British Columbia
Conservation Foundation

Cowichan Lake Erosion Assessment

Draft Report
February 2011

KERR WOOD LEIDAL
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CONSULTING ENGINEERS

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KWL File No. 673.017

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EXECUTIVE SUMMARY

Under the Cowichan Basin Water Management Plan (2007), there is a recommendation to raise seasonal storage on the lake by 30 cm in April – May to increase flow security for the Cowichan River downstream of the Cowichan Lake weir. Several property owners have questioned whether the recommended storage increase would result in significant erosion issues. Given these concerns, there is interest in investigating the nature and root causes of current erosion, as well as in determining whether a higher seasonal lake level above the weir would add to erosion.

Cowichan Lake has a range of shoreline types including cohesive materials, uncohesive materials and manmade. The most common shoreline material is uncohesive sediments such as cobble, gravel and sand. Erosion around the lake is primarily due to waves, which can be generated either by wind or vessels. Wind data for the area suggest that the dominant wind direction is westerly or southerly, which reflects the prevailing topography.

Several sites which are representative of shoreline and wave exposure conditions were selected for detailed examination. Low severity erosion was observed at all the sites around the lake including locally eroded shoreline profiles and dunes, exposed seawall footings and exposed tree roots. Several potential erosion mechanisms were identified, and their relative importance at each site was quantified and ranked. The most important erosion mechanism is thought to be disruption of sediment transport due to seawall and groyne construction, followed by removal of shoreline vegetation, vessel wake waves, changes in water level regime due to Cowichan Lake weir installation and historical log booming practices.

Water levels were analysed using a hydraulic routing model to estimate the effects of the proposed weir raising of 30 cm (from 162.37 m GD to 162.67 m GD). Under the proposed scenario, extreme high water levels are unchanged. For lower water levels, the water level at a given exceedance probability is increased by about 0.25 m on average. The duration of exposure to different water levels was also assessed: elevations between 162.44 m GD and 162.94 m GD would see an 17% percent increase in exposure, while elevations between 161.44 m GD and 162.44 m GD would see a 7% to 12% decrease in exposure. As a result of the proposed weir change, it is likely that some shoreline reshaping due to wave action would occur in the 161.4 m GD to 163.0 m GD elevation range. The shoreline reshaping may take many years and is unlikely to have recreational impacts but could adversely affect some structures and vegetation while providing improved conditions for other structures.

Other on-going processes unrelated to the proposed weir raising could also affect future shoreline erosion. These processes include increasing boat-generated waves, removal of shoreline vegetation over an increasingly large proportion of the shoreline, construction of additional sea walls or groynes and climate change.

Section 1

Introduction

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1. INTRODUCTION

1.1 BACKGROUND

Under the Cowichan Basin Water Management Plan (2007), there is a recommendation to raise seasonal storage on the lake (typically beginning in early April to early May) by 30 cm, to increase flow security for the Cowichan River downstream of the Cowichan Lake weir. Under the recommendation, stored water would be gradually released from the lake over several months with a target of zero storage achieved by late October each year.

There are concerns from some Cowichan Lake shoreline property owners about shoreline erosion associated with Cowichan Lake water levels and wave climates generated by flooding, prevailing winds, riparian land use practices and vessel traffic (especially in the summer).

Several property owners have questioned whether the recommended storage increase would result in significant erosion issues. Given these concerns, there is interest in investigating the nature and root causes of current erosion, both in developed and undeveloped shoreline areas. There is also interest in determining whether a higher seasonal lake level above the weir (increased by 30 cm in April – May) would add to erosion.

Kerr Wood Leidal Associates Ltd. (KWL) has been retained by the British Columbia Conservation Foundation (BCCF) to conduct an assessment of shoreline erosion on Cowichan Lake and determine potential impacts of raising the Cowichan Lake weir on erosion; the findings of the study are provided in this report.

1.2 SCOPE OF WORK

KWL's scope of work is as follows:

1. Gather site data;
2. Collect and analyse wind and water level data;
3. Determine wind-generated and vessel-generated wave climates;
4. Assess existing causes of shoreline erosion; and
5. Project potential changes in shoreline erosion due to raising the Cowichan Lake weir.

Issues that are not included in the scope of this study include:

- inundation mapping;
- effects of water level changes on septic/sewer systems; and
- biological impacts of water level changes.

1.3 REFERENCES

1. U.S. Army Corps of Engineers, "Coastal Engineering Manual, Part III, Coastal Sediment Properties", March 1998.

2. U.S. Army Corps of Engineers, "Coastal Engineering Manual, Part IV, Coastal Geology", January 1995.

3. Griffin, Kohfeld, Cooper and Boenisch, "The Importance of Location for Describing Typical and Extreme Wind Speed Behaviour, a Case Study from the Pacific Northwest, North America", 2010, Draft Awaiting Publication.

4. UMA Engineering, "Feasibility Study for the Lowering of the Cowichan Lake Outlet", Report Prepared for Catalyst Paper Corporation, 2006.

5. Westland Resource Group Inc., "Cowichan Basin Water Management Plan – Water Issues", October 2005.

Section 2

Shoreline Erosion

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2. SHORELINE EROSION

2.1 INTRODUCTION

This section provides a general discussion of shoreline erosion processes, and highlights the processes that are relevant on Cowichan Lake. A specific assessment of erosion on Cowichan Lake is provided later in the report.

2.2 SHORELINE TYPES

Shorelines may be classified in several categories depending on their composition. The three main categories relevant to this project are:

1. cohesive (e.g. bedrock, clay, vegetated);
2. non-cohesive; and
3. manmade.

Cohesive shorelines are composed of materials such as bedrock and clay. Vegetated shorelines also fall into this category. The shoreline materials in this category either have inherent erosion resistance or, as in the case of vegetated shorelines, a degree of erosion resistance due to root strength (as well as a diminishment of wave energy).

Non-cohesive shorelines are composed of granular materials of various sizes, ranging from sand to boulders. Erosion resistance in this category increases with the size of the particles and decreases with increasing steepness of the slope.

Manmade shorelines include various forms of erosion protection treatment, such as riprap and seawalls. If well-designed and constructed, manmade shorelines offer a high degree of erosion resistance. However, the resistance to erosion only affects the treated areas: adjacent unprotected areas (e.g. the natural beach in front of the seawall), may still be vulnerable to erosion.

2.3 EROSIVE FORCES

Shoreline sediments are subject to several forces; these forces are caused by gravity, friction, cohesion, water currents, waves, wind and human activity. The forces can be divided into "constructive forces", which tend to build up shorelines, and "destructive forces", which tend to erode them. The various forces, classifications and comments are provided in Table 2-1.

Table 2-1: Forces Exerted on Shoreline Sediment

Force	Classification	Comment
Gravity	Destructive	Pulls straight down
Friction & Cohesion	Constructive	Resists sediment movement
Water Current	Destructive & Constructive	Can result in sediment erosion and deposition
Waves	Destructive & Constructive	Can result in sediment erosion and deposition depending on wave characteristics
Wind	Destructive & Constructive	Can blow sediment up and down a beach
Human Activity	Destructive & Constructive	Walking on a beach is generally destructive. Placing sediment on a beach is constructive.

Given the climactic conditions on Cowichan Lake, gravity, friction, waves and human activity are the dominant forces which shape the shoreline. The dominant destructive force on Cowichan Lake is caused by waves, which are generated by both winds and boats. Whether a wave is destructive or constructive depends on its' steepness (ratio of height to wavelength); this is discussed further in Section 2.5.

2.4 THE CONCEPT OF SHORELINE EQUILIBRIUM

Shoreline equilibrium can be considered over the timescale of a single storm event, or over several decades. In the latter case, the wave "climate" is of more interest than individual storm events.

The stability or equilibrium of the shoreline is dictated by the sediment budget and the wave energy. When considering a single storm event, the simplest case of equilibrium is if the sediment does not move. For non-cohesive sediments, stability increases with increasing particle size (i.e. boulders are more stable than sand), and decreasing beach slope. If wave forces overpower the forces of friction and cohesion, the sediment will be transported downslope toward the water (in the absence of longshore currents) and the result is that the shoreline will "flatten" (decrease slope) until such time as the sediment cannot be moved anymore (i.e. a new equilibrium is reached). A new equilibrium may or may not be achieved during a single storm event.

A shoreline can be said to be in long-term equilibrium, when the edge of the shore does not shift (for a given water level) over long time periods. Natural shorelines are not necessarily in long-term equilibrium, particularly shorelines composed of cohesive soils (e.g. the White Cliffs of Dover), but some are. It should be noted that a long-term equilibrium does not necessarily mean that no sediment is moved by waves: a beach composed of sand can be in equilibrium as long as the long-term flow of sediment onto the beach is equal to the flow out, so that there is no net loss of sediment to the beach. This requires that there be a sediment source (or sources) feeding the beach, either from upslope erodible areas, or from other areas along the shore (if longshore currents exist).

If the beach is cut off from sediment sources (e.g. by shoreline hardening), this can perturb the existing equilibrium and may result in net erosion and downcutting.

2.5 WAVE EROSION

Waves induce hydrodynamic drag forces on sediment particles. Depending on the wave characteristics (wave height, wave period or time interval between peaks), and the angle of the wave relative to the shoreline, the drag forces can act in several directions.

Wave forces are generally divided into two components: longshore and cross-shore. Longshore forces act parallel to the shore, and cause sediment particles to travel parallel to the shoreline in the direction of wave travel. Cross-shore forces act perpendicular to the shoreline, and can cause sediment to travel up the shoreline and build the beach (constructive) or down the shoreline and erode the beach (destructive).

Longshore forces and the associated longshore (or littoral) drift of sediment that they cause are an important factor in shoreline erosion. A shoreline subject to waves at an angle can stay in equilibrium as long as the longshore drift of sediment onto the beach equals the drift out.

Beaches can be subject to waves of differing heights and directions throughout the year; as a result, the direction of longshore drift can change throughout the year. However, when the wave "climate" in a location is considered (wave heights, periods, directions and durations) there is usually a **net** longshore drift direction. A photo of longshore sediment drift around a groyne (structure constructed perpendicular to the shore) in Yemen can be seen in Figure 2-1.

Figure 2-1: Longshore Sediment Transport around a Groyne (Drift Direction from L to R)

Cross-shore sediment transport can be both destructive and constructive depending on shoreline and wave characteristics. Beaches exposed to seasonally varying wave conditions often have "summer" and "winter" profiles. During the winter, large storm events and higher, steeper waves cause sediment to be transported offshore and deposited in submerged "bars". During the summer, lower, less steep waves cause the sediment to be carried up the beach and redeposited. Photos of a beach in La Jolla, California (taken in winter and summer), which illustrate this process can be found in Figure 2-2.

It should be noted that "summer" and "winter" beach profiles are most pronounced on beaches subject to both wind generated and swell waves. Wind generated waves are steeper, since wave height and wavelength both increase with increasing wind speed. Swell waves are generated by distant storms, and wave heights decrease with distance from the storm while wavelength stays constant, resulting in less steep waves. The waves on Cowichan Lake are almost entirely generated by local winds, therefore they tend to be mostly steep and mostly destructive.

Figure 2-2: Winter (Left) and Summer Beach Profiles, La Jolla, California

2.6 HUMAN IMPACTS ON SHORELINES

Human activity impacts shorelines and shoreline erosion in numerous ways. At the most basic level, simply walking on a beach can cause erosion by displacing sediment which then falls downslope. At first glance this effect might seem insignificant but it has been identified as a significant cause of shoreline erosion in some areas[1].

Another human impact on shoreline erosion is the removal of shoreline vegetation; shoreline vegetation is often removed to provide an unobstructed "beach" area or to improve views. The root systems of vegetation provide cohesion to the soil (a constructive force). When vegetation is removed, the cohesion is lost and the shoreline becomes more susceptible to erosion. Vegetation also diminishes the wave energy impacting the sediment by providing additional flow roughness thereby reducing flow velocities and erosive forces.

[1] At the Dallas Road Bluffs in the City of Victoria, for example.

A common human impact on shorelines is to construct a structural solution to stop or slow erosion; the most common are seawalls, riprap revetments and groynes. Seawalls and riprap revetments are constructed to stop the recession of a shoreline; they are also sometimes constructed purely for grading purposes. Groynes are walls or rubblemound structures that are constructed perpendicular to the shoreline. They can be built for various reasons, such as providing a platform for a pier or road, or to protect a pipeline, but they are also sometimes constructed to interrupt the flow of longshore sediment transport.

The problem with structural solutions to shoreline erosion is that they solve local erosion problems (at least in the short-term) but potentially worsen regional erosion problems. Seawalls and revetments can cut off a source of sediment to the beach, thereby interrupting cross-shore sediment transport resulting in erosion of the beach at the wall toe and at all areas “down drift” of their location. Groynes cut off the longshore drift of sediment directly, often resulting in shoreline erosion down drift (lee-side erosion and up-drift-side sediment deposition can be seen in Figure 2-1).

When the flow of sediment is cut off by structures, usually the only way to prevent resulting erosion problems is to import fill and deposit it on the shoreline; this is called beach nourishment. Because the fill deposited on the shoreline will eventually be carried away downshore or alongshore, beach nourishment must be performed at regular intervals in perpetuity. A thorough coastal engineering and biological study should be conducted before performing beach nourishment.

Rivers and creeks are an important source of sediment for shoreline areas. Human activities which change the amount of sediment being deposited at the river or creek mouth can alter the sediment budget of a shoreline, resulting in erosion or accretion of sediment. For example, river dredging can result in a reduction in available sediment on a shoreline, while land use practices that cause creek bank erosion (e.g. removal of vegetation in the riparian area, or increase in impervious areas and peak runoff flows) could result in an increase in available sediment on the shoreline.

Section 3

Climatic Data

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3. CLIMATIC DATA

3.1 WIND DATA

Wind data were obtained from three sites in the general Cowichan Valley region; details on the sites and data are provided in Table 3-1.

Table 3-1: Wind Data

Site	Owner	Location	Duration	99th Percentile Values	
				Speed (km/hr)	Direction
Nitinat Lake (Aut)	Environment Canada	South end of Nitinat Lake	Nov. 2007 – Present	67	180 (S)
North Cowichan	Environment Canada	Just north of Hwy 18 and Hwy 1 Intersection	Feb. 1994 – Nov. 2000	20	250 (WSW)
Palsson Elementary School	University of Victoria	Town of Lake Cowichan	June 2006 - Present	14	170 (S)
				11	300 (WNW)
Mesachie Lake	BC Wildfire Management Branch	Mesachie Lake	June 1990 - Present	16	90 (E)
				15	225 (SW)

The wind data at each site were processed to determine average, 75^{th}, 90^{th}, 95^{th}, and 99^{th} percentile wind speeds and directions. Dominant directions and corresponding 99^{th} percentile wind speeds are summarized in Table 3-1; wind roses for each gauge are provided in Appendix A. The 99^{th} percentile wind speed is the speed that is exceeded only 1% of the time.

When reviewing the data in Table 3-1, the topography surrounding the climate station must be considered. The Nitinat Lake station is located close to the ocean at the southern end of a north-south oriented valley and shows a strong southerly ocean inflow wind signal (Table 3-1). The wind will tend to shift along the axis of the Cowichan Valley as it moves inland and will become a westerly wind. The North Cowichan station is located at the eastern end of the Cowichan Valley and shows a strong westerly wind signal. The Palsson Elementary School and Mesachie Lake wind gauges are located closest to Cowichan Lake. The Palsson Elementary gauge shows a strong westerly wind signal and a strong southerly wind signal; the Mesachie Lake gauge shows a strong south-westerly wind signal and a strong easterly wind signal. Wind speeds at the Palsson Elementary and Mesachie Lake gauges are lower than the Nitinat and North Cowichan gauges.

The Palsson Elementary School data were processed to determine Summer (June-September) wind speeds and directions; a wind rose is provided in Appendix A. Review of the wind rose indicates that dominant summer and winter wind directions are similar and southerly wind speeds are about 10% lower.

The relative exposure of lakeshore areas to wave-induced erosion is summarized on Figure 3-1. The wind wave energy has been classified as “High”, “Medium” and “Low” and locations of high boating activity (and therefore higher vessel wake wave energy) have been identified. The west side of Saseenos Point is considered to be subject to the highest wind and vessel wake wave energy since it is exposed to relatively long westerly and south-easterly fetches and has higher vessel traffic in the summer.

Potential climate change effects on wind speeds (and therefore wind wave heights) in the Pacific Northwest since 1950 has been studied by Griffin et. al. (3). The study (currently in Draft form and unpublished) found that “Coastal” sites have experienced constant wind speeds while “Mainland” sites have experienced a downward wind speed trend since 1950. Average, 75^{th}, and 95^{th} percentile wind speeds were examined.

3.2 WATER LEVEL DATA

Water level data from Water Survey of Canada Station 08HA009 (Cowichan Lake at Cowichan Lake Weir) from 1962 to 2007 were used for the study. The recorded data were summarized as an exceedance probability chart and processed using a hydraulic routing model to determine water levels with an adjusted weir elevation (from 162.37 m GD to 162.67 m GD).

Water level exceedance probabilities for existing and raised weir conditions are provided graphically in Appendix B. Also provided in Appendix B are graphs of average, maximum and mean water levels over a year for existing and raised weir conditions.

The water level exceedance probability is the percentage of time that a water level is **above** a given level. It is a useful tool for determining durations of exposure of different shoreline elevations to wave action under different water level regimes. Examination of the water level exceedance data indicates that water levels between about 162 m GD (geodetic) and 163 m GD are most common, occurring approximately 65% of the time.

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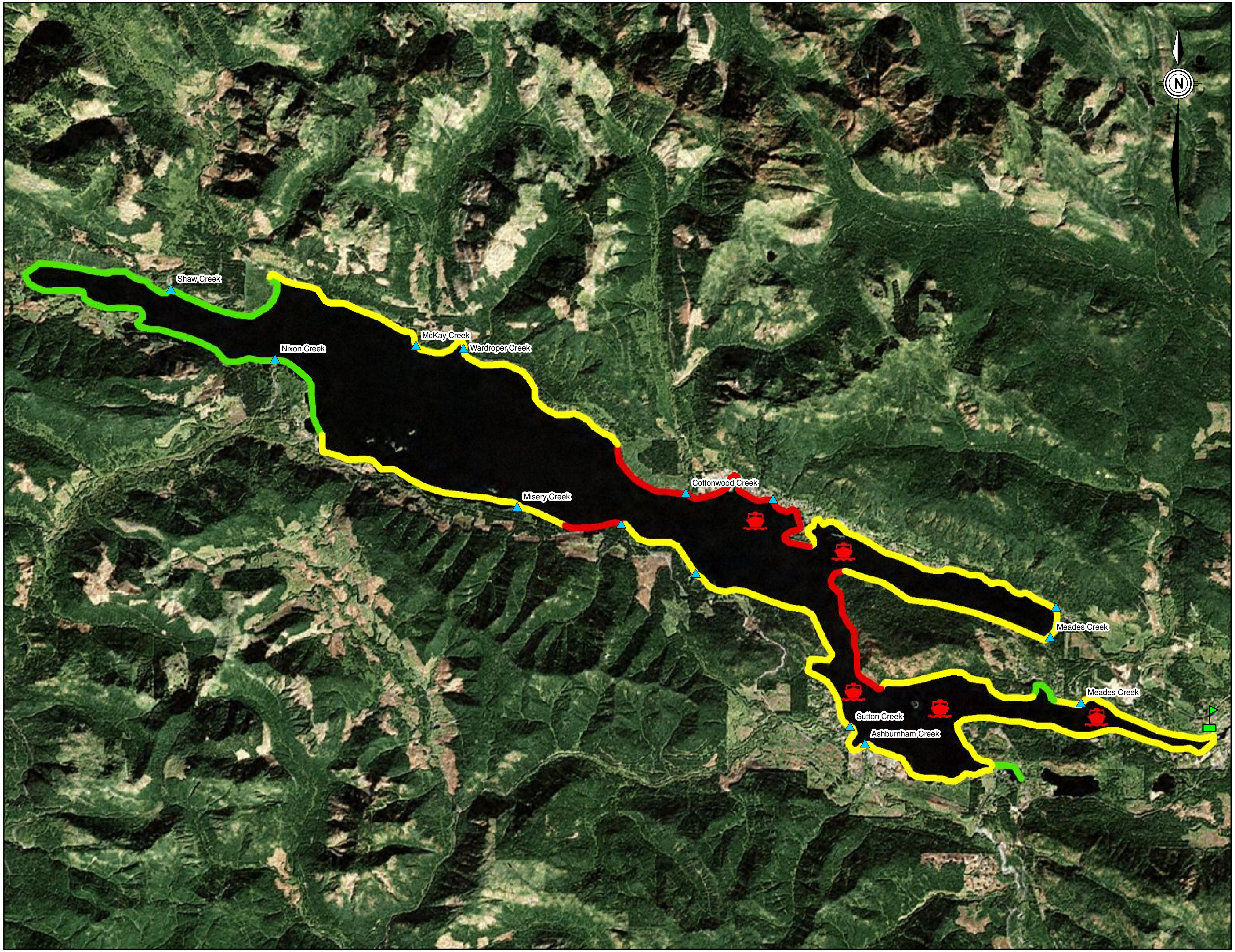

Legend

High Vessel Traffic Area

Creek (Name if Known)

Palsson Elementary School

Wind Wave Energy

High

Medium

Low

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1,000 0 3,000

Scale in Metres 1:90,000

Project No.	Date
673.017	October 2010

Lake Cowichan Wind Wave Energy Map

Figure 3-1

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Section 4

Field Observations

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4. FIELD OBSERVATIONS

4.1 SHORELINE CLASSIFICATION

A lake overview field visit was conducted on September 15, 2010. The intent of the initial field visit was to visually assess the entire lake shoreline by boat, and to classify the shoreline into slope and substrate categories. In view of the large size of the lake, representative sites were picked based on the overview field visit and were examined on a subsequent visit to make more detailed observations.

The overview field visit was conducted by Eric Morris and Erica Ellis (both of KWL), and Mr. Gerald Thom (who provided the boat). Mr. Brooke Hodson was also present for much of the visit. The entire perimeter of Lake Cowichan was viewed from the boat, with stops made to discuss areas of particular interest.

Shoreline areas were classified based on visual assessment (from the boat) of beach slope and substrate. Slope was categorized as follows:

- Low: 0-5°;
- Moderate: 5-20°; and
- High: 20-60°.

Substrate was categorized as follows:

- bedrock;
- sand;
- gravel;
- cobble; and
- boulders.

Additional field notes were made regarding the occurrence of creeks, marsh/wetland areas, vegetated areas, areas with removed vegetation and manmade structures.

Figure 4-1 shows the results of the shoreline classification from the September 15, 2010 field visit. For clarity, the classifications provided on the figure indicate the dominant shoreline in a stretch of lakeshore; small pockets of other shoreline types may be present within the dominant classifications. Of particular note, small marshes are present in protected and undisturbed areas throughout the lake.

As indicated on the figure, the shoreline is dominantly categorized as moderate slope with a cobble, gravel or sand substrate (typically a mix of sediment sizes, with gravel being the most common). High slope areas tend to be mostly bedrock and boulders. Two notably marshy areas are indicated on Figure 4-1 (Bear Lake, and the area around Nantree Park/University of Victoria Lands).

Manmade structures, typically seawalls, boat launches, floats and log breakwaters are common in most of the population centres labelled on Figure 4-1. Structures are less common in the newer development areas (Hawes Bay, Woodland Shores); human impacts are currently limited mostly to removal of shoreline vegetation in these areas.

4.2 SITE OBSERVATIONS

A second field visit was conducted on September 20, 2010 by Eric Morris, Erica Ellis, and Mr. Gary Horncastle of BCCF, who provided the boat. The purpose of the second field visit was to travel to particular sites to make more detailed observations of the shoreline morphology, to look for evidence of erosion and identify potential erosion mechanisms.

Specific sites were selected to represent a range of shoreline types, as well as exposure to waves and levels of human disturbance. Shoreline slope was measured using a clinometer and the sediment size was estimated visually. Sites are summarized in Table 4-1, and Figure 4-1 shows the site (waypoint) locations. Detailed observations from the September 20, 2010 site visit are summarized in Table C-1 in Appendix C.

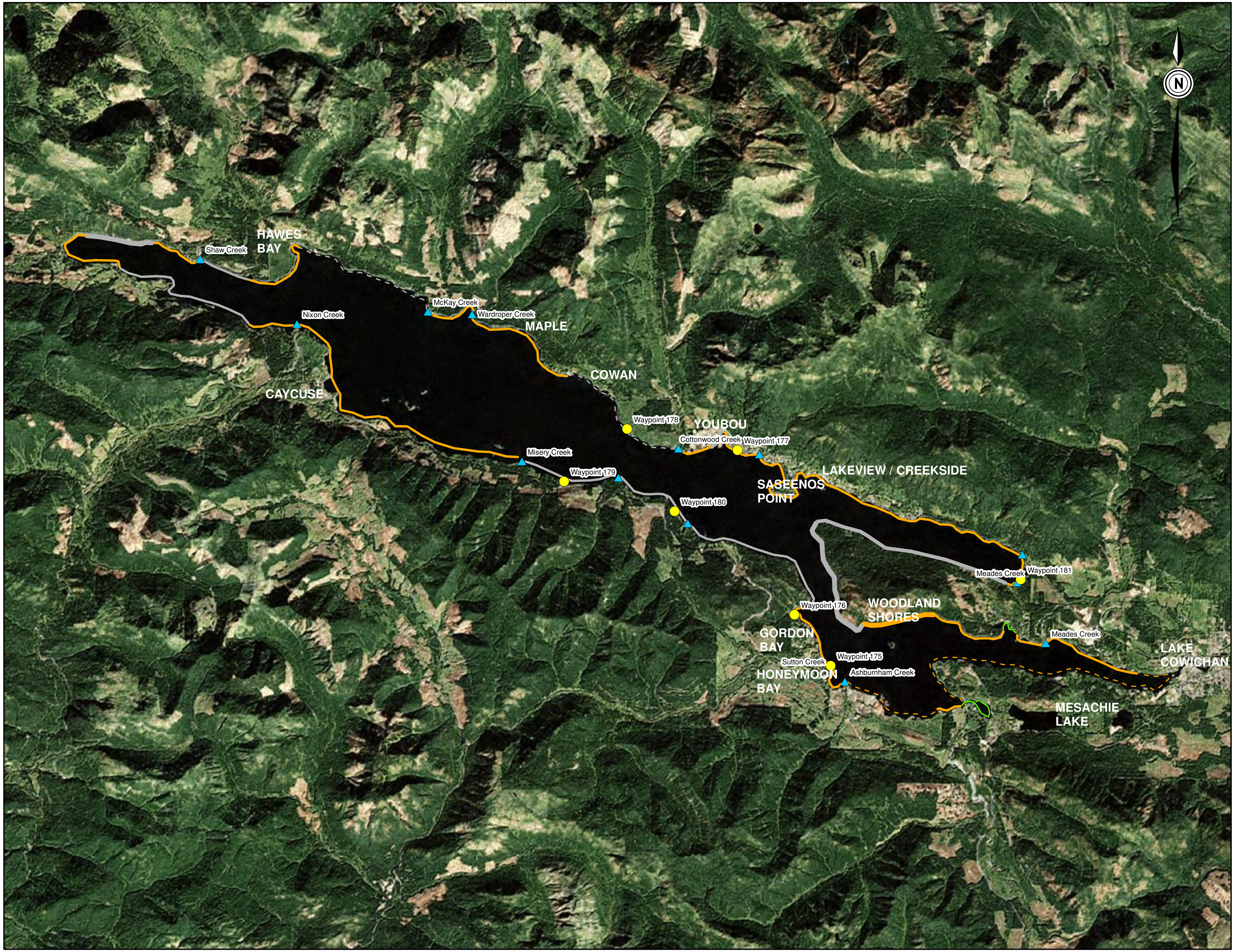
Table 4-1: Summary Site Characteristics

Way-point	Location	Shoreline	Typical Slope	Wave Exposure		Manmade Structures	Vegetation Disturbance
				Wind	Vessel		
175	Honeymoon Bay Recreation Association	Sand to Fine Gravel	15°	Medium	High	Seawalls, Groynes	High
176	Gordon Bay Provincial Park	Sand to Gravel	15°	Medium	High	None	Medium
177	Youbou	Sand to Coarse Gravel	10°	High	Medium	Seawalls, Groynes	High
178	Youbou Lands	Fine Gravel to Coarse Gravel	9°	High	Low	None	Low
179	South Shore Across from Youbou Lands	Fine Gravel	14°	High	Low	None	Low
180	South Shore Across from Youbou (sheltered)	Sand to Fine Gravel	10°	Low	Low	None	Low
181	Spring Beach (Park)	Gravel	10° to 15°	Medium	Medium	None	Low

The sites visited are typical of the lake shore with sand and gravel substrates and moderate slopes. Sites with bedrock substrate (or cobble/boulder), and marsh shorelines were not visited for the following reasons:

- Bedrock, boulder and cobble shorelines have very low susceptibility to erosion in limited-fetch, low wave energy environments such as Cowichan Lake.

- Marshes tend to occur in protected areas that have low wave energy, based on the prevailing wave climate.



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Legend

Slope and Substrate

- High: Bedrock, boulders
- High: Gravel, cobble
- Moderate-High: Bedrock (some cobble, gravel)
- Moderate: Bedrock, boulders
- Moderate: Cobble, gravel, sand
- Low: Boulder, cobble, gravel
- Low: Gravel
- Low: Marsh
- Creek
- Waypoint

Notes:
1. Small marshes are present in protected and undisturbed areas throughout the lake.

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Scale in Metres 1:96,783

Project No.	Date
673.017	October 2010

Lake Cowichan Shoreline Map

Figure 4-1

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Section 5

Assessment of Existing Erosion

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5. ASSESSMENT OF EXISTING EROSION

5.1 OBSERVED EROSION

Signs of erosion are present at all the sites visited on September 20, 2010; however the severity of erosion at each site was found to be relatively low (i.e. no signs of global bank failure, tree toppling due to root undermining or structural collapse were observed at the sites). The following specific indications of erosion were observed:

- Locally eroded slopes revealing underlying materials and dune formation. Locally eroded slopes were found to occur at elevations ranging from about 162 m GD to 164 m GD and were observed at Waypoints 177 (Youbou) and 179 (South Shore Across from Youbou Lands). For reference, water levels between 162 m GD and 163 m GD occur about 65% of the time.

- Eroded seawall toes resulting in exposed footings in some cases. Eroded seawall toes were found at elevations ranging from about 162 m GD to 164 m GD at Waypoints 175 (Honeymoon Bay Recreation Association) and 177 (Youbou).

- Exposed tree roots at elevations around 162.4 m GD were found at all sites except Waypoint 175 (Honeymoon Bay Recreation Association site), which appears to have had all trees removed. In all cases, there was no evidence of new trees establishing themselves at this elevation (except "shooters" from larger trees/bushes). Investigation of the trees in question by Meridian Forest Services on October 7, 2010 (see report in Appendix D) indicates that trees that exhibit root erosion are typically alders and cottonwoods. The trees investigated by Meridian range in age from 36 to 53 years. There are very few, if any, conifers established at this elevation.

5.2 RESIDENT DISCUSSIONS

KWL had discussions with several area residents throughout the project to gain information on vessel traffic patterns, first-hand climate observations, historical events and other relevant information. The key findings from the resident discussions are summarized in Appendix E.

5.3 DISCUSSION OF POTENTIAL EROSION MECHANISMS

INTRODUCTION

This section provides a discussion of potential mechanisms for the erosion observed at each site. At the end of the section, the erosion mechanisms at work at each site are summarized and their relative importance is estimated.

CROSS-SHORE SEDIMENT TRANSPORT

As previously discussed, beaches composed of finer sediment and exposed to seasonally varying wave conditions often have “summer” and “winter” profiles. Cross-shore transport (i.e. movement of sediment up and down the beach slope) occurs at all the sites to varying degrees, and it is only when the flow of sediment is interrupted (i.e. by a seawall) that **progressive erosion** occurs.

Cross-shore sediment transport is thought to be the dominant cause of the local erosion and dune formation at Waypoint 179 (South Shore Across from Youbou Lands). It is believed that the dune formation is **not a sign of progressive erosion at this site** and the beach likely erodes, rebuilds and reshapes as storm events and milder wind/wave events occur at different water levels.

SEAWALL AND GROYNE CONSTRUCTION

As previously discussed, seawalls and groynes can disrupt the flow of longshore and cross-shore sediment transport resulting in net sediment deficiencies and erosion. The sites at Waypoints 175 (Honeymoon Bay Recreation Association) and 177 (Youbou) have seawalls that exhibit toe erosion and footing exposure. There is evidence of a net west to east longshore sediment transport in the accretion and erosion behaviour at the groynes in the area of the Youbou site.

At the Youbou site, exposed wall foundations were found on one property but not at an adjacent property; this would suggest that construction practice likely plays a role in the occurrence and severity of seawall toe erosion. Good seawall construction practice is to locate the footing sufficiently deep to prevent undermining when seasonal scouring occurs, or provide riprap protection for the toe to prevent scour if a shallow footing is constructed.

CLIMATE CHANGE

As previously discussed, analysis of historical data indicates that wind speeds (and, it follows, associated wave heights) in the Pacific Northwest have been relatively constant since 1950. Therefore, increases in wind speed are not thought to be an important factor in causing existing erosion.

Analysis of the historical water level record indicates that maximum water levels have decreased slightly since 1953 and average water levels have not changed therefore water level regime changes due to climate change are not likely a cause of erosion.

COWICHAN LAKE WEIR INSTALLATION

The Cowichan Lake weir was installed in 1957 and raised in 1961 (4). The weir has the effect of holding water levels more constant in summer and early fall than the natural condition, thereby "flattening" the water level exceedance curve.

As previously mentioned, water levels ranging from 162 m GD to 163 m GD now occur approximately 65% of the time (the eroded tree roots observed at most sites are typically located at about 162.4 m GD). Before the weir was installed, the probability of the water level being in this elevation range was likely lower; therefore, the weir has the effect of focussing water levels and wave energy in this band of elevations. This change in the water elevation regime would change the equilibrium profile of the shoreline as illustrated schematically in Figure 5-1.

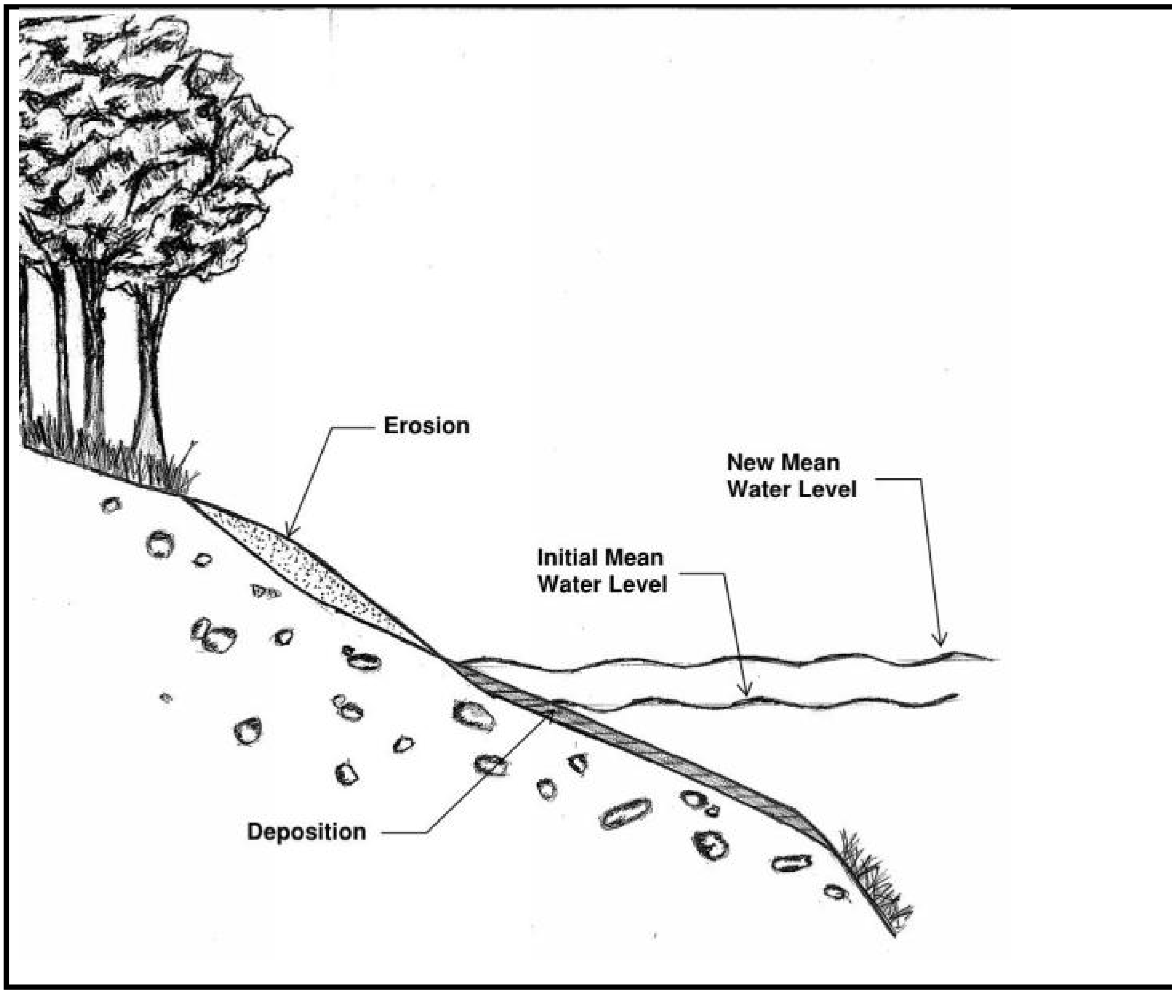

Figure 5-1: Change in Shoreline Equilibrium Profile in Response to Water Level Change

The installation of the weir may explain the observed widespread tree root erosion. When the weir was installed it would have caused a change in the prevailing wave conditions/water levels. It is believed that beaches on the lake would likely have been in equilibrium with the pre-weir conditions, and therefore the weir likely caused a perturbation in that equilibrium. Given that wave energies (and erosive energies) on the lake are relatively small, it may well have taken several years for the beaches to reach a new equilibrium. During the first decade or so after weir installation, some alder and cottonwood trees may have established themselves in what were formerly good growing conditions before weir installation, but subsequently found themselves in an eroded area as the beach transitioned to a new equilibrium profile. This would explain why the root erosion is widespread throughout the lake and why no new trees are establishing themselves at these elevations.

The Cowichan Lake weir installation could explain some of the seawall toe erosion observed, but this is likely a less important factor since most of the seawalls are reported to be constructed in the last 20 years (i.e. a good portion of the beach transition would have occurred before wall construction).

Perceived accelerations in shoreline erosion could be due to the fact that erosion is not noticed until features are exposed (i.e. one doesn't notice the first foot of scour at a seawall toe as much as the last 3 inches when the footing is exposed).

NEARSHORE BATHYMETRIC CHANGES IN YOUBOU FOLLOWING 1946 EARTHQUAKE

Shorelines fronted by nearshore shallow areas are subject to reduced wave energy because waves break in shallow water, thereby dissipating energy. Underwater subsidence due to the 1946 earthquake would result in more wave energy reaching the shoreline and the shoreline eroding until a new equilibrium profile is reached.

It is believed that this is not likely to be a dominant cause of erosion at Waypoint 177 (Youbou) because over 60 years have elapsed since the subsidence occurred and a new equilibrium beach slope has likely been reached.

SHORELINE VEGETATION REMOVAL

Shoreline vegetation removal reduces the cohesion of shoreline materials and increases erosive forces on the sediment, allowing erosion to occur for smaller waves. Removal of shoreline vegetation is a factor in the erosion at the more disturbed sites (Honeymoon Bay Recreation Association, Gordon Bay, Youbou, Spring Beach). Sites at which vegetation was stripped many years ago may now have reached a new equilibrium profile.

LOG BOOM REMOVAL

It is reported that many areas of the lake were once protected from wave action by extensive log booms. The number of log booms gradually decreased until the last ones were removed in about 2001. Log booms shelter the shoreline from wave energy; when sheltered, the beach can remain at a steeper angle and vegetation will grow at lower water levels than the natural "exposed" condition. When the log booms are removed, the shoreline will erode and reach a new equilibrium with the prevailing wave conditions.

Log boom removal could be an explanation for the tree root erosion observed at some of the sites; however, it does not explain the widespread nature of the tree root erosion and is therefore not a likely erosion mechanism.

VESSEL TRAFFIC

Vessel traffic is increasing on the lake and vessels are getting larger and are producing higher wake waves. Vessel traffic and wake waves are a possible contributor to the erosion observed at higher vessel traffic areas (Honeymoon Bay Recreation Association, Youbou).

5.4 SUMMARY

As outlined above, there are numerous potential causes of the erosion observed at Cowichan Lake. The relative importance of each erosion mechanism has been ranked for each site and is shown in Figure 5-2.

The "importance level" is quantified on a scale of 1 to 10. It should be noted that the importance level for each mechanism is not based on data, but solely on the site observations, discussions with local residents and professional judgement. The sum of the importance factors is higher at sites where there are more signs of progressive erosion.

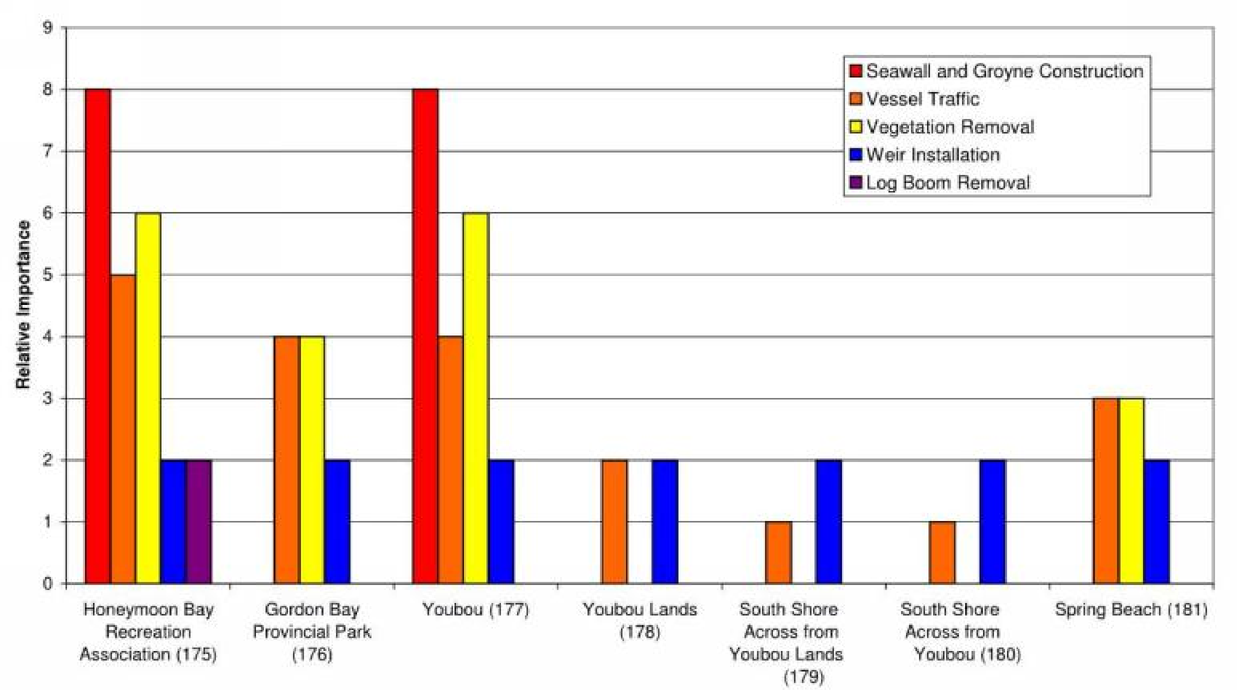

Figure 5-2: Relative Importance of Erosion Mechanisms at Each Site

Section 6

Assessment of Future Erosion

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6. ASSESSMENT OF FUTURE EROSION

6.1 EFFECT OF RAISING COWICHAN LAKE WEIR

It has been proposed that the Cowichan Lake weir be raised by 30 cm to allow the preferred minimum water release rate to be maintained under anticipated climate change conditions. The stored water will be released such that zero storage is achieved on November 5th each year; the total storage amount has been calculated based on future 1 in 10 year drought conditions. It is expected that raising the weir will (1) provide more security/certainty for the base flow in the Cowichan River; and (2) increase the potential for late September/early October pulse flows.

Water level exceedance probabilities for existing and raised weir conditions are provided in Appendix B. Generally, extreme high water levels (that occur less than about 4% of the time) are unchanged. For lower water levels, the level at a given exceedance probability is increased by about 0.25 m on average; for example, the median (50%) water level is currently 162.33 m GD but will rise to 162.58 m GD if the weir is raised. Key water levels with and without raised weir conditions are summarized in Table 6-1.

Table 6-1: Key Water Levels Before and After Weir Raising

Water Level	Elevation (m GD)		Difference (m) (Raised – Existing)
	Existing	Raised Weir	
200-year RP Floodplain (with Freeboard)	167.33	167.33	0.00
20-year RP Extreme	165.09	165.09	0.00
10-year RP Extreme	164.54	164.54	0.00
Average Annual Extreme	164.00	164.00	0.00
Full Storage	162.37	162.67	0.30
Median	162.33	162.58	0.25
Zero Storage	161.40	161.40	0.00

Notes:
1. RP = Return Period
2. "Extreme" is synonymous with maximum.

In order to determine the potential changes in erosion due to the weir, one must examine the duration to which different elevation bands are exposed to wave action (i.e. close to the same elevation as the lake) under existing and future conditions; duration of exposure (as defined as a percentage of time) is provided in Table 6-1.

Table 6-2: Duration of Exposure Under Existing and Proposed Weir Heights

Elevation Band (m GD)	Duration of Exposure (%)		
	Existing	Raised Weir	Difference (Raised – Existing)
163.94 to 164.44	1	1	0
163.44 to 163.94	3	4	1
162.94 to 163.44	10	12	2
162.44 to 162.94	26	43	17
161.94 to 162.44	40	28	-12
161.44 to 161.94	18	11	-7

Note: elevation bands with a notable difference between existing and raised weir duration of exposure have been shaded.

Elevations between 161.44 m GD and 164.44 m GD have been examined, as this is the range expected to see a change under the proposed weir height increase. As can be seen in Table 6-2, elevations above 162.94 m GD have almost no change in water level (and wave) exposure. Elevations between 162.44 m GD and 162.94 m GD see a 17% percent increase in exposure, and elevations between 161.94 m GD and 162.44 m GD see a 12% decrease in exposure; elevations below 161.94 m GD see a decrease in exposure as well.

The following conclusions can be drawn from the water level data:

- The range of elevations that see a significant change in exposure is small compared to the total water level range.
- There will be some shoreline reshaping in approximately the 161.4 m GD to 163.0 m GD elevation range. The shoreline reshaping may take many years and is unlikely to have recreational impacts but could affect structures and vegetation as discussed below.
- Structures with toe elevations between about 162.44 m GD and 162.94 m GD could see a (small) increase in wave induced toe scour while structures with toe elevations less than 162.44 m GD will likely see a (small) decrease in toe scour.
- Currently, tree root erosion is observed at elevations around 162.4 m GD; this elevation could be increased in the order 0.3 m as a result of shoreline reshaping if the weir were raised. Discussion of potential biological or habitat impacts of this change is beyond the scope of this report.

6.2 OTHER EFFECTS

INCREASING VESSEL TRAFFIC

Conversations with local property owners indicate that boat traffic has increased over the years. Cowichan Lake has seen an upsurge in development over the past 10 years, particularly recreational properties. Therefore, there are likely to be more recreational boats on the lake now than in the past, and this trend is also likely to continue. In particular, it was identified that particular styles of recreational boating, such as for wakeboarding, can produce quite large waves (reportedly in the order of 1 m). Increasing boat traffic will increase the wave energy and associated wave-induced erosion; this effect is likely to be felt most during the summer, when recreational boaters are present.

SHORELINE VEGETATION REMOVAL

During the field visit, it was noted that typical development patterns around the lake shore tend to result in naturally-occurring shoreline vegetation being stripped, with the goal of providing open “beach” areas. Shoreline vegetation adds cohesion to the substrate and therefore removing the vegetation will increase the susceptibility of the shoreline to erosion and flatten the equilibrium shoreline slope.

SEAWALL AND GROYNE CONSTRUCTION

Additional seawall and groyne construction will increase disruption of the cross-shore and longshore sediment drift. The disruption results in sediment accretion in some areas and erosion in others to the benefit of some property owners and detriment of others. As previously mentioned, beach nourishment is one of the only “win-win” solutions to erosion on shorelines that have disrupted sediment flow due to seawall and groyne construction. Biological impacts of beach nourishment must be studied prior to implementation.

CLIMATE CHANGE

Coastal wind speeds in the Pacific Northwest have been relatively constant since 1950. Wind speeds are expected to stay constant or drop as global atmospheric circulation systems (Hadley Cells) shift north due to climate change. As a consequence, more erosion due to wind generated waves is not expected in the future.

Expected changes in lake levels due to climate change are documented in the “Cowichan Basin Water Management Plan” prepared for the Cowichan Valley Regional District by Westland Resource Group, 2005. During the winter, rainfall events are expected to become more intense and snowpacks are expected to decrease, resulting in larger runoff and creek flows and higher extreme lake levels. Conversely, summer and early fall drought periods are expected to become longer, resulting in lower water levels. The net effect will be a change in the percentage of time that different elevations are exposed to wave action, resulting in some reshaping of the shoreline profile.

Section 7

Summary and Recommendations

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7. SUMMARY AND RECOMMENDATIONS

7.1 SUMMARY

1. The dominant shoreline erosion force on Cowichan Lake is caused by waves, which are generated by both winds and boats.

2. Dominant wind directions are westerly and southerly. Boat activity is highest around Youbou and in the South Arm of the lake.

3. Shorelines around Cowichan Lake are typically moderately sloped. The most common shoreline material type on Cowichan Lake is a combination of cobble, gravel and sand.

4. Several sites which are representative of shoreline and wave exposure conditions were selected for detailed examination. Low severity erosion was observed at all the sites around the lake including locally eroded shoreline profiles and dunes, exposed seawall footings and exposed tree roots.

5. Several potential erosion mechanisms were identified. The most important erosion mechanism is thought to be disruption of sediment transport due to seawall and groyne construction, followed by removal of shoreline vegetation, vessel wake waves, changes in water level regime due to Cowichan Lake Weir installation and historical log booming practices.

6. Water levels were analysed to estimate the effects of the proposed weir raising of 30 cm. Under the proposed scenario, extreme high water levels are unchanged. For lower water levels, the water level at a given exceedance probability is increased by about 0.25 m on average. Elevations between 162.44 m GD and 162.94 m GD would see a 17% percent increase in exposure, while elevations between 161.44 m GD and 162.44 m GD would see a 7% to 12% decrease in exposure.

7. As a result of the proposed weir change, it is likely that some shoreline reshaping would occur in the 161.4 m GD to 163.0 m GD elevation range. The shoreline reshaping may take many years and is unlikely to have recreational impacts but could adversely affect some structures and vegetation while providing improved conditions for other structures.

8. Other on-going processes unrelated to the proposed weir raising could also affect future shoreline erosion. These processes include increased boat-generated waves, removal of shoreline vegetation over an increasingly large proportion of the shoreline, construction of additional sea walls or groynes and climate change.

7.2 RECOMMENDATIONS

Based on the shoreline erosion assessment summarized above, modest shoreline erosion is occurring around Cowichan Lake. There are multiple processes that contribute to erosion and no simple way of attributing a depth of erosion to the various mechanisms.

Given the concern of property owners around the lake with respect to shoreline erosion, it may be worthwhile to establish some monitoring sites around the perimeter of the lake. This would enable a baseline to be established prior to any changes in the weir height. In addition, it would allow natural seasonal changes in shoreline profile to be characterized.

Should the weir height be raised, the monitoring sites could be used to verify the effect of the new water level regime on the shoreline profile. It is recommended that at least one relatively undisturbed site be chosen (e.g. Site 180 – South Shore Across from Youbou) to limit the number of potential erosion mechanisms at play and allow for easier isolation of the effect of the weir raising.

7.3 REPORT SUBMISSION

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

____

Erica Ellis, M.Sc., P.Geo.
Geoscientist

Prepared by:

____

Eric Morris, M.A.Sc., P.Eng.
Project Manager

STATEMENT OF LIMITATIONS

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the British Columbia Conservation Foundation for the Cowichan Lake Erosion Assessment. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Appendix A

Wind Rose Plots

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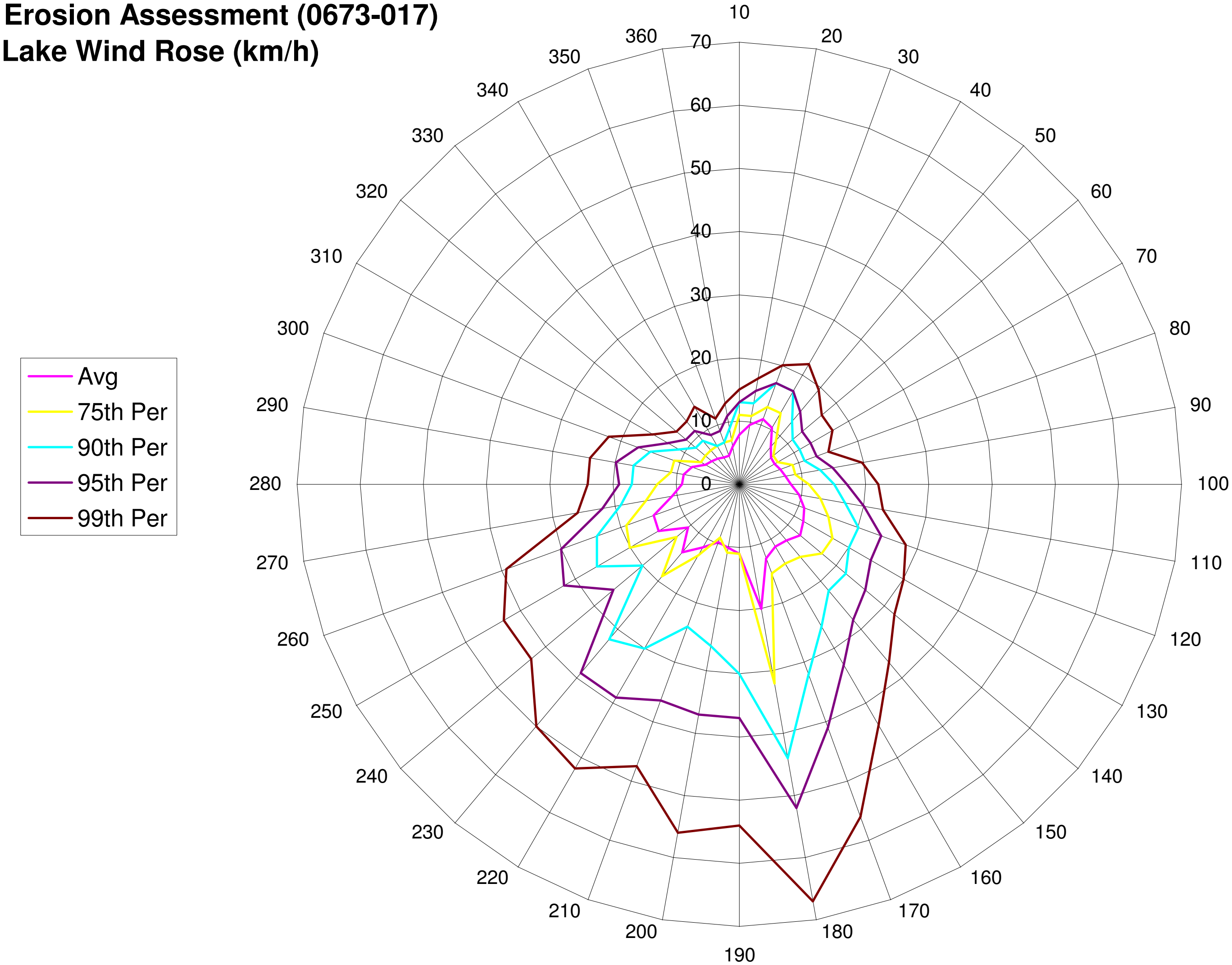
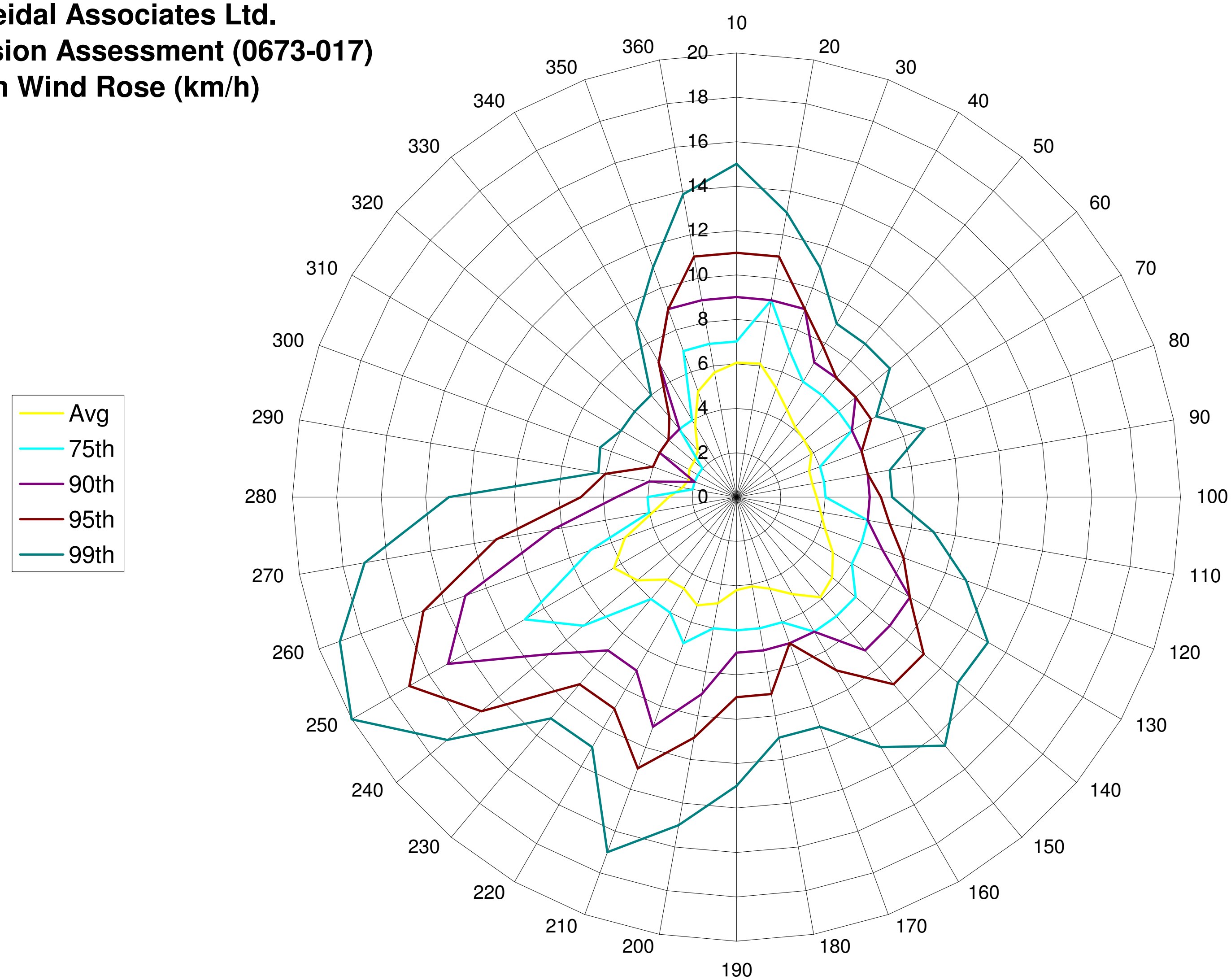
Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
Nitinat Lake Wind Rose (km/h)



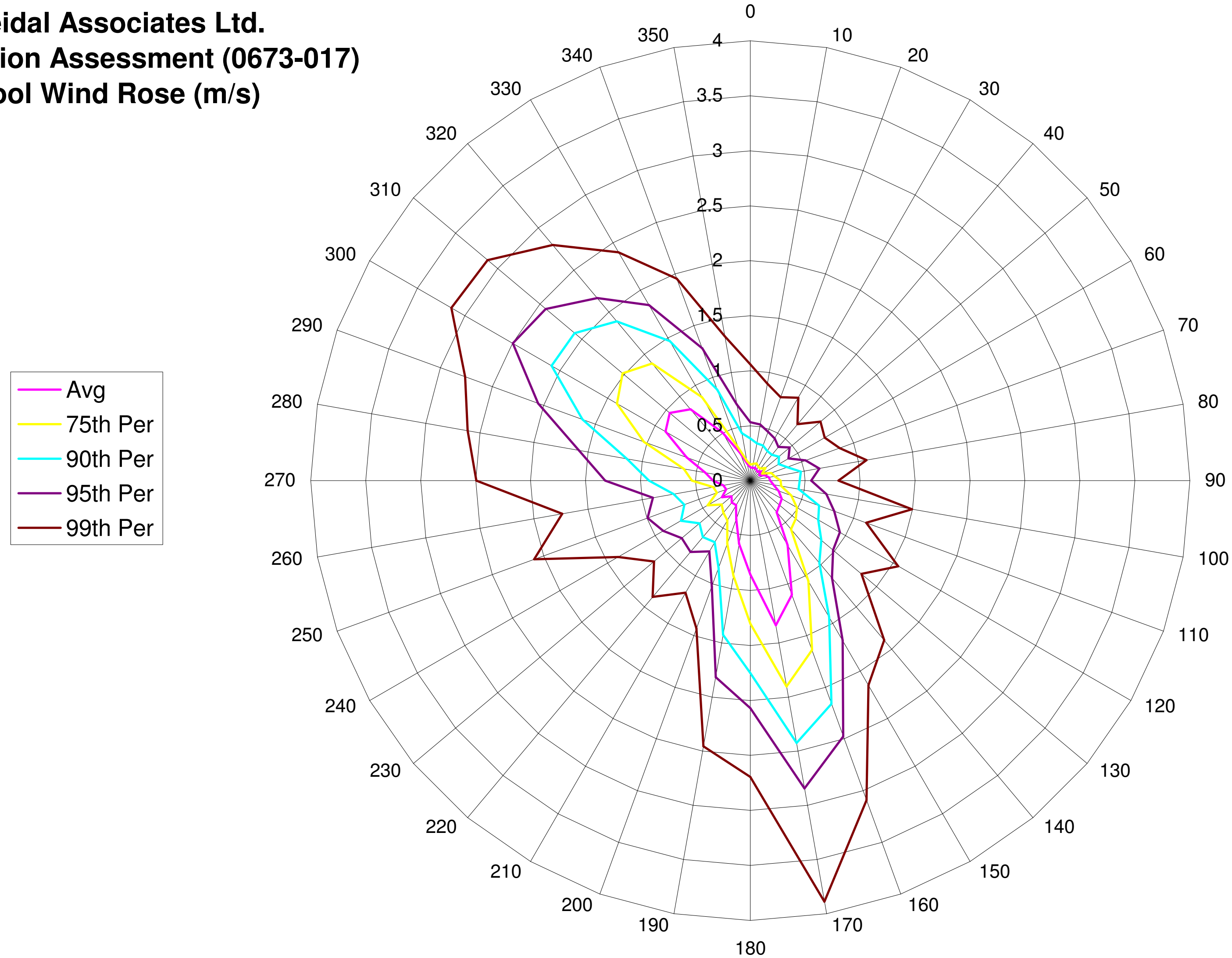
O:\0600-0699\673-017\400-Work\WindHourlyData\HourlyData.xlsNitinat Chart

Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
N. Cowichan Wind Rose (km/h)



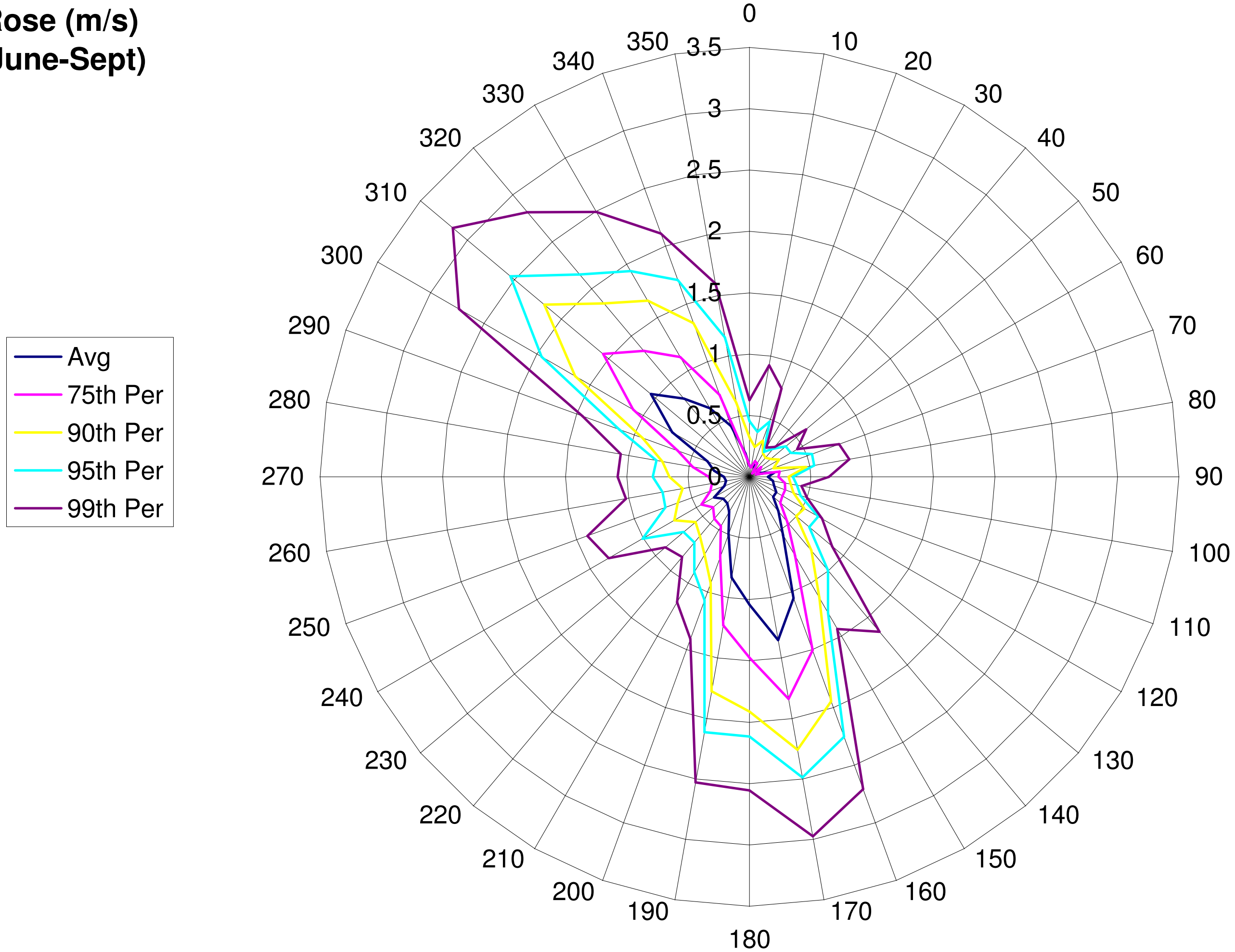
O:\0600-0699\673-017\400-Work\WindHourlyData\HourlyData.xlsN. Cowichan Chart

Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
Palsson School Wind Rose (m/s)

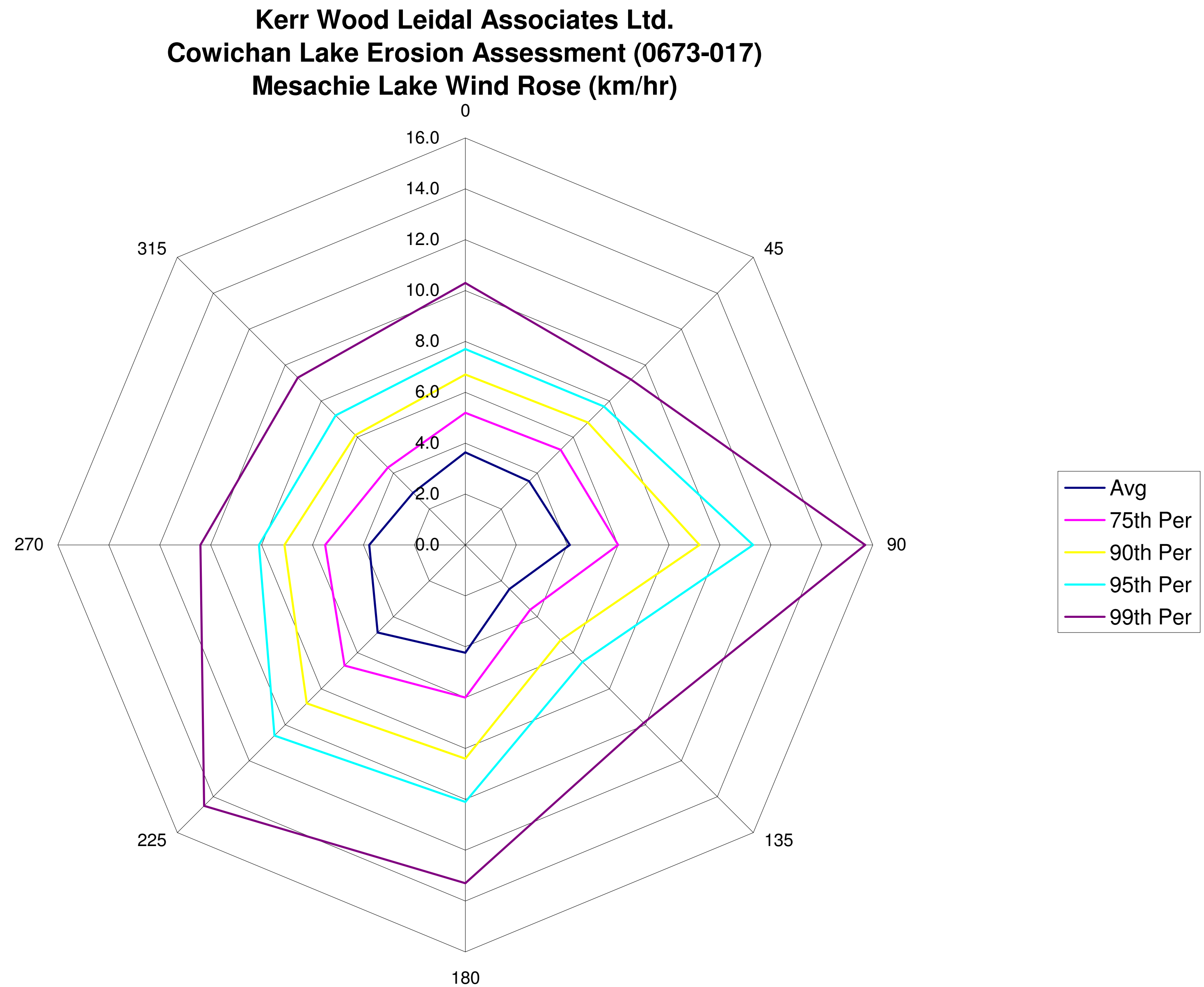


O:\0600-0699\673-017\400-Work\Palsson Elementary School\palsson_wind_hourly.xlsChart5

Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
Palsson School Wind Rose (m/s)
Summer Months Only (June-Sept)



O:\0600-0699\673-017\400-Work\Palsson Elementary School\palsson_wind_hourly_summer.xls



Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
Mesachie Lake Wind Rose (km/hr)
0
45
90
135
180
225
270
315
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Avg
75th Per
90th Per
95th Per
99th Per

Appendix B

Water Level Exceedance Probabilities

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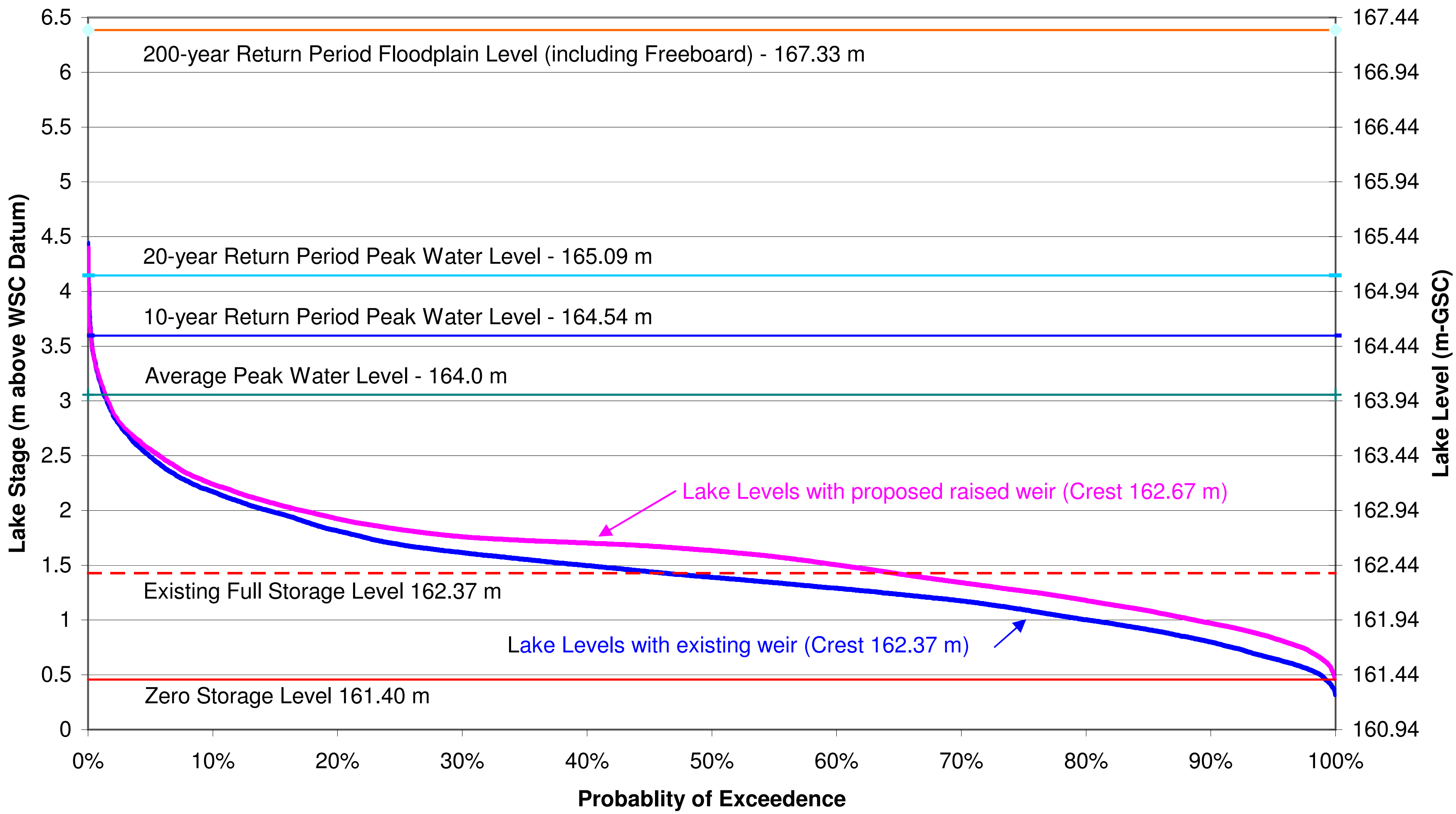
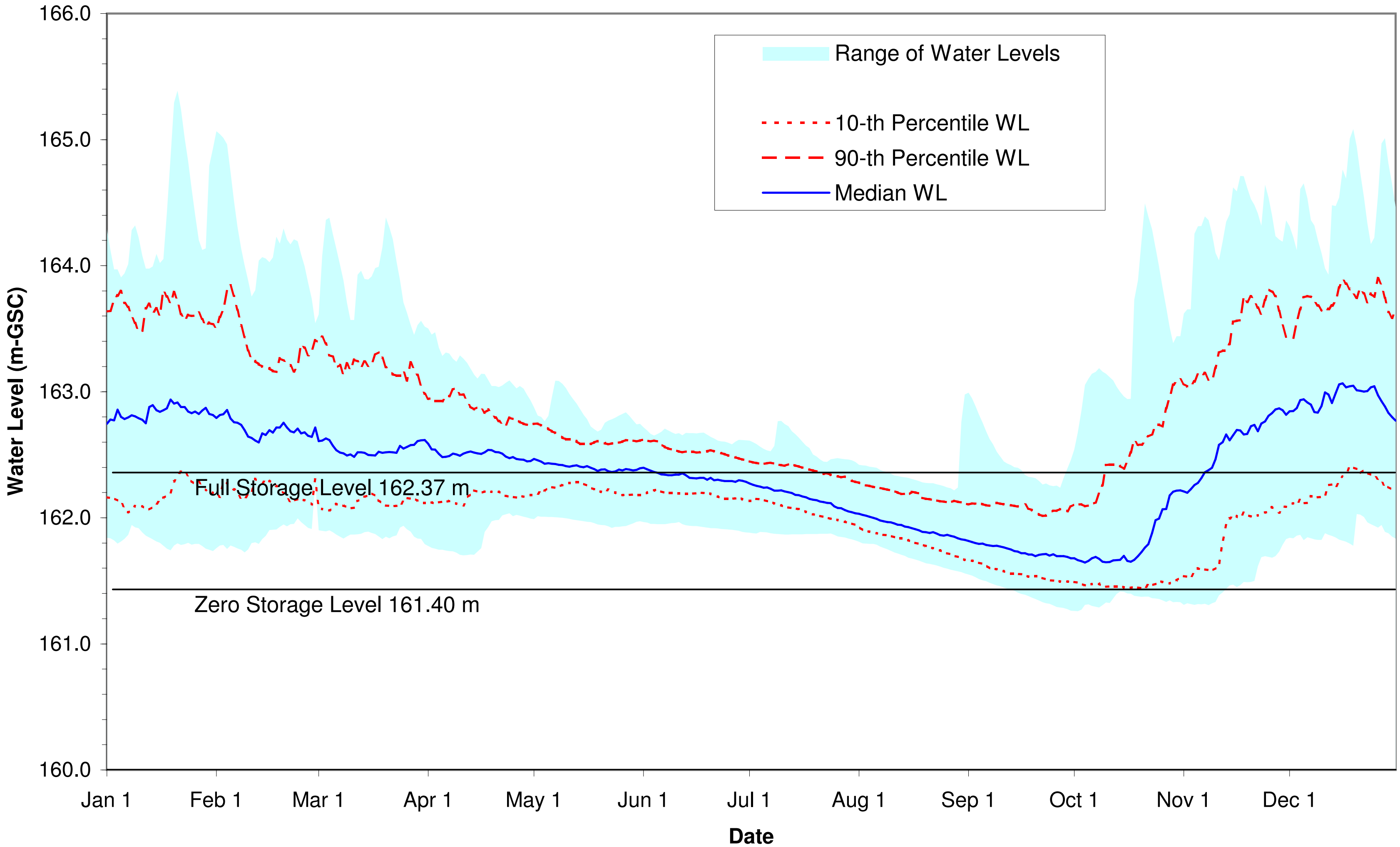
Kerr Wood Leidal Associates
Cowichan Lake Erosion Assessment (Project 0673-017)

Cowichan Lake Levels: 1962 to 2007



O:\0600-0699\673-017\400-Work\Cowichan_Lake_Exceedance_Probabilities.xlsFull Year 62-07 Chart

Kerr Wood Leidal Associates Ltd.
Cowichan Lake Erosion Assessment (0673-017)
Recorded Cowichan Lake Levels - 1962 to 2007



O:\0600-0699\673-017\400-Work\1962-2007RecordedLakeLevels.xlsChart1

Appendix C

Detailed Site Observations from September 20, 2010 Field Visit

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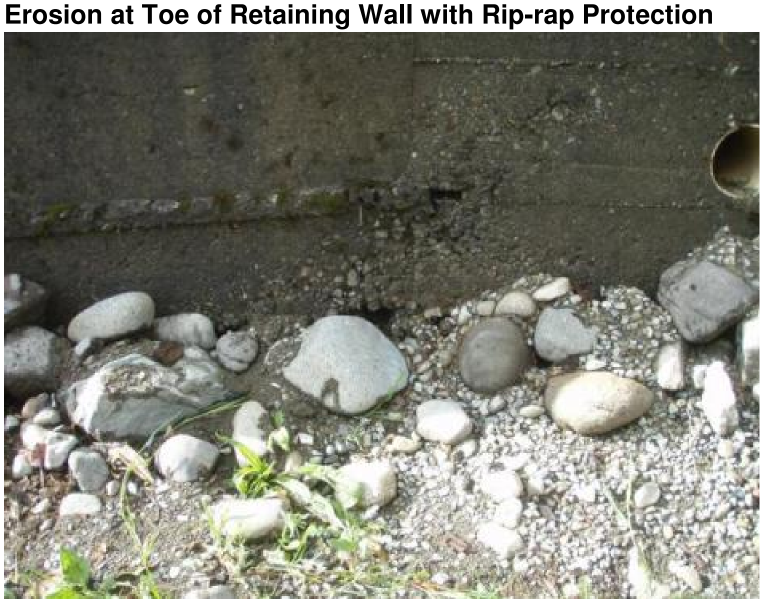
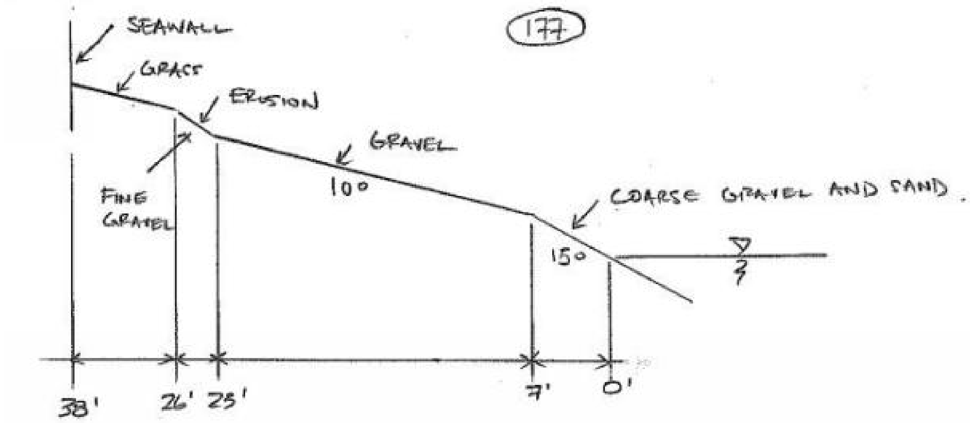
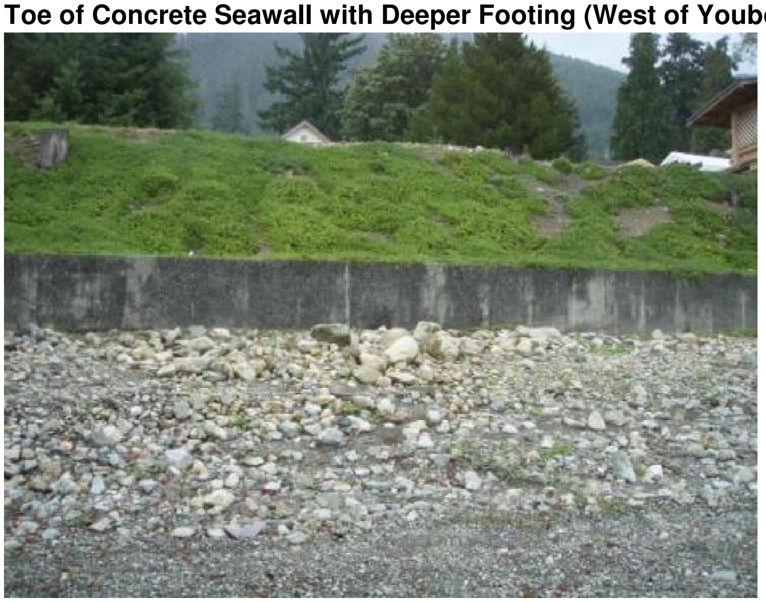
Table1-C: Detailed Field Observations

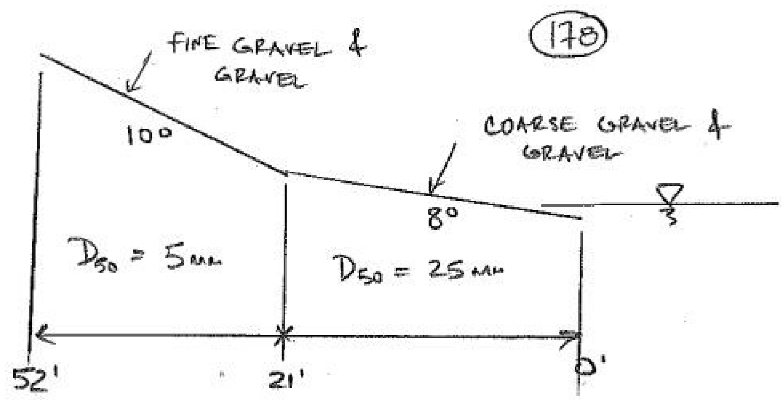
Way-point	Field Observations
175	**Honeymoon Bay Recreation Association, west of Sutton Creek mouth** ▪ beach slope = 15^o ▪ substrate = sand and fine gravel; ▪ fronted by concrete seawall ±0.6 m high located ±0.3 m above water level (varies); ▪ property protected by single log floating breakwater; ▪ riprap (D50 = 75 mm) protecting toe of wall where underside of footing is exposed; ▪ small coarse gravel groyne installed towards east end of wall. **Beach Fronting Honeymoon Bay Rec. Association Property**  **Erosion at Toe of Retaining Wall with Rip-rap Protection** 

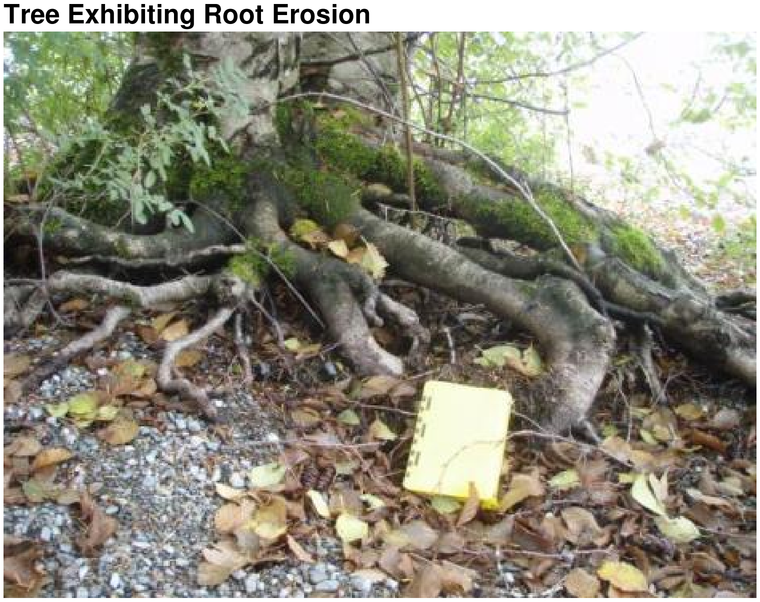
Way-point	Field Observations
176	**Gordon Bay, just east of swim area breakwater;** ▪ 15^{o} beach slope; ▪ substrate = gravel/fine gravel/sand; ▪ root exposure to ±2 m above water level; ▪ no dunes indicating significant erosion at a particular water level; ▪ mature alder trees with eroded roots present; ▪ no young alders growing at same elevation as mature trees; **Root Exposure at Gordon Bay Provincial Park** 
177	**Youbou** ▪ see sketch for slope and substrate; ▪ property fronted by 3-log floating breakwater; ▪ small dunes in gravel section of beach; ▪ erosion at ±1.5 m above water level; ▪ seawalls were installed to west of property in the early 1990s; ▪ no close neighbours have been importing significant quantities of beach fill since the 1980s; ▪ Arbutus Park (several properties to west) imports 1 truck load of beach fill per year; ▪ erosion of Cottonwood roots at 0.6 m above water level, has occurred in the last 5 years; ▪ to the east, rubblemound groyne with pier on top shows evidence of leeside erosion due to interruption of west to east longshore sediment transport; ▪ groynes to the west also show signs of west-side accretion and east-side erosion due to interruption of west to east longshore sediment transport; ▪ house to the east lost about 20 m of beach in one south-east storm event; shore is now armoured with riprap to within 0.1 m of water level;

Way-point	Field Observations
	 **Beach Looking West**  **Erosion at 1.5 m Above Water Level** 

Way-point	Field Observations
	Up-drift Sediment Deposition at a Small Groyne West of the Youbou Property  **Leaside (East) Erosion Cut-back at a Larger Groyne West of the Youbou Property** 

Way-point	Field Observations
	Riprap Revetment to Water Level at Property East of Youbou Property  **Toe of Concrete Seawall with Deeper Footing (West of Youbou Property)** 

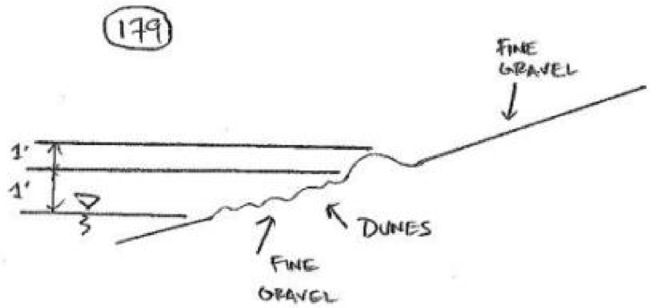
Way-point	Field Observations
	Eroded Toe of Concrete Seawall with Shallow Footing (West of Youbou Property) 
178	**Youbou Lands, West Side** ▪ see sketch for slope and substrate; ▪ westerly exposed gravel beach with no structures; ▪ Alder trees (30 cm diameter trunks), with eroded roots; ▪ Fir trees do not have eroded roots at same location and elevation; 

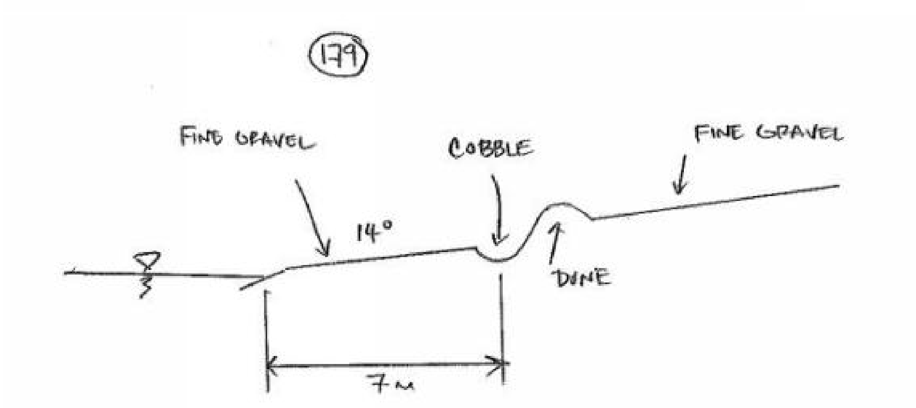
Way-point	Field Observations
	Beach at Youbou Lands Site  **Tree Exhibiting Root Erosion** 

<table>
<tr><th>Way-point</th><th>Field Observations</th></tr>
<tr><td>179</td><td>

South shore of lake, across from Youbou Lands;

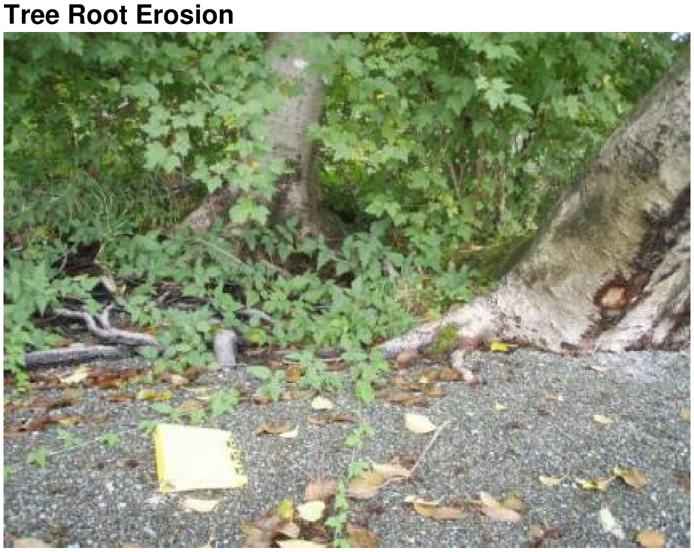
- see sketch for slope
- substrate = uniform fine gravel with little sand;
- many small dunes;
- major dune at +/- 0.3 m above water level;
- tree root erosion at +/- 0.6 above water level.





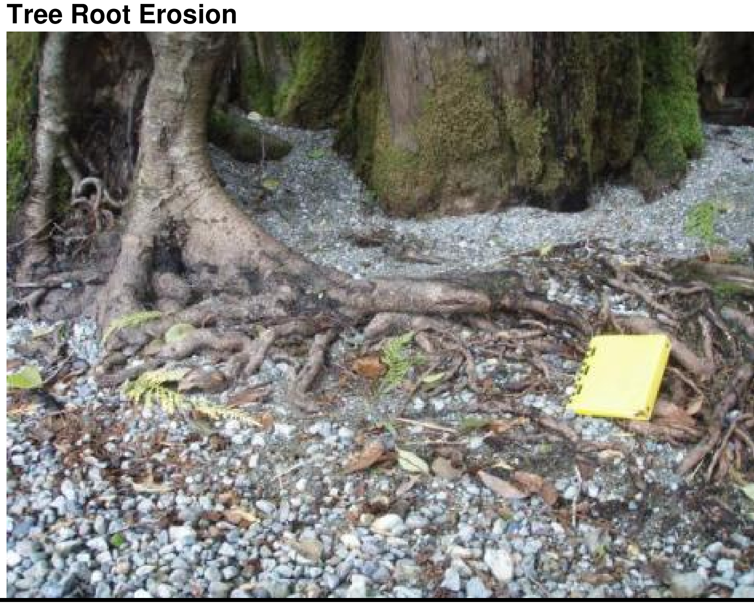
Large Dune at South Shore Site

</td></tr>
</table>

Way-point	Field Observations
180	**South shore, across from Youbou (gravel beach sheltered from westerly waves)** ▪ slope = 10^{o}; ▪ substrate = sand and fine gravel; ▪ very small dunes; ▪ creeping vine to within ±0.6 m of water level; ▪ Alder/Cottonwood root erosion present all along beach at ±0.5 m above water level; **Sheltered South Shore Site**  **Tree Root Erosion** 

<table>
<tr><th>Way-point</th><th>Field Observations</th></tr>
<tr><td>181</td><td>East end of North Arm, “Spring Beach”;
▪ slope = 10°-15°;
▪ uniform gravel;
▪ erosion of tree roots present from ±0.5 m to 1 m above water level.

Spring Beach


Tree Root Erosion
</td></tr>
<tr><td colspan="2">Notes:
1) Lake water level at time of observations (September 20, 2010) approximately 161.81 m GD.</td></tr>
</table>

Appendix D

Meridian Forest Services Report

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

MERIDIAN
Forest Services Ltd.

Box 128
Qualicum Beach, BC
V9K 1S7
Website: www.meridianforest.ca

October 8, 2010 Our File: BCCF-1

J.C. (Craig) Wightman, RPBio.
Senior Fisheries Biologist
Living Rivers – Georgia Basin/Vancouver Island
BC Conservation Foundation
Nanaimo, BC
V9S 3Z7

Dear: Craig,

Subject: Cowichan Lake Soil Erosion Project ~ Tree Sampling Data

Please find attached, the results and observations of the field assessment (age sampling) of dominant trees at the four sites identified by BCCF along the shore of Cowichan Lake.

Trees selected for sampling met the criteria outlined by Eric Morris, M.A.Sc., PEng. – Project Manager- of Kerr Wood Leidal Associates Ltd.

Please call if you have any questions or concerns.

Thank you.

Regards,
Meridian Forest Services Ltd.

Darin Brown, RFT
Field Operations Manager

DWB: dwb

1. Purpose and Scope

On October 7th, 2010, Darin Brown of Meridian Forest Services Ltd. conducted tree age sampling with the assistance of Gary Horncastle, a BCCF Representative, and Brooke Hodson, a resident.

The scope of the field assessment was to age trees > 1' in diameter at four chosen sample sites along the shoreline of Cowichan Lake. Additional data was recorded to identify site and stand conditions near the sample trees.

2. Site Observations

Trees that grow in the seasonally flooded shoreline of Cowichan tend to send out extensive lateral root systems due to excessive moisture and/or restrictive rooting conditions. The energy the tree uses, searching for stability for the root system, takes away from its' vertical growth and the trees tend to be shorter. All the alders sampled had extensive root systems heading to higher and drier ground. These lateral roots are being exposed to wave actions resulting in the fines and gravels being washed away, causing elevated root systems.

3. Results and Recommendations

Site #	1	2	3	4
Location	**Youbou Lands Site**	**Brooke's House**	**Sheltered South Shore Site**	**Spring Beach (East End North Arm)**
Lats	48°52'47.48"N	48°52'29.20"N	48°51'35.17"N	48°50'43.19"N
Longs	124°15'27.37"W	124°13'2.13"	124°14'20.42"W	124° 6'58.83"W
Photo #	Attached	Attached	Attached	Attached
Elevation	161 – 162m	161 – 162m	161 – 162m	161 – 162m
Stand Type	Alder 50%, Fir 30% and Maple 20%	Cottonwood 100%	Alder 90% and Fir 10%	Fir 60%, Maple20% and Alder 20%
Tree Species	Alder	Cottonwood	Alder	Alder
Diameter	48cm	66.5cm	46.6cm	41.2cm
Height	16.2m	19.5m	23.8m	23.5m
Age	36	53	38	41
Rooting Condition	Extensive Lateral root system-15cm of wash	Average Lateral Root system-10cm of wash	Extensive Lateral root system-25cm of wash	Extensive Lateral root system-25cm of wash
Pathogens	None	Beaver Damage-scars	None	None
Stem High Water Line	0.2m	0.4m	0.7m	0.9m
Present Water Line	10.8m Below Stem	2.6m Below Stem	5.0m Below Stem	9m Below Stem
High Water Line	1.2m Above Stem	3.8m Above Stem	5m Above Stem	4.9m Above Stem
Primary Wind Dir.	106° (Windward)	92° (Parallel)	111° (Lee)	111° (Windward)
Secondary Wind Dir.	286° (Parallel)	272° (Parallel)	291° (Windward)	291° (Lee)

4. Photos

Site #1

Site #2

Site #3

Site #4

Appendix E

Resident Discussions

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

APPENDIX E

1. DISCUSSIONS WITH RESIDENTS

Discussions were conducted with Mr. Brooke Hodson and Mr. Gerald Thom who are lakeside residents and accompanied the team on the first day of field work and Ms. Diana Gunderson who provided information on historic log booming practices.

Some important information learned during local resident discussions is as follows:

- Shoreline erosion seems to have accelerated in Youbou since about 2000.

- In Youbou, the lake floor was once shallow several hundred feet from the shoreline. A large earthquake that occurred in 1946 caused local subsidence and now the water is 100 feet deep only 50 ft offshore.

- Shoreline vegetation is gradually being removed throughout the lake as development occurs. There is already considerable disturbance of shoreline vegetation in developed areas (e.g. Town of Lake Cowichan, Youbou) but disturbance is ongoing, most notably at the western end of the lake which is just beginning to be developed.

- Boat traffic is increasing throughout the lake. Traffic starts around May 24 and ends in early October.

- Boat traffic is highest in the south arm and around Youbou.

- The largest boats currently on the lake are about 36 ft long.

- Wakeboarding boats generate large waves (in the order of 1 m high) and these boats are becoming more common.

- There was a handful of tug boats that operated on the lake prior to 1980. The number dropped off steadily until the last one stopped operating in 2000.

- Log booms were used all around the lake for storing logs before there were any mills in the area (late 1800's and early 1900's). These booms were pulled to the shoreline near the mouth of the river, near the Town of Lake Cowichan, and stored until the river was high so they could be "run" down the river to a mill at Cowichan Bay. When rails came to the area, load-outs were established so logs could be transported by train. The Town of Lake Cowichan load-out was active until the 1960's so boom storage along the shoreline near the Town of Lake Cowichan was prevelant. In the 1940's and

1950's with the establishment of local mills (Youbou, Honeymoon Bay and Mesachie Lake) large booming grounds were necessary nearby to maintain a ready supply of logs. There were booms in the bay in front of the Youbou mill and along to shoreline to the west. There were booms from Bear Lake past the Honeymoon Bay mill. Mesachie Lake was totally covered with booms. Mesachie Lake closed in the 1960's, Honeymoon Bay closed in 1978ish, and Youbou closed in about 2000. There was a Cedar mill where Point Ideal is now located, and there was log storage in that area until the early 1970's. Today there is a small private booming ground just east of the Forestry Camp (a log salvage operation). As booms were moved or used, others appeared. The truly seasonal log booms were the ones that were taken down the river.