Airport) and just under 5 years, based on the recorded maximum wave height.

The highest predicted tides reached 4.2 m at 08:00 hr at Campbell River on November 12th (**Figure A-21**). The highest observed tide level reached 4.56 m at 08:00 hr, indicating a storm surge of 0.36 m. The maximum recorded storm surge reached 0.6 m at 14:00 hr (coinciding with the time of the highest winds). The tide level was at 4.35 m (0.35 m higher than a normal HHW level) at the peak of the storm. The coincidence of the high tide, intense southeast winds and large waves produced a severe storm event capable of causing significant erosion along the shoreline.

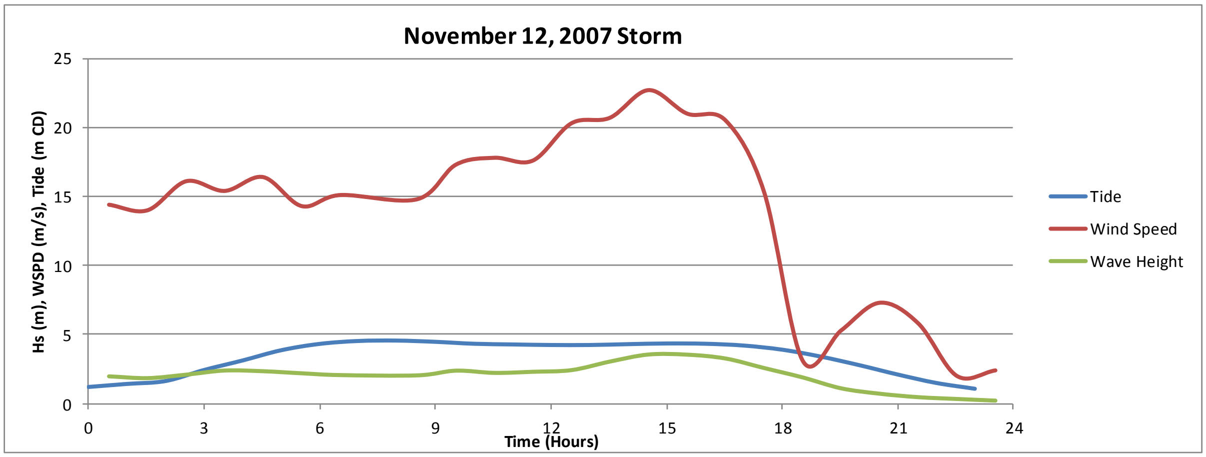


Figure A-21. Wave heights, wind speed and tide levels during November 2007 storm near Campbell River.

Figure A-22 shows the predicted variation in deep water wave height along the foreshore at Campbell River. The predicted maximum wave height (H_S) during the storm was 3.6 m. Wave refraction and shoaling calculations were made to estimate the near-shore wave heights (at 4 m depth). The general pattern is the same as for the case in 2010, with the highest wave heights occurring on the south side of Willow Point near the Ken Forde boat ramp.

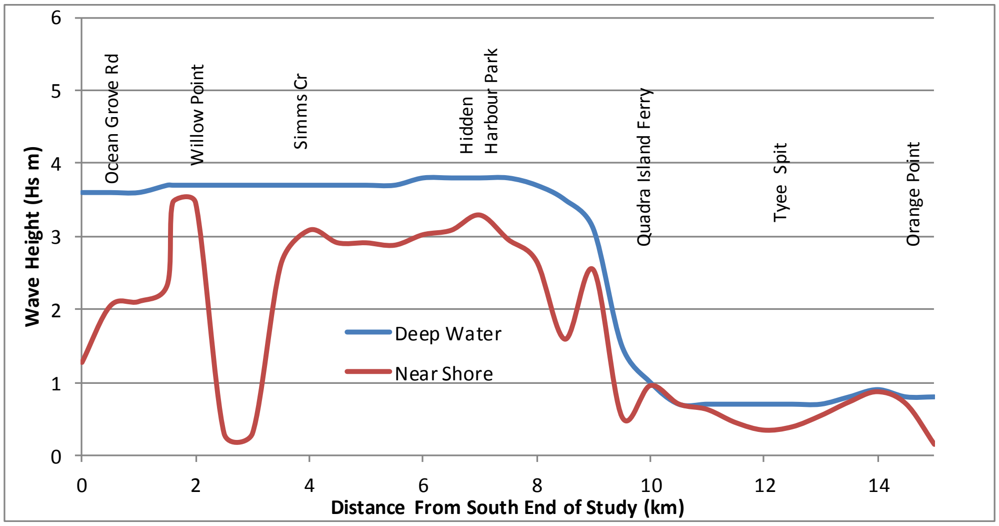
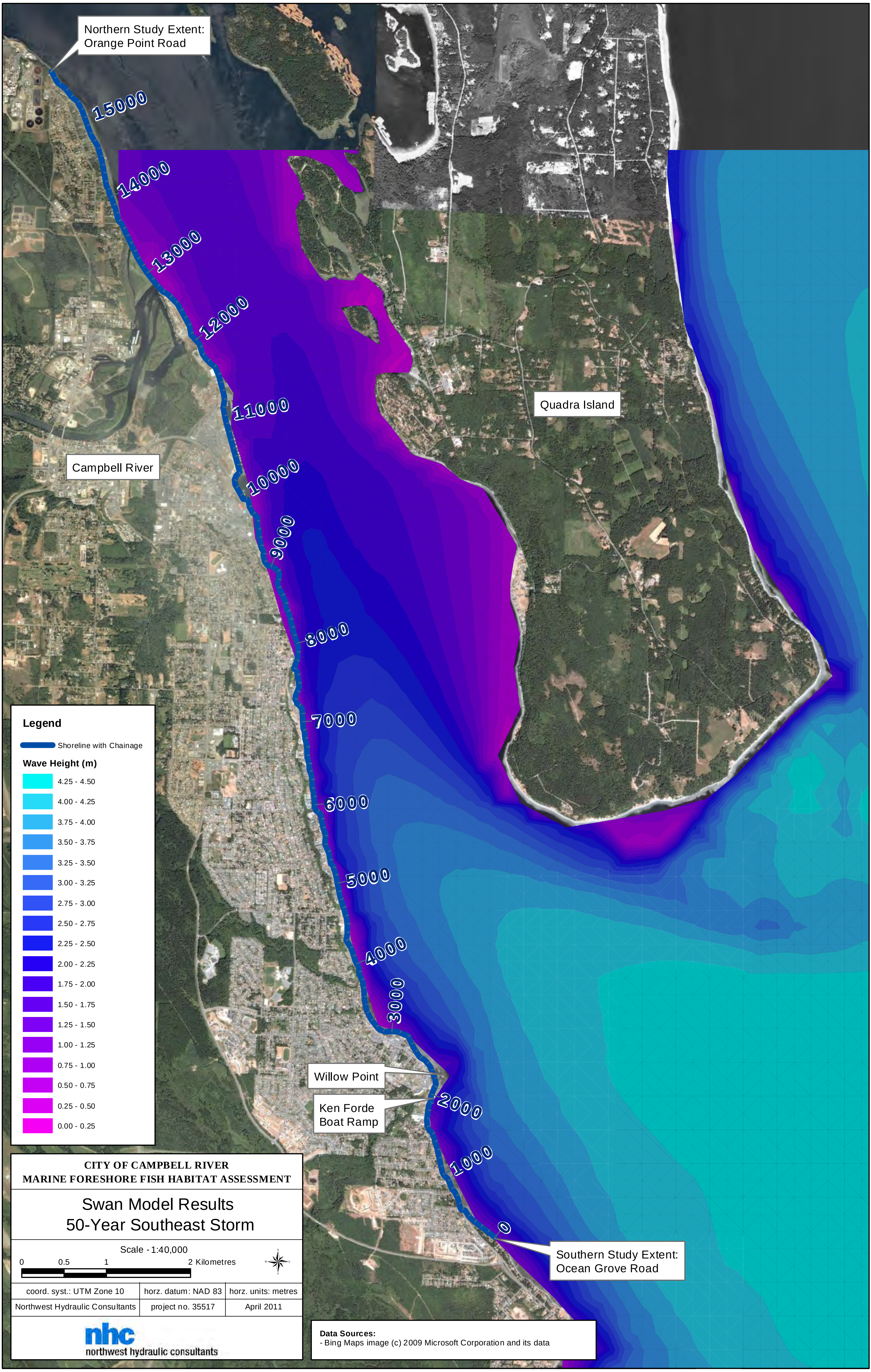


Figure A-22. Variation in wave height along the Campbell River shoreline during the November 12, 2007 storm.

3.5 50-YEAR STORM EVENT

Figure A-23 shows the distribution of waves near Campbell River for a 50-year southeast storm as computed by the SWAN model. The maximum wave height reached 4.4 m just south of Cape Mudge. The waves decreased northwards as they entered Discovery Passage, reducing to about 3.5 m at Willow Point and the Ken Forde Boat Ramp. The wave height decreased rapidly north of Hidden Harbour, reaching less than 0.75 m at Tyee Spit.



CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Swan Model Results
50-Year Southeast Storm

coord. syst.: UTM Zone 10 | horz. datum: NAD 83 | horz. units: metres
Northwest Hydraulic Consultants | project no. 35517 | April 2011

Data Sources:
- Bing Maps image (c) 2009 Microsoft Corporation and its data

Figure A-23

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4 COASTAL FLOOD LEVELS

4.1 PRESENT CONDITIONS

The Coastal Flood Level is used for setting the safe elevations and set-backs of buildings and other infrastructure constructed in coastal British Columbia. The BC Ministry of Environment's published coastal flood level for Campbell River is elevation 3.5 m Geodetic (freeboard included). This level was established by Klohn Crippen Consultants in 1989 (BC MOE, 1989) as follows:

- The "Natural Boundary" along sections of the shoreline was estimated by visual site inspections and then determined by surveying to be el. 2.0 m Geodetic;
- A freeboard allowance of 1.5 m was added to the elevation of the Natural Boundary.

This approach was commonly used in the past, although it does not explicitly account for the statistical distribution of extreme tides, storm surges and wave runup.

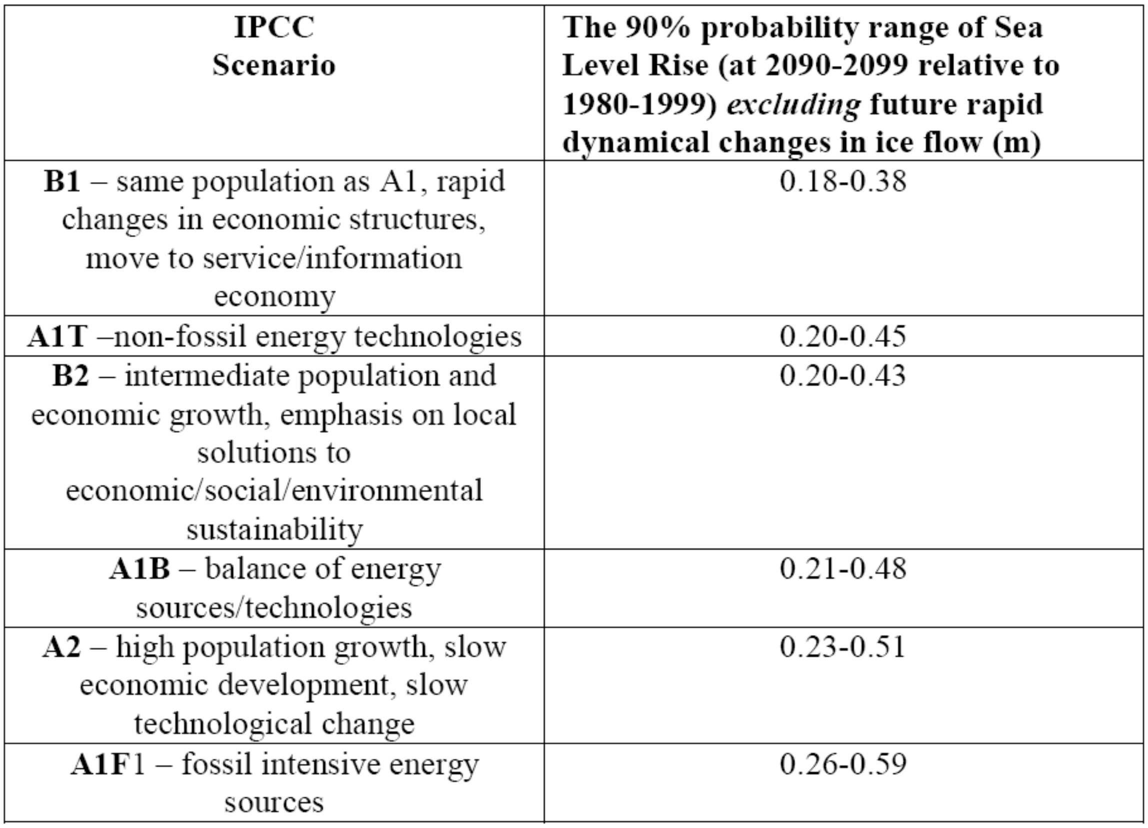
The computed wave runup and surveyed high water levels from the December 2010 storm exceeded BC MOE's published Coastal Flood Level at several locations in the study area (Table A-9). For example, the surveyed high water mark at the Hidden Harbour condominiums reached up to elevation 5 m Geodetic or 1.5 m above the designated Coastal Flood Level. The published Coastal Flood Level may be appropriate for conditions in the river estuary and in the very sheltered northern part of the study area, but is not appropriate for the more exposed conditions along the southern half of the study area.

4.2 EFFECT OF CLIMATE CHANGE

4.2.1 BACKGROUND INFORMATION

It is now generally accepted that global climate change is occurring and that this change is responsible for the observed ongoing rise in global sea level. Thompson *et al.* (2008) summarized the current understanding of sea level variability in the world ocean, with particular focus on the coastal regions of British Columbia, including estimates for future global and regional sea level rise and their uncertainties. These results were based primarily on scientific studies reported by the International Panel on Climate Change (IPCC) in their 2007 report, but also accounted for future local land level changes due to tectonics and other geological factors. Based on historical surveys and tide gauge information, sea level in British Columbia rose by 0.18 m on average over the 20th Century.

Table A-10: Range of global sea level rise estimates (Thompson et al 2008).



IPCC Scenario	The 90% probability range of Sea Level Rise (at 2090-2099 relative to 1980-1999) *excluding* future rapid dynamical changes in ice flow (m)
B1 – same population as A1, rapid changes in economic structures, move to service/information economy	0.18-0.38
A1T –non-fossil energy technologies	0.20-0.45
B2 – intermediate population and economic growth, emphasis on local solutions to economic/social/environmental sustainability	0.20-0.43
A1B – balance of energy sources/technologies	0.21-0.48
A2 – high population growth, slow economic development, slow technological change	0.23-0.51
A1F1 – fossil intensive energy sources	0.26-0.59

The future rate of sea level rise is very uncertain at this time, but is expected to be higher than in the past. The 2007 IPCC report provided a range of estimates, depending on different growth scenarios (). Typical sea level rise estimates by the IPCC (2007) for the year 2100 ranged from between 0.3 m up to 0.6 m.

Thompson *et al*. (2008) estimated sea level rise to the year 2100 for several locations on Vancouver Island including Nanaimo and Victoria. These estimates ranged from 0.11 m (based on the mean IPCC value) up to a high of 0.8 m.

In June 2010, the BC Ministry of Environment published draft guidelines for coastal flood hazard management (BC MOE, 2010). This study adopted higher rates of future sea level rise than Thompson *et al.* (2008), citing more recent research in progress. Figure A-24, reproduced from the draft BC Ministry's report, indicates a median estimate of 0.8 m sea level rise by 2100 and a "high" estimate of 1.2 m.

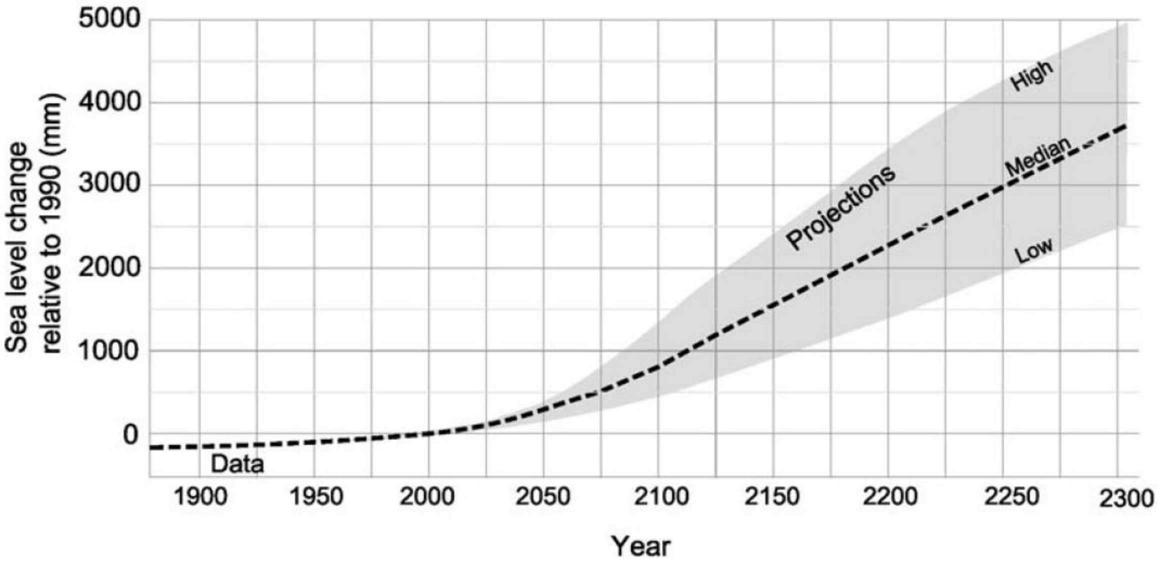


Figure A-24. Projection of sea level rise in BC (from BC MOE, 2010).

It should be noted that the BC MOE results were still in draft form and are still in the process of being finalized.

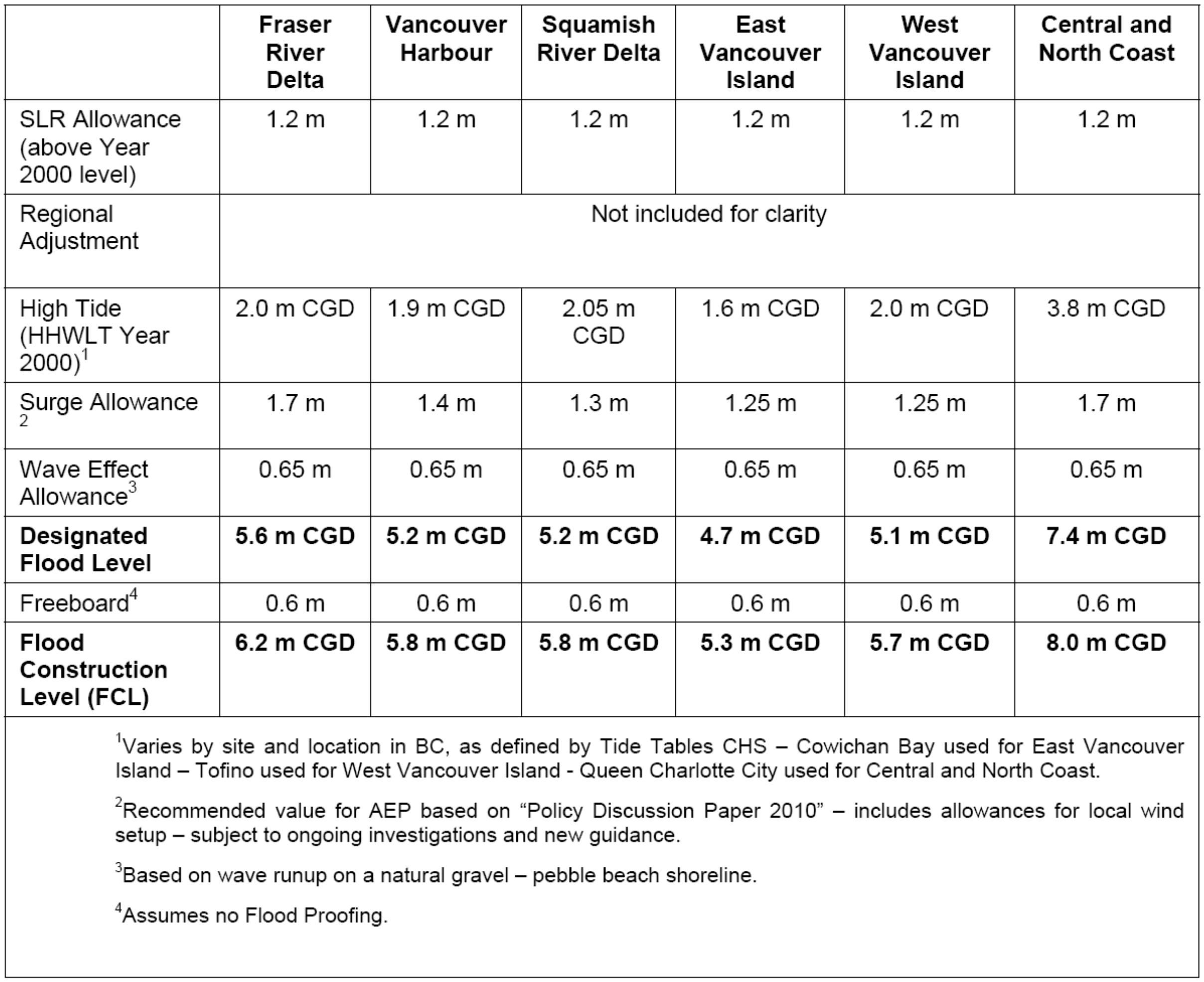
4.2.2 EFFECT ON COASTAL FLOOD LEVELS

BC MOE's 2010 draft guidelines provided estimates of updated coastal Flood Construction Levels (FCL) for coastal BC that incorporate sea level rise projections. These new guidelines are intended to replace the existing land use management guidelines that were introduced in 2004. The 2010 draft guidelines include the following statement:

> *The FCL shall be a minimum elevation for habitable floor level or underside of wooden construction and shall be based on and include allowances for Year 2100 sea level rise and High Tide Levels associated storm surge and wave effects for the designated storm and freeboard.*

Table A-11 summarizes BC MOE's proposed flood levels and Flood Construction Levels for 2100 at various locations in BC. The revised Flood Construction Level is elevation 5.3 m Geodetic (freeboard included) for the east coast of Vancouver Island. This level includes a wave runup allowance of 0.65 m, which is representative of relatively sheltered natural gravel beaches, not exposed sites or steeply sloping riprapped revetments where wave runup could be considerably higher (up to 3.5 m).

Table A-11. Designated Flood Construction Level in 2100 (from BC MOE, 2010 Draft).



	Fraser River Delta	Vancouver Harbour	Squamish River Delta	East Vancouver Island	West Vancouver Island	Central and North Coast
SLR Allowance (above Year 2000 level)	1.2 m	1.2 m	1.2 m	1.2 m	1.2 m	1.2 m
Regional Adjustment	Not included for clarity					
High Tide (HHWLT Year 2000)[1]	2.0 m CGD	1.9 m CGD	2.05 m CGD	1.6 m CGD	2.0 m CGD	3.8 m CGD
Surge Allowance[2]	1.7 m	1.4 m	1.3 m	1.25 m	1.25 m	1.7 m
Wave Effect Allowance[3]	0.65 m	0.65 m	0.65 m	0.65 m	0.65 m	0.65 m
Designated Flood Level	**5.6 m CGD**	**5.2 m CGD**	**5.2 m CGD**	**4.7 m CGD**	**5.1 m CGD**	**7.4 m CGD**
Freeboard[4]	0.6 m	0.6 m	0.6 m	0.6 m	0.6 m	0.6 m
Flood Construction Level (FCL)	**6.2 m CGD**	**5.8 m CGD**	**5.8 m CGD**	**5.3 m CGD**	**5.7 m CGD**	**8.0 m CGD**

[1] Varies by site and location in BC, as defined by Tide Tables CHS – Cowichan Bay used for East Vancouver Island – Tofino used for West Vancouver Island - Queen Charlotte City used for Central and North Coast.

[2] Recommended value for AEP based on "Policy Discussion Paper 2010" – includes allowances for local wind setup – subject to ongoing investigations and new guidance.

[3] Based on wave runup on a natural gravel – pebble beach shoreline.

[4] Assumes no Flood Proofing.

Therefore, the proposed coastal flood level is applicable only to the sheltered north half of the study area in Campbell River (north of Km 10). Even so, the new level is 1.8 m higher than the present FCL that was established in 1989. This change will have a major impact on the floodplain extent and depth of flooding in the downtown portion of Campbell River. **Figure A-25** shows the present floodplain boundary in the main portion of the town with the new FCL that will potentially result. Increasing the coastal FCL from el. 3.5 to el. 5.3 m will extend the southern floodplain boundary inland by up to 400 m in some portions of the town. An updated floodplain map should be prepared to show the revised extent. The updated mapping should extend south to the southern limit of this study. This will require acquiring additional topographic information using LIDAR mapping techniques.

The shoreline cross sections surveyed in January 2011 illustrate the effect of the increased coastal flood level at several different locations in the southern portion of the study area. **Figure A-26** and **Figure A-27** show the sections, along with the present coastal FCL for Discovery Passage and the proposed coastal FCL including climate change (June 2010 Draft). **Figure A-28** and **Figure A-29** show the updated flood level at several sites in the study area. BC MOE's proposed updated FCL is higher than many sections of the existing highway and will designate many presently developed areas as floodplain. It should be noted that the coastal FCL in the southern portion of the study area will be higher than the value given in **Table A-11**, since this section is more exposed and is subject to greater wave runup. Therefore, the flood levels shown in **Figure A-26** and **Figure A-27** are intended solely to show the effect of sea level rise on the flood extent and are not intended for regulatory purposes.

Figure A-25. **Floodplain extents based on existing mapping (Campbell and Quinsam Rivers, BC MOE, 1989) and on future sea level rise scenario.**

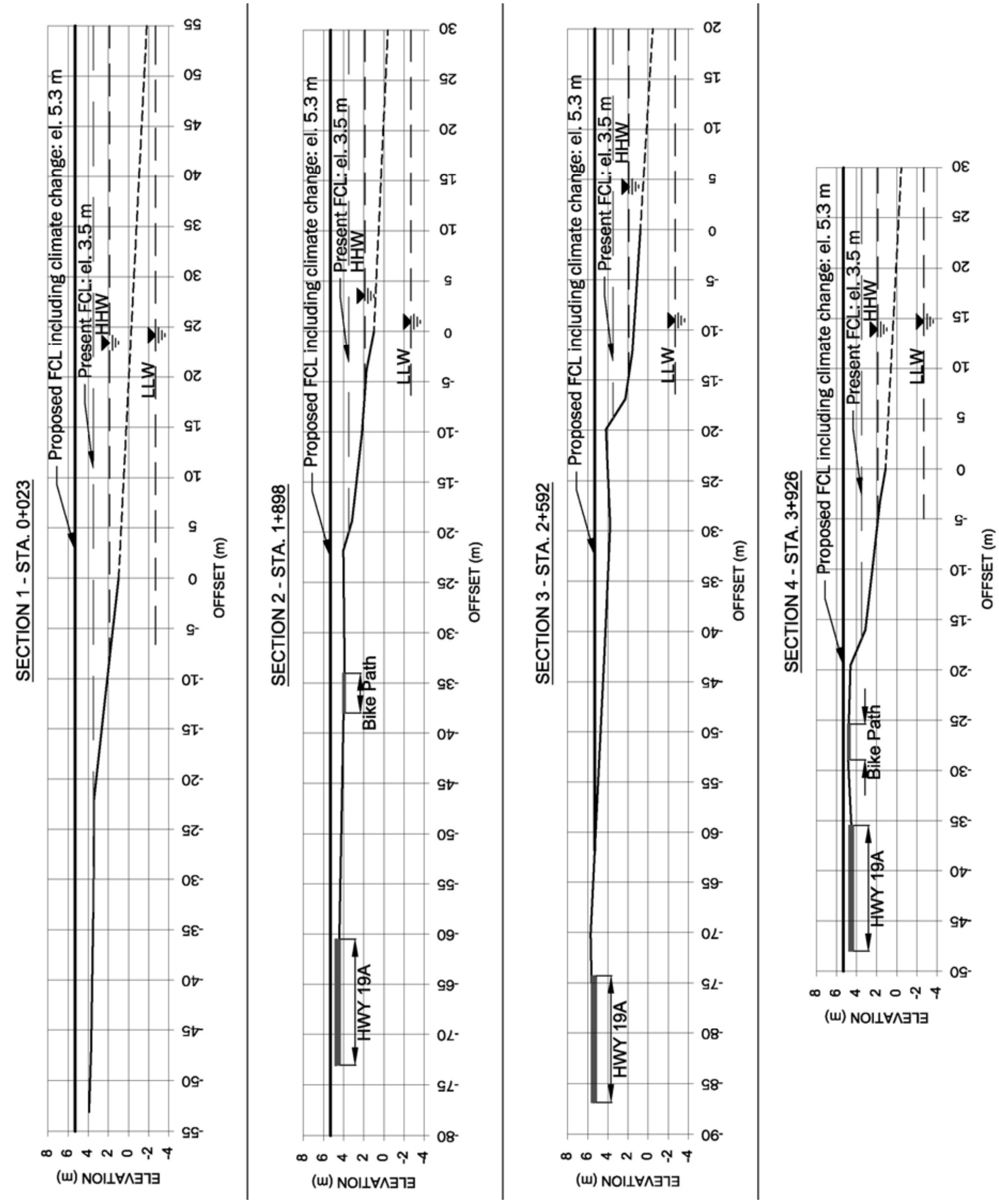


Figure A-26. Shoreline profiles – Sections 1 to 4, showing BC MOE's present and proposed Coastal FCL.

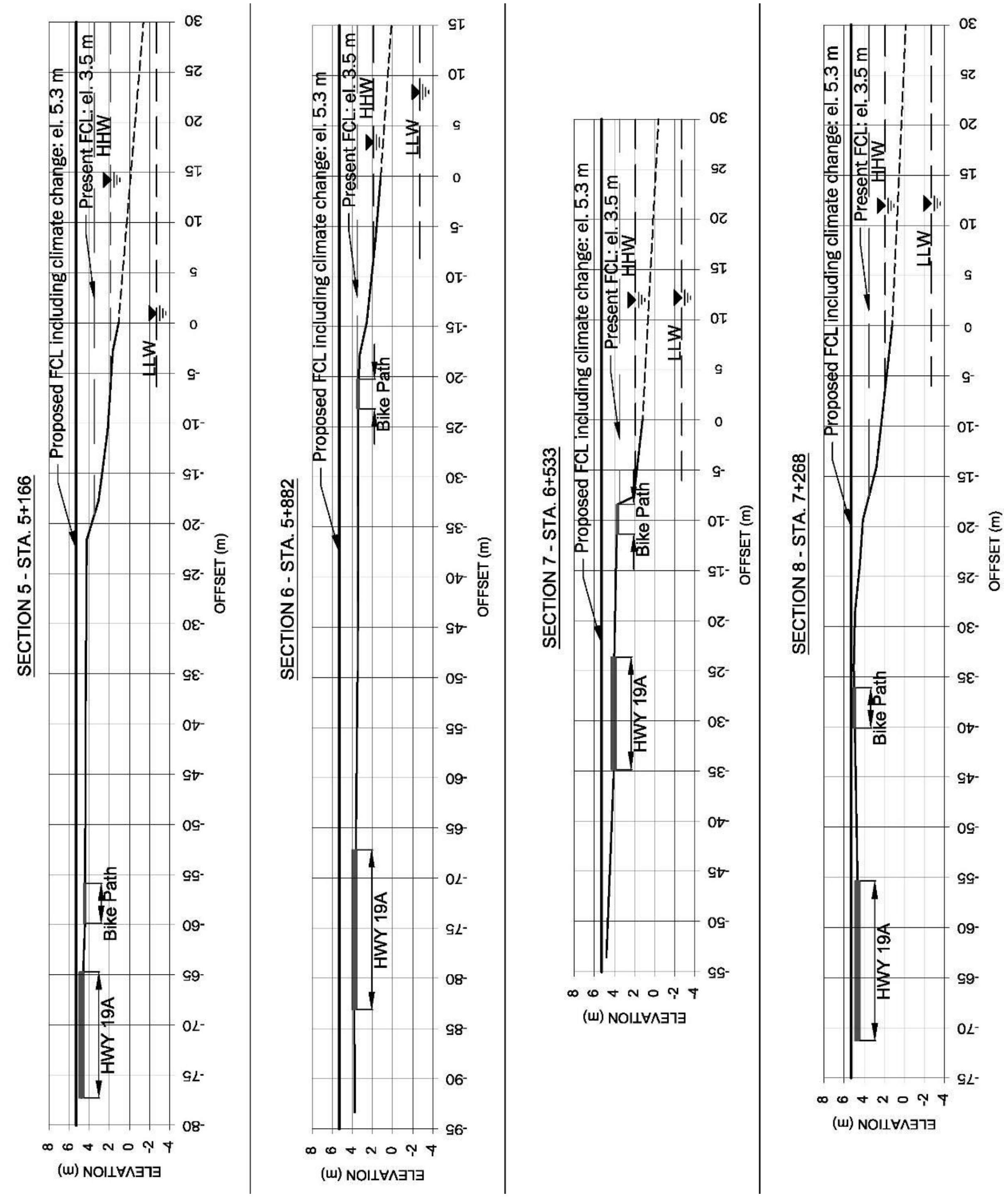


Figure A-27. Shoreline profiles – Sections 5 to 8 showing BC MOE's present and proposed Coastal FCL.

Figure A-28. Surveyor indicating the elevation of the draft BC Flood Construction Level (with proposed sea level rise included at a) Ocean Grove, and b) near Rotary Beach Park (photos taken 17 January 2011).

Figure A-29. Surveyor indicating the elevation of the draft BC Flood Construction Level (with proposed sea level rise included at a) Hidden Harbour, and b) at Rotary Beach Park (photos taken 17 January 2011).

The 2010 BC MOE guidelines provide additional requirements for determining the setbacks incorporating the effect of future sea level rise. These new guidelines state:

> *Building setback shall be the greater of 15 m from the future estimated natural boundary of the sea at Year 2100 or a horizontal distance until the natural ground elevation contour reach the Year 2100 projected FCL. On existing parcels, if meeting the new guidelines would sterilize all land use and all building given the current zoning, the Approving Officer may agree to modifying setback requirements provided this is augmented through a restrictive covenant stipulation of the hazard, building requirements and liability disclaimer.*

This revised setback definition could affect future land use over a large portion of the study area.

Additional site specific studies are required to produce updated floodplain mapping and final Flood Construction Levels in the study area. This will require obtaining LIDAR surveys of the foreshore and developed areas to produce new base maps, as well as additional coastal flood studies to determine the wave runup and ocean level under a 200-year return period storm event.

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APPENDIX B

BOAT RAMP INVESTIGATIONS

TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF PHOTOS

1 INTRODUCTION

This document represents **Appendix B** of the report *City of Campbell River Marine Foreshore Habitat Assessment and Restoration Plan*, prepared by Northwest Hydraulic Consultants, Current Environmental, and Murdoch de Greeff Inc. This appendix describes the results of a detailed investigation of the coastal processes affecting operation of the City-owned boat ramps at Campbell River. Additional details about the study rationale, area of study, and methodology can be found in the body of the main report.

The City of Campbell River operates two public boat launches within the study area: 1) Ken Forde Boat Launch and 2) Big Rock Boat Launch. Both require regular maintenance to clear the ramps and foreshore areas of sediment and debris, which would otherwise prevent use of the facilities. Sediment and debris can accumulate very rapidly in the winter months and the boat ramps can require almost continuous maintenance. Maintenance activities have had to be curtailed in recent years due to a higher level of awareness of habitat issues and the potential damage to the shoreline environment that can result.

The purpose of this investigation into the boat launch issues is to provide a more in-depth assessment of the natural shoreline processes as they impact boat launch use and maintenance, as well as to provide a boat launch maintenance plan and alternative scenarios for an engineered solution that would significantly reduce maintenance.

1.1 STUDY AREA AND PROJECT DESCRIPTION

The study area for the overall foreshore investigation extends from Ocean Grove Road in the south to Orange Point Road in the north. It encompasses approximately 16 km of shoreline that is managed by the City of Campbell River and includes numerous shoreline types. For the purposes of the shoreline investigations, the study area has been divided into seven geomorphic reaches (see main report). The Ken Forde Boat Launch marks the northern limit of Reach 1 – Southern Beaches, while the Big Rock Boat Launch is located in the central portion of Reach 3 – Middle Beaches.

Appendix A of this report provides an in-depth analysis of the wind and wave climate affecting the study area. The three southern reaches – which also include Willow Point – comprise the section of the study area that is most exposed to large waves generated by winds from the southeast. The majority of storms come from the southeast and these winds are most prevalent in the winter, though they can occur during summer months as well. The prevalence of winds from the southeast is the driver for the dominant direction of longshore sediment transport, which is northwards along the shoreline. Storms that occur during higher tide stages have a greater potential to transport sediment due to the smaller calibre of material on the upper beach. **Photo B-1** shows the sediment grain-size distribution on the beach to the north of Ken Forde – the finer gravel at the top of the beach gives way to coarser gravel further down the beach. Waves breaking during lower tide stages do not effect this material.

Photo B-1. **Sediment grain-size gradation at Ken Forde Boat Ramp (photo taken 16 June 2010).**

1.1.1 KEN FORDE BOAT LAUNCH

The Ken Forde Boat Launch is located immediately south of Willow Point at the northern end of a long section of open beach. A paved ramp extends from the elevation of the adjacent parking lot across the beach to low tide on a slope that is slightly steeper than the adjacent beach. The south side of the ramp is protected by a rock groyne extending laterally from the beach front at an elevation that is up to 1 m higher than the adjacent beach. The north side of the ramp runs parallel to the base of a large rock structure that was installed to protect the mouth of Willow Creek. This structure extends laterally from the beach front and has an elevation well above high tide (Figure B-1) and appears to be very effective at interrupting sediment transport northwards along the beach..

Figure B-1. **Aerial view of Ken Forde Boat Launch showing rock groyne to the south and rock structure to the north (2007 orthophoto).**

The boat launch was originally constructed and maintained by a local Campbell River resident but has subsequently been adopted by the CoCR. The boat launch location was therefore chosen based on proximity to the original developer's place of business rather than to minimise ongoing maintenance. Recent upgrades to the facility include a large parking lot and a building that houses washroom facilities.

1.2 BIG ROCK BOAT LAUNCH

The Big Rock Boat Launch is situated approximately 2 km north of Willow Point within a long, straight section of gravel and cobble beach. A paved ramp extends from the elevation of the parking lot, across the beach to the lower tide level. A pair of curved rock groynes have been installed on either side of the ramp that extend up to 40 m from shore with an elevation of approximately 1 m above mean tide (Figure B-2). The groynes were installed to reduce infilling of the ramp area with gravel that migrates along the beach as longshore transport. The area inside the groynes forms a protected basin at lower tide levels.

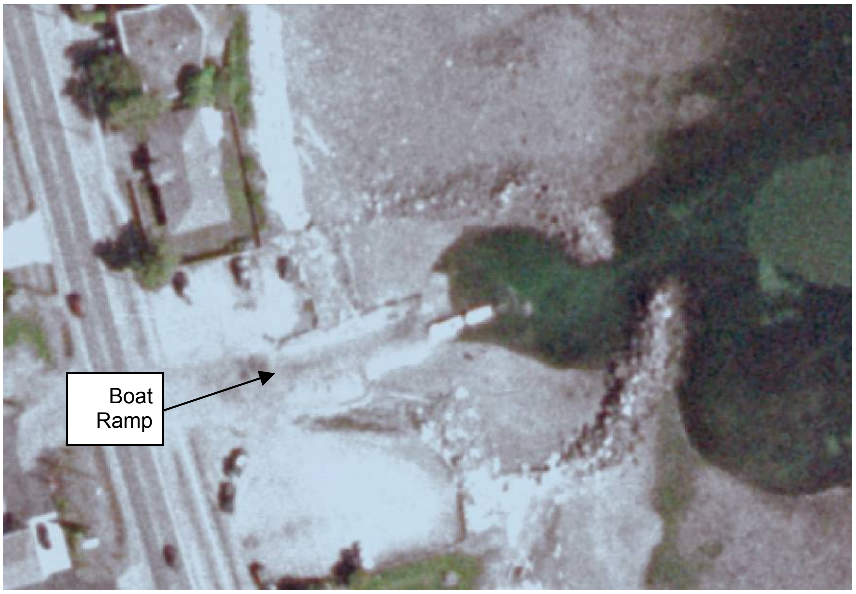

Figure B-2. **Aerial view of Big Rock Boat Launch showing rock wings extending from shore (2007 orthophoto).**

2 MAINTENANCE ISSUES

Sediment and debris are transported along the beaches within the study area and are deposited on the boat ramps, resulting in temporary ramp closures. In the past this material was removed by City crews using machinery as part of regular maintenance and the material was spoiled onsite or placed on the downdrift side of the ramp. With increased awareness of the potentially harmful effects of the maintenance activities on the shoreline habitat, the annual frequency of ramp clearing has been limited, leading to long periods of time where public access to the boat ramps is not available. Public expectations about the City's maintenance responsibilities are often in conflict with the City's legal requirements to abide by environmental regulations.

2.1 MAINTENANCE EFFORT

Maintenance activities related to the boat ramps fall into two categories: 1) yearly maintenance – significant effort per occurrence, and 2) ongoing maintenance – smaller effort per occurrence. Unfortunately there is no formal record of actual maintenance activities but annual budget allotment provides a reasonable proxy of maintenance effort (Table B-1).

Table B-1. Summary of City expenditure on boat ramp maintenance, 2004 to 2010 (source CoCR).

Year	Budget	Actual	Details
2004	$8,900	$8,900	Budget was spent
2005	$6,000	$6,000	Budget was spent
2006	$9,096	$9,096	Budget was spent
2007	$9,326	$9,326	Budget was spent
2008	$9,993	$10,024	
2009	$10,623	$5,537	Ken Forde not cleared
2010	$9,929	$7,656	Additional $50,000 allotted to foreshore study

Table B-1 shows that in the years prior to 2009, the available budget was spent entirely. Given the ease with which the ramps, and particularly Ken Forde ramp, can become clogged (see below), presumably additional effort would have been expended if more funds were available. The Ken Forde ramp was not cleared in 2009 and only half of the available budget was spent. 2009 marks the beginning of a shift in policy within the City towards compliance with DFO guidelines on sediment removal from the foreshore environment. Review of stories published in the local Campbell River newspaper indicates an increase in negative reaction from the public regarding limitations on the use of the boat ramps due to sediment and debris blockage.

Annual maintenance is typically performed as a single large effort to remove sediment that has built up over the course of the previous season. In 2010 this major maintenance was performed at both Big Rock and Ken Forde boat ramps during summer low-tide conditions. Approximately 150 m^3 of material was removed from the Ken Forde boat ramp with an additional 200 m^3 that had been stockpiled onsite from the previous year. 500 m^3 of material was removed from Big Rock, which includes a much larger excavation area inside the 'basin' formed by the twin groynes. From photographs, the material appears to be comprised of medium to fine gravel and sand.

The frequency of ongoing maintenance is related to the incidence of large wind events that generate waves of sufficient magnitude to mobilise sediment and woody debris that is present within the shoreline system. Indirect observation of sediment and debris deposition at both the Ken Forde and Big Rock boat ramps indicates that storms of moderate to large magnitude can deposit significant amounts of sediment, particularly during higher tide stages. For example, sediment and debris were present on both ramps during an initial site inspection on 31 November, 2010 (Photo B-2), and despite being cleared of debris in late-December, the Ken Forde ramp was again observed to be filled with debris during a site inspection on 17 January 2011 (Photo B-3).

Photo B-2. Sediment and debris depositing on Ken Forde boat ramp during the 31 November 2010 storm.

Photo B-3. **Sediment and debris clogging Ken Forde boat ramp on 17 January 2011. The ramp was cleared in late-December, 2011.**

2.2 SEDIMENT DYNAMICS

The dominant direction of sediment transport along the shoreline in the southern reaches of the study area is from south to north. Sediment also moves laterally to the shoreline between the upper portion of the beach and the lower inter-tidal zone. Structures that project from the shore, such as the protective groynes at the two boat launches and the rock spur protecting the mouth of Willow Creek will interrupt the along-shore sediment transport and result in sediment accumulation on the updrift side. Conversely, shoreline armouring or protection that results in a steepening of the upper beach and shore face tends to change the energy balance with respect to incoming waves. A shallow beach profile results in breaking waves that dissipate their energy but a steep profile causes reflection of the wave energy back out to the beach. In this reflective environment there is a tendency for sediment stored on the upper portion of the beach to be transported away from shore into the lower inter-tidal zone, where it can then be subsequently re-mobilised onto the beach during wave events that coincide with a rising tide. Photo B-4 shows an aerial view of Ken Forde boat ramp during a medium tide. Sediment deposits are visibly accumulating on the updrift side of the groyne and in the lower inter-tidal area at the end of the groyne.

Both the Ken Forde and Big Rock boat ramps incorporate physical structures that result in both interruption of along-shore sediment transport as well as reflection of waves from the shoreline. The groyne-like structures on the updrift side of the ramps tend to mitigate the process of along-shore transportation on the ramps but are of insufficient size to provide maintenance-free use of the facilities. The groyne-like structures on the downdrift side of the ramps appear to contribute to retention of the material that is deposited on the ramp. At Ken Forde the downdrift structure was installed to protect the mouth of Willow Creek, while at Big Rock the downdrift structure was installed at the same time as the updrift structure.

Photo B-4. **Oblique aerial view of Ken Forde Boat Ramp (photo taken 18 January 2011).**

Figure B-4 shows orthophotos of Ken Forde Boat Launch taken in 2005 and 2007 during relatively low tide conditions. The ramp in both photo years appears to be clear of sediment and the beach to the south of the ramp widens steadily until it is interrupted by the protective groyne. An accumulation of sediment in front of the Willow Creek estuary structure would appear to indicate that the beach would naturally extend into Willow Point if not for the imposition of these structures. In effect, the Ken Forde Boat Ramp is located in the zone of greatest natural deposition along the reach.

This process is also evident in earlier aerial photos of the boat ramp, shown in Figure B-5. These un-corrected photos from 1984 and 1992 suggest that there was a loss of sediment from the area in front of Willow Creek. In the 1984 photo Willow Creek drains across the beach almost perpendicular to the shoreline, while in the 1992 photo the channel has migrated northwards significantly, suggesting that sediment in this area has been lost. There may have also been an accumulation of sediment within the beach to the south of the ramp but differences in tide level obscure the comparison.

Figure B-6 shows orthophotos of Big Rock Boat Launch taken in 2005 and 2007 during relatively low tide conditions. The ramp in both photo years is clear of sediment and the area between the groynes is mostly clear of sediment. These photos illustrate the relatively straight section of coastline immediately north and south of the ramp as well as the indentation to the beach front caused by the interruption to the along-shore sediment system that is created by the two groynes. The trench across the beach immediately to the north of the boat ramp is not associated with a known stormwater outfall or other mapped structure but does not appear to be caused by natural processes.

Figure B-7 is a portion of an un-corrected airphoto from 1992 showing the condition of the Big Rock boat ramp at that time. Tide height is much higher than either the 2005 or 2007 orthophotos. There are two main changes that have occurred in the intervening time. The 1992 photo shows that there was a much larger number of logs on the beach at that time. Also, the parking lot area immediately to the south of the boat ramp appears to have extended further out over the shoreline and was possibly held up by a retaining wall, which is not present today.

2.3 WAVE MODELLING

The height of wind-driven waves is proportional to wind speed, duration of time that the wind is blowing, and the distance over which the wind is acting on the wave (fetch). In open water the wave travels relatively unimpeded but as the wave nears the shore, there is an interaction between the base of the wave and the ocean bed, causing drag and loss of wave height. There is also a sheltering effect for portions of the shoreline depending on the direction that the wave is originating from.

Wind-driven waves in the study area were predicted using a numerical model for a large wind event coming from the southeast. Details of the model results are presented and discussed in Appendix A of this report. Figure B-3 provides a summary of the wave model results for the study area, comparing the open water wave height to the near-shore waves. It is interesting to note that the waves arriving at the shoreline in the vicinity of the Big Rock Boat Ramp (between Simms Creek and Hidden Harbour) are modified by interaction with the shoreline and shallow bed so that they are significantly reduced from the open-water waves that are generated offshore. In contrast, the waves arriving at the shore in the vicinity of the Ken Forde Boat Ramp are relatively unaffected by these interactions so that they are of a similar size to those generated in open water. This situation also exists at the Quadra Island Ferry but there the overall wave heights are much lower. The area of shoreline at Ken Forde experiences the largest waves in the entire study area, indicating that this area is a particularly unsuitable site for a boat ramp structure.

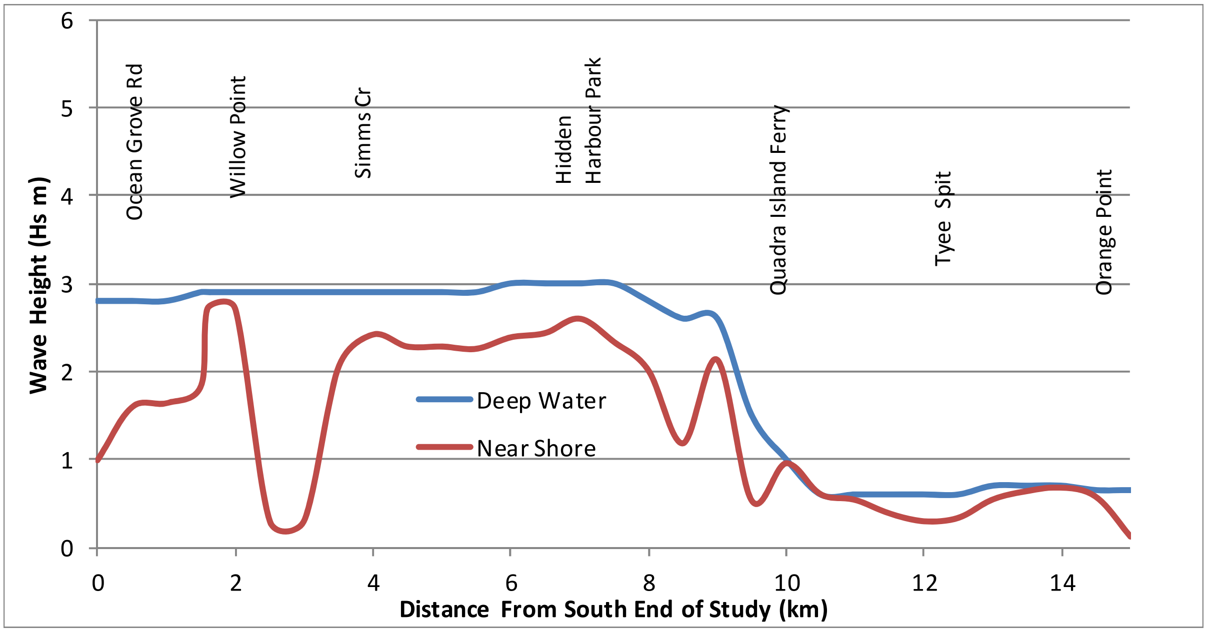

Figure B-3. Variation in wave height at Campbell River – December 23, 2010 storm event.

2.4 WAVES AND SEDIMENT TRANSPORT

South east storms transport gravel and woody debris northwards along the foreshore. Based on results from Appendix A, significant sediment movement occurs approximately 18 days/year at the Ken Forde Boat Ramp, and although the distribution of these wind events cannot be predicted accurately, there would be a higher probability of occurrence during the winter months. Sediment transport occurs slightly less frequently at the Big Rock Boat Ramp because the waves are somewhat modified as they transition from open water to the near-shore. The existing ramps partially interrupt the northward littoral drift so when sediment transport occurs, the ramp becomes blocked. Depending on the timing between the wind events and tide levels, Ken Forde Boat Ramp can theoretically become blocked up to 18 days each year.

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Ken Forde Boat Launch

Scale - 1:2,000

0 50 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	21-Jan-2011

Reference Maps

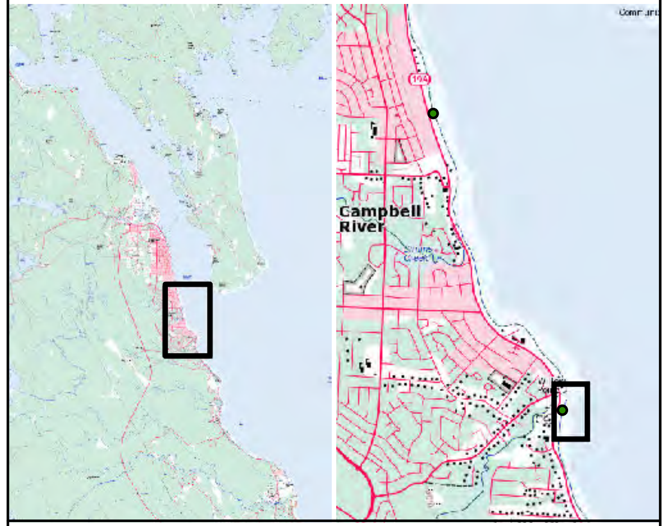

Figure B-4

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Figure B-5. **Ken Forde Boat Ramp as shown in un-corrected airphotos from a) 1984, and b) 1992. North is approximately towards the top of the photos.**

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

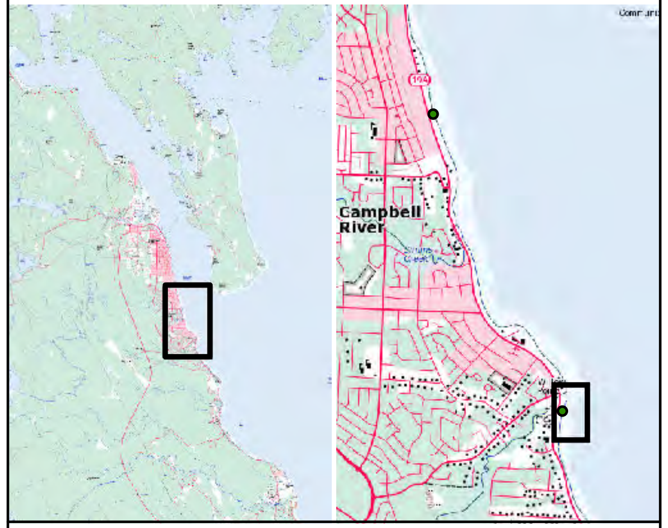
McCallum Park Big Rock Boat Launch

Scale - 1:2,000

0 50 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	21-Jan-2011

Reference Maps



MSN, \\192.168.100.12\projects\35517_CoCR_Marine_Foreshore\GIS\35517_MSN_FigBoatRampBigRock1.mxd

Figure B-6

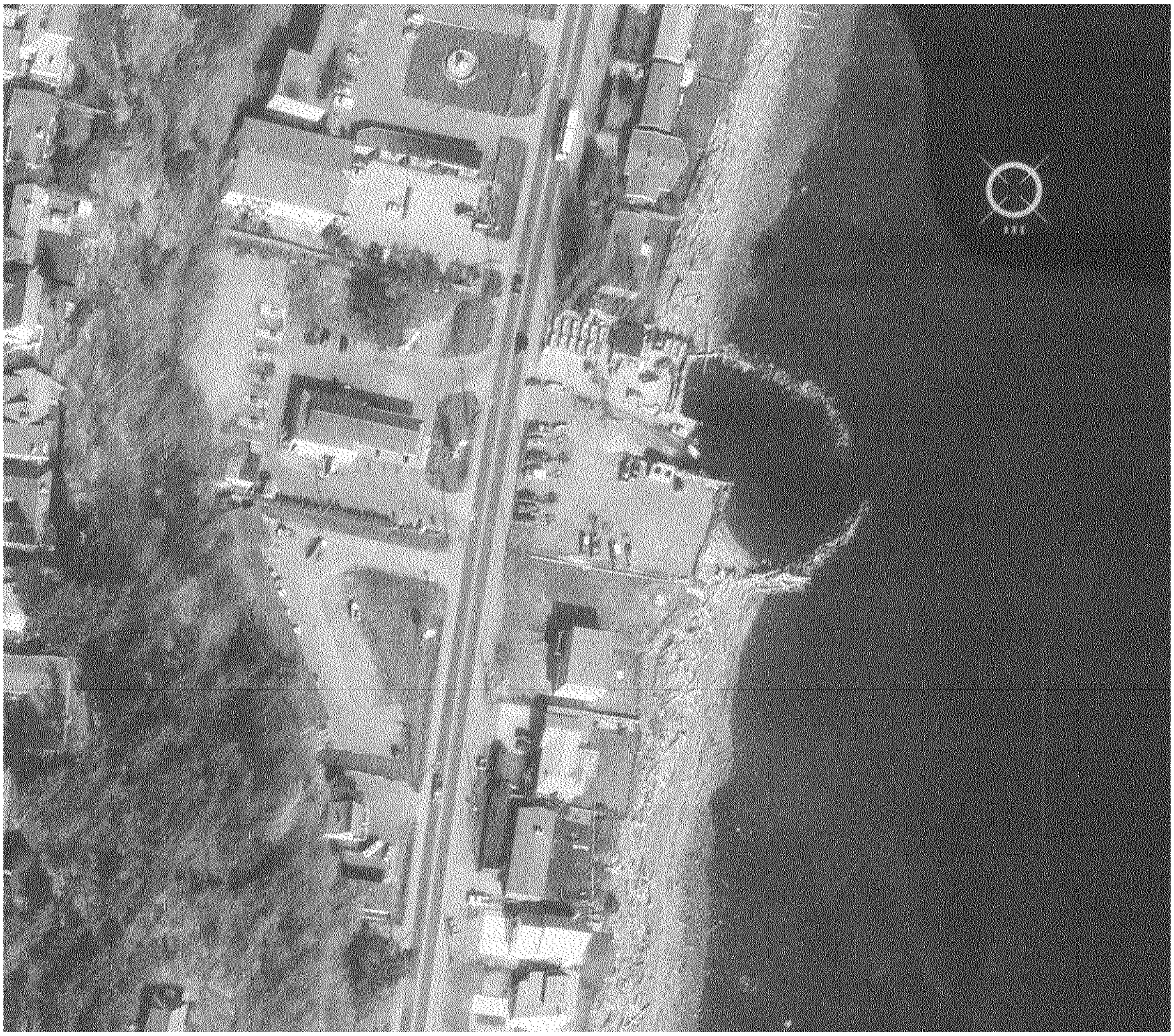


Figure B-7. **Big Rock Boat Ramp as shown in an un-corrected airphoto 1992. North is approximately towards the top of the photos.**

3 MANAGEMENT OPTIONS

The status quo management approach to boat launch maintenance is no longer viable. The City would like to adopt an approach that is consistent with current environmental practices, provides overall benefit to the shoreline environment, and provides maximum benefit to the public at a reasonable cost. The data and analysis presented in this appendix, as well as the main body of this report, provide the basis for adjusting the current approach or for adopting a new approach.

Table B-2 provides a summary of the elements that would be adopted to adjust the current approach as well as a number of options for consideration in a new approach. Clearly there is a need for further strategic discussion regarding the approach that the City will ultimately take. At an operational level, the City can adopt the Adjusted Current Approach following suitable budget analysis. The options outlined in the New Approach present a range of choices, each with potential significant consequences for the public, the environment, and the City's budget. The following sections in this chapter provide additional details regarding these various option elements as follows:

- Rapid Biological Assessment – Section 3.1
- Upgrade to Ken Forde ramp – Section 3.2

Table B-2. Summary of approach options for boat ramp management.

Adjusted Current Approach	New Approach
• Rapid biological assessment prior to ramp clearing activities • 'Annual' maintenance to occur as before • 'Ongoing' maintenance to occur as needed throughout the year • Adopt a beach sediment nourishment program • Use sediment and debris to construct and maintain 'soft' shore protection sites	• Close Ken Forde permanently and relocate to Adams Park • Close Ken Forde during the winter months • Close both ramps during the winter months • Close both ramps permanently and provide discounted launching at Discovery Marina • Significant capital investment to upgrade Ken Ford

Details of the beach nourishment program and methods for installing 'soft' shore protection projects are included in Chapter 7 of the main report.

3.1 RAPID BIOLOGICAL ASSESSMENT

Work permits and Fisheries Authorization documents typically reference a ‘fisheries window’ for working in riverine areas. A similar period of time for which works can occur within the marine environment does not exist because of the greater variety of species present in this environment results in a near-continuous use of the foreshore area. The following sections outline the rationale and proposed approach to performing a rapid biological assessment to ensure that proposed works, such as ramp clearing, will have a minimal adverse impact on the biological system.

These guidelines and protocol are tailored specifically to forage fish species. As forage fish spawning beaches are protected under Section 35 of the *Fisheries Act* as critical fish habitats, mitigation measures to manage or reduce potential risk to these species are required for proposed projects that may impact these areas.

3.1.1 INTERTIDAL SPAWNING FORAGE FISH HABITAT AND SPAWNING SEASONS

Marine intertidal (foreshore) spawning forage fishes include, but are not limited to, surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*). The following guidelines refer to critical spawning habitats and spawning periods of surf smelt, Pacific sand lance.

Surf smelt and Pacific sand lance are obligate users of upper intertidal sand-gravel beaches for spawning and incubation of their eggs (Penttila, 1978, 2007).

In general, surf smelt appear to have distinct spawning seasons as well as a year round spawning stock (Penttila 2007). Surf smelt spawning seasons can be classified as May-October, fall/winter as September-March, or year round (Penttila 2007). Pacific sand lance spawning seasons is generally regarded as occurring from November - February with the majority of spawning activity occurring in the first half of the season (Penttila 2007). Recently, sand lance spawning activity has been detected in late October at some Puget Sound locations (Penttila *pers com*). Sand lance are known to spawn at Saratoga Beach in December[1].

Both species are known to spawn over several weeks and often multiple broods can be detected within an individual spawning-bearing sediment sample. For both species, egg incubation periods are mainly temperature dependent with summer incubation lasting approximately 14 days and fall/winter eggs from 30-45 days (Penttila 2007).

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[1] Data as to precise spawning times in other areas of coastal British Columbia are available from Emerald Sea Biological. These data are currently being posted on the Forage Fish Data Management Atlas, Community Mapping Network.

3.1.2 SHORELINE WORKS – PROTOCOL TO MITIGATE IMPACTS TO FORAGE FISH SPAWNING

In this case, “shoreline works” are defined as those works which involve any disturbance of substrates in the median to high intertidal zone of the nearshore.

In light of the fact that surf smelt are known to spawn throughout the year and that there is currently no information on forage fish spawning in the Campbell River area, there is no definitive “reduced risk work window” within which works can proceed without risk to these species. As such, the recommended approach is to complete forage fish spawning surveys at proposed project locations prior to commencing work to limit disruption to spawning activity or loss of incubating eggs. These surveys are to determine if spawning has recently occurred or if forage fish embryos are present in the area. These surveys must be conducted by a Qualified Environmental Professional (QEP) with proven experience in forage fish spawning habitat surveys. Surveys at the project location are to follow standard protocols (Section 3.1.3).

Note that, in general, the majority of shoreline work is completed during the summer season due to the longer daylight hours within which to work and the occurrence of stronger low tides during daytime hours than in winter.

It is recommended that, following the end of the work period, monthly surveys for spawning activity will continue for one year.

WORKING IN OR AROUND POTENTIAL INTERTIDAL FORAGE FISH SPAWNING HABITAT

These guidelines apply to foreshore areas where data are deficient or non-existent with respect to the presence of forage fish spawning and/or duration of spawning period; and these beaches have been identified as suitable for intertidal spawning forage fish following a habitat suitability assessment by a QEP with proven experience in forage fish spawning habitat surveys. Sand lance are known to spawn at Saratoga Beach in December. There are currently no known forage fish spawning areas in the Campbell River area; this is due to a lack of sampling and assessment work in the area.

Prohibited work periods at **potential** *spawning beaches:*

1. Works are prohibited from November – February[2].
    a. Works may be permitted if it commences within 7 days in the summer or 14 days in the winter after the location is inspected by a QEP with proven experience in forage fish spawning habitat surveys and it is determined that no spawning is occurring or has recently occurred, and that no incubating embryos are present. The project may be further conditioned to require completion within a particular time.

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[2] this is known sand lance spawning season throughout the Salish Sea; we have data for December in Powell River and Comox; and now Powell River

   b. If no embryos are detected, the area must be resurveyed for the presence of spawning activity (eggs detected) every 7 days during the duration of the works.
   c. If spawning activity is detected in subsequent surveys, works will be delayed until surveys show no spawning is occurring, has recently occurred and no incubating embryos are present.

WORKING IN OR AROUND **CONFIRMED** INTERTIDAL SPAWNING FORAGE FISH HABITAT

Prohibited work periods at confirmed spawning beaches. There are currently no documented or confirmed forage fish spawning areas in the Campbell River area; this is because of the lack of sampling and assessment work in the area.

Prohibited work periods at ***confirmed*** *spawning beaches:*

1. During previously documented spawning periods/seasons, particularly during *core*[3] spawning times, at the beach location or within the reference area.
2. At any time spawning activity is occurring as determined by spawning surveys conducted by a QEP with proven experience in forage fish spawning habitat surveys (Section 3.1.1).
3. At any time during embryo incubation (Section 3.1.1).
4. Where data are incomplete to establish a spawning season:
   a. April-October: Two weeks before or after any known spawning date identified by a qualified biologist.
   b. Sept – March: Four weeks before or after any known spawning date identified by a qualified biologist.
5. Where the surf smelt spawning season at the project location is six months or longer, surveys must be conducted by a biologist acceptable to DFO two weeks AND 48 hours prior to work commencement to determine that no spawning is occurring, has recently occurred, or embryos are incubating. The area should be resurveyed for the presence of spawning activity (embryos detected) once every 7 days during the duration of the works. Work can commence if embryos are absent. If spawning activity is detected in subsequent surveys, works will be delayed until surveys show no spawning is occurring, has recently occurred and no incubating embryos are present.

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[3] “core” spawning times is during a spawning season where the majority of spawn is continuously present, usually in higher densities than at other times during that spawning season.

3.1.3 *SAMPLING PROTOCOLS*

1. Spawning surveys are to be conducted by a QEP with proven experience in forage fish spawning habitat surveys and experienced in conducting field sampling according to Washington Department Fish and Wildlife protocols, recently adopted by and in use in British Columbia (Emerald Sea Biological, 2006).
   - Specifically, surveys for spawning activity must encompass the entire beach length. Sampling will occur at the project location and along the beach length according to standard protocols (200 – 300 m sampling stations). This is to ensure that spawning is detected throughout the entire spawning "bed" which generally encompasses an area of suitable habitat larger than the footprint of individual project works. The number of samples and area of sampling will be determined by the biologist in charge.
2. Lab analysis of field collected sediments are to be conducted by a QEP with proven experience in forage fish spawning habitat surveys and experienced in conducting species verification, embryological classification and brood analysis.
3. Egg incubation periods can be extrapolated following embryological classification and verified by a biologist experienced in conducting these analyses.
4. Spawning duration can be extrapolated through a brood analysis of collected embryos.

3.1.4 *SAMPLE BUDGET FOR FIELD SURVEYS*

A sample task list and time budget to complete a pre-work Rapid Biological Assessment survey is provided in Table B-3. An appropriately qualified QEP could be retained through and on-call contract with a per-assessment bid price. Depending on the structure of the contract and the volume of expected work, a survey could be conducted for approximately $400. It may be possible that costs could be reduced through volunteer recruitment or municipal staff training programs.

Table B-3. Sample task and time allotment to perform a Rapid Biological Assessment survey for shoreline works.

Task	Personnel	Hours
Spawn Survey – Field Sample – 200 m length	QEP	2
Laboratory Analysis	QEP	1.5
Reporting/Communications	QEP	1
Courier/Misc Expenses		at cost

3.1.5 DATA SHARING AGREEMENT – (NON-COMPULSORY)

Although not required prior to obtaining a permit to commence shoreline works, the project proponents are asked to share survey data collected at the project location. Data collected can be submitted to Emerald Sea Biological for posting on the Forage Fish Data Management Atlas[4] (a project of DFO, Coastal Conservation Institute of BC, and the BC Shore Spawners Alliance).

3.2 UPGRADE KEN FORDE BOAT RAMP

NHC was tasked with developing a conceptual design for an engineered solution to debris deposition and maintenance issues at Ken Forde Boat Ramp. The objectives of the investigation were to prevent debris and gravel from burying the ramp during wind events.

3.2.1 KEY DESIGN ISSUES

A rubble groyne was previously constructed immediately south of the ramp, presumably to trap the littoral drift. However, the groyne is too low and too short to prevent debris from being transported onto the ramp during large wave events during high tide conditions. In order to prevent the overtopping of the groyne, the structure needs to be expanded both vertically, as well as laterally to prevent sediment from transporting around the tip of the structure.

A tidal pool containing sensitive habitat is situated immediately offshore from the ramp. Building a rubble mound structure into this feature would not be permitted without significant additional habitat compensation and mitigation works. Therefore, the tidal pool constrains the length of a potential new structure.

3.2.2 CONCEPTUAL DESIGN OF GROYNE

A new groin could be installed to the south of the boat ramp to prevent gravel and woody debris from depositing on the ramp. The structure needs to extend above HHW to prevent floating debris and sand-sized sediment depositing on the ramp during storms. The structure needs to extend sufficiently far offshore to deflect sediment movement around the end of the ramp.

Figure B-8 shows a conceptual design of the proposed groyne structure. The overall crest length is 60 m, with the end of the groyne located near the edge of the tidal pool. The base width of the structure varies from about 9 m near the shore to 14 m near its seaward end. The alignment of the groyne is curved to shelter the ramp from south-

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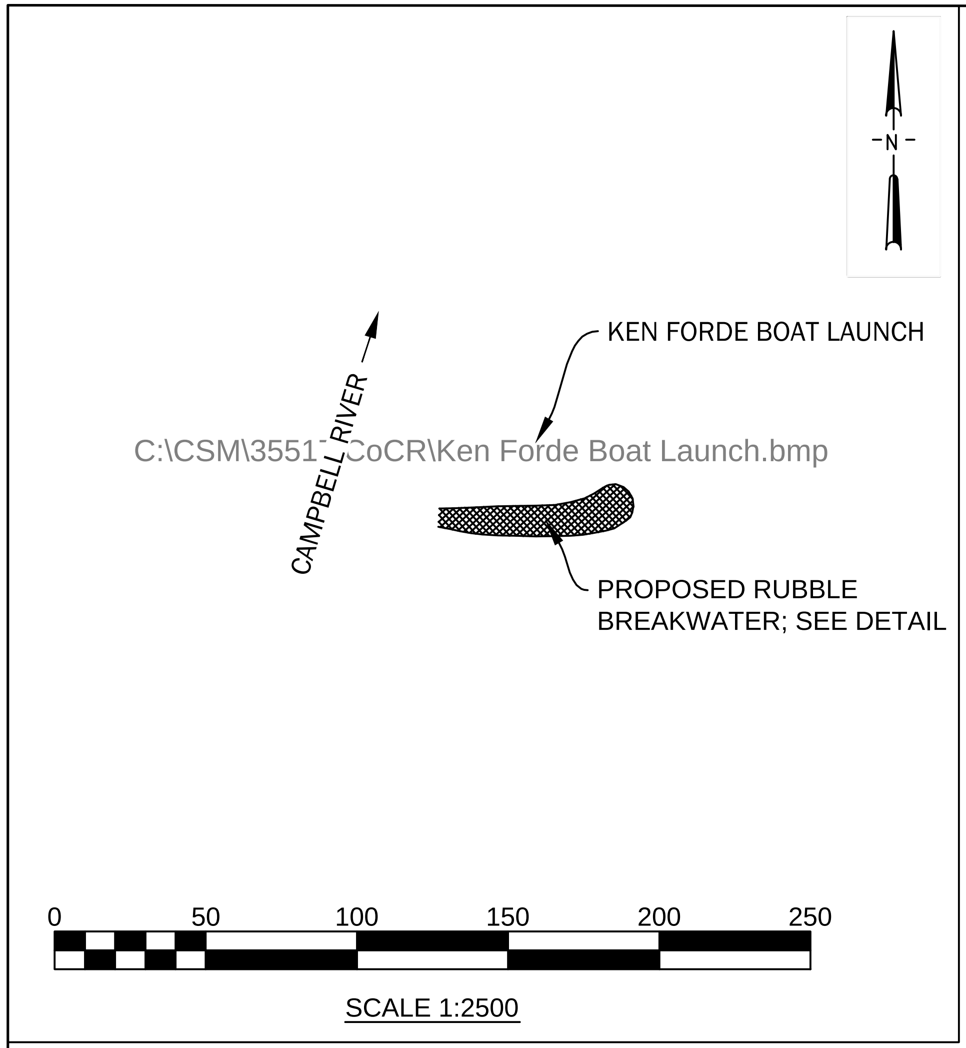
[4] Contact Ramona de Graaf at foragefish.bc@gmail.com

NOT FOR CONSTRUCTION



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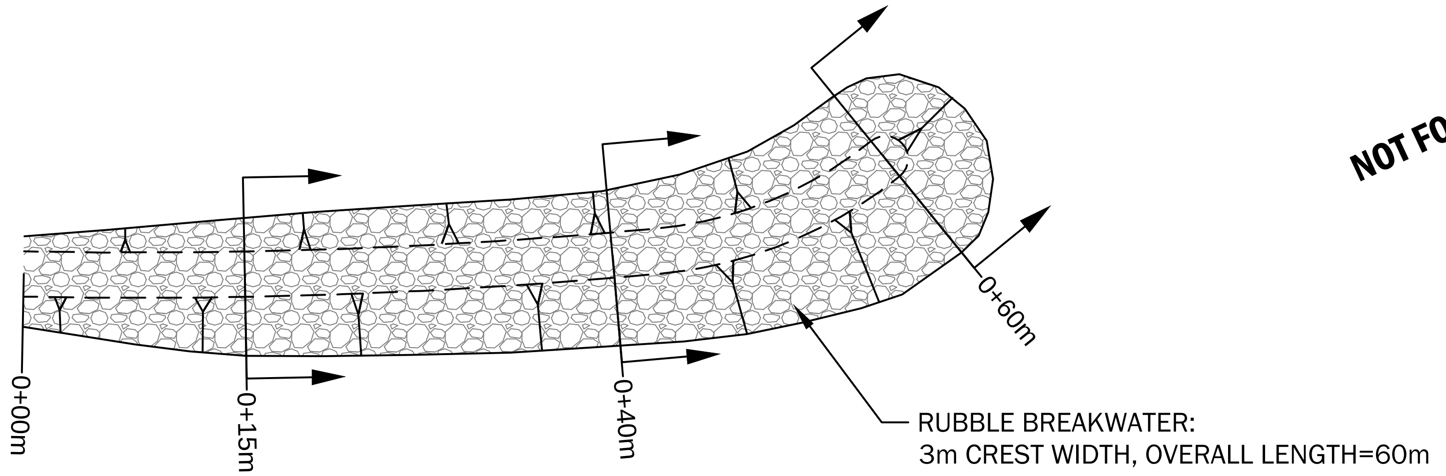
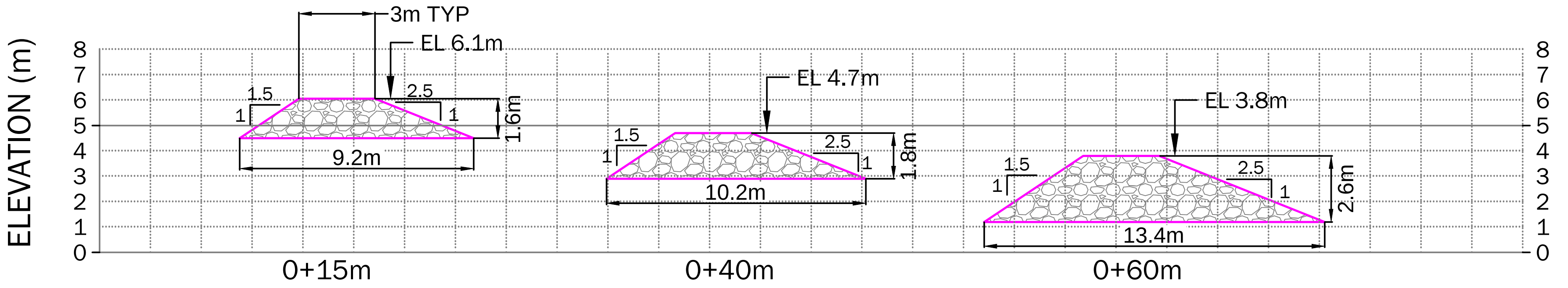


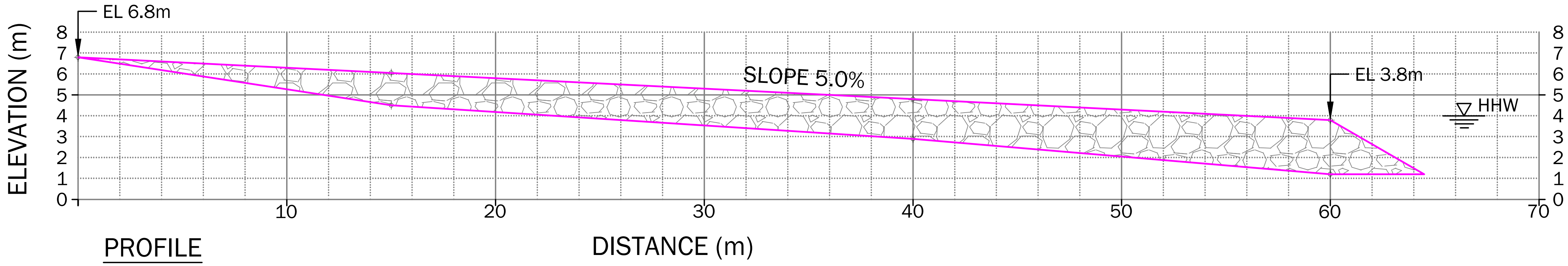
DETAIL
SCALE 1:500

TIDE LEVELS (IN CHART DATUM)
HHWLT= 4.8m
HHW = 4.0m
MT = 2.9m
LLW = 1.2m
LLW LT= 0.2m



SECTIONS
SCALE 1:250

NOTE
1. ALL ELEVATIONS SHOWN ARE IN CHART DATUM
2. NOMINAL RIPRAP SIZE IS 1860kg (900mm)



PROFILE
SCALE 1:250

nhc
northwest
hydraulic
consultants

No:	Description:	By:	Date:

Revisions:

Scale:	AS SHOWN
Designed By:	DGM
Drawn by:	CSM
Reviewed By:	
Date:	7-APR 2011
Project No:	3-5517

Figure B-8

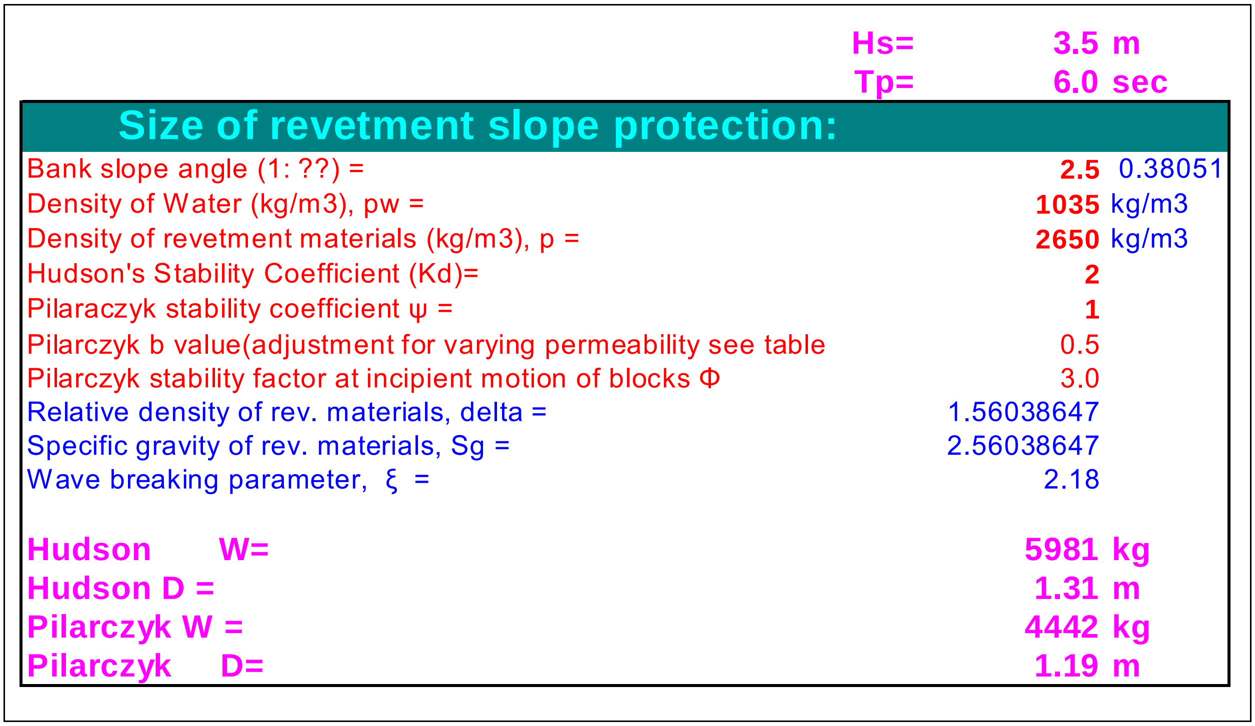
CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT
KEN FORDE BOAT RAMP:
CONCEPTUAL DESIGN OF BREAKWATER
SHEET 1 OF 1

Drawing No: 3-5517-003 Rev: 0

easterly waves and to deflect sediment movement around the end of the structure into deeper water.

The groyne will need to be constructed of heavy riprap to withstand the large waves predicted for this site and to prevent erosion. For the purposes of developing a conceptual design, a wave height of 3.5 m was chosen as the design storm event (Table B-4), having a return period of approximately 20 years. Some displacement of rock during more severe storms could be tolerated, given its overall function. Under these conditions, 1,200 mm (4.4 tonne) rock would be required at the head of the structure. At more sheltered portions of the structure, the rock size could be reduced to 800 mm (1.3 tonnes). Estimates of material volumes for the structure are listed in Table B-5.

Table B-4. Summary of design wave calculations for Ken Forde Boat Ramp.



Hs= 3.5 m
Tp= 6.0 sec

Size of revetment slope protection:

Bank slope angle (1: ??) =	**2.5**	0.38051
Density of Water (kg/m3), pw =	**1035**	kg/m3
Density of revetment materials (kg/m3), p =	**2650**	kg/m3
Hudson's Stability Coefficient (Kd)=	**2**	
Pilaraczyk stability coefficient ψ =	**1**	
Pilarczyk b value(adjustment for varying permeability see table	0.5	
Pilarczyk stability factor at incipient motion of blocks Φ	3.0	
Relative density of rev. materials, delta =	1.56038647	
Specific gravity of rev. materials, Sg =	2.56038647	
Wave breaking parameter, ξ =	2.18	
Hudson W=	**5981**	**kg**
Hudson D =	**1.31**	**m**
Pilarczyk W =	**4442**	**kg**
Pilarczyk D=	**1.19**	**m**

Table B-5. Estimated material quantities.

Item	Unit	Quantity
Riprap	Tonnes	2,000
Granular Underalyer	Cubic metres	400
Excavation	Cubic metres	400

A preliminary cost estimate for the structure was made using unit cost rates from other nearby projects on Vancouver Island. Construction of works on the foreshore generally carries a higher cost than similar terrestrial projects due to the limited construction time at low tide and the need for additional environmental mitigation and compensation. Given these issues, the estimated cost of the structure is $191,000 (Table B-6).

Table B-6. Cost estimate for groyne breakwater at Ken Forde Boat Ramp.

Item	Unit Cost	Quantity	Cost
Riprap	$45/tonne	2,000	$90,000
Granular Underlayer	$50/m^3	400	$20,000
Excavation	$25/m^3	400	$10,000
Mitigation and Compensation			$20,000
Surveys	L.S.		$6,000
Engineering and environmental monitoring	L.S.		$20,000
Sub-total			$166,000
Contingency (15%)			$25,000
Total (excluding taxes)			**$191,000**

4 REFERENCES

Emerald Sea Biological, 2006. INSERT REFERENCE FROM W. FLEENOR.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Penttila, D. 1978. INSERT REFERENCE FROM W. FLEENOR.

APPENDIX C

MARINE SHORELINE DEVELOPMENT PERMIT AREA SAMPLE REGULATIONS

TABLE OF CONTENTS

1 INTRODUCTION

This document represents **Appendix C** of the report *City of Campbell River Marine Foreshore Habitat Assessment and Restoration Plan*, prepared by Northwest Hydraulic Consultants, Current Environmental, and Murdoch de Greeff Inc. This appendix provides a set of sample guidelines that could be used to develop a Marine Shoreline-specific Development Permit Area for the City of Campbell River.

It is not the intention of the report authors to dictate the language that should be used by the City in the SOCP, nor have we provided completely refined text for inclusion in the SOCP. However, we have completed a critical review of the Central Saanich OCP Shoreline DPA Guidelines text (as provided in this Appendix), and have identified some of the obvious adaptations that the City of Campbell River will have to make to render the Central Saanich approach applicable to Campbell River's shoreline DPA. The general changes include:

- Fix obvious spelling or grammatical errors present in the original document;
- Remove 'District of Central Saanich' or 'District' and replaced with 'City of Campbell River' or 'City';
- Replaced '15 m setback' with '30 m setback';
- Removed the section addressing 'Rocky Shores' as this does not apply to the Campbell River area; and
- In keeping with the recommendations included in the main body of this report, we have included ballasted log structures within the list of potential shore protection measures in Section2.1.11.

In addition to the above changes, we recommend that the City consider the inclusion of the following elements;

- Change the applicability of the regulations to apply to development that is proposed to occur on any lot fronting the shoreline, rather than any development that occurs within the 30 m setback zone;
- Include language to reflect the emerging importance of sea level rise and the updated Coastal Flood Construction Levels that are currently at the draft stage of development by the Province. These regulations have the potential to limit development over a much larger area of the Campbell River foreshore than would otherwise be accounted for in the blanket 30 m setback zone;
- A separate Development Permit Area identified on Schedule 8 – the Marine Shoreline Development Permit Area, which is drawn to reflect inclusion of all waterfront lots, not simply a 30 m buffer; and
- Confirmation that Section 2.1.7 (7) is appropriately worded to match guidelines and regulations that the City may have specific to storm water management.

The City of Campbell River will need to review these draft guidelines and adapt them as appropriate.

2 RECOMMENDED MARINE SHORELINE DEVELOPMENT PERMIT AREA GUIDELINES

2.1.1 DESIGNATION

That part of the City of Campbell River indicated as Marine Shoreline Development Permit Area (see note above) on Schedule 8, Environmentally Sensitive Areas, is designated as a development permit area pursuant to Section 919.1(1)(a) of the *Local Government Act*.

Note: the above paragraph should be adapted for the City of Campbell River with appropriate references.

2.1.2 JUSTIFICATION

Section 919.1(1)(a) authorizes local government to designate development permits where protection of the natural environment, its ecosystems and biological diversity is desired and can be justified. Section 919.1(1)(b) authorizes local government to designate development permits for the protection of development from potentially hazardous conditions.

The City's shoreline areas have high ecological values. Due to their physical and biological characteristics and situation, they need to be carefully managed to avoid potential negative impacts of development. Residential development, and associated shoreline improvements or protection measures can threaten the ecological and physical integrity of the foreshore and valuable upland.

The effects of natural coastal processes, such as tides, ocean currents, and wind-generated waves, can pose a hazard to public and private infrastructure, as well as pose a risk to human life. The potential effects of climate change, including rising sea levels are expected to exacerbate the existing hazard. Future development along the City's shoreline will need to be carefully managed in light of these existing and potential hazards.

In an effort to balance development opportunities with conservation of the ecological values of the shoreline, a development permit is required for all development proposed on properties that have a portion that abuts the natural boundary of the sea.

2.1.3 GENERAL OBJECTIVES

- To plan and regulate new development in a manner that preserves and protects the long-term physical integrity and ecological values of the City of Campbell River's shoreline and associated foreshore and upland areas.
- To guard against erosion and avoid damage to public property.

- To ensure public safety.
- To balance development opportunities with the ecology of the shoreline environment.
- To maintain the public's use and access to these important recreation areas in a manner that does not compromise the ecological integrity of the shoreline or put users at undue risk.

2.1.4 APPLICATION

The Marine Shoreline Development Permit Area (DPA) applies to all of those properties within the City that have a portion that abuts the natural boundary of the ocean as shown on Schedule 8 of the SOCP.

This Development Permit requirement applies to all development proposed within the Marine Shoreline DPA. A development permit is required for the following development activities where such activities involve the subdivision of land, construction of, addition to, or alteration of a building or structure, or the alteration of land, except where such activities are specifically exempt:

a. Removal, alteration, disruption, or destruction of vegetation;
b. Disturbance of soils;
c. Construction or erection of buildings and structures, including shoreline protection structures;
d. Creation of non-structural impervious or semi-impervious surfaces;
e. Flood protection works;
f. Construction of roads, trails, docks, wharves, and bridges;
g. Provision and maintenance of sewer and water services;
h. Development of drainage systems;
i. Development of utility corridors; and
j. Subdivision as defined in section 872 of the *Local Government Act*.

2.1.5 DEVELOPMENT PERMIT EXEMPTIONS

The following activities are exempt from the requirement for a development permit. Despite these exemption provisions, owners must meet any other applicable local, provincial or federal requirements:

a. Development or alteration of land occurring outside of the Development Permit Area as determined by a BC Land Surveyor or another qualified person;

b. Development, upon submission to the City of a written statement from a Qualified Environmental Professional with relevant experience confirming the absence of a sensitive ecosystem within the area that would be affected by the proposed work (for example, due to mapping error);

c. The placement of impermanent features, such as benches, tables and garden ornaments;

d. Development on land where a conservation covenant under section 219 of the *Land Title Act* is registered against title, is granted to the City or a recognized conservancy and includes provisions which protect shoreline ecosystems in a manner consistent with the applicable DPA guidelines;

e. Repair, maintenance, alteration or reconstruction of existing legal or legal non-conforming buildings, structures or utilities provided there is no alteration of undisturbed land or vegetation (a building permit may still be required);

f. Repair and maintenance of existing roads, driveways, paths and trails, provided there is no expansion of the width or length of the road, driveway, path or trail, and no creation of additional impervious surfacing, including paving, asphalting or similar surfacing.

g. Removal of trees deemed hazardous by a qualified arborist that threaten the immediate safety of life and buildings;

h. Removal of invasive plants or noxious weeds on a small scale within the Development Permit Area: and

i. Normal farm practices protected by the *Farm Practices Protection (Right to Farm) Act* or other applicable provincial legislation or guidelines on properties assessed as a farm under the *BC Assessment Act*;

j. The removal of invasive plants or noxious weeds within the Development Permit Area provided such works are conducted in accordance with a vegetation management plan prepared by a certified Arborist or Qualified Environmental Professional, and measures are taken to avoid sediment or debris being discharged into a watercourse or onto the foreshore and the area is replanted immediately in accordance with established best management practices.

k. Construction of a fence so long as no native trees are removed and the disturbance of native vegetation is restricted to 0.5 m on either side of the fence.

l. Municipal public works, undertaken or authorized by the City of Campbell River.

m. Park and works services, undertaken or authorized by the City of Campbell River or provincial or federal government departments.

n. Gardening and yard maintenance activities within an existing landscaped area, such as lawn mowing, tree and shrub pruning, vegetation planting and minor soil disturbance that do not alter the general contours of the land.

o. The construction of a small accessory building such as a pump house, gazebo, garden shed or play house if all the following apply:

- The building is located within an existing landscaped area;
- No native trees are removed;
- The building is located a minimum of 10 m from the natural boundary of the sea or, where the bank has a slope greater than 3 : 1 , 10 m from the top of bank; and,
- The total area of small accessory buildings is less than 10 m^2.
- Emergency actions required to prevent, control or reduce an immediate threat to human life, the natural environment or public or private property including:
- Forest fire, flood, and erosion protection works;
- Protection, repair or replacement of public utilities;
- Clearing of an obstruction from a bridge, culvert, dock, wharf or stream;
- Bridge repairs.

2.1.6 GENERAL GUIDELINES

1. Development of the shoreline area should be limited and not negatively impact the ecological health of the immediate area or impede public access.
2. Shoreline protection measures (see also Section 2.1.11) should be limited to that necessary:
    a. To prevent damage to existing structures or established uses on adjacent upland; or
    b. To prevent damage to a proposed public land use.
3. New upland or shoreline structures or additions should be located and designed to avoid the need for shore protection works. Only if all options to locate and design without the need for shore protection measures are exhausted should such works be considered.
4. When required:
    a. Apply the ‘softest’ possible shore protection measure that will still provide satisfactory protection; and
    b. Limit the size of shore protection measures to the minimum necessary.

5. All structural shore protection measures should be installed within the property line or upland of the natural boundary, whichever is further inland. “Soft” shoreline protection measures that provide restoration of previously damaged ecological functions may be permitted seaward of the natural boundary subject to obtaining necessary approvals from the provincial and federal governments.

2.1.7 SPECIFIC SHORELINE PROTECTION GUIDELINES

NEW DEVELOPMENT/SUBDIVISIONS

1. Using geotechnical analysis of the site and shoreline characteristics, subdivision applications should ensure that the lots created will not require shore protection measures in order for useable, safe building sites to be created.
2. New development on steep slopes or bluffs shall be set back sufficiently from the top of the bluff to ensure that shore protection measures will not be necessary during the life of the structure, as demonstrated by a geotechnical analysis for the said structure.
3. Shore protection measures should not be allowed for the purpose of providing a sufficient setback to meet zoning requirements (i.e., where the setback could not be achieved without such measures).
4. Shore protection measures that will cause erosion or other physical damage to adjacent or down-current properties shall not be supported.
5. “Hard” structural shore protection measures (e.g. concrete walls, lock block, stacked rock, etc.) may be considered in support of new development only when a geotechnical and biophysical analysis provides conclusive evidence that:
    a. The erosion is not being caused by upland conditions, such as the loss of vegetation and drainage associated with the proposed development;
    b. All possible on-site drainage solutions away from the shoreline edge have been exhausted;
    c. Non-structural measures, planting vegetation, or installing on-site drainage improvements, are not feasible or not sufficient to address the stabilization issues; and
    d. The shore protection measure will not result in a net loss of shoreline ecological functions in the short and long term (i.e. any unavoidable damage to shoreline habitat will be more than off-set by habitat compensation works that have a lasting benefit).
6. New driveways and septic systems should not be located in the development permit area. If such a location cannot be avoided, the encroachment into the DPA must be minimized, and the design and construction of the road or septic system be supervised by a qualified coastal professional to ensure that the objectives and

guidelines of the DPA are met to the satisfaction of the City and Vancouver Island Health Authority as applicable.

7. Stormwater outflows shall have water quality and water quantity/erosion control features installed satisfactory to the City, so as to avoid impacts on slope stability and fish habitat and to comply with stormwater management guidelines and policies of the City.
8. Where this DPA includes native plant species or plant communities dependent on a marine shoreline habitat that are identified locally, provincially, or federally as sensitive, rare, threatened or endangered, or have been identified by a qualified environmental professional as worthy of particular protection, their habitat areas should be left undisturbed. If disturbance cannot be entirely avoided, development and mitigation/compensation measures shall be undertaken only under the supervision of the qualified environmental professional with advice from applicable senior environmental agencies.

CHANGES TO EXISTING DEVELOPMENT

1. Shore protection measures should not be allowed for the purpose of extending lawns or gardens, or to provide space for additions to existing structures or new outbuildings.
2. New structural shore protection measures along the shoreline may be considered for the protection of existing structures or to protect habitat restoration projects or hazardous substance remediation projects, if the following criteria are met:
    a. A report provided by a qualified coastal professional (QCP) provides conclusive evidence that the existing structure is at risk from shoreline erosion caused by tidal action, currents, or waves. Evidence of normal sloughing, erosion of steep bluffs, or shoreline erosion itself, without a scientific or geotechnical analysis, is not sufficient demonstration of need;
    b. The erosion is not being caused by upland conditions, such as the loss of vegetation and/or drainage conditions. The geotechnical analysis should evaluate on-site drainage issues and address drainage problems affecting the shoreline before considering structural shoreline stabilization;
    c. Non-structural measures, such as locating new buildings and structures further from the shoreline, planting vegetation, or installing on-site drainage improvements, are not feasible or not sufficient; and
    d. The shore protection works will not result in a net loss of shoreline ecological function, as determined by a qualified environmental professional with experience in assessing development effects on marine shoreline ecology.
3. An existing shore protection measure may be replaced if the existing works can no longer adequately serve its purpose provided that:

a. The replacement shore protection measures should be of the same size and footprint as the existing works, unless required to prevent shoreline erosion as determined by a qualified coastal professional;

b. The replacement shore protection measures should be designed, located, sized, and constructed to assure no net loss of ecological functions;

c. Replacement walls or bulkheads should not encroach seaward of the natural boundary of an existing shore protection measure unless there are significant safety or environmental concerns that could only be addressed via such an encroachment. In such cases, the replacement shore protection measures should utilize the 'softest' approach possible and abut the existing shore protection works; and

d. Where impacts to critical marine habitats would occur by leaving the existing works, existing works can be removed as part of the replacement measure.

2.1.8 GUIDELINES FOR SPECIFIC SHORELINE TYPES

Beach Shores may consist of broad silty /sandy beaches or gravely/blocky rubble beaches or mixed rock with beach sediment, and may be classified as either a drift-sector or pocket beach of Class 1, 2, or 3 rating. With this type of shoreline, the following guidelines apply:

1. Ensure that a minimum 30 m setback for new buildings and structures, additions to existing buildings and structures, or the placement and removal of fill is maintained.
2. Where shore protection measures are necessary, make use of "beach nourishment designs, which add appropriately sized material to the upper beach, creating a natural beach slope and beach armour.
3. Use of seawalls and rip rap embankments are generally not acceptable except when no alterative shore protection design is possible (e.g. on existing narrow lots at the base of the marine scarp).
4. Retain or restore an average 30 m (with a 5 m minimum) wide shoreline zone (i.e., shoreline vegetation) over a minimum 50% of shore length.
5. Where marine scarp areas are under other development permit area designations for geotechnical hazards (slope stability), these areas should be reviewed with respect to protection from shoreline erosion as well.

Marsh Shores include both mudflat and delta areas, and are generally highly sensitive and productive natural areas. The intertidal (foreshore) zone in this area is typically dynamic, changing in response to large stream flows and storm events. Though dynamic, the shore zone in these areas is generally accreting rather than eroding. It is important to allow sufficient space to allow these natural sediment processes to occur. With this type of shoreline, the following guidelines apply:

1. Provide a property-specific assessment with respect to building setbacks and shore protection designs, as stream sediment processes are important and will vary from site to site.
2. Dredging or filling of marsh shore should not be permitted.
3. Use of marsh shore areas should be limited to park or conservation uses that do not require structural intrusions.
4. Where shore protection measures are necessary, make use of "beach nourishment" designs, which add appropriately sized material to the upper beach, creating a natural beach slope and beach armour.
5. Sea walls and rip rap embankments should not be used to protect these shoreline areas.
6. Retain or restore an average 30 m wide (with a 5 m minimum) shoreline zone (i.e., shoreline vegetation) over at least 50% of shore length.

2.1.9 CONSTRUCTION PRACTICES

EROSION CONTROL

All development within this DPA should be undertaken and completed in such a manner as to prevent the release of sediment to the shore or to any watercourse or storm sewer that flows to the marine shore. An erosion and sediment control plan, including actions to be taken prior to land clearing and site preparation and the proposed timing of development activities to reduce the risk of erosion, may be required as part of the development permit application.

MONITORING

The implementation of required environmental mitigation, restoration or enhancement planting or measures approved under a development permit should be monitored by a qualified environmental professional until all such measures have been completed and the Professional has provided a report confirming completion to a standard acceptable to the City.

2.1.10 VEGETATION MANAGEMENT, RESTORATION AND ENHANCEMENT GUIDELINES

1. Existing, native vegetation should be retained wherever possible to minimize disruption to habitat and to protect against erosion and slope failure.

2. Existing trees and shrubs to be retained should be clearly marked prior to development, and temporary fencing installed at the drip line to protect them during clearing, grading and other development activities.
3. If the area has been previously cleared of native vegetation, or is cleared during the process of development, replanting should be required in accordance with these guidelines or requirements specified in the development permit.
4. Vegetation species used in replanting, restoration or enhancement should be selected to suit the soil, light and groundwater conditions of the site, should preferably be native to the area, and be selected for erosion control and/or fish and habitat wildlife habitat values as needed. Suitably adapted, non-invasive, non-native vegetation may also be considered acceptable.
5. Replanting requirements should be set out in plans developed as part of the development permit application and should form part of the development permit.
6. All replanting should be maintained by the property owner for a minimum of 1 year from the date of completion of the planting. This requires removal of invasive, non-native weeds (e.g., Himalayan blackberry, Scotch broom, English ivy) and irrigation. Unhealthy, dying or dead stock should be replaced as part of the maintenance.

2.1.11 SHORE PROTECTION MEASURES DESIGN GUIDELINES

Shore Protection Measures are the range of modification measures to the shoreline, or adjacent seaward or landward areas, for the purpose of protection against erosion. Structural protection methods are often referred to as “hard” and “soft.” "Hard" measures refer to those with solid, hard surfaces, such as concrete bulkheads, while "soft" structural measures rely on less rigid materials, such as biotechnical vegetation measures or beach enhancement. There is a range of measures varying from soft to hard that include:

- Vegetation enhancement
- Biotechnical measures
- Beach enhancement/restoration
- Anchor trees
- Gravel placement
- Ballasted log structures
- Rock (rip rap) revetments
- Gabions
- Concrete groins
- Retaining walls or bulkheads
- Seawalls

SOFT (more natural)

↓

HARD (engineered)

In general, ***the harder the construction measure, the greater the impact on shoreline processes,*** including sediment transport, geomorphology, and biological functions.

1. Materials used for shoreline stabilization should consist of inert materials. Stabilization materials should not consist of debris or contaminated material that could result in pollution of tidal waters.
2. Revetments (rip rap slopes) and bulkheads (retaining walls) should only be constructed if no other alternative exists.
3. Where revetments are proposed:
    a. They should not result in the loss of shoreline vegetation or fish habitat;
    b. The size and quantity of materials used should be limited to that necessary to withstand the estimated energy of the location's hydraulic action and prevent collapse; and
    c. Designs shall be prepared by a qualified coastal professional.
4. Where bulkheads are proposed:
    a. They should not to be located where geo-hydraulic processes are critical to shoreline conservation. Feeder bluffs, marshes, wetlands, spits or hooks should be avoided;
    b. They should be located parallel to and landward of the natural boundary of the sea, as close to any natural bank as possible;

c. They should allow the passage of surface or groundwater without causing ponding or saturation; and

d. They should be constructed of stable, non-erodible materials that preserve natural shoreline characteristics. Adequate toe protection including proper footings and retention mesh should be included. Beach materials should not be used for fill behind bulkheads.

2.1.12 BEACH NOURISHMENT AND UPLAND FILL GUIDELINES

1. Fill upland of the natural boundary greater than 10 cubic meters in volume should be considered only when necessary to assist in the enhancement of the natural shoreline's stability and ecological function.
2. Such fills should be located, designed, and constructed to protect shoreline ecological functions and ecosystem-wide processes, including channel migration.
3. Fill below (seaward of) the natural boundary should be considered only when necessary to assist in the enhancement of the natural shoreline's stability and ecological function, typically as part of a beach nourishment design.
4. All upland fill and beach nourishment materials should be clean and free of debris and contaminated material. All fill and beach nourishment proposals are subject to review and approval by the appropriate provincial and/or federal authorities.

2.1.13 GUIDELINES FOR PUBLIC SHORE ACCESS, ROADS AND PATHWAYS

1. Ensure that shore protection measures do not restrict appropriate public access along the shoreline except where such access is determined to be infeasible because of incompatible uses, safety, security, or harm to ecological functions.
2. Where feasible, incorporate ecological restoration and public access improvements into the project.
3. Public road or pathways should not result in a net loss of shoreline ecological functions.
4. Public access development in extremely sensitive areas should be restricted or prohibited.
5. Fill should not be placed at or below the natural boundary for the purposes of providing a trail or walkway.
6. Parking areas should be placed away from the shore, buffered or landscaped, and constructed so as to minimize erosion and water pollution by controlling storm runoff. Structural measures such as catch basins, oil separators, filtration

trenches or swales, unpaved or permeable all weather surfaces should be considered for this purpose.

2.1.14 GUIDELINES FOR THE CONSTRUCTION AND REPLACEMENT OF EXISTING DOCKS AND BOAT LAUNCH FACILITIES

1. Docks and wharves should ensure that public access along the shore is maintained, and should serve multiple users rather that one dock per property.
2. Docks and wharves should be sited to avoid impacts on sensitive ecosystems such as eelgrass beds, fish habitat, and natural processes such as currents and littoral drift.
3. Docks should be constructed in a manner that permits the free flow of water beneath. Supports should be located on a hard substrate.
4. Floating docks should not rest on the bottom at any time and a minimal, moveable ramp should be utilized to connect the dock with the shore rather than a fixed wharf or pier.
5. Piers and pilings and floating docks are preferred over solid-core piers.
6. Docks should not use unenclosed plastic foam or other non-biodegradable materials that have the potential to degrade over time. Docks should be constructed of stable materials that will not degrade water quality. The use of creosote-treated pilings is discouraged.

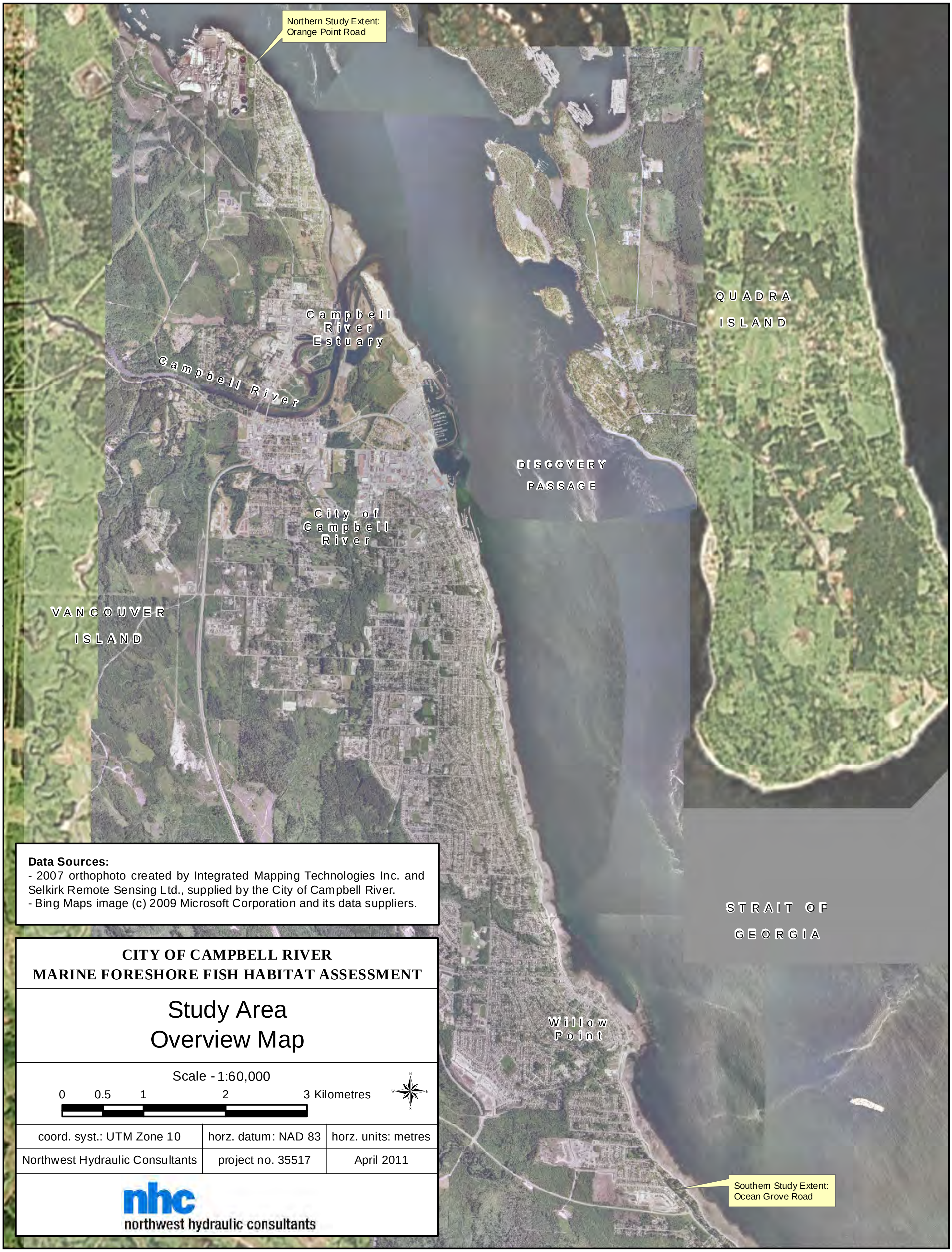
3 REFERENCES

OCP 1600, 2010. The District of Central Saanich, Official Community Plan, Appendix 1 to OCP bylaw no. 1600. District of Central Saanich, amended to October 15, 2010, 170 pp.

APPENDIX D

MAPS

LIST OF MAPS



Data Sources:
- 2007 orthophoto created by Integrated Mapping Technologies Inc. and Selkirk Remote Sensing Ltd., supplied by the City of Campbell River.
- Bing Maps image (c) 2009 Microsoft Corporation and its data suppliers.

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Study Area
Overview Map

Scale - 1:60,000

0 0.5 1 2 3 Kilometres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	April 2011

nhc
northwest hydraulic consultants

MSN, \\192.168.100.12\projects\35517_CoCR_Marine_Foreshore\GIS\35517_MSN_MapOverview1.mxd

Map 1

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Physiography and Infrastructure

Map 2, Sheet 1 of 4

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

nhc
northwest hydraulic consultants

Data Sources:
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MSN, 35517_CoCR_Marine_Foreshore\GIS\35517_MSN_MapsPhysiography1.mxd

Map 2.1

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Physiography and Infrastructure
Map 2, Sheet 2 of 4

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
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nhc
northwest hydraulic consultants

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Map 2.2

Legend

▲ Outfalls	Seawalk and Walkway	Geomorphic Reaches
Streams	City Parks	1. Southern Beaches
Contours	Non-Park City-Owned Parcels	2. Willow Point
Management Reaches	▨ Proposed Estuary WMA	3. Middle Beaches
Shoreline with Chainage	Survey Cross-sections	4. Southern Bluffs
		5. Industrial
		6. Estuary
		7. Northern Bluffs

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Physiography and Infrastructure

Map 2, Sheet 3 of 4

Scale - 1:6,200

0 200 400 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

nhc
northwest hydraulic consultants

Data Sources:
- Contours, hydrography, roads, parcel boundaries, parks, boat launches and sewer outfalls supplied by the City of Campbell River.
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Map 2.3

Legend

- ▲ Outfalls
- Streams
- Contours
- Management Reaches
- Shoreline with Chainage
- Seawalk and Walkway
- City Parks
- Non-Park City-Owned Parcels
- ▨ Proposed Estuary WMA
- Survey Cross-sections

Geomorphic Reaches

- 1. Southern Beaches
- 2. Willow Point
- 3. Middle Beaches
- 4. Southern Bluffs
- 5. Industrial
- 6. Estuary
- 7. Northern Bluffs

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Physiography and Infrastructure

Map 2, Sheet 4 of 4

Scale - 1:6,200
0 200 400 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
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Map 2.4

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Ecological Inventory

Map 3, Sheet 1 of 4

Scale - 1:6,200
0 200 400 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

nhc northwest hydraulic consultants
current ENVIRONMENTAL

Data Sources:
- Approximate eelgrass bed locations identified by Cynthia Durance, December 2010.
- Bald eagle nest locations supplied by the City of Campbell River.
- Clam bed and kelp bed data layers are part of the BC Coastal Resource Information Management System. These data were acquired from GeoBC.
- The commercial crab fishery layer was acquired from GeoBC.
- Contours, hydrography, roads, parks, boat launches and sewer outfalls supplied by the City of Campbell River.
- 2007 orthophoto created by Integrated Mapping Technologies Inc. and Selkirk Remote Sensing Ltd., supplied by the City of Campbell River.

Map 3.1

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Ecological Inventory
Map 3, Sheet 2 of 4

Scale - 1:6,200

0 200 400 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

nhc northwest hydraulic consultants

current ENVIRONMENTAL

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Map 3.2

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Ecological Inventory

Map 3, Sheet 3 of 4

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

nhc
northwest hydraulic consultants

current
ENVIRONMENTAL

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Map 3.3

Legend

- Bald Eagle Nest
- ▲ Outfalls
- Streams
- Contours
- Seawalk and Walkway
- City Parks
- ▨ Proposed Estuary WMA
- ▨ Commercial Crab Fishery
- Clam Bed
- Kelp Bed

Eelgrass Bed
- continuous
- patchy
- transplant

Backshore Condition
- Poor
- Poor-Moderate
- Moderate

Forage Fish Spawning Habitat Classification

	Substrate Suitability	Restoration Effort to Improve or Maintain
	None	High
	Low	Moderate-High
	Low-Moderate	Moderate
	Moderate	Low

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Existing Conditions
Ecological Inventory
Map 3, Sheet 4 of 4

Scale - 1:6,200
0 200 400 Metres

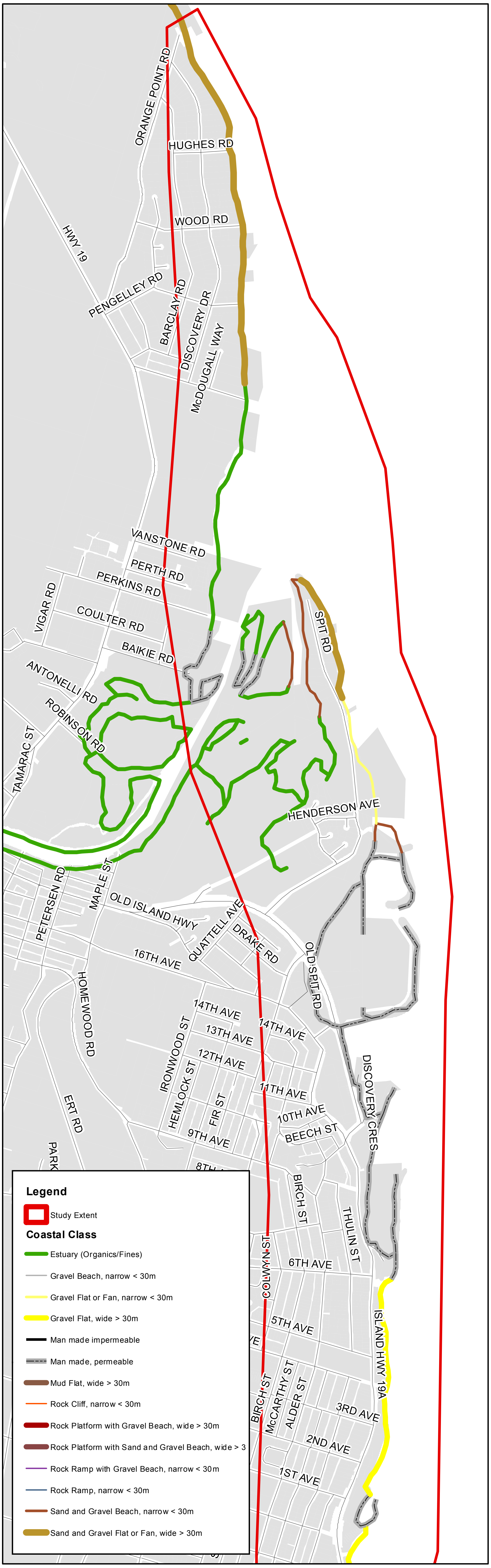
coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
project no. 35517	March 2011	

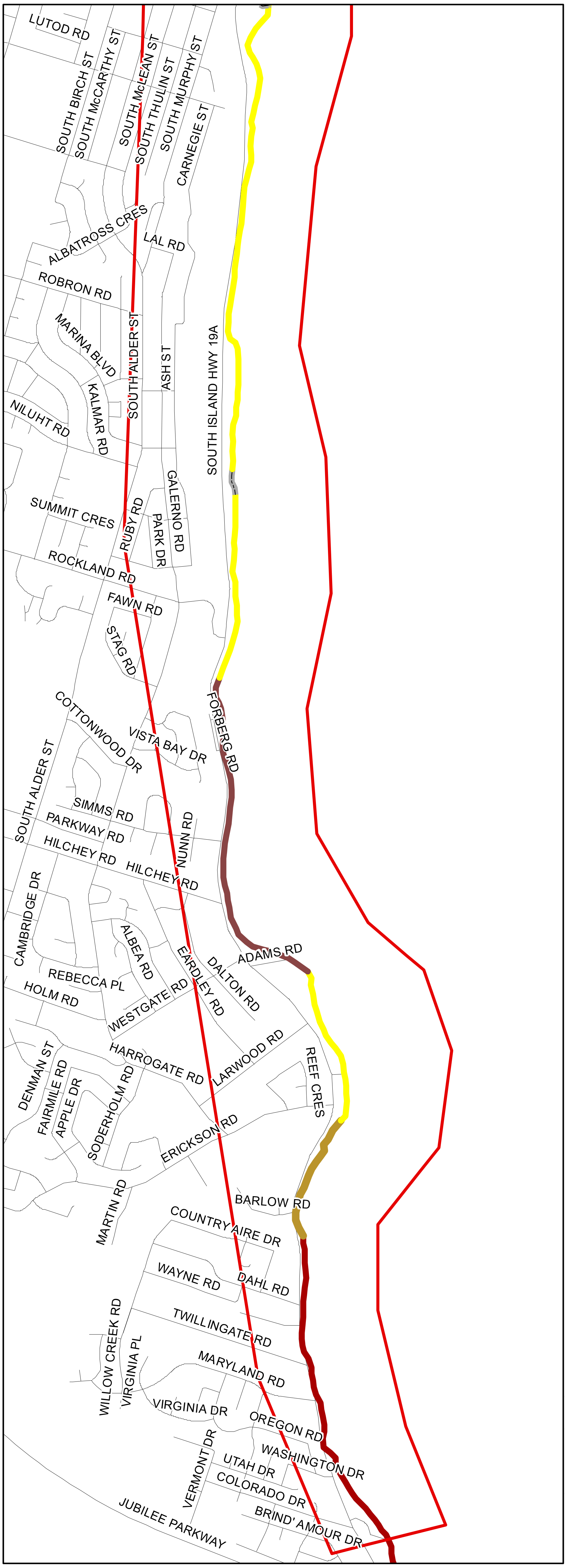
nhc northwest hydraulic consultants
current ENVIRONMENTAL

Data Sources:
- Approximate eelgrass bed locations identified by Cynthia Durance, December 2010.
- Bald eagle nest locations supplied by the City of Campbell River.
- Clam bed and kelp bed data layers are part of the BC Coastal Resource Information Management System. These data were acquired from GeoBC.
- The commercial crab fishery layer was acquired from GeoBC.
- Contours, hydrography, roads, parks, boat launches and sewer outfalls supplied by the City of Campbell River.
- 2007 orthophoto created by Integrated Mapping Technologies Inc. and Selkirk Remote Sensing Ltd., supplied by the City of Campbell River.

Map 3.4

Map 4.1





City of Campbell River

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

BC Coastal Class

Scale - 1:20,000

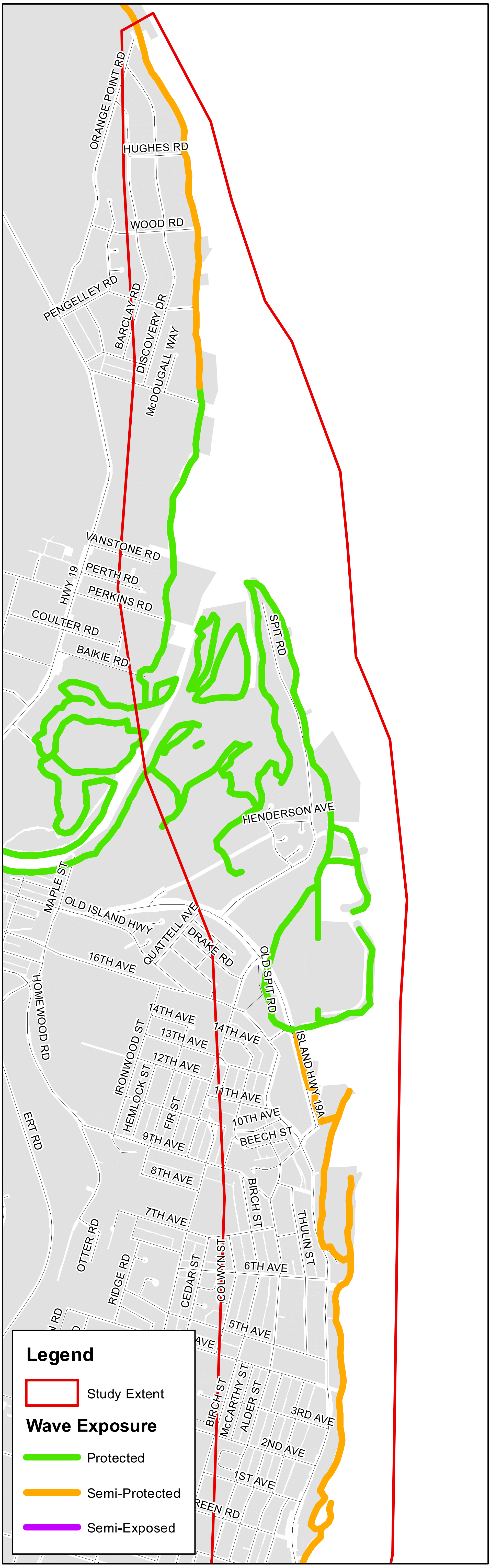
0 250 500 1,000 Metres

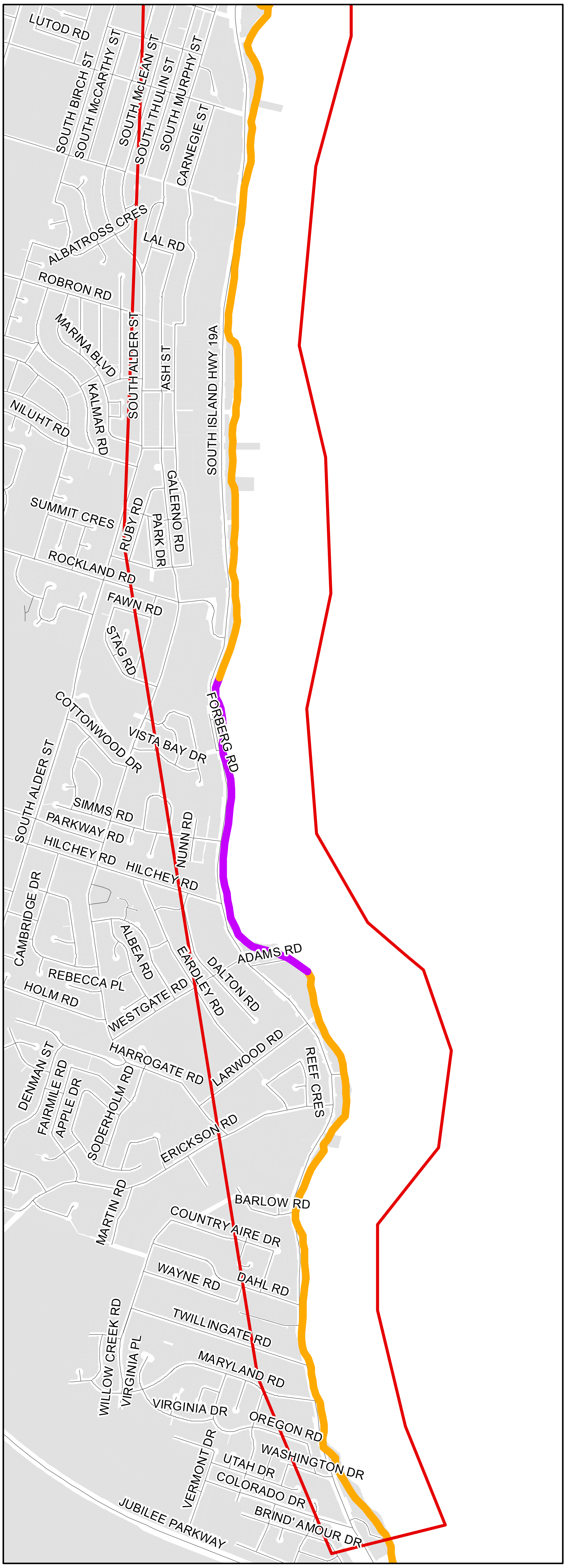
coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35413	08-Feb-2011

This product uses the BC Shorezone dataset. For more information, visit the following: ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/rpts/BCBiophysicalShore-ZoneMapping.pdf

Created by Neil Borecky, J:\Neil\03-10 Shorezone\Final Maps\35517_ShorezoneFig_CoastalClass_v92_airphoto.mxd

Map 4.2





City of Campbell River

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Wave Exposure

Scale - 1:20,000

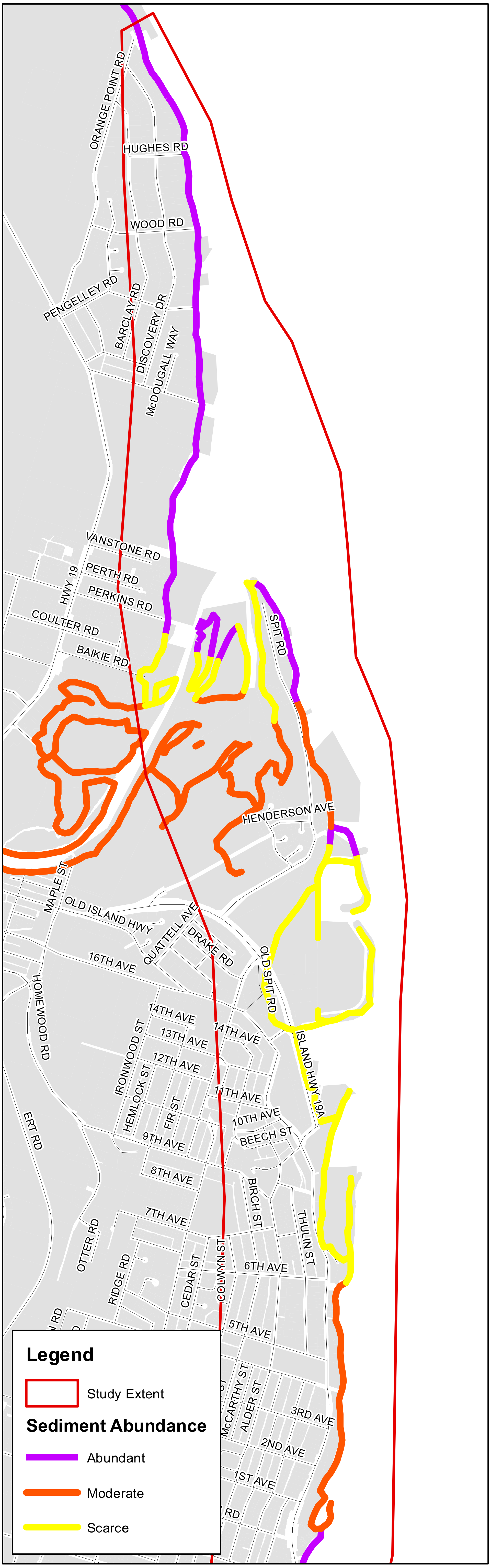
0 250 500 1,000 Metres

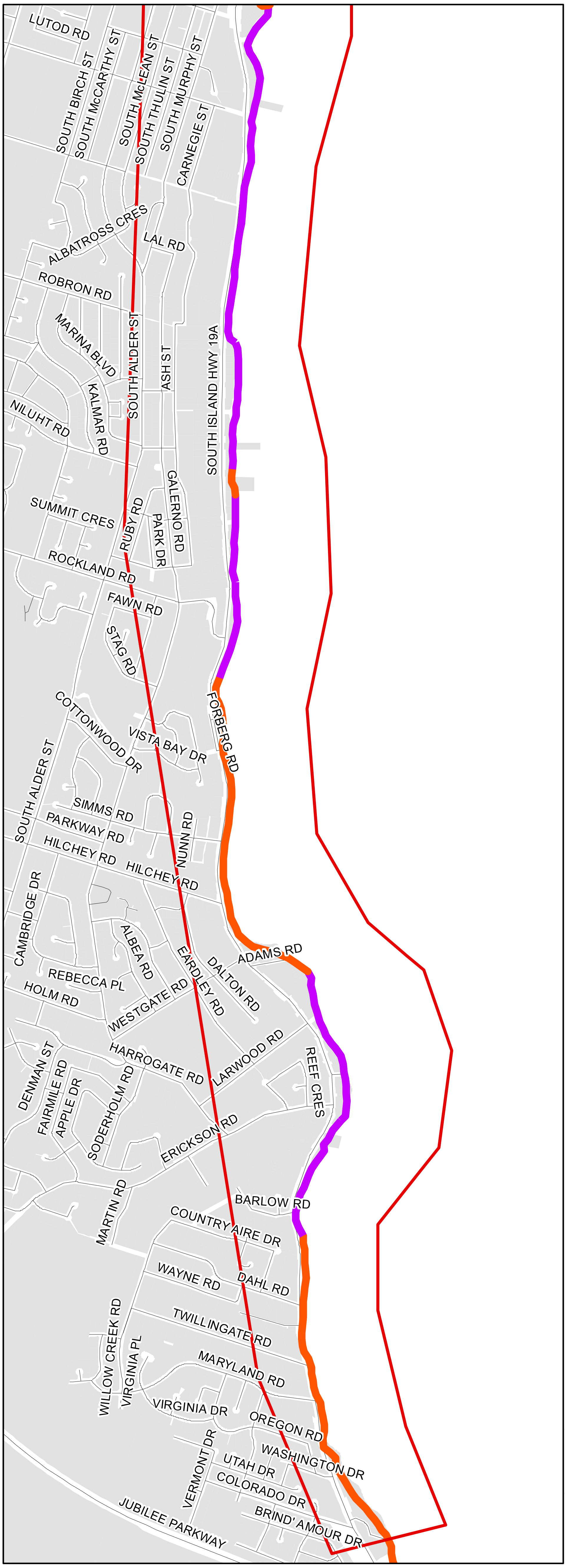
coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35413	08-Feb-2011

This product uses the BC Shorezone dataset. For more information, visit the following: ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/rpts/BCBiophysicalShore-ZoneMapping.pdf

Created by Neil Borecky, J:\Neil\03-10 Shorezone\Final Maps\35517_ShorezoneFig_WaveExposure_v92.mxd

Map 4.3





City of Campbell River

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Sediment Abundance

Scale - 1:20,000

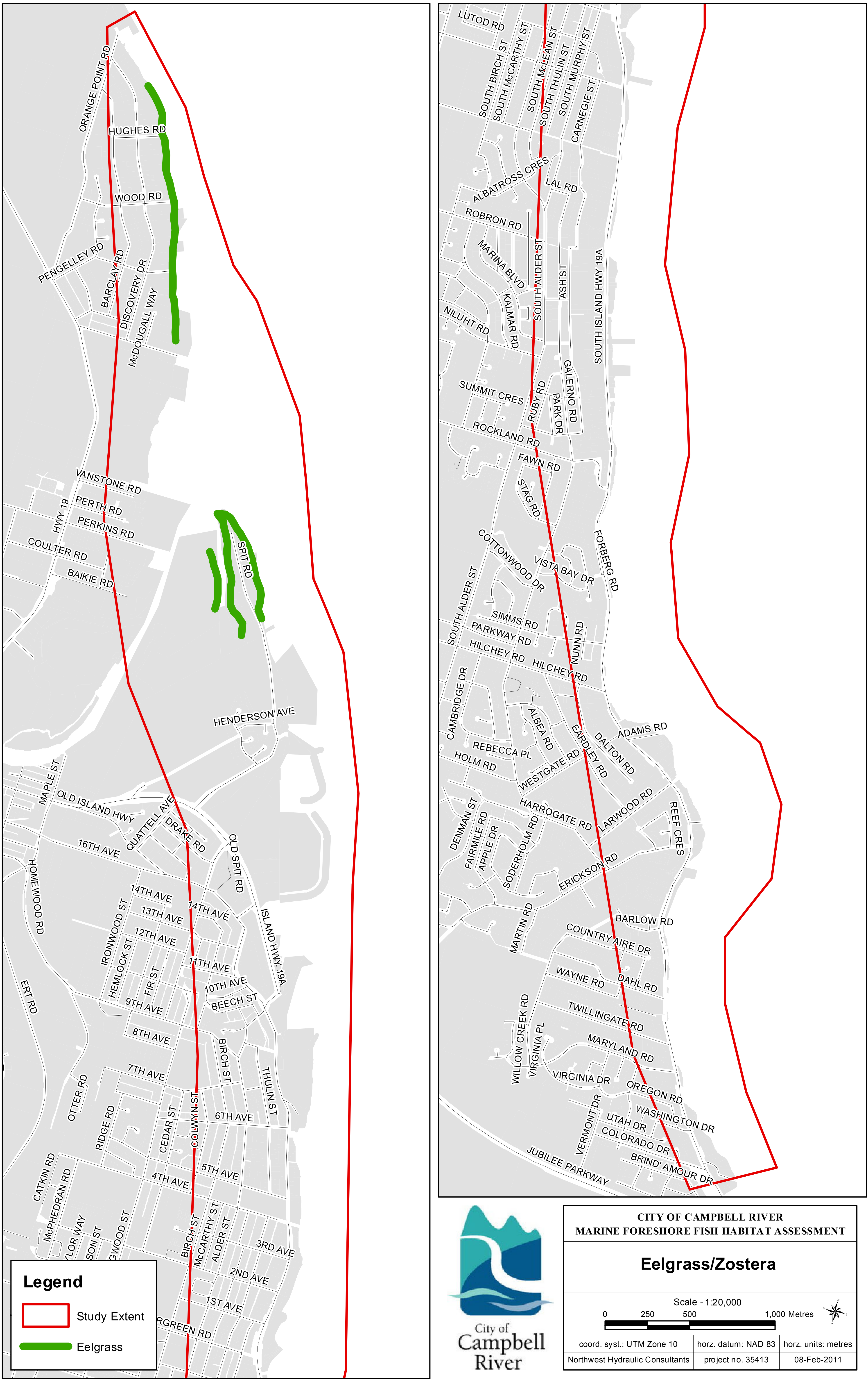
0 250 500 1,000 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35413	08-Feb-2011

This product uses the BC Shorezone dataset. For more information, visit the following: ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/rpts/BCBiophysicalShore-ZoneMapping.pdf

Created by Neil Borecky, J:\Neil\03-10 Shorezone\Final Maps\35517_ShorezoneFig_Sediment Abundance_v92.mxd

Map 4.4



City of Campbell River

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Eelgrass/Zostera

Scale - 1:20,000

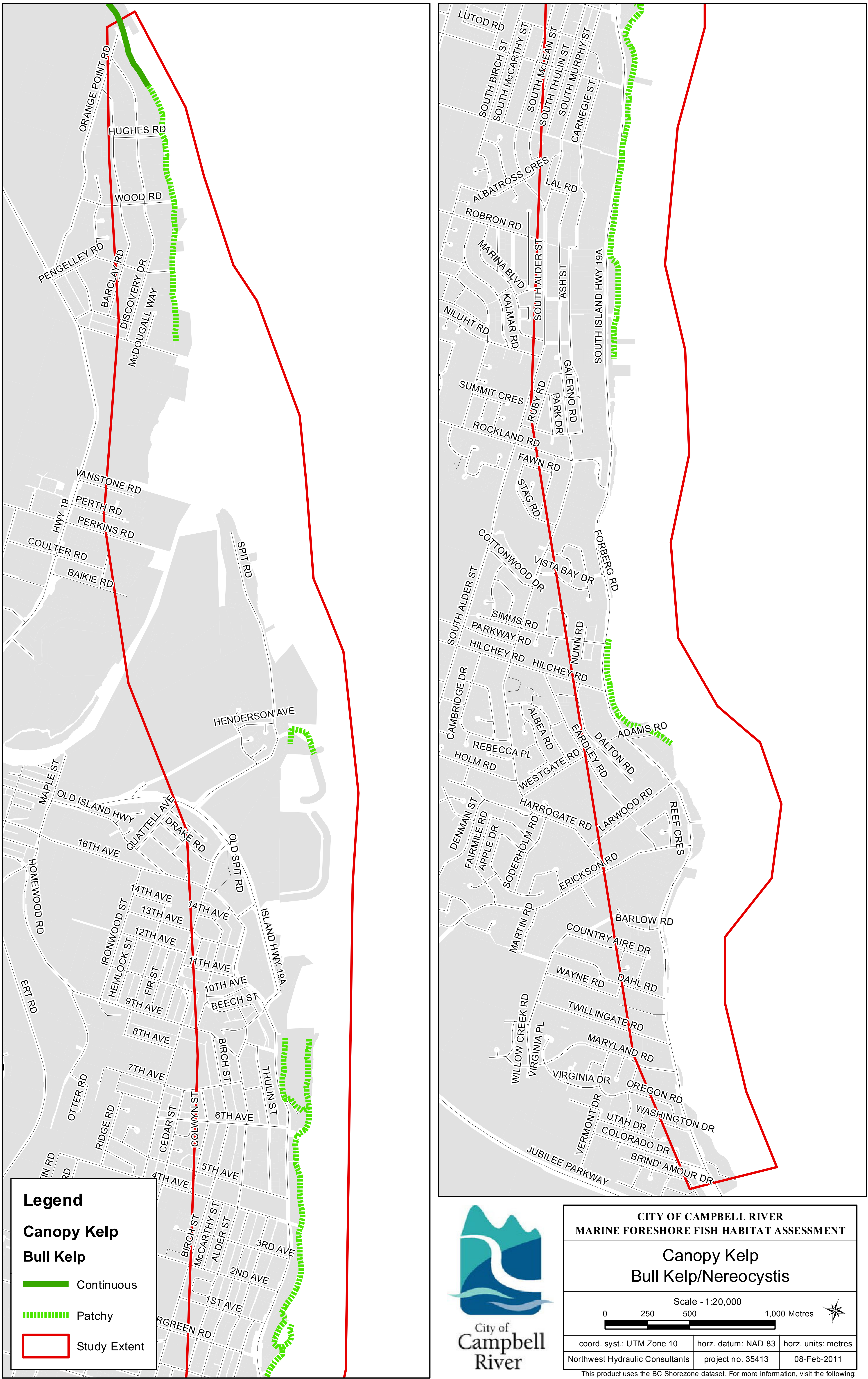
0 250 500 1,000 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35413	08-Feb-2011

This product uses the BC Shorezone dataset. For more information, visit the following: ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/rpts/BCBiophysicalShore-ZoneMapping.pdf

Created by Neil Borecky, J:\Neil\03-10 Shorezone\Final Maps\35517_ShorezoneFig_Eelgrass_v92_airphoto.mxd

Map 4.5



Legend

Canopy Kelp

Bull Kelp

🟩 Continuous

▨ Patchy

☐ Study Extent

City of Campbell River

CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Canopy Kelp
Bull Kelp/Nereocystis

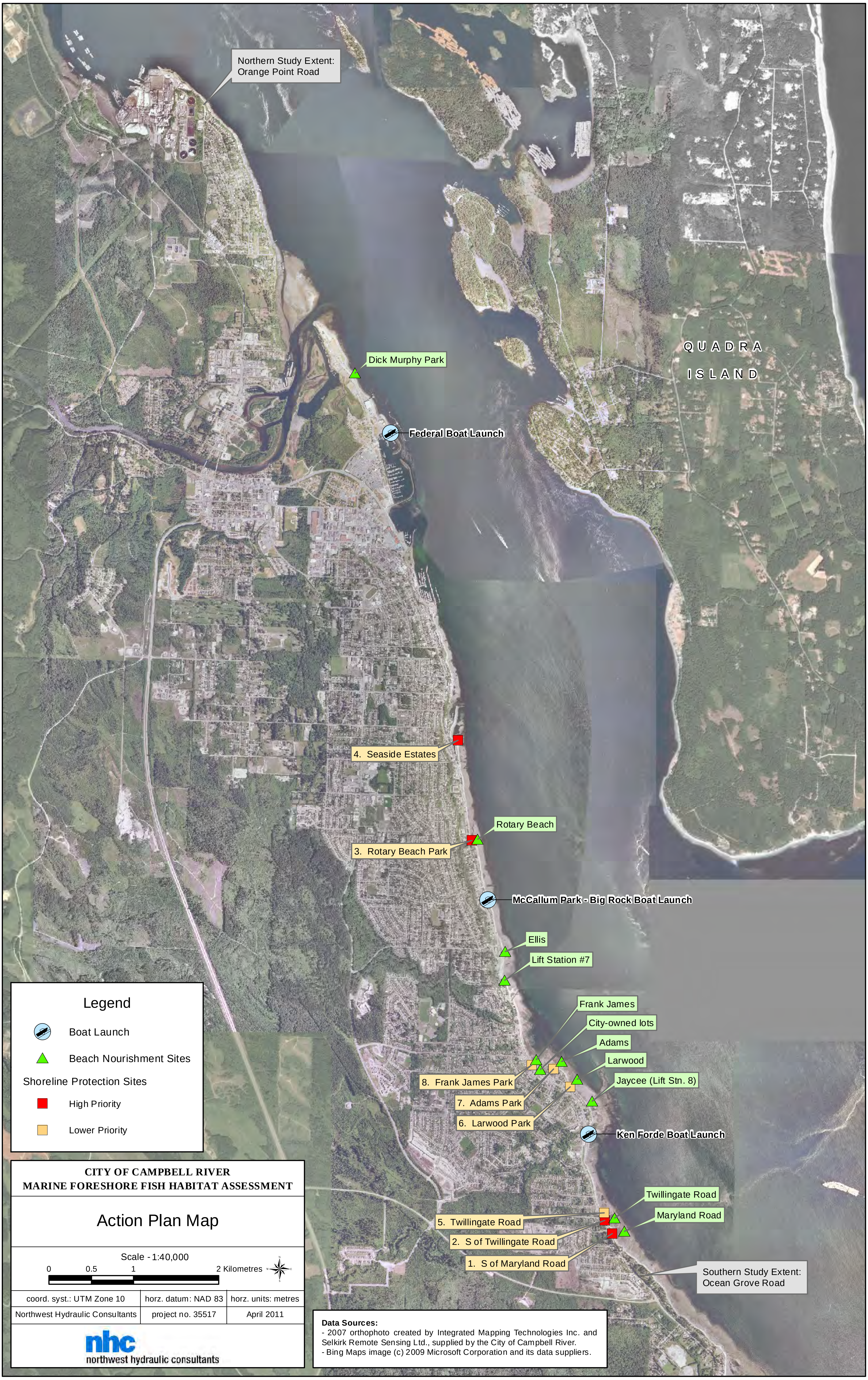
Scale - 1:20,000

0 250 500 1,000 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35413	08-Feb-2011

This product uses the BC Shorezone dataset. For more information, visit the following:
ftp://ftp.gis.luco.gov.bc.ca/pub/coastal/rpts/BCBiophysicalShore-ZoneMapping.pdf

Created by Neil Borecky, J:\Neil\03-10 Shorezone\Final Maps\35517_ShorezoneFig_Kelp_v92.mxd



CITY OF CAMPBELL RIVER
MARINE FORESHORE FISH HABITAT ASSESSMENT

Action Plan Map

Scale - 1:40,000

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 35517	April 2011

nhc
northwest hydraulic consultants

Data Sources:
- 2007 orthophoto created by Integrated Mapping Technologies Inc. and Selkirk Remote Sensing Ltd., supplied by the City of Campbell River.
- Bing Maps image (c) 2009 Microsoft Corporation and its data suppliers.

Map 5

MSN, \\192.168.100.12\projects\35517_CoCR_Marine_Foreshore\GIS\35517_MSN_MapActionPlan1.mxd