Foreshore Inventory and Mapping

Mabel Lake

Prepared For:

Fisheries and Oceans Canada
Regional District North Okanagan &

Prepared By:

ECOSCAPE ENVIRONMENTAL CONSULTANTS LTD.

November, 2010
File No.: 09-485

FORESHORE INVENTORY AND MAPPING

Fisheries and Oceans Canada and Project Partners

Mabel Lake

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EXECUTIVE SUMMARY

Throughout the first years of the new millennium, the Shuswap watershed has experienced intensive development activity within most areas. As the population within the Shuswap watershed has grown, development has spread to more remote areas. It is becoming readily apparent that the increased development is degrading areas within the watershed which is known for its natural beauty and high recreational values, resulting in impacts on fish, wildlife, and water quality. The spread of development to remote areas is the result of an increasing demand for lake side seasonal cabins and year round residences with better overall servicing. For less developed areas, now is an opportune time to address lakeside development concerns to better manage future shoreline impacts.

In response to the need for better lake planning and management, Fisheries and Oceans Canada and the Regional District North Okanagan undertook an inventory of Mabel Lake to document the current condition of the foreshore and to help develop a more integrated approach to watershed management. This report has been prepared based upon the belief that it is possible to manage this shoreline and the natural areas surrounding it in a sustainable manner.

The Shuswap watershed contributes significantly to the overall production of salmon in the Fraser River Basin and to the genetic diversity of Fraser salmon populations. Mabel Lake and its tributaries support sockeye, chinook, and coho salmon. Coupled with these sea run species, there are also important populations of rainbow trout, kokanee, mountain whitefish and char. Mable Lake also contains populations of coarse species, which are often forage fish. Finally, shoreline areas also provide important habitat for numerous wildlife species, including raptors (e.g., Osprey), song birds, large game (e.g., deer and moose), and numerous others populations of avian and mammal fauna.

Currently, lake management projects in the province of BC follow a three step process described below. For this project, steps 1 and 2 below were completed.

1. Foreshore Inventory and Mapping (FIM) is a protocol that is used to collect baseline information regarding the current condition of a shoreline. The FIM uses a mapping based (GIS) approach to describe shorelines. These inventories provide information on shore types, substrates, land use, and habitat modifications. This new information has been combined where possible, with other mapping information such as previous fisheries inventories, recent orthophotos, and other information.

2. An Aquatic Habitat Index (AHI) is generated using the FIM data to determine the relative habitat value of the shoreline. This index follows similar methods that were developed for Shuswap Lake and is similar to other ongoing assessments along lakes in the Kootenays. The Aquatic Habitat Index uses many different factors such as biophysical criteria (e.g., shore type, substrate information, etc.) fisheries information (e.g., juvenile rearing suitability, migration and staging areas), riparian conditions (e.g., width and type of riparian area), and modifications (e.g., docks, retaining walls, etc.) to estimate the relative habitat value of a shoreline segment. The Habitat Index classifies this information in a 5-Class system from Very High to Very Low and describes the relative value of the different shorelines areas to one another (i.e., describes shorelines areas within Mabel Lake to each other and not to other lakes (e.g., Shuswap).

3. Shoreline Management Guidelines are prepared to identify the Shoreline Vulnerability or sensitivity to changes in land use or habitat modification. Shoreline Vulnerability zones are based upon the Aquatic Habitat Index described above. The Shoreline Vulnerability Zone uses a risk based approach to shoreline management, assessing the potential risks of different

activities (e.g., construction of docks, groynes, marines, etc.) in the different shore segments. The Shore Line Management Guidelines document is intended to provide background information to stakeholders, proponents, and governmental agencies when land use changes or activities are proposed that could alter the shoreline thereby affecting fish or wildlife habitat.

Fisheries and Oceans Canada (DFO) and project partners are currently undertaking numerous environmental reviews within the lower Shuswap watershed and this is inventory is one component of a larger watershed overview. The FIM (Step 1) and AHI (Step 2) steps discussed above were completed for Mabel Lake as outlined in this report.

Foreshore Inventory and Mapping results (FIM) for this project provides valuable information regarding features, habitats, and other information for the shorelines of Mabel Lake. A summary of the data collected indicates the following:

- The level of impact along the Mabel Lake shoreline was determined based upon a categorical description of the level of disturbance observed along the lake. It is estimated that 10% of the shoreline has a high level of impact (greater than 40% disturbance) which accounts for 8.3 km of shoreline. Areas of moderate (between 10 to 40% disturbance) and low impact (less than 10% disturbance) account for 6% or 4.8 km and 30% or 24.5 km of the shoreline respectively. There is an estimated 44.4 km or 54% of shoreline that is believed to have little to no impact. Impacts along the shoreline include lakebed substrate modification, riparian vegetation removal, construction of retaining walls, etc. In total, it is estimated that 89% or 73 km of the shore length is natural and 11% or 8.8 km is disturbed;

- The most predominant land use around the lake is natural Crown areas (76%), followed by Single Family residential areas (9.7%). Other common land uses include rural areas, parks, and recreational areas;

- Wetlands are the most rare shore type around the lake, accounting for only 0.2% of the shoreline length. The most common shore types around the lake are Gravel and Rocky shores, which account for 14% and 63% respectively. Gravel and rocky shores are 70% and 96% natural respectively;

- Aquatic vegetation occurs along 35.4% of the shoreline length and is an important habitat feature for juvenile salmonids. Of this, emergent vegetation was the most commonly observed (e.g., emergent grasses, willows, or other areas with vegetation inundated during high water). Native beds of submergent vegetation were only documented along 8.4% of the shoreline, and areas of floating vegetation were only observed along 0.1%;

- The following summarizes habitat modifications observed:
    - Docks were the most common modification observed, with a total of 152. Both pile supported and floating docks were observed.
    - Retaining walls were the next most predominant modification, with a total of 107. It was observed that some retaining walls extended beyond the high water level of the lake and this construction practice is not compliant with Best Management Practices (i.e. bio-engineering practices for new walls or repairs to existing walls). These retaining walls occupied approximately 3% of the shoreline, or over 2.6 km;

- Groynes were the next most commonly observed modification, with over 90 observed. Lakebed cobbles and boulders were most commonly used to construct groynes and it is probable that construction may have required the use of heavy equipment in some instances. The use of lakebed substrates to construct groynes has resulted in significant impacts to emergent vegetation, which is an important juvenile salmon habitat feature. Groynes along the shoreline were typically constructed to improve access and create gravel/sand beaches.
- There were a total of 10 concrete boat launches and 4 marinas.
- Substrate modification was observed on 9% of the shore length and was most commonly associated with groynes, retaining walls, transportation land uses, and sand importation to create beaches,

The findings of the FIM indicate that the foreshore areas of Mabel Lake have been impacted by current and historic land use practices. The current trend of reliance on Best Management Practices and voluntary compliance with the regulations and guidance documents are not resulting in the required protection of important fish and wildlife habitats along the shoreline. It was apparent that neighbors tended to mimic each others activities and this trend has been observed across many watersheds. Finally, there were some shoreline modifications that encroached onto Crown land (i.e., below the high water level). Given this, all agencies and stakeholders need to work with the public on better communication and education to ensure that everyone is aware of the habitats present, their values, and the potential influences development activities may have upon them. Recommendations for public awareness and education are presented to facilitate public involvement and compliance in the protection of foreshore areas. The combination of education and cooperative enforcement will help reduce the continued losses of habitat along the shoreline and help promote stewardship of the foreshore.

The Aquatic Habitat Index (AHI) for Mabel Lake provides valuable information regarding the estimated habitat values of different shoreline areas. The AHI is a categorical scale of relative habitat value that ranks shoreline segments from Very High to Very Low (Very High, High, Moderate, Low, and Very Low). The following summarizes the results of the AHI analysis:

- The AHI found that approximately 35.5% of the combined shoreline is ranked as High or Very High. Many of these areas occurred adjacent to critical stream floodplains (e.g., Wap and Middle Shuswap River), wetlands, along highly vegetated gravel or cobble shoreline areas, and other habitats around the lake (e.g., outflow of Lower Shuswap River).

- Approximately 26.3% of the shoreline was of Moderate habitat value relative to other shoreline areas. Moderate habitat value areas generally occurred along gravel or cobble shorelines that are not considered important migration of staging areas. Also, many moderate value shorelines occur adjacent to previously developed areas.

- The AHI found that approximately 32.9% of the shoreline is ranked as Low Value. Most of these areas occur in long stretches of Crown land that were not surveyed in detail due to budgetary constraints. Also, these areas tended to have a high predominance of cliff or rocky, bedrock areas which score lower in the AHI than more productive gravel or cobble shoreline areas with aquatic vegetation. Future assessments at a finer scale resolution are required to increase the accuracy of these rankings.

- The AHI found that approximately 4.1% of the shoreline is ranked as Very Low habitat value. These areas are mostly found along highly developed shorelines and are quite different than natural shore types conditions.

- All areas of the shoreline are considered salmonid habitat (e.g., staging areas, rearing areas, spawning habitats) and even segments only identified as having low juvenile habitat suitability still contribute to overall salmonid production in the lake.

- The AHI highlights the importance of the connection between our diverse streamside, wetland and lakeshore habitats. Stream confluences and their adjacent features (e.g., shore marshes, large woody debris, and diverse riparian vegetation communities) are areas that tend to contain the highest fish and wildlife diversity. These areas are extremely important for maintaining viable populations, and most importantly are water quality buffers that are required to preserve source drinking waters.

- The AHI also includes a restoration analysis for instream features only. This analysis was accomplished by removing negative habitat parameters in the index and assessing which segments increased in relative habitat value. The restoration analysis did not include an assessment of how changes in riparian condition would improve relative habitat value. This analysis indicates that there are opportunities to repair impacted habitats. Habitat restoration opportunities include removal of groynes, bioengineering retaining walls, planting or native riparian vegetation, etc. These habitat benefits will work to restore impacted habitats and reverse the current trends of habitat degradation. Habitats restoration opportunities should be pursued as part of any development or redevelopment applications. The restoration analysis did not consider restoration of impacted riparian habitats.

Recommendations have been presented that are intended to aid foreshore protection, guide future data management, and for future biophysical inventory works. One of the key recommendations presented was as follows:

- Shoreline Management Guidelines are the final step in the three step shoreline management process. Shoreline Management Guidelines are required and it is strongly recommended that they be completed. These guidelines can be used to develop shoreline policies, bylaws, or Official Community plans. Once developed, the guidelines will allow decision makers to make informed land use decisions across multiple agencies. Finally, development of such guidelines will also streamline the permitting and regulatory processes at these different governmental levels by focusing limited resources on areas or activities that pose the greatest risks.

The inventories and analysis completed as part of this study should help protect important shoreline resources around Mabel Lake. At this time, important shoreline areas have been inventoried (FIM) and the relative sensitivity (AHI) has been determined. Although there were many impacts observed along the lake shorelines, there are extremely important habitats present that are in good to excellent condition. Now that these shoreline areas have been identified, they should be considered as part of any shoreline land use and marine development proposals.

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DISCLAIMER

The results contained in this report are based upon data collected during surveys occurring over a one week period. Biological systems respond differently both in space and time and exhibit extreme variability. For this reason, conservative assumptions have been used and these assumptions are based upon field results, previously published material on the subject, and air photo interpretation. Due to the inherent problems of brief inventories (e.g., property access, GPS/GIS accuracies, air-photo interpretation concerns, etc.), professionals should complete their own detailed assessments of shore zone areas to understand, evaluate, classify, and reach their own conclusions regarding them. Data in this assessment was not analyzed statistically and no inferences about statistical significance should be made if the word significant is used. Use of or reliance upon conclusions made in this report is the responsibility of the party using the information. Neither Ecoscape Environmental Consultants Ltd., Fisheries and Oceans Canada, Regional District of North Okanagan, project partners, nor the authors of this report, are liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected and presented.

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1.0 INTRODUCTION

The desire to live and recreate in the Shuswap watershed has resulted in a dramatic increase in development pressure on the system. Fisheries and Oceans Canada, the City of Enderby, and Regional District North Okanagan have undertaken a number of planning initiatives to better manage growth and develop land use policies along the lower Shuswap River and Mabel Lake. Through these planning processes and initiatives, it has become readily apparent that development in the Shuswap Watershed has the potential to, or has already, impacted fish, wildlife, and/or water quality in the lakes and rivers. Project partners are working cooperatively with each other to better address multi jurisdictional concerns.

It is a complex relationship between development pressure, the natural environment, and social, economic and cultural values. To balance these various community values, a solid understanding of aquatic and riparian resource values, land use interests, concerns of local residents is needed to develop long-term planning and policy objectives. Development of long term planning objectives at the local, provincial and federal agencies is also required so that our aquatic resources are effectively managed. Detailed shoreline inventories increases the knowledge base of the environmental resources present, allowing all stakeholders to understand how development may affect these habitat features. With this information, more informed land use planning decisions can be made that better balances the different pressures that exist and protects our important natural resources.

Managers at all levels of government recognize the importance of managing our watersheds in a sustainable manner. The general public often has concerns about their watersheds and doesn't understand how they are being managed. Current management practices being implemented throughout British Columbia in the Shuswap, Okanagan and Kootenay regions are utilizing a three step process to help integrate environmental data with land use planning information to facilitate review and decision making processes. For this project, steps 1 and 2 below were completed. The three step process involves the following steps:

1. Foreshore Inventory and Mapping (FIM) – FIM is a broad scale inventory process that attempts to define and describe the shoreline of our large and small lake systems. The inventory provides baseline information regarding the current condition, natural features of the shoreline, and its level of development (e.g., # of docks, groynes, etc.). Sufficient data is collected that will allow managers and the public to monitor shoreline changes over time and to measure whether proposed land use decisions are meeting their intended objectives. This baseline inventory provides sufficient information to facilitate identification of sensitive shoreline segments as part of step 2 below.

2. Aquatic Habitat Index or Ecological Sensitivity Index (AHI) – The AHI utilizes data collected during the FIM, field reviews, and other data sources (e.g., Land and Data Warehouse, previously published works, etc.) to develop and rank the sensitivity of the shoreline using an index. An index is defined as a numerical or categorical scale used to compare variables with one another or with some reference point. In this case, the index is used to compare the sensitivity of the different shoreline areas around the lake to other shoreline areas within the lake (i.e., the index compares the ecological or aquatic sensitivity of different shoreline areas within the lake system to each other rather than to other lake shorelines). The index provides an indication of the relative value of one shoreline area to another.

3. Development of Shoreline Management Guidance Documents - Guidance documents are the final step in the process. Guidance documents are intended to help land managers at all levels of government quickly assess applications and is intended to be the first step for review, planning, and prescribing shoreline alterations (i.e., land development) by applicants and review agencies.

This report presents Step 1 and Step 2 for Mabel Lake. Ongoing efforts in the development of the Shuswap Lake Shoreline Guidance document will help facilitate quick completion of Step 3 for Mabel Lake.

2.0 PROJECT OVERVIEW

The Shuswap watershed supports many anadromous (sea run) and non-anadromous (non-sea run or resident) fish stocks, which significantly contribute to First Nations', commercial, and sport fisheries. These fish stocks also have significant cultural value, contributing to local eco tourism opportunities, such as sockeye spawning observations in the Adams and Shuswap Rivers. Also, the watershed provides critical habitats for numerous fish and wildlife fish species. Finally, the watershed is a source drinking water for the residents of missing listings of Communities. For these reasons, protection of the various environmental values is extremely important. This watershed includes both the Lower Shuswap River and Mabel Lake in the North Okanagan, which are the focus of this assessment.

The Lower Shuswap River and Mabel Lake are important natural resources in the North Okanagan for ecological, social and economical reasons. These areas are experiencing increased development pressure and these development activities are influencing natural resource values. Responsible and appropriate management of these resources is recognized by the Regional District of North Okanagan and DFO as vital to the future of this region. Community members have raised a number of concerns with regard to the impacts adjoining land uses and recreational uses are having on these important waterways. The Lower Shuswap River and Mabel Lake foreshore mapping project has provided an opportunity for the project partners to support an initiative that will inform future policy development and allow for improved future management of these resources. The information generated from this project and future steps, including the development of shoreline management guidelines (and Habitat Index for the Lower Shuswap River), should ensure improved policy development and management of the Lower Shuswap River and Mabel Lake by all responsible agencies. From a local government perspective the project will provide a valuable resource that can be used to make an informed assessment of land use applications in the area. Finally, these works can also be used in the development of Official Community Plan and Local Area Plan policies.

The local residents have expressed strong desires to preserve and protect these different public resources. The intent of this project is to provide a baseline overview of the shoreline condition of Mabel Lake. The methodology employed for this assessment is discussed in detail below and is a provincial standard that is being used to map shorelines around the province. The mapping protocol will allow stakeholders to understand what the current condition of the shoreline is, to set objectives for better shore management in Official Community Plans or other policy documents, and measure and monitor changes in the shoreline overtime.

2.1 Project Partners

Numerous different parties have contributed to the success of this project. Foreshore Inventory and Mapping (FIM) protocols have been developed over the last 5 years and have become a standardized approach to shoreline inventory. Numerous different local governments, non-profit organizations, biological professionals, and provincial and federal agencies have contributed to the development of the FIM protocol and Appendix A (Detailed methods) provides a more accurate list of contributing parties.

This project was funded by the following agencies and organizations:

1. Fisheries and Oceans Canada provided financial support, staff resources, and equipment to complete this project;
2. The Ministry of Environment provided assistance with field efforts; and,
3. The Regional District North Okanagan also provided financial support.

2.2 Objectives

The following are the objectives of this project:

1. Compile existing map base resource information for Mabel Lake;
2. Foster collaboration between the RDNO, Enderby, DFO local staff, Ministry of Environment, First Nations bands, and the local communities;

3. Provide an overview of foreshore habitat condition on the lake;

4. Inventory foreshore morphology, land use, riparian condition and anthropogenic alterations;

5. Obtain spatially accurate digital video of the shoreline of the lake;

6. Prepare the video and GIS geo-database for loading onto the Community Mapping Network at www.cmnbc.ca.

7. Collect information that will aid in prioritizing critical areas for conservation and or protection and lake shore development;

8. Make the information available to planners, politicians and other key referring agencies that review applications for land development approval; and,

9. Integrate information with upland development planning, to ensure protection of sensitive foreshore areas in order to ensure that lake management planning is watershed based.

The FIM and AHI completed as part of this assessment will begin to address many of these objectives. Completion of Step 3, Shoreline Management Guidelines is required to address the more detailed planning aspects to address some of the objectives.

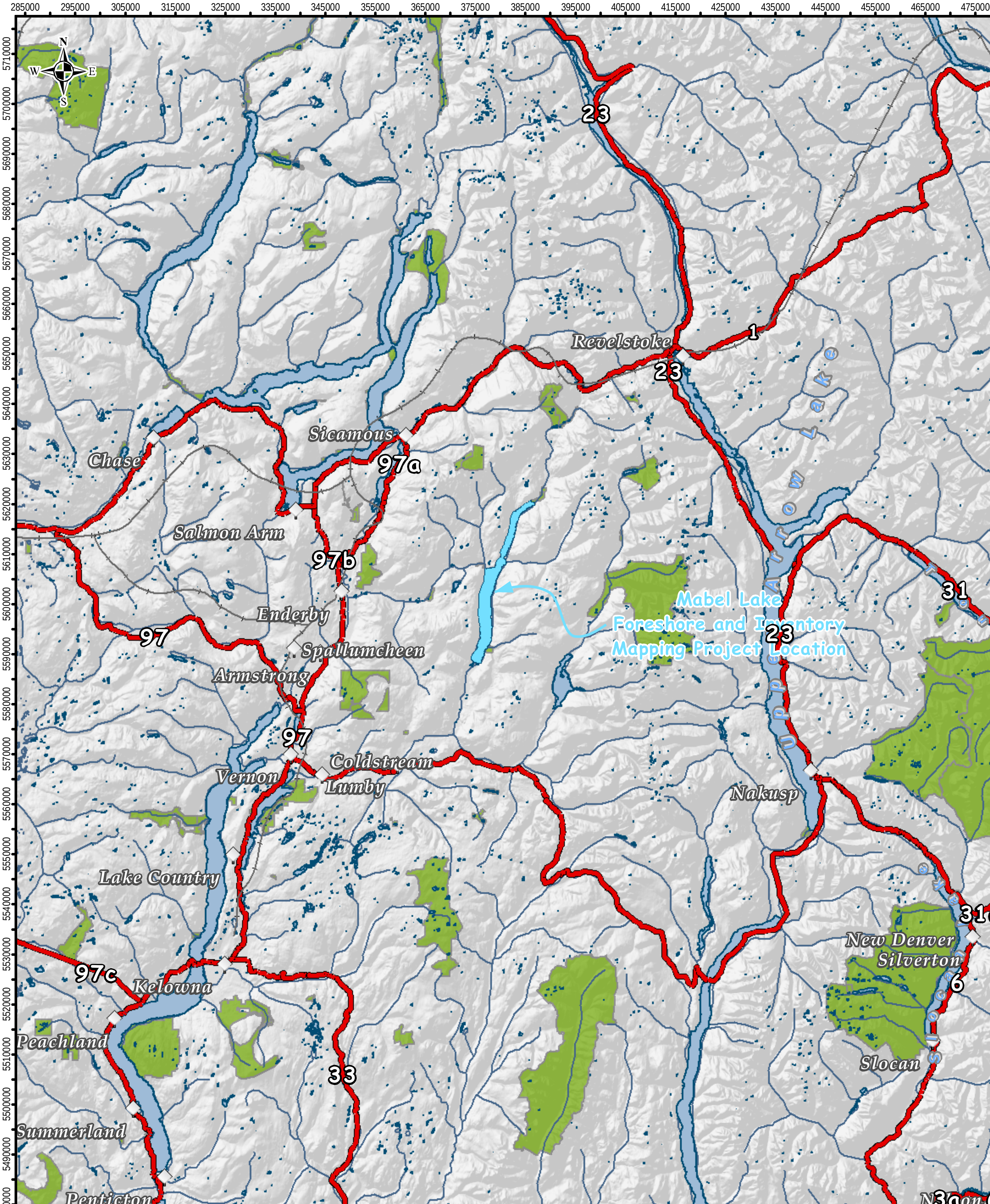
2.3 Description of the Mabel Lake Study Area and Shuswap Lake Watershed

The Shuswap Lake watershed consists of six oligotrophic lakes including Shuswap Lake, Adams Lake, Little Shuswap Lake, Mara Lake, Sugar Lake, and Mabel Lake (Williams *et al*, 1989). Each of these different lakes has important tributaries including the Eagle River, Adams River, Scotch Creek, Seymour River, Anstey River, Wap River, Tsuius Creek, Noisy Creek and Shuswap/Little Shuswap Rivers. It has been noted that 35 of the 37 tributaries of Shuswap Lake contains one or more important fish stocks (DFO, 1995). These lakes provide important habitats for a variety of fish and wildlife and there are numerous assessments that have investigated the salmonid populations within the lake system.

The Mable Lake watershed generally occurs within one local government jurisdiction which is the Regional District North Okanagan. The watershed is an important source of drinking water for local people and for downstream residents of the various different jurisdictions. This highlights the importance of maintaining a high quality drinking water and is critical to maintaining the current lifestyle that occurs there. The importance of the watershed cannot be underestimated. Reports have shown that the Shuswap watershed is one of the most important tourist destinations in the interior, second only to the Okanagan Valley (CSRD, 1988).

For this project, the focus was the shoreline areas of Mabel Lake. Mabel Lake is an important large lake in the Shuswap watershed. There are numerous important fish stocks that rely upon this lake and there have been no significant shore length inventories completed to date.

The general location of the study area is found in Figure 1.



Mabel Lake
Foreshore Inventory and Mapping
Figure 1 - Project Location

10 5 0 10 20 30 Kilometers
1:1,000,000

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Fisheries and Oceans Canada / Pêches et Océans Canada

2.4 Important Fisheries Resource Information

The Shuswap watershed contributes significantly to the overall production of salmon in the Fraser River Basin and to the genetic diversity of Fraser salmon populations. Shuswap Lake and its tributaries support sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), coho (*O. kisutch*) and small populations of pink salmon (*O. gorbuscha*). In 2002, Interior Fraser River coho salmon (IFC) which are present in the Shuswap watershed, were designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Shuswap is one of the most important salmon producing lake systems in British Columbia and is one of only a few that supports "multiple timing" sockeye salmon stocks which is an important diversity attribute to maintain. This diversity of fish stocks, genetic strains, and multiple timing is essential because it creates a buffer against major changes in habitat resulting from changing land uses or climate.

The salmon stocks are also very important to First Nations' culture. The stocks contribute substantially to First Nations' bands, commercial and sport fisheries, as well as having significant cultural value. The fish stocks are also components contributing to local eco-tourism opportunities (e.g. salmon spawning viewing in the Shuswap and Adams Rivers). Mabel Lake is the only lake in the Ministry of Environment Region 8 and one of the few in all of BC that has historically provided a recreational fishery for migrating chinook salmon. Coupled with the important sea run salmon stocks, there are numerous resident salmonid fish species. These species also contribute to local First Nations' foods and recreational fisheries including rainbow trout (*O. mykiss*), kokanee (*O. nerka*), bull trout (*Salvelinus confluentus*), whitefish, and lake char (*S. namaycush*).

Salmon are a "keystone species" in the Shuswap watershed. Adult salmon are a critical fall food source for bears, eagles and other species and the spawned out carcasses of the adults provide fertilizer for terrestrial and aquatic ecosystems. Salmon also act as an indicator species for the overall health of the Shuswap ecosystem because they are highly sensitive to changes in their habitat (e.g., reductions in water quality).

The above section provides a brief overview of the importance of fisheries resources in the Shuswap system. The importance of these fishery resources must be considered during land use planning exercises, and provides the basis and rationale for completion of this shore line inventory project. Mabel Lake is an important component of the Shuswap watershed and is directly linked to fisheries production. In Mabel Lake, key fish species include coho, chinook, sockeye, kokanee, rainbow trout, bull trout, lake char, burbot, and whitefish.

The current management objectives of the province for resident fish populations in Mabel Lake are to improve the recreational fishery for rainbow trout and kokanee (Redfish Consulting, 2007). The Okanagan Region Large Lake Operational Management Plan contains an important summary of current fisheries issues related to the maintenance of these fish stocks. The report includes specific recommendations for resident fish habitat in Mabel Lake to improve these fisheries.

2.4 Foreshore Management Overview

A three step process is currently being used as a shoreline management template in the province. This three step process has been previously described in other sections of this document, but generally involves the following three components: inventory using the FIM, an analysis of relative habitat value using an AHI, and development of shoreline management guidelines.

3.0 FORESHORE INVENTORY & MAPPING METHODOLOGY

The Foreshore Inventory and Field Mapping detailed methodology (FIM) is found in Appendix A. This inventory is based upon mapping standards developed for Sensitive Habitat Inventory and Mapping (SHIM) (Mason and Knight, 2001) and Coastal Shoreline Inventory and Mapping (CSIM) (Mason and Booth, 2004). The development of mapping initiatives such as SHIM, FIM, and CSIM is an integral part of ecologically sensitive community planning. The following sections summarize specific information for the Mabel Lakes Foreshore Inventory and Mapping.

3.1 Field Surveys

Field surveys were conducted between November 3 and 4, 2009 using a Fisheries and Oceans Canada boat and operator. Insert Mabel Lake Elevation at time of filed survey Pre field reviews were completed daily and mapping was conducted in an organized fashion. Safety reviews, daily weather reviews and assessments were conducted routinely to ensure that all members participating in the survey were familiar with field conditions.

Field surveyors were each assigned data to collect during the surveys. Field assessors used 2 ft by 3 ft, scaled colour air photos with cadastre and topographic information to assist with field data collection. Two TRIMBLE GPS units with SHIM Lake v. 2.6 (FIM Data dictionary name) were carried and a hurricane antennae was also used. Finally, digital photographs, with a GPS stamp, were collected.

Other field surveys conducted included the GPS digital video, completed by Fisheries and Oceans Canada staff. The specifics of the GPS digital video are discussed in the FIM methodology. This work was completed on October 8, 2009 and is an extremely important part of documenting the current condition of the shoreline.

The principle objectives of these video and photographic surveys were to:

- Provide a photographic documentation of the shoreline for the main areas of development;
- To record data relating to the presence or absence of development such as retaining walls and boat launches.

Weather during the surveys was generally overcast, and no significant storm events occurred. Weather is an important consideration, particularly during the photo and video documentation portions of the assessment. Good photo documentation is vital because data analysis following data collection can be hindered by poor photography.

Local First Nations bands were contacted to help conduct field surveys for this assessment. However, due to other inventory commitments during the surveys they were unable to participate.

3.2 Methodology

All of the methods outlined in Appendix A for Foreshore Inventory and Mapping projects were carried out for this assessment. Daily information collected was downloaded to a laptop as a backup. Once downloaded, the entire database was reviewed for accuracy and corrections were made as necessary. Ecoscape has attempted to ensure the data is as accurate as possible. However, due to the large size of the dataset, small errors may be encountered. These errors, if found, should be identified and actions initiated to resolve the error.

The following additional information was collected during field surveys:

1. The spatial extent of emergent grasses on flood benches, and areas of submergent and floating vegetation were mapped and photographed, to determine the approximate area where aquatic vegetation occurs. Aquatic vegetation includes any plants growing below the high water level of the lake because these areas are important fish habitat. Also, areas of extensive overhanging vegetation (from the high water level) were also mapped. Due to the late timing of surveys, additional areas of vegetation may also occur. Finally, high resolution air photos were only available for a portion of the shoreline; therefore, air photo interpretation accuracy is not as good within lower resolution air photo areas and information has been prepared as accurately as possible with data available.

2. Substrate mapping of significant breaks or changes in substrate was conducted to determine where major changes in substrates occur. This substrate mapping was cursory, until a more defined methodology can be developed.

3. Small stream confluences, seepage areas, and other features were also recorded.

4. Attempts were made to map the locations of boat launches, boat mooring zones / haul outs, extensive riparian areas, and other features of interest. Not all locations of these features could be mapped due to the quality of air photos available at the time of survey.

3.2.1 Aquatic Vegetation Mapping and Classification

Aquatic vegetation mapping was carried out for the entire shoreline. For the purposes of this assessment, aquatic vegetation includes any plant life occurring below the high water level of the lake (including flood benches). Although some of the plants are not truly aquatic, all are hydrophilic (water loving) and contribute to fish habitat. Vegetation mapping was completed by digitizing vegetation polygons from field observations recorded on air photos. Aquatic Vegetation polygons are similar to Zones of Sensitivity identified by the Okanagan and Windermere projects. Vegetation communities were classified using the Wetlands of British Columbia – A guide to identification (Mackenzie and Moran, 2004) and were categorized as:

Marsh (Wm)

A marsh is a shallowly flooded mineral wetland dominated by emergent grass-like vegetation. A fluctuating water table is typical in marshes, with early-season high water tables dropping throughout the growing season. Exposure of the substrates in late season or during dry years is common. The substrate is usually mineral, but may have a well-decomposed organic veneer derived primarily from marsh emergent. Nutrient availability is high (eutrophic to hyper-eutrophic) due to circum-neutral pH, water movement, and aeration of the substrate.

Low Bench Flood Ecosystems (Fl)

Low bench ecosystems occur on sites that are flooded for moderate periods (< 40 days) of the growing season, conditions that limit the canopy to tall shrubs, especially willows and alders. Annual erosion and deposition of sediment generally limit understory and humus development.

Mid Bench Flood Ecosystems (Fm)

Middle bench ecosystems occur on sites briefly flooded (10-25 days) during freshet, allowing tree growth but limiting tree species to only flood-tolerant broadleaf species such as black cottonwood and red alder.

Swamp

A swamp is a forested, treed, or tall-shrub, mineral wetland dominated by trees and broadleaf shrubs on sites with a flowing or fluctuating, semi-permanent, near-surface water table. Swamps occur on slope breaks, peatland margins, inactive floodplain back-channels, back-levee depressions, lake margins, and gullies. Tall-shrub swamps are dense thickets, while forested swamps have large trees occurring on elevated microsites and lower cover of tall deciduous shrubs.

Aquatic Vegetation

Sites not described by the current nomenclature developed by Mackenzie and Moran (2004) were stratified into the following biophysical groups:

1. Emergent Vegetation (EV) generally refers to grasses, *Equisetum* spp. (i.e., horsetails), sedges, or other plants tolerant of flooding. Coverages within polygons needed to be consistent and well established to be classified as EV. These areas were generally not dominated by true aquatic macrophytes and tended to occur in steeper sloping areas.

2. Sparse Emergent Vegetation (SEV) refers to the same vegetation types as emergent vegetation, but in these areas coverage was generally not very dense or was very patchy. This vegetation was often patchy, due to the association with rocky beaches or due to intensive beach grooming.

3. Overhanging Vegetation (OV) consists typically of broadleaf vegetation that is growing over the lake, shading the near shore littoral zone. Overhanging vegetation was mapped where it observed. Overhanging vegetation also occurred with Emergent Vegetation (EVOV) and with Sparse Emergent Vegetation (SVOV).

4. Submergent Vegetation (SUB) areas generally consisted of native *Potemogeton* spp. and is considered aquatic vegetation that does not break the water surface for most of the growing season. These areas were uncommon and only occurred in a few shallow bay areas.

5. Floating Vegetation (FLO) areas generally consisted of species such as native *Potamogeton,* pond lilies, and other types of vegetation that has vegetative parts that floats.

3.2.2 GIS and FIM Database Management

Data management for this project followed methods provided in Appendix A and generally involved the following steps:

- Data and photos were backed up to a computer/laptop on a daily basis.
- A GPS camera that stamps photos and creates GIS shapefiles, and GPS video were used to facilitate data review and interpretation.
- Air photo interpretation was completed using high resolution air photos that were acquired during flights in the summer of 2008.
- During data analysis, numerous checks were completed to ensure that all data was analyzed and accounted for.
- A spatial elevation model was run using GIS software, in combination with air photo interpretation and TRIM shoreline files to accurately determine the high water level of the lake. It is believed that for the length of the shoreline, the high water level used is within 5 m of the mean annual high water level for at

least 50% of the lake. The HWL assessment for Mabel Lake could be improved with higher resolution air photos when they become available. A site specific survey must be conducted to accurately determine the high water level for any site specific considerations and the line presented in this assessment should not be considered a surveyed HWL.

The following data fields were added to the FIM data dictionary

1. An Electoral Area field was added to define the electoral area within a Regional District that shoreline segments were part of.

2. A Community Field was added to the database but has not been utilized.

3. Several fisheries fields were added. These fisheries fields are similar to the Zones of Sensitivity that were developed for the Okanagan and Windermere projects. The following describes fisheries fields added and the original data source for the fields:

    a. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was prepared by Ecoscape for this project. Since shoreline utilization data is unavailable, the juvenile rearing was based upon known rearing habitat requirements (e.g., proximity to spawning streams, littoral area, field observations, etc.). Please refer to the methodology section for the Aquatic Habitat Index to find out how juvenile rearing categories were developed for this project.
    b. Migration – Probable juvenile and adult fish migration routes (Yes or No) are important migration corridors used by resident and anadromous fish at some point in their life cycle. These routes were prepared for this project and are based upon areas where fish will concentrate during significant spawning or out migrations from streams. Ecoscape prepared spatial files identifying areas of key migration and these areas were reviewed by Fisheries and Oceans biologists for confirmation based upon stock assessment surveys. To develop these migrations areas, key habitat characteristics were used and included adjacency to spawning rivers, outmigration considerations, and review of fish life history characteristics. The limited data available for migration corridors on this lake has resulted in some assumptions regarding these corridors and further research is recommended to better understand the spatial extents of their occurences.
    c. Staging – Staging areas are areas where fish will concentrate or congregate prior to migrations. Staging areas were digitized based upon liaison with Department of Fisheries Oceans field staff through the course of field work and the assessment. Field staff indicated to Ecoscape where fish were known to stage or hold prior to migrations and shore areas where migrations are likely present were identified (Yes or No). In general, these areas are loosely defined and vary over space and time. The information presented is limited to areas around the narrows and mouths of streams, where fish are known to congregate before migrations. It may not entirely reflect all

locations or spatial extents of staging areas. Future surveys should be used to better understand where mature adults hold during migrations.

d. Mussels - Mussel communities were readily apparent in littoral areas near the outflow of the Lower Shuswap River from Mabel Lake. No data regarding the mussel community could be found during our literature review (e.g., Conservation Data Center, EcoCat, Ecological Catalogues, etc.) and therefore, this was added as a field.

4. Aquatic Habitat Index (AHI_CUR) field was added. This field reflects the results of the AHI discussed below.

5. An Aquatic Restoration potential analysis (AHI_POT) was also completed by removing instream features from the AHI results. This analysis provides a summary of potential locations where habitat improvements are possible along the shoreline. This analysis *does not consider improvements to riparian vegetation*.

4.0 AQUATIC HABITAT INDEX METHODOLOGY

An Aquatic Habitat Index (AHI) is a tool that is used to help assess the relative habitat value of a shoreline relative to other areas within the lake. An index is a numerical or categorical scale used to compare variables with one another. Use of an index to assess shoreline sensitivity has been utilized on Okanagan Lake (Schleppe and Arsenault, 2006) and Windermere Lake (McPherson and Hlushak, 2008). Indices are also currently in preparation for numerous lakes in the Kootenays. The purpose of the AHI is to facilitate land use planning around shorelines by identifying the relative value of shoreline areas within a lake system. The relative habitat value of an area can then be used to infer the environmental sensitivity of the shoreline (i.e., areas of higher relative value have greater environmental sensitivity).

The AHI utilizes a number of parameters collected during the FIM. The index uses a points based mathematical index to assign the relative habitat value to each different parameter. Features that have impaired the habitat value (e.g., groynes) are assigned negative scores to better reflect the current condition of the shoreline. The intent of this analysis was to compare the shoreline to its natural state.

A subsequent analysis was conducted to determine the habitat potential of a segment. This analysis involved removing ALL negative habitat parameters to determine if shoreline restoration could achieve a measurable benefit. This Habitat Potential index can be used to help assess where restorative efforts should be directed. The habitat potential analysis did not include effects of riparian restoration due to the extent of database and predictive mapping that would be required to facilitate such an analysis.

The index generated has only utilized information that is available. In many instances, data gaps were identified. As more information is collected regarding shoreline areas of Mabel Lake, the Aquatic Habitat Index may need to be updated.

4.1 Parameters

The parameters of the index each reflect a certain type of habitat found along the shoreline. The parameters were broken down into three categories as follows:

1. Biophysical;
2. Fisheries;
3. Shoreline Vegetation; and,
4. Modifications;

The following table identifies the parameters and logic used in the index.

Table 1: The parameters and logic for the Aquatic Habitat Index of Mabel Lake.

Category	Criteria	Maximum Point	Percent of the Category[1]	Percent of the Total[1]	Logic	Uses Weighted FIM Data	Value Categories
Biophysical	Shore Type	15	33.3	13.8	% of Segment * Maximum Point	Yes	Stream Mouth = Wetland (15) > Gravel Beach = Rocky Shore (12) > Sand Beach (8) = Cliff /Bluff (8), Other (5)
	Substrate	12	26.7	11.1	% Substrate * Maximum Point	Yes	Cobble (12) > Gravel (10) > Boulder = Organic = Mud = Marl (8), Fines = Sands (4) > Bedrock (2)
	Percentage Natural	5	11.1	4.6	% Natural * Maximum Point	No	
	Aquatic Vegetation	5	11.1	4.6	% Aquatic Vegetation * Maximum Point	No	
	Overhanging Vegetation	4	8.9	3.7	% Overhanging Vegetation * Maximum Point	No	
	Large Woody Debris	4	8.9	3.7	# of Large Woody Debris/km * Relative Value * Maximum Point	No	**Relative Value** >15 LWD (1) > 10 to 15 LWD (0.8) > 5 - 10 LWD (0.6) > 0 - 5 LWD (0.4) > 0
Fisheries	Juvenile Rearing	12	30.0	11.1	High (12), Moderate (6), Low (3)	No	High (12), Moderate (6), Low (3)
	Migration Corridor	8	20.0	7.4	Present (8), Absent (0)	No	Present (8), Absent (0)
	Staging Area	8	7.1	7.4	Present (8), Absent (0)	No	Present (8), Absent (0)
	Mussel	12	30.0	11.1	Present (12), Absent (0)	No	Present (12), Absent (0)
Shoreline Vegetation[2]	Band 1	8	66.7	7.4	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	Yes	**Vegetation Bandwidth Category** 0 to 5 m (0.2) < 5 to 10 m (0.4) < 10 to 15 m (0.6) < 15 to 20 m (0.8) < 20 m (1)
	Band 2	4	33.3	3.7	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	Yes	**Vegetation Quality Category** Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (1) > Coniferous Forest = Mixed Forest (0.8) > Herbs/Grasses = Unvegetated (0.6) > Lawn = Landscaped = Row Crops (0.3) > Exposed Soil (0.05)
Modifications	Retaining Wall	-1.80	15.8	1.7	% Retaining Wall * (-2)	No	% Retaining Wall * (-2)
	Docks	-2.87	25.3	2.6	# Docks/km * (-0.05)	No	# Docks per Kilometre * (-0.05)
	Groynes	-4.69	41.3	4.3	# Groynes/km * (-0.1per groyne)	No	# Groynes per Kilometre * (-.1)
	Boat Launch	-1.00	8.8	0.9	# Launches * (-0.25 per launch)	No	# Launches * (-0.25 per launch)
	Marina	-1.00	8.8	0.9	# Marina * (-1 per marina)	No	# Marina * (-1 per marina)

1. Numbers have been rounded to the nearest whole number. All calculations were completed without rounding.

2. The Shoreline vegetation category has been calculated to include an estimate of quantity (i.e., bandwidth) and quality (i.e., relative value). In cases where two bands are present, there is a higher diversity which is more productive, resulting in a higher score.

The parameters selected for the index were similar to the other indices developed. A description of each is found below.

4.1.1 Biophysical Parameters

The following summarizes the biophysical parameters of the index:

1. Shoretype – A shoreline type is related to many aspects of productivity. Previous habitat indices (e.g., Schleppe and Arsenault, 2006) have used a habitat specificity table to determine the value of a shoreline. This similar approach was used for Windermere Lake (McPherson and Hlushak, 2008). However, in these previous versions, wetlands were difficult to account for utilizing the fish habitat specificity approach originally developed for Okanagan Lake (Schleppe and Arsenault, 2007). Wetlands are considered to be highly valuable shoreline areas for several reasons, including their contributions to biodiversity, biomass, and water quality. Other aspects of the fish habitat specificity approach developed for Okanagan and Windermere Lakes are appropriate and have been utilized in this assessment. The general habitat specificity for Mabel Lake follows that of Windermere and Okanagan, except that Wetlands have been defaulted to the highest value possible shore value (i.e., equivalent to a stream confluence) because of their rarity on this lake, their contributions to habitat diversity, and their contributions to biomass and water quality.

2. Substrate – Substrates also relate directly to productivity. There are generally two types of productive substrates, those utilized for spawning and those that produce more biomass. The substrates values and parameters used for Mabel Lake are similar to the Shuswap, Okanagan and Windermere. More information regarding the rationale of this parameter please refer to the indices developed for the Okanagan and Windermere.

3. Percent Natural –Areas of natural shoreline have a relative habitat value that is greater than disturbed shoreline areas because the condition of the habitat is better. The value of this parameter in the index is similar to the Shuswap and slightly less than Okanagan and Windermere Lakes. The relative percentage of the parameter was dropped slightly from Okanagan and Windermere to ensure that previous habitat alterations did not reduce the value of lakes habitats too much.

4. Aquatic Vegetation – In more recent versions of the FIM database, more detailed information regarding aquatic vegetation was collected. In the Shuswap and Mabel system, all vegetation below the HWL is considered productive. Since the FIM now allows analysis of this parameter, it was added to the index following the same methods as Shuswap Lake. The benefits of aquatic vegetation are many and include forage, biomass production, cover, etc.

5. Overhanging Vegetation – In the more recent versions of the FIM, more detailed information regarding overhanging vegetation was collected. In the Shuswap system, overhanging vegetation was not frequently documented. Since it provides nutrients and opportunities to forage, it was added to the index.

6. Large Woody Debris – In the more recent versions of the FIM, more detailed information regarding large woody debris was collected. In the Shuswap Lake system, Large Woody Debris was not present in many areas. Woody debris was absent for several reasons including proximity to significant sources such as large rivers or from "beach grooming" activities by residents. Since it large woody debris provides nutrients, cover, and opportunities to forage, it was added to the index. Numerous studies have identified the importance of large woody debris to salmonids in lake and stream systems.

4.1.2 Fisheries Parameters

The fisheries parameters used for the Aquatic Habitat Index were based upon those described above in Section 3.2.2 – GIS and Data Management. These different parameters are considered important for fish production in the Mabel system and were prioritized in the AHI accordingly. These are similar to areas identified as Zones of Sensitivity in the Okanagan and Windermere projects. The following were the fisheries parameters added to the AHI:

1. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was prepared for this assessment. Juvenile rearing values were prepared using an index similar to the AHI. The index prepared was based upon original surveys of Shuswap Lake by Graham and Russell (1979) and Russell *et al* (1981) who documented juvenile utilization along the shoreline. In these assessments, habitat criteria similar to those collected in the FIM were utilized to assess areas as High, Moderate, or Low Juvenile Rearing Value. Similar to Russell's approach, a Juvenile Habitat Suitability Index was developed for Mabel Lake (without a field sampling confirmation component). The following criteria were used in the Juvenile Rearing Habitat Suitability Index for Mabel Lake.

Table 2: The parameters and logic for the Juvenile Rearing Habitat Suitability of Mabel Lake.

Category	Criteria	Maximum Point	Percent of the Category[1]	Logic	Uses Weighted FIM Data	Value Categories
Criteria	Shore Type	12	22.6	% of Segment * Maximum Point	Yes	Stream Mouth (12) > Wetland (8) > Gravel Beach = Rocky Shore (4) > Sand Beach (4) = Cliff /Bluff (1), Other (1)
	Substrate	9	17.0	% Substrate * Maximum Point	Yes	Organic(9) = Mud (9) = Marl (9) = Fines (9) > Boulder (8) > Cobble (7) > Gravel (7) > Bedrock (4) > Sands (3)
	Aquatic Vegetation	5	9.4	Aquatic Vegetation Category Score	No	**Aquatic Vegetation Category Score** Aq. Veg > 80% = 5, Aq. Veg 50% to 80% = 3. Aq. Veg < 50% = 1
	Littoral Width	12	22.6	Littoral Width Category Score	No	**Littoral Width Category** Wide (>50m) = 12, Moderate (10 to 50 m) = 8, Narrow (<10m) = 3
	Overhanging Vegetation	1	1.9	% Overhanging Vegetation * Maximum Point	No	
	Large Woody Debris	4	7.5	Large Woody Debris Category Score * Maximum Point	No	**Large Woody Debris Category Score** >15 LWD (1) > 10 to 15 LWD (0.8) > 5 - 10 LWD (0.6) > 0 - 5 LWD (0.4) > 0
	Migration Corridor	5	9.4	Present / Absent	No	Present (5), Minor (0)
	Salmonid Spawning Stream Present	5	9.4	Present / Absent	No	Present (5), Minor (0)

The juvenile rearing suitability is only one fishery criteria and only comprises 11% of the overall Mabel Lake AHI. The above index has not been field confirmed using a sufficient sampling protocol but is consistent with best estimates of productive juvenile areas in Mabel Lake. Duplicate parameters between the AHI and the Juvenile Rearing suitability index occur because of correlations that exist between the different parameters (i.e., the estimate of shore type productivity is correlated with juvenile rearing habitat suitability for example). Because duplicates can only account for a *maximum* of 3.1% of individual criteria in the index (i.e., Shore Type in AHI (13.8%) X Shore Type Juvenile Rearing (22.6%)), they do not represent a significant enough duplication to significantly alter the outcome of the analysis.

2. Migration – Juvenile fish migration routes are the most important migration corridors and these were prepared based upon selection of known spawning areas in streams. The areas generally only encompass shoreline areas where fish must either migrate out from or into a river system. These areas overlap extensively with Staging Areas. Migration routes consider both resident (e.g., rainbow and kokanee) and anadromous salmon species.

3. Staging – Staging areas were digitized based upon liaison with Department of Fisheries Oceans field staff through the course of field work and the assessment. Field staff indicated to Ecoscape where fish were known to stage or hold prior to migrations. The areas generally only encompass shoreline areas where fish must either migrate out from or into to. These areas overlap extensively with Migration areas.

4. Mussels –In the Okanagan, the known location of the Western Ridged Mussels have been included in shore line management policies because there are very few locations where this species is known to occur. Since our surveys were not extensive enough to rule out the presence of the Western Ridged Mussel (WRM), we have included it in our habitat index. Also, mussel species, such as the WRM and others, often have complex life cycles involving a host species of fish (see Freshwater Mussels of the Pacific Northwest for more information (Nedeau *et al*.). The presence of these species are indicative of complex trophic interactions and can be a signal of watershed health (i.e., they can be indicator or keystone species also). For these reasons, a mussel criterion is included within the index.

4.1.3 Shoreline Vegetation Parameters

The Riparian parameters added to the index were similar to those added in the Shuswap, Okanagan and Windermere Lakes. However, the newer versions of the FIM provided a distinction between the lakeside vegetation (Band 1/Riparian) and the areas behind (Band 2/Upland). To address this new data available, the index was modified slightly. The index was modified to include a factor assessing vegetation quality (i.e., tall shrubs thickets or wetland areas have a higher quality than landscaped yards). As with the other indices, vegetation bandwidths were categorized and points were assigned. Vegetation bandwidth categories included 0 to 5 m, 5 m to 10 m, 10 m to 15 m, 15 m to 20 m and greater than 20 m. The Band 1 vegetation, directly adjacent to the lake was given more points than the Vegetation Band 2 because of its direct proximity to aquatic habitats.

4.1.4 Habitat Modifications

Habitat modification parameters are described by Schleppe and Arsenault (2006). These descriptions provided a good rationale for inclusion of these different parameters in the AHI. Other habitat modifications parameters, such as Percent Substrate Modification or Percent Roadway were not included in the analysis because they may compound (i.e., groynes typically constructed from shoreline substrate modification, therefore gets counted twice). The following is quoted directly (shown in italics) from Schleppe and Arsenault (2006) completed by EBA Engineering Consultants Ltd. The City of Kelowna provided permission to utilize data from their assessment. Further information on these parameters can also be found in the Windermere Lake assessment (McPherson and Hlushak, 2008). Textual areas below that are not in italics have been added to the wording of Schleppe and Arsenault for specific references regarding the applicability to this project.

Retaining Walls

Retaining walls are considered to be negative habitat features for a variety of reasons. These structures are generally constructed to armour or protect shorelines from erosion. Kahler et al (2000) summarized the effects of piers, docks, and bulkheads (retaining walls) and suggested that these structures may reduce the diversity and abundance of near shore fish assemblages because they eliminate complex habitat features that function as critical prey refuge areas. Kahler et al. (2000) found evidence of positive effects for armouring structures along a shoreline in the published literature. Carrasquero (2001) indicated in his review of overwater structures that retaining walls might also reduce the diversity of benthic macroinvertebrate communities more than other structures such as riprap shoreline armouring because they reduce the habitat complexity.

Natural erosion along a shoreline can be the result of removal of riparian or lakeside vegetation, which may have been the cause of the erosion in the first place. In other cases, retaining walls have been constructed to hold up soil material, possibly reclaiming land, so that lawns can be planted or for other landscaping purposes. As indicated in the FIM report by the RDCO, the construction of structures by residents, may lead to neighbours imitating their neighbours. Also, construction of one retaining wall may lead to energy transfer via waves resulting in erosion somewhere else. The above arguments highlight the consequences of retaining wall construction and the potential negative habitat effects that they have.

On the Mabel system, many retaining walls have been constructed to create level building areas or level areas for turf and landscaping. This construction has resulted in significant impacts to riparian vegetation and foreshore substrates.

Docks

The negative effects of docks on fish habitat are controversial. On one hand docks may provide areas of hiding from ambush predators, reductions in large woody debris inputs, and these structures are often associated with other anthropogenic disturbances such as retaining walls (Kahler et al. 2000; Carrasquero 2001). On the other hand, docks also provide shaded areas that can attract fish and provide prey refuge, and pilings can provide good structure for periphyton growth (Carrasquero 2001). Numerous factors, such as the scale of study and the cumulative effects of these structures, are also important and should be considered when discussing overwater structures (Carrasquero 2001).

Docks have also been documented to increase fish density due to fish's general congregation around structure, but decrease fish diversity in these same areas (Lange 1999). Coupled with this result, Lange also found that fish diversity and density were negatively correlated with increased density and diversity of shoreline development, meaning that increases in dock density may reduce fish abundance and diversity. Chinook salmon have been documented to avoid areas of with increased overwater *structures (e.g., docks) and riprap shorelines, and therefore, construction of these structures may affect juvenile migrating salmonids (Piaskowski and Tabor, 2000).*

Regardless of the controversy, it is apparent that docks do affect fish communities and the degree of effects are most likely related to the intensity of the development, the scale of the assessment, and fish assemblage life history requirements. Different fish assemblages may respond differently to increased development intensity, and fish assemblages containing salmonids may be more sensitive than southern or eastern fish assemblages (e.g., bass, perch, and sunfish, etc.). It is for these reasons that dock density was included in the index, and that docks were treated as a negative parameter, with increasing dock density considered as having more negative effects than lower dock densities.

In the Mabel system, docks pose their own interesting concerns in addition to those above. In this system, the large natural drawdown of the lake, results in construction of mostly floating docks. These floating docks cover the substrate and deter fish from utilizing these areas. On Okanagan Lake, it has been observed that kokanee avoid spawning under large shaded areas (e.g., docks in excess of 3 or 4 m in width that area close to current water level, J. Schleppe and K. Hawes, personal observation during shore spawning surveys on Okanagan Lake), degrade / shade shoreline vegetation, result in requests for dredging, and facilitate moorage in shallow water resulting in prop scour. These impacts pose unique challenges to site specific and lake wide dock management practices on this lake system. On Mabel Lake, it is possible that the extensive boating recreation around Kingfisher has resulted in a loss of or degradation to native submergent vegetation from factors such as prop scour. Also, in this area, it is probable that prop scour is harming mussel individuals.

Another interesting aspect of the Mabel system, is the large number of mooring buoys that exist at the outlet of the lake into the Lower Shuswap river. The mooring buoys at this location were often installed using large concrete anchors such as lock blocks. The footprint of the anchors for the buoys has resulted in a substantial reduction in productive littoral habitats.

Groynes

Groynes are structures that are constructed to reduce or confine sediment drift along a shoreline. These structures are typically constructed using large boulders, concrete, or some other hard, long lasting material. Reducing the movement of sediment materials along the shoreline can have a variety of effects on fish habitat, including increasing the embeddedness of gravels. Published literature regarding the specific effects of groynes on fish habitat are few, but because these structures are often considered Harmful Alterations, and Disruptions of Fish Habitat (HADD) as defined under the federal Fisheries Act, they are believed to have negative effects, mostly associated with the loss of area available for fish (e.g., Murphy 2001)

In the Mabel watershed, groynes are habitat modifications that result in localized impacts that are significant. The total extent of impacts observed was not as significant as

Shuswap Lake, but the individual occurrences have resulted in similar localized effects. Construction of these features was most often accomplished by utilizing local lake bed substrates. Removal of these substrates to groynes has resulted in significant degradation of habitat including loss of emergent vegetation zones, possible sediment deposition in possible char spawning zones (unconfirmed), destabilization of shoreline substrates, etc. Migration of juvenile fish may also be affected by groynes. Although not as well understood, it is probable that these structures are forcing migrating juveniles to deeper water zones where they are more susceptible to predation.

Boat Launches

Boat launches were considered to be a negative parameter within the AHI. Boat launches are typically constructed of concrete that extends below the high water level. The imperviousness of this material results in a permanent loss of habitat, which ultimately reduces habitat quality and quantity for fish. Concrete does not allow growth of aquatic macrophytes, and reduces foraging and/or refuge areas for small fish and macroinvertebrates. The extent of the potential effects of boat launches relates to their size. Thus, multiple lane boat launches tend to have a large effect on fish habitat than smaller launches with fewer lanes because there is more surface area affected. The AHI treated each different boat launch lane as one unit, and therefore one launch could have multiple boat ramps. The intent of using the data in this fashion was to incorporate the size of the structure (i.e., more ramps, decrease in available habitat).

Other impacts of boat launches include prop scour of substrates in shallow water launches.

Marinas

Marinas are a concentration of boat slips, offering a place of safety to vessels. Marinas likely have a variety of effects, but there is very little literature investigating the positive or negative habitat consequences of marinas. Large marinas also tend to have breakwaters, which can further affect wave action, sediment scour and deposition, and circulation. In general, when marinas are constructed in the littoral zone there tends to be a large increase in shading, which reduces the potential for aquatic macrophyte growth and therefore reduces the productivity of a particular shoreline area. Also, marinas tend to have other activities associated with them, including extensive boat movements, which can reduce the use of an area by more timid species (e.g., rainbow trout). Other activities in marinas include fuelling stations, boat cleaning, bilge water, and sanitary waste disposal stations. Each of these activities has the potential to alter benthic communities, possibility altering the fish assemblage (i.e., congregations of more tolerant species and displacement of less tolerant species) and potential resulting in a loss in biodiversity, which can ultimately affect fish and/or fish habitat. Marinas also tend to be associated with other high intensity land developments, which may have a variety of effects including reducing water quality through inputs of chemicals, etc., increases in water turbidity, reduction in oxygen concentration, etc.

The above were common modifications that were observed that could be easily quantified and added to the habitat index. The negative effect of modifications was reduced from the Shuswap Lake AHI. This was done because the extent and magnitude of impacts observed were less. These criteria would have resulted in too much of a devaluing effect if they were not reduced in weighting when compared to Shuswap.

4.2 Index Ranking Methodology

The AHI was used to analyze the relative habitat value of a segment to those compared around the different lakes assessed. The output of the index is a five class ranking system, ranging from Very Low to Very High. Two different runs of the index were completed as follows:

1. Current Value (AHI_CUR) – This is the current index value for each shore segment based upon the total biophysical, riparian, fisheries, and modifications present.

2. Potential Value (AHI_POT) – This is the value of habitat index when the modifications are removed. It is the total value based upon the biophysical, riparian, and fisheries parameters only. This highlights segments where restoration is possible and would have the most potential benefit of removal of instream works. This category does not consider riparian restoration impacts.

4.2.1 Calculating the Index

The AHI consists of a variety of parameters and each parameter has a range in potential scores based upon the physical properties of each shore segment. Table 1 contains the logic and the maximum score possible for a particular habitat parameter. To calculate the index score, the score for a shore segment was applied based upon the physical characteristics in the FIM database for that segment. Weighted averages were used where possible to most accurately evaluate the score. Once the scores had been assigned to all parameters, the total scores for each different category 1) Biophysical, 2) Fisheries, 3) Shoreline Vegetation; and, 4) Modifications were summated for each segment. The total habitat value for each shoreline segment included all positive and all negative index parameters.

The output of the AHI is a five class ranking system, ranging from very low to very high. This ranking reflects the current value of the shoreline. To calibrate the index, the Shuswap Lake index was used as a baseline because of the many similarities between the two systems. From this base, numerous iterations were run (i.e., the index was run at least 50 times) and changes were made as necessary to reflect current conditions. For each iteration of the index, the minimum, maximum, median, and distribution of scores was reviewed. After reviewing the distribution of the data from the iterations, logical score breaks were used to determine the category for Very High, High, Moderate, and Low. These breaks were made because of the clustering of scores based upon the output of the results. Ultimately, the value of habitat is a continuum, and there is room for some interpretation of this information. Further review, addition, and improvements to the index are encouraged and this database has been designed to allow inclusion and update of information. The ultimate purpose of the index is to act as a flagging tool based upon information currently available.

For the most part, criteria within this index were identical to Shuswap, which was expected due to similarities between the systems. The following are noted differences and rationale:

Modifications

1. The negative value of retaining walls was lowered by 1 point. This was done because the extent of retaining wall impacts appeared to be less around Mabel Lake than Shuswap Lake.

2. The negative value of docks was reduced by 50%. This was done because the number and extent of moorage related impacts was substantially less than Shuswap.

5.0 DATA ANALYSIS

5.1 General

General data analysis and review was completed for the FIM database. Data collected was reviewed and analysis focused on shore segment length. Analyses for this project were completed as follows:

1. The shoreline length for the shore segment was determined using GIS and added to the FIM database;

2. For each category, the analysis used the percentage natural or disturbed field to determine the approximate shoreline segment length that was either natural or disturbed. This was done on a segment by segment basis. In some cases, the percentage natural or disturbed was reported because it made comparison easier than comparing shoreline lengths.

The above summarizes the general analysis approach. The following sections provide specific details for the biophysical analyses.

5.2 Biophysical Characteristics and Modifications Analysis

Biophysical characteristics of the shoreline segments were analyzed. For definitions of the categories discussed below, please refer to Appendix A (Detailed Methods) for a description / definition. The following summarizes the analyses that were completed:

1. Percent distribution of natural and disturbed shoreline;
2. Total shoreline length that remained natural or disturbed for each slope category that occurs along the shoreline;

3. Total shoreline length that remains natural or has been disturbed for each land use identified along the shoreline;
4. Total shoreline length that remained natural or has been disturbed for each shore type that occurs along the shoreline;
5. Total length of shoreline that contained aquatic vegetation, emergent vegetation, floating vegetation, or submergent vegetation;
6. Total number of modification features recorded along the shoreline. This data represents point counts taken during the survey and is reported for groynes, docks, retaining walls, marinas, marine rails, and boat launches; and,
7. Total shoreline length of different shoreline modifiers (roadways, substrate modification, and retaining walls) was determined.

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5.3 Aquatic Habitat Index Analysis

A brief summary of the shoreline lengths and shore types is presented. The summary provides information regarding the AHI results (Very High to Very Low) analyzed by shore type, including the percent of the shoreline that is within each of the AHI categories.

6.0 RESULTS

The following section provides an overview analysis of Mabel Lake system. Data is presented graphically and summarized in the text for ease of interpretation. Data tables for the different analyses are presented in Appendix B.

6.1 Biophysical Characteristics of Mabel Lake

Foreshore Inventory and Mapping was completed on 82,063 m (82.1 km) of shoreline on Mabel Lake. The total length of disturbed shoreline was 8,760 m (8.8 km), which represents 11% of the shoreline (Figure 2). The total length of natural shorelines was 73,303 m (73 km), which represents 89% of the shoreline (Figure 4).

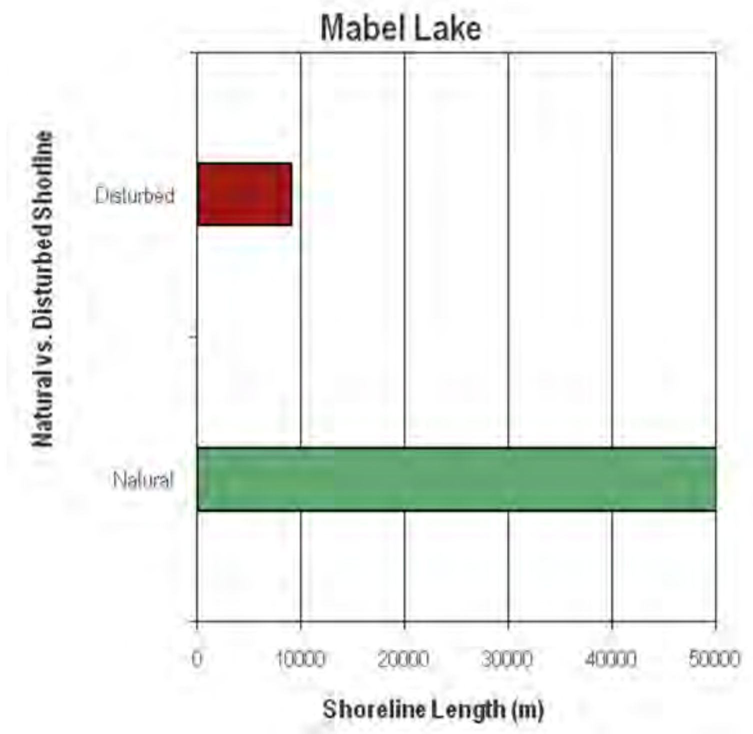

Figure 2 The total shoreline length that is either natural or disturbed on Mabel Lake

The slope analysis is a summary of slope categories (% slope) that occur in upland areas above the high water mark. Areas of a lower gradient tend to have the highest level of disturbance, likely because they are easier to develop. Benches, Low and Moderate gradient areas on Mabel Lake were disturbed along 85% (0.4 km), 12.4% (2.5 km) and 14% (4 km) of their respective shore lengths within these slope categories. Along steeper shorelines in Mabel Lake, disturbance only occurred along 5.5% (1.8 km) and 0% (0 km) of the steep and very steep shore lengths respectively.

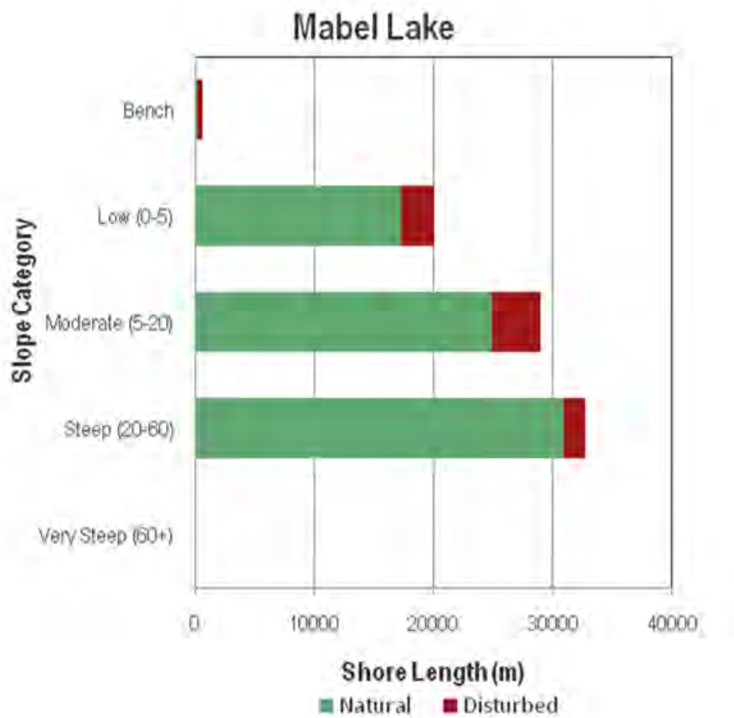

Figure 3 The total shoreline length that is either natural or disturbed along different shore gradients around Mabel Lake

Around Mabel Lake, the largest land use type observed was natural areas which accounted for 75% or 62 km of shoreline. These natural areas along the shore zone were approximately 98% natural. The next most predominant land use along the shorelines was Single Family residential, which accounted for 9.7% of the total shoreline length or approximately 7.9 km of shoreline. Single family development also includes strata style developments that have single family units within the development. Within the single family areas, approximately 67% or 5.3 km of shoreline is disturbed while only 33% or 2.6 km remains natural. The next most significant land use occurring around the lake was rural areas, followed by parks. Parks and rural areas occurred along 8.5% and 4.1% of the shoreline respectively and these areas were generally quite natural. Riparian impacts and substrate modification were the most significant impacts observed in these different areas.

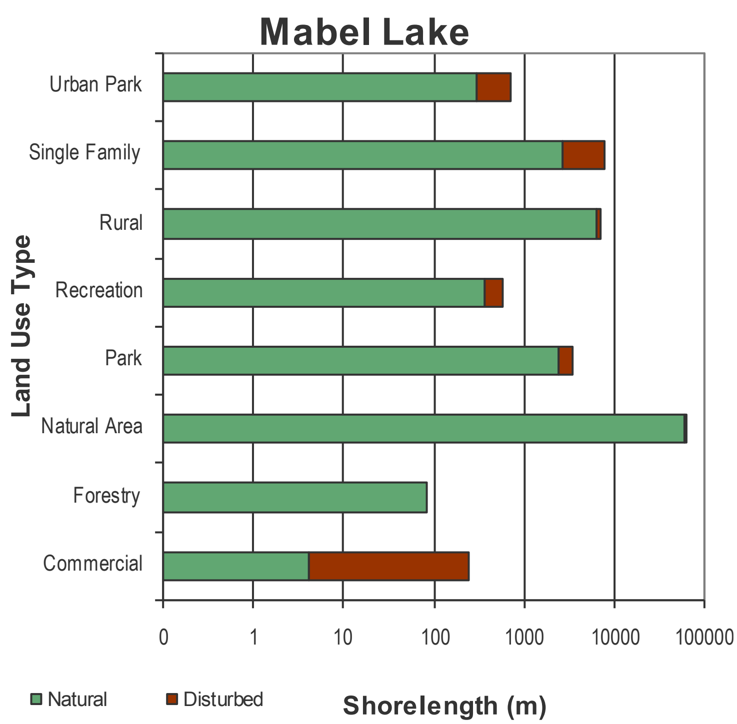

Figure 4 presents the natural and disturbed shoreline length by the different types of land use (logarithmic scale) occurring around Mabel Lake.

The most predominant shore type observed around Mabel Lake was rocky shores, which accounted for 63% or 52.8 km. Rocky shores were mostly natural, with only 4% or 2.0 km being disturbed. Data was collected documenting current condition of the shoreline and it should be noted that groyne construction along rocky shorelines has created areas of gravel or sand beaches. Gravel beaches are the next most predominant shore and occur along 14.4% or 11.8 km of the shore. In gravel beach areas the shoreline is 69% natural (8.3 km). Stream confluences and Cliff/bluff areas each occurred along approximately 9-10% of the shoreline and these shore areas were 85% and 99% natural respectively. Wetland shore types were not very common around the lake, and represented only 0.2% of the total shoreline length. Within wetland shore areas, 70% still remain natural (~100 m).

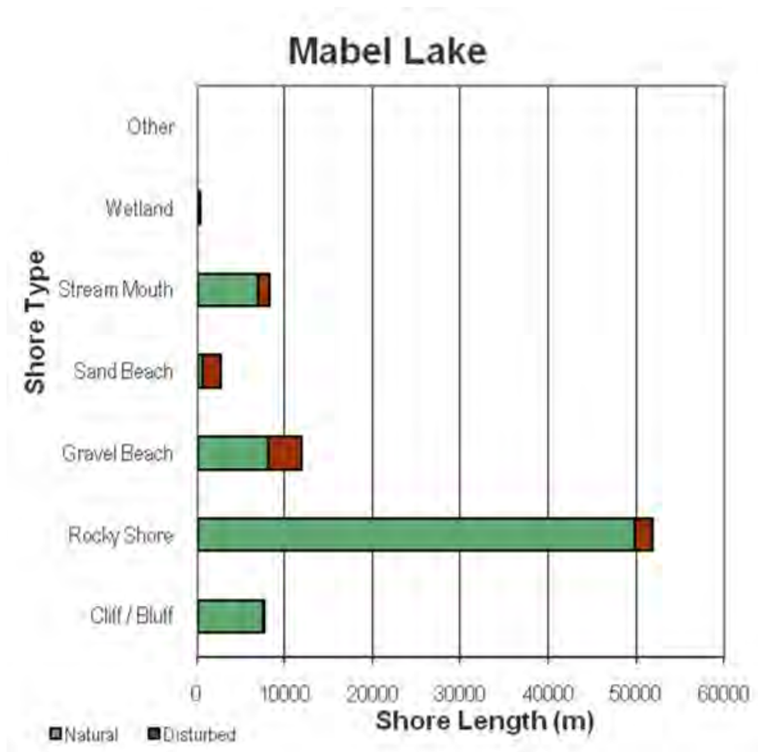

Figure 5 presents the length of natural and disturbed shoreline along each of the different shore types on Mabel Lake.

Aquatic vegetation is loosely defined as any type of emergent, submergent, or floating vegetation that occurred below the high water level. Thus, the aquatic vegetation field includes true aquatic macrophytes and those plants that are hydrophilic or tolerant of periods of inundation during high water level. Studies have shown that even terrestrial vegetation, during periods of inundation provides important food for juvenile salmonids and other aquatic life and this is why it has been included (Adams and Haycock, 1989). There is approximately 29 km of shoreline that has aquatic vegetation, which represents approximately 35% of the total shoreline length. The total area of both dense and sparsely vegetated areas with aquatic vegetation is 750,790 m^2. Most of the vegetation that was observed was emergent and grass like, which occurred along 35% of the shoreline or 28 km. Areas of native submergent vegetation and floating vegetation were very rare on these lakes and were only observed in along 8% or 6.9 km and 0.1% or 0.08 km respectively. Floating vegetation was located in Segment 17 only. Timing of surveys was not optimal to collect data regarding submergent and floating aquatic vegetation areas.

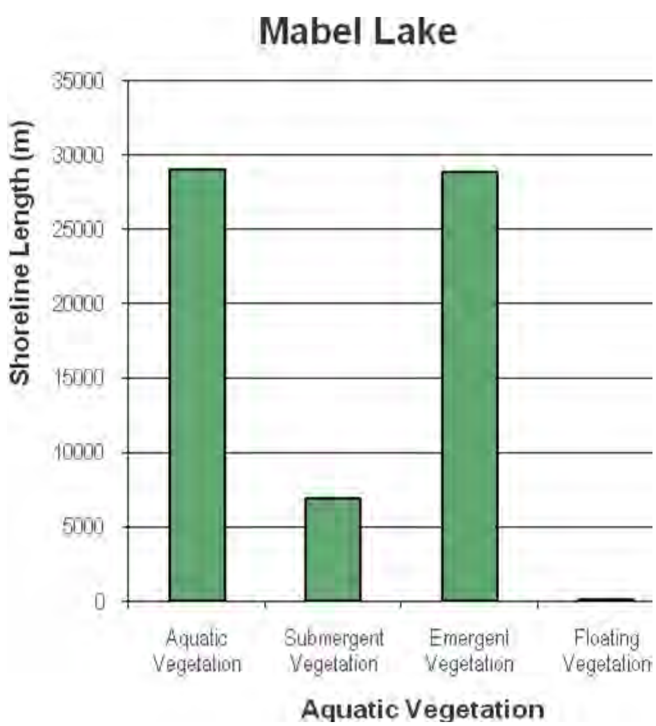

Figure 6 presents the total shoreline length that has aquatic, submergent, emergent, and floating vegetation along Mabel Lake.

Docks were the most commonly observed type of shoreline modification. There were a total of 152 docks counted during the assessment. Retaining walls and groynes were the next common type of modification found and they were 107 and 90 respectively. Mooring buoys were also counted and there were a total of 204, which were concentrated around the outflow of the Lower Shuswap River. There are a total of 4 marinas with greater than 6 boat slips and there are a total of 10 concrete boat launches[1]. The above numbers highlight the significant number of different structures that occur around Mabel Lake.

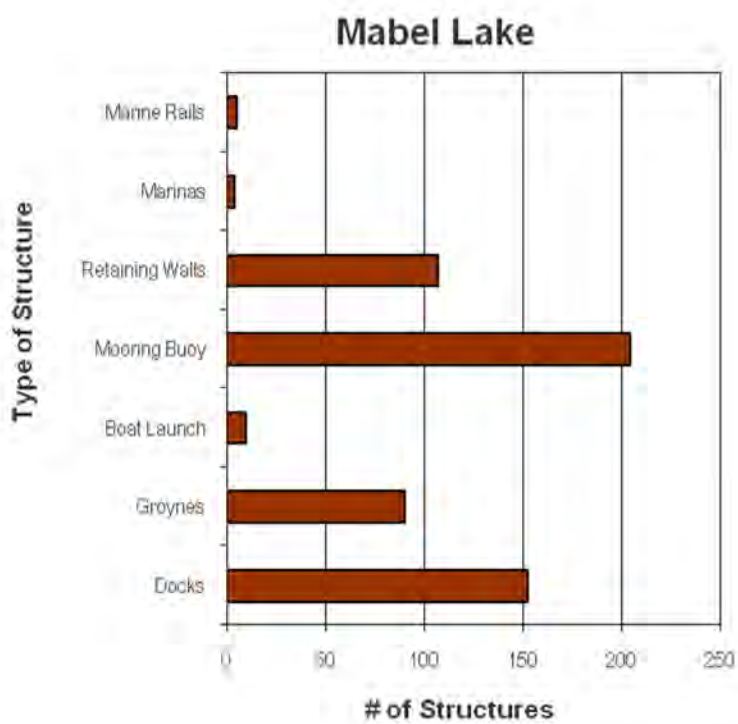

Figure 7 presents the total number of different shoreline modifications that occur around Mabel Lake.

[1] Only concrete boat launches were counted during the assessment. This total does not include gravel accesses to the lake.

The percentage of the shoreline that was impacted by roads, retaining walls, and where substrate modification has occurred was recorded. These estimates allowed an approximation of the total shoreline length that has been impacted by these different activities (Figure 11). By far, substrate modification was the most substantial impact that was observed along the shoreline. In total, it is estimated that 9% or 7.5 km of shoreline has experienced substantial substrate modification. Substrate modification was variable and was most commonly associated with construction of groynes to create gravel beaches, importation of sands, historic fills (e.g., retaining walls below HWL) or associated with road (e.g.., structural fill material, etc.). Retaining walls were the next most substantial impact to the shoreline and it is estimated that 3% or 2.6 km has been impacted by retaining walls. Finally, roadways accounted for less than 1% or 0.1 km. There were no areas of railway observed along the shoreline.

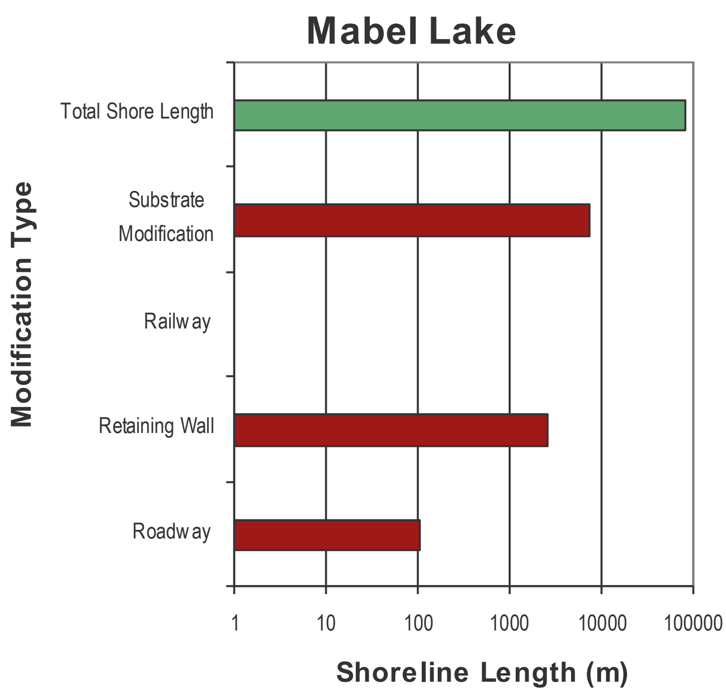

Figure 8 presents the total shoreline length that has been impacted by substrate modification, road and railways, and retaining walls along Mabel Lake (logarithmic scale). Most of these impacts were observed in developed portions of the lake.

The amount of foreshore modification by these different mechanisms may seem high, but is corroborated by the estimated level of impact observed. It is estimated that 10% of the shoreline has a high level of impact which accounts for 8.3 km of shoreline. Areas of moderate and low impact account for 5.7% or 4.8 km and 30% or 24.5 km of the shoreline respectively. There is an estimated 54.2% or 44.4 km of shoreline that is believed to have little to no impact.

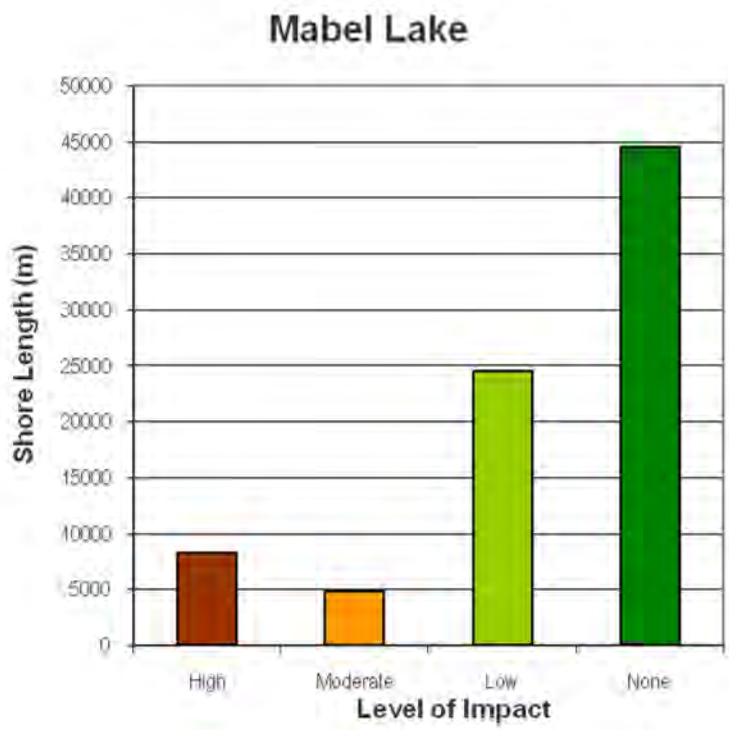

Figure 9 presents the level of impact (High, Moderate, Low, or None) observed along Mabel Lake.

6.2 Summary of Foreshore Modifications

The lakeshore of Mabel Lake contains habitats that are critical for wildlife (e.g., Bald Eagle, etc.) and fish populations (e.g., coho, chinook, rainbow trout, etc.). The lake provides drinking water for many different local government and First Nation's jurisdictions both around it and downstream. This combination of important fish, wildlife, and water quality considerations make it vital to identify, manage and protect the shoreline area. The data collected during this assessment provides the information necessary to begin to manage this resource effectively because it provides a baseline upon which goals and objectives can be created and monitored.

The shoreline of this lake is estimated to remain 89% natural based upon the results of this survey. This relatively natural state is considered a key feature of the lake and is not indicative of many lakes where private holdings are present. However, developed portions of the lake contain impacts that are of the same style and magnitude as observed in other parts of the Shuswap Lake system, indicating that development related impacts only occur along a smaller area of the shoreline rather than the impacts being of a lesser magnitude.

As with other shoreline studies (e.g., Shuswap Lake, Okanagan Lake, etc.), lower gradient shoreline slopes tended to have higher disturbance, with the exception of floodplains of the major tributaries (e.g., Upper Shuswap River). The most notable disturbances that were observed were foreshore modification typically in the form of substrate alteration (e.g., boat launches or groynes) and riparian vegetation disturbance. There is almost no large scale industry around the lake, and impacts from commercial moorages and forestry log yards are substantially less than Shuswap Lake. Within more intensely developed areas, many natural aquatic vegetation communities remain and many "pockets" of natural shoreline exist. Although many areas have experienced negative habitat alterations, most of the floodplains around the lake are still in functioning condition and are key critical habitat features supporting numerous fish and wildlife species. Many of these critical areas can be impacted by future land use decisions. The above highlights the need for ongoing and continued management and planning to ensure these important resources are protected.

Varying degrees of foreshore development are present along Mable Lake. During the field surveys, numerous observations were made and are summarized in point form below:

- The most significant impact observed below the high water level along the shorelines was the construction of groynes and associated substrate modification. The construction of groynes has resulted in numerous impacts including: 1) the loss of aquatic vegetation (actual loss has not been determined), 2) a loss in cover along the shoreline, 3) the physical loss of habitat through alteration of shorelines from a rocky shore to gravel or sand beaches, 4) loss of structure complexity, 5) has resulted in an increased erosion risk around the shoreline, 6) and an increased sediment input that may have reduced shore spawning success for different species. The extent of habitat related loss associated with substrate modification have not been determined as part of this assessment. In many cases, the construction of groynes required the use of heavy equipment (or significant manual effort). All groynes observed were constructed on Crown lands below the high water level, and it is likely that many, if not all, were not permitted under the BC Water Act or Federal Fisheries Act.

- In many areas, it is apparent that aquatic vegetation[2] has been lost due to foreshore disturbance such as substrate modification. In these areas, emergent riparian vegetation (e.g., willows and cottonwoods), grasses and sedges, and other types of vegetation have all been cleared. It is believed that most of this vegetation removal is the result of beach creation (i.e., beach grooming). The losses of soil material that aquatic vegetation grows will likely take years or decades to naturally regenerate, if it does at all. The continued losses of this vegetation will further

[2] Aquatic vegetation is defined here as any vegetation below the high water level, including shrubs, herbs, and grasses, whether they are true aquatic macrophytes (e.g.,*Potamogeton* spp.) or hydrophilic species (e.g., reed canary grass).

impact juvenile salmonids during high water in the spring when they are known to feed upon organisms within the vegetation (Adams and Haycock, 1989).

- Riparian vegetation disturbance has changed the vegetation type from natural broadleaf or coniferous associations to landscaped, lawn, or un-vegetated associations along many shore segments. The substantial losses of riparian vegetation have not been quantified as part of this assessment. There are significant opportunities for riparian habitat enhancements along the shoreline of the lake in disturbed areas.

- Several private boat launches constructed out of concrete were observed. These boat launches were almost all associated with vehicular access, which has impacted riparian vegetation. It is conservatively estimated that these boat launches have resulted in the loss of at least 2,500 m^2 of habitat around the lakes (assuming the average boat launch is 2.4 m wide and 6 m long, which is presumed to be an underestimate given the large drawdown on Mabel Lake). It is likely that most of these boat launches were constructed without a provincial Water Act, federal Fisheries Act approval or have a Crown land tenure.

- Retaining wall construction around the lake was apparent in nearly all privately held areas, even remote cottage areas. Retaining walls were constructed out of varying materials, but frequentlyCsubstrates from the lakebed were used to construct the walls. As mentioned above, it is probable that many of the retaining walls observed have been constructed without a Water Act or Fisheries Act approval.

- There appears to be a proliferation of buoys on the important mussel habitats that were identified at the outflow of the Lower Shuswap River. There are a total of 163 buoys within Segments 57 through 60, and 1 and 2 (areas at the outflow where mussels were present).

- Docks were the most commonly observed shoreline modification. Many of the docks observed were not constructed following best management practices which require elevated walkways on piles to floating portions in deeper water zones at low water level. In many areas, these docks were observed grounding (i.e., floating portions were not elevated at low water level), the docks were not elevated, or were left at the waters edge. The impact of non compliance is small on an individual scale, but cumulatively the extent of habitat related degradations are noticeable and measureable (i.e., numerous grounding docks can potentially remove aquatic vegetation which is important to rearing salmonids). The relative impact of docks on Mable Lake was less than Okanagan Lake or Shuswap Lake, which is positive. However, it will be important to work towards better compliance to ensure future impacts of docks are mitigated.

- Boat wake erosion, Crown land trespass, and moorage buoys were observed. Also, evidence of prop scour was present in the outflow areas of the Lower Shuswap River, which may be resulting in harm to individual mussels and potential downstream sediment migration to salmon spawning areas. However, detailed assessments and quantification of these impacts was not fully assessed.

6.3 Aquatic Habitat Index Results

The results of the Aquatic Habitat Index are best reviewed graphically. The attached Figure Binder presents the spatial results of the assessment. The figure binder has been prepared to show a summary of all the information contained within this report.

The Aquatic Habitat Index uses biophysical information to assess the relative value of a shoreline area. The AHI indicates that approximately 35.5% of the shoreline is ranked as Very High and High. Twenty six (26%) of the shoreline length is moderate, and the remaining 38.2% is ranked Low and Very Low. Areas of high and very high habitat value were typically located adjacent to natural flood plains, stream confluences, wetland areas, or were associated with gravel and rocky shorelines with aquatic vegetation in a natural state. Most of the lower value sites were located along steep, rocky shorelines (e.g., cliff bluff, or rocky shore with bedrock) or in areas impacted by development.

Low Habitat Value accounted for 32.9% or 27.9 km of the total length. This is the result of two factors. First, there are numerous steep shoreline areas with lots of bedrock around the lake and these have a lower AHI ranking because they are utilized to a lesser extent by fish (and are subsequently given a lesser weighting in the AHI). Second, more emphasis was placed on sampling developed areas due to budgetary constraints. The focused sampling efforts resulted in many smaller gravel beach areas of higher value being lumped with lower value cliff bluff areas along the long stretches of Crown land. The above highlights the need for further, more detailed inventory of natural areas to better understand the relative habitat value of the large expanse of natural areas around the lake. Further investigation into the shoreline areas would yield more accurate results (e.g.., some of these shoreline may have higher juvenile rearing capability or smaller pockets within cliff bluff shorelines that have a higher value that is diluted by the long segment length).

Shore line areas with a Moderate Value habitat accounted for 26.3% or 21.6 km of the shoreline. High value areas accounted for 20% or 16.2km and only 15.6% of the shoreline is currently estimated to have Very High value (12.8 km). Very Low habitat values account for only 4.1% or 3.4 km of the shore line. The Very Low value sites were generally documented in more developed areas.

Table 3: Summary of the Current Value and Potential Value shoreline lengths, number of segments, and percentage of the shoreline for the different AHI index categories (Very High to Very Low)

Categories	Current Value			Potential Value		
	# of Segments	Shoreline Length (m)	% of Shoreline	# of Segments	Shoreline Length (m)	% of Shoreline
Very High	11	12821.1	15.6	13	13735.4	16.7
High	20	16294.5	19.9	18	15380.2	18.7
Moderate	15	21573.6	26.3	18	22515.5	27.4
Low	12	27977.5	34.1	9	27035.6	32.9
Very Low	2	3396.4	4.1	2	3396.4	4.1
Total	60	82063.0	100.0	60	82063.0	100

The Current Value of the shorelines was analyzed for each different shore type (Table 3). The analysis indicated that Very High Value shorelines occurred mostly adjacent to Stream Mouth areas or Rocky and Gravel shores. Most of the Very Low value habitat was found on sand or gravel beach areas.

The Potential Value summary presents what the habitat value would be if the modifications were removed (Table 4). This analysis highlights areas where restoration may result in a benefit. It is important to note that this analysis does not consider riparian improvements. Riparian improvements would also likely result in habitat improvements which have not been accounted for in this analysis. In general, there was a shift from very low upwards. Subsequent analysis may help better interpret where restoration may be more feasible and result in the most improvement.

The following segments have the highest potential for restoration (excluding potential riparian restoration efforts):

1. 2 – Located at the cabins across from Kingfisher on the western shoreline of Mabel Lake.
2. 26 – Located on the eastern shore, approximately 8 km boat distance from the southern end of the lake.
3. 29 – Located on the eastern shore, approximately 9 km boat distance from the southern end.
4. 54 – Located approximately 500 m south of a small unnamed tributary (watershed code: 128-835500-36300) or approximately 6 km (boat distance) from the outlet of the Shuswap River.
5. 60 – Located in Kingfisher near the community boat launch.

Table 4: Summary of the Aquatic Habitat Index results for the different shore types for the Current Value of the Shoreline.

Categories	Current Value			Cliff / Bluff		Rocky		Gravel		Sand		Stream Confluence		Wetland		Other	
	# of Segments	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline
Very High	11	12821.1	15.6	59.7	0.5	3988.9	31.1	2049.5	16.0	0.0	0.0	6555.8	51.1	167.2	1.3	0.0	0.0
High	20	16294.5	19.9	0.0	0.0	8075.8	49.6	4861.2	29.8	2241.9	13.8	1115.6	6.8	0.0	0.0	0.0	0.0
Moderate	15	21573.6	26.3	1748.1	8.1	16792.3	77.8	2571.7	11.9	186.5	0.9	275.1	1.3	0.0	0.0	0.0	0.0
Low	12	27977.5	34.1	3181.1	11.4	22299.7	79.7	2205.2	7.9	0.0	0.0	291.4	1.0	0.0	0.0	0.0	0.0
Very Low	2	3396.4	4.1	2541.7	74.8	635.4	18.7	43.8	1.3	175.4	5.2	0.0	0.0	0.0	0.0	0.0	0.0

Table 5: Summary of the Aquatic Habitat Index results for the different shore types for the Potential Value of the Shoreline.

Categories	Potential Value			Cliff / Bluff		Rocky		Gravel		Sand		Stream Confluence		Wetland		Other	
	# of Segments	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline	Shoreline Length	% of Shoreline
Very High	13	12821.1	15.6	0.0	0.0	4273.4	33.3	2239.1	17.5	0.0	0.0	6995.9	54.6	167.2	1.3	0.0	0.0
High	18	16294.5	19.9	0.0	0.0	7791.3	47.8	4671.5	28.7	2241.9	13.8	675.4	4.1	0.0	0.0	0.0	0.0
Moderate	18	21573.6	26.3	1748.1	8.1	17278.0	80.1	3027.9	14.0	186.5	0.9	275.1	1.3	0.0	0.0	0.0	0.0
Low	9	27977.5	34.1	3181.1	11.4	21814.0	78.0	1749.1	6.3	0.0	0.0	291.4	1.0	0.0	0.0	0.0	0.0
Very Low	2	3396.4	4.1	2541.7	74.8	635.4	18.7	43.8	1.3	175.4	5.2	0.0	0.0	0.0	0.0	0.0	0.0

7.0 RECOMMENDATIONS

7.1 Foreshore Protection

The following provides a list of recommendations for foreshore protection. Some of the recommendations below are similar to other recent FIM reports (e.g.., Schleppe and Arsenault, 2006). In cases of similarity, credit to the work should be given to the original authors. The following are recommendations for development of foreshore protection policies:

1. **Environmentally Sensitive Areas should be identified because they are extremely important to maintain as habitat for fish and wildlife**. Environmental development permit areas (EDP's) are a primary tool for municipalities and local government. At this time, most municipalities require a development permit prior to the onset of construction for lakeside residences. It will be important for local governments to integrate the FIM collected during this assessment with other important datasets such as the Sensitive Ecosystem and Inventory (SEI), Sensitive Habitat and Inventory (SHIM), etc. *All lakeside areas identified in this report should be designated as development permit areas if this has not already been accomplished.* A specific shoreline guidance document should be developed for the shoreline as discussed below to facilitate inter agency review of applications that may affect Very High and High value areas.

2. **A Shoreline Guidance Document (Step 3) should be developed by local government, the Ministry of Environment, First Nations bands, and Fisheries and Oceans for Mabel Lake.** The AHI provides a basis for identification of sensitive shoreline areas, forming the basis for a risk based approach to lake shore management. The shore guidance document will facilitate inter governmental cooperation for lake shore management. Funding should be sought to complete this next step.

3. **Standard terms of reference for professional reports should be developed for environmental assessments of development applications to ensure that all development applications provide a minimum standard of assessment.** Development of a standard Terms of Reference has been completed by many local governments within the Okanagan to address the variety of different reports received and ensure a minimum standard of assessment is completed. Development of a Terms of Reference should be done in partnership with other governmental agencies, such as Fisheries and Oceans Canada and the Ministry of Environment to help offset costs of document development. The Regional District Central Okanagan, City of Kelowna, Regional District of Okanagan Similkameen, and District of West have well developed terms of reference that could be used as templates. The Terms of Reference will outline professional requirements for assessments in the region and provide a list of considerations that environmental professionals must address as part of a development application. The provincial

Riparian Areas Regulation does not provide a sufficient terms to address all potential impacts to aquatic habitats that may exist and should not be relied upon as the exclusive requirement for development applications. Site specific assessments are a critical component of a development permit process because every proposal is unique and the Terms of Reference will help address the uniqueness of different areas, such as red listed ecosystems, species at risk, and their habitats. The inventories and data within this document should be provided as part of the terms of reference (i.e., the GIS data, air photos, and other biological information contained in this report should be provided).

4. **Habitat restoration opportunities should be achieved wherever possible by identifying them during the development review processes.** In highly urbanized areas, examples include dismantling of groynes, placement of large woody debris, live staking and re-vegetating shoreline regions, riparian restoration, etc. It may be useful to identify the potential for restoration opportunities in the standard terms of reference discussed above. There is significant opportunity for partnerships (i.e., multi agency partnerships with stewardship groups) to be formed to help facilitate habitat restoration around the lakes.

5. **Core habitat areas are extremely important to maintain and should be identified as early as possible in the development process.** Core habitat areas are larger scale areas (i.e., cannot be identified on a property by property basis through a process such as a Riparian Areas Regulation assessment) that should be mapped and identified. These areas typically contain or are associated with red listed ecosystems or habitats for species at risk and may not necessarily be in close proximity to a shoreline area (e.g., a large river floodplain confluence that contains a red listed cottonwood ecosystem that provides habitat for red listed species such as the Western Screech Owl). Detailed assessments and identification of core habitat areas for conservation should be done as early in the development process as possible to reduce potential impacts from land use decisions (e.g., zoning a property for commercial purposes without understanding what values are present may result in a obligations for a minimum build-out that has significant impacts that are difficult to mitigate later on in the process such as at subdivision). Numerous different possibilities exist for areas identified as sensitive, including Section 2.19 No Build / No Disturb Covenants, creation of Natural Areas Zoning bylaws (i.e., split zoning on a property), or by other mechanisms (donation to trust, etc.). The Very High and High shoreline areas are considered important areas where mechanisms such as this may be required to protect key habitat features.

6. **Environmental information collected during this survey should be available to all stakeholders, relevant agencies, and the general public.** Environmental information, including GIS information and air photos, are an extremely important part of the environmental review process because they provide a lot of information regarding the current condition of an area. This information should be available to the public, including all air photos, GIS files, and other electronic documents. One agency should take the lead role in data management and any significant studies that add to this data set should be incorporated and updated accordingly.

7. **Compliance and enforcement monitoring of approved works is required, with consequences for failure to construct following standard best practices or failure to apply for necessary permits.** There were numerous examples of historical and recent poor practice observed during this survey and other surveys of interior lakes along Shuswap, Windermere, Moyie and Monroe, Mara, and Okanagan Lake have identified similar problems. An increase in compliance and enforcement monitoring at all levels of government is required because current practices do not appear to be working effectively (i.e., there were numerous, recent examples of construction inconsistent with BMPs).

8. **An Environmental Advisory Commission or other suitable body should be created and be included in the development review process to involve local residents.** The Regional District of Central Okanagan has created an Environmental Advisory Commission, which functions similar to an Advisory Planning Commission. The commission was created based upon the belief that local residents should contribute to the stewardship of their natural resources. In the CSRD, the SLIPP process has incorporated both political and resident representatives. A process such as this may provide an avenue to address the environmental concerns of residents and act as an advising committee to relevant stakeholders and governmental agencies. Further, a commission such as this may also be a valuable resource to local governments that do not have the in house expertise to adequately review and provide comment on potential environmental impacts development may have. Recent research that indicates that environmental policy at a local or regional scale may be most effective at protecting sensitive ecosystems that exist (Koonce *et al.,* 1996) and a commission such as this would be useful to provide comment to politicians regarding ongoing activities in the area because it would empower the local populace to take an active role in environmental management. In the Central Okanagan, members of the EAC work on a volunteer basis.

9. **Development and use of best practices for construction of bioengineered retaining walls is required.** Bioengineering has many different meanings. Concise guidelines and best management practices should be developed that is consistent with standard practices of bioengineering.

10. **A communication and outreach strategy should be developed to inform stakeholders and the public of the findings of this study and improve stewardship & compliance**. Initially, it is recommended that notice of the availability of this report and associated products are available on the Community Mapping Network. The information should be forwarded to the Shuswap Lake Integrated Planning Process, local First Nations, Integrated Land Management Branch, Ministry of Environment, Transport Canada, Indian and Northern Affairs Canada, City of Enderby, North Okanagan Regional District, any Kingfisher residents associations, lease holders associations and local stewardship groups.

11. **Lake shore erosion hazard mapping should be conducted for private lands to identify areas at risk, which will stream line the review process and reverse the damaging trend of unnecessary hard armoring and construction of retaining walls along the shoreline of the lakes.** Also, this methodology would be helpful to identify areas that are sensitive to boat wake erosion. The province has formalized methodology for lakeshore hazard mapping and this methodology, or some adaptation of it, would be preferred (Guthrie and Law, 2005). This mapping should be integrated with the FIM data, and be completed for each segment. Flooding, terrain stability, alluvial fan hazard mapping should also be considered for developing areas along the lakeshore. Until lakeshore erosion hazard mapping is completed, it is advisable to only consider shoreline protection works on sites with demonstrated shoreline erosion. To accomplish this, reports by engineers or biologists should accompany proposals for shoreline armoring to ensure that works are required, minimize impacts and use bioengineering techniques.

12. **Storm water management plans should be included in all development applications that alter the natural drainage patterns.** It appears that development along the lakeshore has previously occurred without the benefit of comprehensive storm water management plans, which has resulted in small streams being diverted and discharge locations to the lake being relocated. This can result in erosion of non conditioned foreshores and impacts to shore spawning areas. It is recommended that storm water management plans be required as part of development processes. Ecoscape understands that the Regional District of North Okanagan currently has these requirements in their Official Community Plan.

13. **Local, provincial, and federal governments should only approve proposed developments with net neutral or net positive effects for biophysical resources, if feasible.**

14. **Developments that have "significant" adverse effects to any biophysical resource (e.g., spawning areas) should not be approved on the basis that compensatory habitat works may offset such effects unless suitable rationale and arguments are presented (e.g., it benefits the general public versus an individual).**

15. **Compensatory works resulting from projects or portions of projects that could where harmful alterations, destruction, or disruption of fish habitat could not be avoided must follow the DFO Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat[3]. The works must be consistent with the "No Net Loss" guiding principle of The Department of Fisheries and Oceans Policy for the Management of Fish Habitat.**

16. **Habitat enhancements should not be considered in cases where incomplete or ineffective mitigation or compensation is proposed.**

17. **Habitat mitigation and compensatory efforts of biophysical resources should occur prior to, or as a condition of any approval of shoreline-altering projects.** To ensure that works are completed, estimates to complete the works and bonding amounts should be collected. These bonds will ensure performance objectives for the proposed works are met and that efforts are constructed to an acceptable standard.

18. **Development of land use alteration proposals should only be approved if the compromises or trade-offs will result in substantial, long-term net positive production benefits for biophysical resources.**

19. **Low impact recreational pursuits (biking, non motorized boating, etc.), pedestrian traffic and interpretive opportunities should be encouraged**. These activities should be directed to less sensitive areas, and risks to biophysical resources should be considered. Only activities that will not diminish the productive capacity of biophysical resources should be considered.

20. **Helical screw anchors should be utilized as a first choice for mooring buoy anchors.** The significant numbers of mooring buoys with concrete anchors has been identified as a measurable loss of productive habitat. All current mooring buoys and any new mooring buoys should be installed using screw anchors and should follow other applicable legislation.

[3] Note that the Riparian Areas Regulation does not address habitat compensation requirements because they fall under the jurisdiction of Fisheries and Oceans Canada.

7.2 Future Data Management

Future data management is extremely important to ensure that data collected during this survey is available, accurate, and up to date. In our review, there is not much information available for the Mabel Lake system. Future data collection should be integrated into this concise GIS dataset. The following are recommendations for future use of the FIM dataset:

1. **One agency should take the lead role in data management and upkeep**. This agency should be responsible for holding the "master data set". Although the data may be available for download from numerous locations, one agency should be tasked with keeping the master copy for reference purposes. The Community Mapping Network is currently publishing many of the data sets that have been collected. Sufficient funding must be allocated to CMN to keep up with management of the data because as there becomes more datasets costs of management will increase.

2. **A summary column(s) should be added to FIM GIS dataset that flags new GIS datasets as they become available.** Examples of this include new location maps for rare species, fish, etc. Other examples include the addition of appropriate wildlife data. Where feasible, these new data sets should reference the shore segment number (see below).

3. **The Segment Number is the unique identifier. Any new shoreline information that is provided should reference and be linked to the shore segment number.**

4. **Review and update of FIM and mapping should occur on a 5 to 10 ten year cycle.** Review and update of the FIM will be required to determine if shore line goals and objectives are being achieved. In a perfect world, changes to the FIM data set would be done as projects are approved (i.e., real time). However, at this time, it is unlikely that the multiple government agencies responsible have the capability to establish such a system.

7.3 Future Inventory and Data Collection

The following are recommendations for future biophysical inventory that will help facilitate environmental considerations in land use planning decisions:

1. **Data regarding shore spawning locations for resident and anadromous fish species is limited.** Numerous resident fish species, including kokanee, burbot, bull trout, lake trout, and rainbow trout have been identified within the lake system. In our review, there is limited data regarding shore spawning or other key habitat areas for these fish species. Future inventory of important areas for these species should be conducted. This is one of the operational management recommendations for Mable Lake (Redfish Consulting, 2007).

2. **The Juvenile Rearing Suitability Index should be field confirmed**. The rearing index that was developed for this project is based upon surveys in Shuswap Lake. There are differences between the two systems and the index developed for Mable should be adjusted according to results of a field program that samples different shore line areas and types. This type of analysis could also be replicated across different lake types to better assess the relative value of different shoreline areas to juvenile salmonids. Similar investigations into utilization and importance of the different shore types by resident fish stocks may also yield information regarding the relationships between juvenile rearing suitability, fish stocks, and shore type.

3. **A field sampling program of the different shoreline areas should be developed to confirm the results of the AHI**. The AHI has been developed based upon information that is currently available for Mabel Lake and based upon review of other studies. However, numerous assumptions have been built into the index and a field sampling program should be developed to confirm the results of the assessment and to test assumptions of the index.

4. **The bivalves of Mabel Lake should be inventoried to identify any species of significance and their importance with the lake system.** The bivalve area observed at the outflow of the Lower Shuswap River has been included in the index because our field surveys indicated this was a unique feature. A field survey of mussels in the lake should be conducted to increase the knowledge base and to help assess whether this is a relevant criteria in the index and whether it is weighted appropriately. Further, additional mussel locations may also exist around the lake that should be considered.

5. **The Sensitive Habitat Inventory and Mapping (SHIM) is a GIS based stream mapping protocol that provides substantial information regarding streams and watercourses and should be conducted on all watercourses around the lake**. Mapping should focus on our significant salmonid rivers and streams first, and then one smaller tributaries containing resident fish habitat, followed by non fish bearing waters. This mapping protocol provides useful information for fisheries and wildlife managers, municipal engineering departments (e.g., engineering staff responsible for drainage), and others. This information is also extremely useful for Source Water Protection initiatives because it identifies potential contaminant sources in an inventory.

6. **Critical river spawning areas for resident and anadromous fish (sea run) should be identified through further inventory.** At this time, Ecoscape is digitizing important river spawning areas in the lower Shuswap River. However, other critical river spawning areas in the Wap and Upper Shuswap river have not been mapped. Identification of these locations for fish within or migrating through Mabel Lake is important so that resource and land use managers are more aware of their locations. This is one of the operational management recommendations for Mable Lake (Redfish Consulting, 2007).

7. **Future river and shore spawning enumerations should identify the spatial locations of spawning activity and estimates of spawning numbers should be kept in a spatial fashion.** Shore and river spawning areas are critical habitat features necessary to the maintenance of healthy populations. Spatial data regarding the locations and numbers of individuals will allow managers to track changes over time and better relate changes in the watershed to changes in fish production. GIS enumeration will be a key component any successful, long term fisheries management project. This is one of the operational management recommendations for Mable Lake (Redfish Consulting, 2007).

8. **Wetlands are extremely productive and important components of our ecosystems and these features should be inventoried**. Numerous low flood and mid flood benches and shore marshes were mapped during this survey. Detailed Wetland Inventory and Mapping (WIM) of these features are recommended. Detailed mapping of terrestrial wetlands is also important to ensure that linkages between foreshore and upland areas are achieved.

9. **Sensitive Ecosystem and Inventory (SEI) and Terrestrial Ecosystem Mapping (TEM) are useful terrestrial mapping tools and these inventories should be completed**. These assessments help land managers identify sensitive terrestrial zones which can be integrated into the FIM, SHIM, and WIM GIS datasets.

10. **An inventory of high value habitat islands in urbanized areas should be conducted in areas of concentrated settlement.** In many cases, small sections of higher habitat quality were observed in segments ranked Moderate to Low. These areas were typically areas that had well-established native vegetation or relatively natural shorelines. Development applications proposed in these "islands" of higher habitat quality should avoid disturbance to these "islands" as much as possible. A survey of these small "islands" would clarify which segments contain "islands" and would help aid planning objectives. This could form part of a riparian mapping exercise.

11. **A carrying capacity analysis of the lake should be completed.** The Carrying Capacity of a lake is defined as the point where a lakes ability to accommodate recreational use (e.g., boating) and residential occupation without compromising adjacent upland areas, biological resources, aesthetic values, safety, and other factors. Biological systems are extremely difficult to predict and manage. Currently, these fish and wildlife ecosystems are experiencing rapid changes due to a variety of factors including but not limited to land development (e.g., water consumption may be exceeding the capacity of some streams, etc.) and climate change. At this point, it appears that the significant biological resources around the lake are maintaining viable populations. Determining the threshold upon which cumulative effects will have measurable and noticeable impacts is very difficult and therefore a conservative approach is required. Determining carrying capacities on our large, interior lake systems is currently one of the most significant challenges to lakeshore management because it impacts many cultural, social, and environmental values of residents.

12. **A survey, on a home by home basis, should be conducted to help educate home owners.** A home owner report card could be prepared that would provide land owners with a review of the current condition of their properties. The assessment should provide them with sufficient information to help land owners work towards improving habitats on their property. This assessment is not intended to single out individual owners, but rather to help owners understand the importance of habitat values present on their properties.

13. **The addition of new segment breaks in long segments should be assessed in the future.** Some segments, predominantly in more natural areas, are quite long. Future mapping updates may wish to assess some new segment breaks on longer segments as more information is collected. Features should be considered as part of more detailed segment mapping include the locations of small tributaries, seepages, streams in natural areas, etc.

14. **Native beds of submergent and floating vegetation should be mapped in detail.** Native beds of submergent and floating vegetation were extremely rare on Mabel Lake. More detailed mapping, maybe as part of a Wetland Inventory and Mapping project, would help better classify and described these rare, sensitive features. A good example of these communities is located in Segments 93 and 84

8.0 CONCLUSIONS

The following report has documented the current condition of 82 km of shoreline on Mabel Lake. The assessment provides substantial background information summarizing the current condition of the upland and terrestrial zones and foreshores of Mabel Lake. An Aquatic Habitat Index (AHI) was developed that used biophysical information collected during the survey to rank the relative environmental sensitivity of the shore zone areas around the lakes. Recommendations are presented to help integrate this information into local land use planning initiatives.

There is approximately 89% of the shoreline that remains in natural conditions, representing approximately 73.3 km of shoreline. In total, 15.6% of the shoreline is ranked as Very High Value and these very high habitat value areas tended to occur on either stream confluences or their associated floodplains, or on gravel and rocky shores with suitable rearing habitats (i.e., lots of aquatic emergent vegetation). Approximately 4.1% is ranked very low value and these areas tended to be on low gradient gravel and sand areas that have been impacted. A significant length of shoreline was ranked as low and most of these areas occur on steep sloped, Crown lands.

The most notable shoreline modifications that were observed were retaining walls and groynes. In total, approximately 9% of the shoreline has had substantial substrate modification from groynes, beach grooming or construction of retaining walls. These impacts, along with riparian vegetation disturbance, are considered the most significant habitat degradations observed around the lake.

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GLOSSARY OF TERMS AND ACRONYMS

Alluvial Fan / Stream Mouth – Alluvial fans are considered to be areas where a stream has the potential to have a direct active influence (e.g., sediment deposition or channel alignment changes) on the lake.

Allocthonous Inputs - Organic material (e.g., leaf litter) reaching an aquatic community from a terrestrial community.

Anadromous – Anadromous fish as sea run fish, such as Coho, Chinook, and Sockeye salmon.

Aquatic Habitat Index (AHI) -The index is a ranking system based upon the biophysical attributes of different shoreline types. The index consists of parameters such as shore type, substrate type, presence of retaining walls, marinas, etc. to determine the relative habitat value based upon a mathematical relationship between the parameters.

Aquatic Vegetation – Aquatic vegetation consists of any type of plant life that occurs below the high water level. In some instances, aquatic vegetation can refer to grasses and sedges that are only submerged for short periods of time.

Biophysical – Refers to the living and non-living components and processes of the ecosphere. Biophysical attributes are the biological and physical components of an ecosystem such as substrate type, water depth, presence of aquatic vegetation, etc.

Best Management Practice (BMP) - Is a method or means by which natural resources are protected during development or construction. For example, the Ministry of Environment have been recently creating documents containing guidelines for work in and around water.

Emergent Vegetation - Emergent vegetation includes species such as cattails, bulrushes, varies sedges, willow and cottonwood on floodplains, grasses, etc. Emergent vegetation is most commonly associated with wetlands, but is also occurs on rocky or gravel shorelines.

Fisheries and Oceans Canada (DFO) – Federal agency responsible for management of fish habitats

Fisheries Productivity - The maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend.

Floating Vegetation - Floating vegetation includes species such as pond lilies and native pondweeds with a floating component.

Foreshore – The foreshore is the area that occurs between the high and low water marks on a lake.

Foreshore Inventory Mapping (FIM) -FIM is the methodology used to collect and document fish and riparian habitats lake corridors and was performed by the Regional District of Central Okanagan and partners. A full discussion of this mapping can be found in Regional District of Central Okanagan (2005)

Georeferencing - Georeferencing establishes the relationship between page coordinates on a planar map (i.e., paper space) and known real-world coordinates (i.e., real world location)

Groyne – A protective structure constructed of wood, rock, concrete or other materials that is used to stop sediments from shifting along a beach. Groynes are generally constructed perpendicular to the shoreline

Instream Features – Instream features are considered to be construction of something below the high water mark. Instream features may include docks, groynes, marinas, etc.

Lacustrine – Produced by, pertaining to, or inhabiting a lake

Lentic - In hydrologic terms, a non-flowing or standing body of fresh water, such as a lake or pond.

Life History – Life history generally means how an organism carries out its life. Activities such as mating and resource acquisition (i.e., foraging) are an inherited set of rules that determine where, when and how an organism will obtain the energy (resource allocations) necessary for survival and reproduction. The allocation of resources within the organism affects many factors such as timing of reproduction, number of young, age at maturity, etc. The combined characteristics, or way an organism carries out its life, is a particular species' life history traits.

Lotic – In hydrologic terms, a flowing or moving body of freshwater, such as a creek or river.

Non Anadromous – Non anadromous fish are fish that do not return to the sea to mature. Examples include rainbow trout (excluding steelhead), bull trout, and whitefish.

Retaining Wall – A retaining wall is any structure that is used to retain fill material. Retaining walls are commonly used along shorelines for erosion protection and are constructed using a variety of materials. Bioengineered retaining walls consist of plantings and armouring materials and are strongly preferred over vertical, concrete walls. Retaining walls that occur below the Mean Annual High Water Level pose a significant challenge, as fill has been placed into the aquatic environment to construct these walls.

Sensitive Habitat Inventory Mapping (SHIM) - The SHIM methodology is used to map fish habitat in streams.

Shore zone - The shore zone is considered to be all the upland properties that front a lake, the foreshore, and all the area below high water mark.

Streamside Protection and Enhancement Area (SPEA) - The SPEA means an area adjacent to a stream that links aquatic to terrestrial ecosystems and includes both the existing and potential riparian vegetation and existing and potential adjunct upland vegetation that exerts influence on the stream. The size of the SPEA is determined by the methods adopted for the Provincial Riparian Areas Regulation.

Stream Mouth / Stream Confluence / Alluvial Fan – Stream mouths are considered to be areas where a stream has the potential to have a direct active influence (e.g., sediment deposition or channel alignment changes) on the lake.

Submergent Vegetation – Submergent vegetation consists of all native vegetation that only occurs within the water column. This vegetation is typically found in the littoral zone, where light penetration occurs to the bottom of the lake. Eurasian milfoil is not typically considered submergent vegetation as it is non native and invasive.