
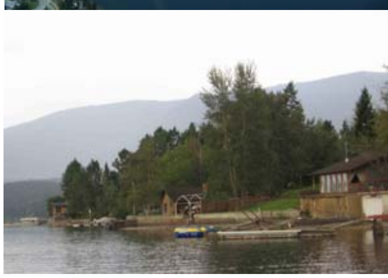

Windermere Lake Foreshore Fish and Wildlife Habitat Assessment

Prepared for:
East Kootenay Integrated Lake Management Partnership

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Interior Reforestation Co. Ltd.

Interior Reforestation Co. Ltd.

Final Report
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Executive Summary

Interior Reforestation Co. Ltd. (Interior Reforestation) was retained by the East Kootenay Integrated Lake Management partnership to perform a fish and wildlife habitat assessment of Windermere Lake. The objective of the assessment was to gather information about important fish and wildlife habitats along the shoreline so that Shoreline Management Guidelines could be prepared using scientifically based rankings and identification of Zones of Sensitivity (ZOS). The methods employed in this study closely followed those developed by Schleppe and Arsenault (2006) of EBA Engineering Consultants Ltd. for a similar study along the Kelowna Shoreline (Okanagan Lake)..

This assessment involved completion of several components, including: historical air photo analysis, fish and fish habitat assessment, segment ranking for fish and wildlife using a Habitat Index (HI) analysis, and identification of fish and wildlife ZOS. Project set-up (e.g., site selection, sampling techniques) and field components were completed by EKILMP professionals, while all office activities (e.g., analysis, literature review, reporting) were completed by Interior Reforestation professionals. The Foreshore Inventory Mapping (FIM) report completed in 2007 was used as a baseline for physical data. Fish, bird, wildlife habitat/occurrence and aquatic invertebrate presence/absence data was obtained over a one-year period during the summer (late July) and fall (late September) of 2007. This data was augmented in the office using a literature review.

The historical air photo analysis compared extent of foreshore disturbance for 1968, 1988, 1995 and 2004 (partial orthophoto coverage). The analysis revealed that in 1968 approximately 61% of the shoreline had already been disturbed and that by 1995 an additional 13% of the shoreline was disturbed (totaling 74% of the shoreline).

The fisheries sampling was the largest component of the field work program with a total of 18 different sites selected along the shoreline. These sites occurred across a range of different shore types (e.g. gravel beach, sand beach etc.) with different levels of development. Snorkel surveys were conducted consistently for nearly all sites and were thus the focus for relative abundance results; however, supplemental data was also provided by minnow trap, seine and shore/boat observations. In general, the fish assemblage in Windermere Lake showed that a diversity of species inhabit the foreshore including seven native species (of which three are considered sport fish) and two non-native species (i.e. largemouth bass and pumpkinseed fish). Based on the literature and historical findings, an additional seven species likely inhabit the lake. Some of these species are considered provincially and/or federally sensitive species (bull trout and westslope cutthroat trout) or regionally significant species (burbot) due to population declines. Of all species, the redside shiners were most abundant, representing 88% of the fish community sampled. Largemouth bass followed, representing 6% of the total community sampled in the combined summer and fall results. Sport fish (i.e., bull trout, burbot, mountain whitefish, westslope cutthroat trout, rainbow trout, kokanee) were either non-existent or were found in relatively low numbers. These fish are believed to be suffering population declines as a result of several human induced factors. They are also only expected to use the lake as a migration corridor through to their natal spawning grounds and for the rearing stages. It is likely that largemouth bass and northern pikeminnow have replaced these historical sport fish as the key predators in the lake. The lake outlet downstream to Athalmer was identified as a culturally significant and important area for fish, requiring further study.

Wildlife results focused on field findings and their significance for bird data and of any other sensitive species (badger, great blue heron) or habitats (wildlife trees) observed. For the most part, sensitive habitat discussions have been covered in the subsequent ZOS section. In total, 57 different species of birds were found during this study, of which 54% were migratory species. Generally, the greatest diversity of birds occurred at sites offering undisturbed habitat structure, particularly vegetation components (including emergent aquatic vegetation, riparian vegetation, wetlands, native grasslands and forest). A literature review of badger and great blue heron habitat requirements indicated that these species could be negatively impacted by development. A Conservation Data Centre query identified several potential sensitive species in the area. This included: 1 nonvascular plant species,

74 vascular plant species, 8 invertebrate species and 24 vertebrate species. Although detailed inventories for nesting birds and other plant and animals species were not conducted, the foreshore is expected to be important to many species, due to its diversity of high quality habitats present. Wildlife trees were an additional habitat noted at several locations around the lake that are considered important to wildlife and deserving of protection.

The Habitat Index (HI) analysis used the physical characteristics of the shoreline collected during the FIM and biological data collected during this assessment to quantitatively rank the Ecological Value for each of the shoreline segments. The HI was designed in such a way that positive habitat features, such as shore type, extent natural, vegetation bandwidth and wetlands, added to the habitat value, while features such as docks, marinas and retaining walls decreased habitat value. Index parameters were weighted based upon their importance or overall contribution to fish and wildlife habitat. Results indicate that approximately 65% of the shoreline is Very High or High, 3% is Moderate and 32% is Low or Very Low value habitat. Areas of highest value tended to occur along the undeveloped sections of the lake, or where disturbances were considerably set-back from the shoreline. Residential areas generally had the lowest rankings.

The Ecological Potential for each of the segments was also determined by running the HI index with the negative instream structures removed (i.e. docks, groynes, marinas, boat launches and retaining walls). This provided a ranking showing what increases in value could be experienced with restoration. This analysis determined that with removal of instream structures, a total increase of 15% (or 5.0 km) of shoreline ranked as Very High or High and 17% (or 6.0 km) ranked as Medium could be experienced. As well no shoreline would be valued as being low or very low. The segments where improvements would be evident were concentrated along the developed areas of the lake, (particularly along the south eastern to central eastern shores).

Several habitats were identified as being highly important to fish and wildlife and sensitive to development during this study. These ZOS habitats included: wetlands, creek mouths, native grasslands, wildlife habitats and corridors, gravel/cobble spawning habitat, biologically productive areas and unimpacted/natural areas. A discussion on the significance and sensitivity of each of these habitats is provided and all ZOS have been mapped. The intent of each ZOS is to highlight potential sensitive areas for fish and wildlife that may require assessment prior to development or where development should be constrained.

Overall, this study revealed that there are still important and ecologically viable ecosystems in the area. With appropriate planning these can be maintained for both humans and animals to thrive in. The results of this assessment are intended to increase the effectiveness and coordination of foreshore management activities at Windermere Lake, leading to improved ecosystem structure and function and integration of human use with environmental protection. Specifically, these results and the associated recommendations should be used to prepare a guide which will direct decisions on areas where future developments could occur, areas requiring protection and suitable areas for restoration. Continued baseline monitoring inventories, including wildlife tree surveys, nesting surveys and inventories of plant species will continue to add to the understanding of the Windermere Lake foreshore.

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The following individuals carried out fieldwork for this assessment:

Department of Fisheries and Oceans: Bruce MacDonald, Tola Coopper and Louise Porto; and

Ministry of Environment: Peter Holmes and Kristen Murphy.

The report was completed by the following Interior Reforestation Professionals:

Sherri McPherson, BSc., R.P. Bio., Aquatics Biologist - was the primary author of this report;

and

Darcy Hlushak, ADGIS, B.Sc., Geomatics Specialist - completed the GIS Modeling, Arial Photo review and all Mapping components of this activity.

Jon Bisset, Senior Aquatic Biologist and Mike Robinson, Aquatic Biologist completed internal reviews of the report, prior to submission to EKILMP.

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Disclaimer

The results contained in this report are based upon data collected during a one-year survey. Since biological systems respond differently both in space and time, the assumptions contained within the text are based upon field results and previously published material on the subject. Data in this assessment was not analysed statistically. Use or reliance upon biological conclusions made in this report is the responsibility of the party using the information. Neither Interior Reforestation Co. Ltd., nor the authors of this report are liable for accidental mistakes, omissions or errors made in its preparation because best attempts were made to verify the accuracy and completeness of data collected and presented. The outcomes of the Fisheries Abundance Analysis, Habitat Index Ratings and Zones of Sensitivity delineations are largely the result of data collected by other parties. Interior Reforestation and the authors assume that data collected are accurate and reliable.

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1 Introduction

Windermere Lake is located in the southern interior of British Columbia (BC). The lake is moderate in size, with a surface area of 1610 hectares and perimeter length of 36.3 km. It is also quite shallow with an average depth of 3.4 m and a maximum depth of 6.4 m. As a result, most of the lake (95%) is classified as littoral area, meaning that light can penetrate to the bottom allowing large aquatic plants or macrophytes to grow. In spite of it size, Windermere Lake provides a diversity of important values to both humans and fish and wildlife.

The local communities surrounding Windermere Lake as well as a plethora of summer tourists use the lake for their drinking water and recreation activities including boating, swimming and fishing. The lake is also valued for its inherent fish and wildlife and natural aesthetic features. These natural elements in recent years have been impacted as a result of unprecedented growth in the area. As an example, nutrient enrichment is a concern, with there being evidence of the lake becoming more enriched or eutrophic with time (Masse and Miller 2005). Development pressures are expected to continue in the area as long as Alberta maintains its strong economy which creates a demand for recreational and investment properties (OCP 2008).

1.1 Foreshore Management

Human induced impacts on the lake environment are a concern to many people in the area. The East Kootenay Integrated Lake Management Partnership (EKILMP) formed in early 2006 in response to these concerns. The partnership is comprised of federal, provincial and local governments, First Nations and environmental organizations including:

Core Group

- Regional District of East Kootenay
- Fisheries & Oceans Canada
- Integrated Land Management Bureau
- Transport Canada: Navigable Waters and Office of Boating Safety
- Interior Health Authority
- Canadian Columbia River Intertribal Fisheries Commission (CCRIFIC) representing Akisqnuk First Nation, Shuswap Indian Band and Ktunaxa Land and Resource Council
- BC Ministry of Environment (Water Stewardship, Environmental Protection & Environmental Stewardship divisions)
- Wasa Lake Land Improvement District
- Wildsight

Windermere Interest Participants

- District of Invermere
- Wildsight: Lake Windermere Project
- Others as identified
- Village of Canal Flats

The EKILMP's objective is to protect lakes in the East Kootenays by producing land use and development guidance on best practices and restrictions of use where necessary and encouraging more integrated and coordinated approaches (EKILMP 2006). Windermere Lake was an immediate priority for the group, because of its intense development pressures. In 2006, the EKILMP completed a field assessment and had Interior Reforestation Co. Ltd. (Interior Reforestation) complete the Foreshore Inventory and Mapping Report (FIM) on Windermere Lake using the Sensitive Habitat Inventory Mapping Techniques (SHIM) prepared by the Community Mapping Network (Mason, B. and R. Knight 2001).

The FIM provided an overview of the available data on the Windermere Lake foreshore and it inventoried and mapped the physical characteristics of the foreshore. Some key findings from the FIM report were as follows (McPherson and Michel 2007):

- The foreshore area is made up of several shoreline types including vegetated shore (30%), wetland (20%), low rocky shore (19%), cliff bluff (15%), sand beach (8%) and gravel beach (7%).
- 62% of the foreshore had been disturbed by human alterations. Main sources of disturbance were the Canadian Pacific Railway (CPR), residential and private recreational developments which covered 29%, 24% and 11% of the foreshore length respectively. The disturbances occurred over much of the low lying easily moved shore types, such as vegetated, low rocky shore, sand beach and gravel beach. The most disturbed areas were at the north end of the lake.
- Most of the natural areas remain along the south east end of the lake, which is designated as Indian Reserve and made up of cliff/bluff and wetland shore types.
- Natural park land was only found over 2.5% of the foreshore.
- Retaining walls were the main foreshore modification, with nearly 450 inventoried around the lake. The greatest concentrations (30/km) were found at the north east end of the lake.
- Wetlands were prevalent and found along most of the undeveloped stretches of the lake's foreshore.
- 58% of the shoreline had an overall low Level of Impact (LOI), while 17% was determined to be highly impacted (high LOI).

Data on the lake including that collected during the FIM study can be obtained from the Community Mapping Network's website (http://www.shim.bc.ca/)

With the pending development of the Official Community Plan (OCP) by the Regional District of East Kootenay (RDEK), the EKILMP enacted the next step of gathering baseline fish and wildlife data in 2007. This inventory was outlined as an action item in the FIM, which suggested that identification of critical habitat areas for species was an important step to complete in order to direct planning around the lake. EKILMP collected fish and wildlife field data in the summer and fall of 2007, and following a Request for Proposal (RFP) process, awarded the reporting component of the fish and wildlife findings to Interior Reforestation.

A similar foreshore data collection and analysis process was completed along the shore zone of Kelowna, on Okanagan Lake, (Schleppe and Arsenault 2006; and hereafter referred to as the Okanagan Lake F&W Report). EKILMP collected data in a similar manner to the Okanagan Lake F&W Report and thus requested that the reporting and analysis for the Windermere Lake study use the Okanagan Lake F&W Report as a template.

1.2 Significance of the Foreshore Environment to Fish and Wildlife

This section provides general background to describe why foreshore environments are so important. In doing so, it gives insight into why resource agencies and other organizations continue to put so much effort into studies such as this leading to their effective management and/or protection. Holmes (Ministry of Environment), has provided the following description on the overall importance of foreshore/lakeshore habitats, with a focus on wildlife.

> *Lakeshores form a transitional ecological community between aquatic and terrestrial habitats, referred to as an ecotone. Ecotones are important for wildlife since they provide the benefits of differing habitats in close proximity to each other. Lakeshore*

habitats are important for a variety of invertebrates and vertebrates for nesting, feeding, resting and protection from the elements and predators. Vegetated foreshores help to reduce erosion through both soil stabilization and through a reduction in the erosional energy of rainfall and wave action. Leaf litter and fallen branches/trees provide food and/or habitat for aquatic organisms including fish breeding and feeding sites. The vegetation is distinct from upland habitats due to the presence of water and in ecological terms is considered more productive than drier or wetter habitats.

The lakeshore riparian habitat is typically a narrow ecosystem that varies in size depending on the influence of water. Even though this is a very important ecosystem, adjacent habitats also provide attributes required by many species dependent on lakes. Clay banks, wildlife trees, coarse woody debris, adjacent wetlands, tributaries, grassland, forested habitats and shrub cover provide important components of life cycle requirements. For instance, six species of ducks in British Columbia are secondary cavity nesters and require wildlife trees (dead or decaying standing trees) to nest in. They select cavities excavated by primary cavity nesters such as pileated woodpeckers or northern flickers in either deciduous or coniferous trees that are usually greater than 50 cm diameter breast height (dbh). They prefer trees near the lake or pond but in cases such as the wood duck, will select wildlife trees up to 500 meters from the lake. Therefore, management of development pressures around lakes must take into account these other habitat attributes. Several species are also known to depend on the lakes for foraging while nesting habitats may be several kilometers away, such as the Common Loon.

Very few studies have been undertaken to assess the impacts on wildlife resulting from increased development around lakes. One in-depth study showed increased lakeshore development does have a significant influence on the presence of some breeding bird species (Lindsay et al., 2002). They studied the effect of lakeshore development on various species of birds, focusing on the differences in species diversity and ecological guild (species with common habitat requirements or behavior) composition. They examined: the avian abundance, richness and diversity values; ecological guild diversity and dominance, and; species/guild associations at developed and undeveloped lakes. Their study involved breeding bird surveys and habitat classification of 34 paired lakes (17 developed/17 undeveloped) with sample sites extending 50 meters inland. The study showed the most dramatic effects from development on lakeshores changed the occurrences of nesting guilds. Developed lakes had more seed-eaters and fewer species dependent on insects and shrub nesting birds. It is inferred that supplemental feeding by bird feeders and increased occurrence of non-native ornamental vegetation increases the abundance of the seed-eaters guild. They did not show any significance that these species were an out competing presence but did find increased abundance of detrimental species such as cowbirds that are brood parasites. The reduction in shrub nesters was explained by the removal of shrubs in yards and by increased success of predators such as raccoons (Pocyon lotor) and domestic cats.

Lakeshore vegetation, habitat structure and species use is commonly altered by anthropogenic disturbances. Types of disturbance include direct habitat loss, loss of native plant communities, avoidance, alteration of predator prey relationships and direct mortality. For instance, road and house construction results in direct habitat loss and alterations of natural drainage patterns. Conversion of natural vegetation to ornamentals results in removal of native nesting and foraging habitats. Human presence reduces species use of desired attributes through avoidance and through alteration of structure such as kids playing in a sand or clay bank and destroying nesting sites of bank swallows. Most predator species tend to avoid areas with high human densities which results in prey species congregating in these areas and abnormal population levels. For example, grizzly bears would have been abundant *around Lake Windermere prior to human settlement, but due to their fear of humans have vacated these habitats and prey species such as deer have flourished. Many species considered a nuisance, such as bats, are killed by property owners and as mentioned earlier, domestic animals prey on birds and other small vertebrates.*

T*here are several habitat attributes associated with lake ecosystems that play an important role in the life cycle of species associated with lakes and ponds. These can be divided into three general zones around the lakeshore - open water, littoral and upland. The shallow open water areas provide easy access to benthic habitats for species such as diving ducks and river otters. The littoral zone contains specialized habitat for many invertebrates that are important food sources for vertebrates. Emergent and submergent vegetation can be present throughout the open water and littoral zones and provide nesting and foraging areas for many species. The upland zone contains the most diverse amount of attributes. These include wildlife trees, coarse woody/large organic debris (CWD/LOD), overhanging vegetation, adjacent wetlands, grasslands, forests and clay banks*. Table 1 provides examples of organisms which utilize these habitats.

Table 1. Known habitat for fish and wildlife associated with the foreshore (Holmes 2008)

Habitat Type	Species	Utilization
Forest Canopy Cover	• Ungulates • Small mammals	• Cover • Feeding
Wildlife Trees	• Great blue heron • Woodpeckers • Bats • Nuthatches, chickadees • Salamanders • Small mammals • Owls	• Nesting • Feeding • Roosting • Perching
Coarse Woody Debris	• Amphibians • Reptiles • Small mammals • Woodpeckers • Bears	• Cover • Dens/nesting • Food storage • Food source (invertebrates)
Shrub Cover	• Western toad	• Cover
Grasslands	• Long-billed curlew • Ungulates	• Feeding • Overwintering
Clay Banks	• Bank swallow	• Nesting
Adjacent Wetlands	• Western Toad • Rubber boa • Ducks	• Rearing
Littoral zone	• Shore birds • Fish • Invertebrates	• Feeding • Spawning • Rearing
Shallow Lake Edges	• Long-toed salamander • Western Toad • Fish	• Egg laying • Rearing
Emergent/Sub-emergent Vegetation	• Long-toed salamander • Northern Leopard Frog • Ducks/geese • Fish	• Egg laying • Nesting • Feeding • Rearing • Migration path

Habitat complexity in the littoral zone is particularly important to fish productivity. Coarse woody debris (CWD), aquatic macrophytes, and substrate compositions are examples of habitats important to fish that often become compromised as a result of residential development. These habitats provide many functions including predation refugia, foraging substrates, spawning or nesting habitat, cover from the sun and nutrient cycling (Schindler et al. 2000 and Engel 1990). The littoral zone is also particularly important for early life-history stages of fish (Radomski and Goeman 2001). Residential developments can impact these habitats through direct removal of vegetation, construction of structures (such as piers, docks and marinas), and alteration of the shoreline with riprap or concrete (e.g., retaining walls and groynes). There have been some studies, particularly from the Eastern United States, examining the potential effects that lakeshore residential development may have on these habitats and fish. For example, Schindler et al. (2000) found that extensive residential development significantly reduced the growth rate and productivity for bluegill sunfish (*Lepomis macrochirus*) in eastern temperate lakes. They speculated that the growth rate decreases were associated with significant losses of coarse woody debris (CWD) and riparian tree density reported by Christensen et al. (1996) for the same lakes. Radomski and Goeman (2001) found that developed shorelines had substantially less emergent and floating leaf vegetation than undeveloped shorelines; and that the abundance of three fish species in Minnesota Lakes was positively correlated with emergent and floating plants. At developed sites and in lakes with greater development density, Jennings et al. (2003) also found that the quantity of woody debris, emergent vegetation and floating vegetation decreased and that littoral sediments contained more fine particles increasing substrate embededdness. Embededdness occurs in the substrates when finer materials (silts/sands) fill in the interstitial spaces between courser substrates and bind them together (J. Bisset pers. comm.). It is a concern because it reduces flow/permeability, surface area for phytoplankton and invertebrates and can smother eggs (J. Bisset pers. comm.). Woodford and Meyer (2002) found that these human caused riparian and littoral zone alterations also impact amphibians. Their study revealed that green frog densities of were reduced where CWD and wetland plants were removed.

Overall, the studies reveal that human activity can induce significant changes in the physical structure of the lake environment and that these losses of natural habitats are a management concern. Further, when these impacts are considered cumulatively for an area, they interact in complex ways to alter fish and wildlife growth and production rates. Jennings et al. (2003) found that cumulative changes to watersheds and riparian zones were associated with measurable differences in littoral habitats that may not be detectable at smaller scales. Radomski and Goeman (2001) delve into this topic by describing that that shoreline management, which is often conducted through regulations and permits, fails to address the cumulative effects on aquatic habitats. They state that natural resource management agencies should do more to discourage actions that cause small losses or alterations to aquatic habitat. This is an objective the EKILMP is striving to meet at Windermere Lake through this study and subsequent strategic planning exercises.

1.3 Environmental Vision

The biophysical analysis that is utilized in this report is intended to provide scientifically defensible Shoreline Management Guidelines to planners, developers and environmental managers, so that responsible, informed and holistic decisions regarding future developments and activities could occur. Without environmentally sound Shoreline Management Guidelines, land development within the important foreshore area will continue to be proposed and evaluated on a lot-by-lot basis, without the necessary knowledge of values, sensitivities and potential constraints posed by ecological systems (Schleppe and Arsenault 2006). A lot-by-lot approach also does not incorporate or consider the cumulative effects of small habitat modifications (Jennings *et al* 1998). This integrated and collaborative approach to lake management will help provide more timely and cost effective reviews of proposals (EKILMP 2006). The Shoreline Management Guidelines are intended to provide a science-based, long-term plan that identifies and integrates the management of environmentally sensitive areas with the vision of the community, policies of local government, regulations of external agencies and the general principles of “best management” for protection of the environment (Schleppe and Arsenault 2006).

As summarized in the Windermere Lake FIM, a Foreshore Policy document does exist for Windermere Lake; however, it was prepared in 1993, only covers the east side of the lake and needs to be made current since it was intended to provide interim guidance for development in advance of the OCP being developed (RDEK 1993). The District of Invermere also commissioned and adopted a Lake Management Strategy in 2001; however it also does not cover all portions of the lake (RDEK 2008).

On March 13, 2008, the Regional District of East Kootenay presented a final draft of the OCP for Windermere Lake (RDEK 2008). The “environmental vision” of a region is guided by the beliefs of the residents and is part of what makes a region distinct (Schleppe and Arsenault 2006). The importance of recognizing and preserving environmental values are identified throughout Windermere Lake’s OCP. Firstly, policies for the document have been developed within the framework of “*Sustainable Development*” and “*Smart Growth*”. Protecting environmental areas is inherent to both of these strategies.

The <u>Goals</u> of the OCP, as they relate to the environment include but are not limited to:

- *Encourage the management of Crown land to fully consider a range of environmental, recreational, cultural and resource interests;*
- *To direct future development to areas that will minimize further habitat fragmentation and protect ungulate winter range, environmentally sensitive areas and wildlife corridors;*
- *Develop land use policies that will assist in preserving the ecological integrity of Lake Windermere, the foreshore of Lake Windermere, the Columbia River and Columbia Wetlands and the other water resources located within the plan area; and*
- *Consider opportunities for economic diversification that utilize a non-land altering approach*.

Policies have been outlined to address Windermere Lake specifically (Section 10 of the OCP). Here the lake’s environmental values of providing potable water and fish and wildlife habitat are recognized. Preparation of a formal Lake Management Plan was identified as being important. This would help direct planning so that anthropogenic impacts on the lake do not exceed the ecological carrying capacity and degrade drinking water quality. In addition to guiding the development of a Lake Management Plan, several policies relating to the environment are presented as a subset of the Lake Windermere Section (10.3), including:

- *Retaining walls, groynes or breakwaters should create fish habitat and maintain natural ecosystem function along the foreshore.*
- *Activities are to be in accordance with provincial and Federal Guidelines for the Protection of Aquatic Habitat.*
- *No new marinas or marina expansions will be supported until the Lake Management Plan is developed.*
- *Natural vegetation is to be retained and invasive species are encouraged to be controlled.*
- *Policies derived from this Fish and Wildlife Assessment Report and the subsequent Guidance document will be supported*.

“Environmental Considerations” (Section 12), makes up a substantial portion of the OCP. This section provides objectives and policy in terms of Environmentally Sensitive Areas, Wildlife Habitat and Corridors and Water Resources. A brief summary of each of these sections is provided.

<u>Environmentally Sensitive Areas:</u>
The objectives for this section are to: a) protect environmentally sensitive areas, b) support their restoration, rehabilitation or enhancement, and c) to address invasive plant species.

There are 12 policies addressing these objectives. Relevant policies will be discussed throughout the report to provide background and support analysis/mapping.

Wildlife Habitat and Corridors
The objectives of which are to a) maintain habitat connectivity to support movement of wildlife species, and to b) encourage the protection of unique natural ecosystems. There are 9 policies associated with meeting these objectives, and these as well will be further referenced throughout this document to provide support.

Water Resources
The objectives for this relate to: a) responsible use and protection of the water resources and water quality; and b) protection, rehabilitation and enhancement of wetland and riparian areas. There are 8 policies associated with meeting this objective and will be referenced in this report as relevant.

The OCP outlines that the landowner is required to obtain a Development Permit when altering the lands in Environmentally Sensitive Areas. Development permit guidelines for the protection of the natural environment are described in Section 21.4 of the OCP. Overall, *activities in environmentally sensitive areas are to be conducted in an environmentally sensitive manner that minimizes disruption or alteration of the environmental integrity.* This section of the OCP further identifies that the landowner is *to provide notice that the areas provide unique characteristics that warrant special review and consideration and prescribe appropriate mitigation. This is intended to protect valuable fish and wildlife habitat and movement corridors associated with the Lake, its wetlands and creeks and other identified environmentally sensitive areas.* Several associated Guidelines have been provided to help protect these sensitive areas.

Overall, the OCP provides a clear environmental vision showing the importance of protecting unique and sensitive areas and the water resources of the Windermere Lake area for human, fish and wildlife inhabitants. The Shoreline Management Guidelines that ensue from this study will help support these policies by providing baseline information on the foreshore species and habitats of significance and a monitoring program to review its success. The Shoreline Management Guidelines will also use a Habitat Index to provide an ecological sensitivity rating for segments along the foreshore and provide a GIS map which shows these results in order to help direct decision making. The intent is to maintain or improve the ecological value for the segments into the future. The Habitat Index can be revisited and the scores rerun in order to see if this goal is being met.

Significant portions of the Windermere Lake foreshore are not included in the OCP due to jurisdictional responsibilities. These include the lands in the Columbia Lake Indian Reserve #3, located on the southeast slopes of the lake, and in the District of Invermere, along the northwest shore. This study will review the fish and wildlife values around the entire perimeter of Windermere Lake, regardless of jurisdiction.

1.4 Objectives

The overall objectives of this study were to summarize shoreline habitat use by the different life stages of native fish and wildlife and use this information to determine the environmental sensitivity of Windermere Lake shoreline segments. These objectives will be achieved through completion of the following activities:

- Perform a historical review of modifications along the foreshore of Windermere Lake;
- Prepare a summary of the life histories of the native and non-native fish assemblages within Windermere Lake;
- Field assess and report on fish utilization and fish habitat values along the foreshore of Windermere Lake;
- Provide Site Descriptions which include identification of Shore Type for each of the 2007 sample sites, utilizing 2007 field notes and the 2006 FIM results;
- Assess wildlife (e.g., avian), wetland and other key or rare features along the foreshore of Windermere Lake;
- Prepare an index that ranks habitats along the foreshore of Windermere Lake based on biophysical attributes using existing data (e.g., 2006 FIM results and literature) and field data.
- Identify key fish and wildlife habitats around the lake and map them as Zones of Sensitivity.

This information will be used to develop guidelines for management of shoreline features. These guidelines are planned to be prepared as a separate document following the completion of this report.

1.5 Study Area

The study area for this project encompasses the foreshore of Windermere Lake. An overview of the study area showing 2006 Segment locations and respective 2007 Sample Sites is provided in Figure 1.

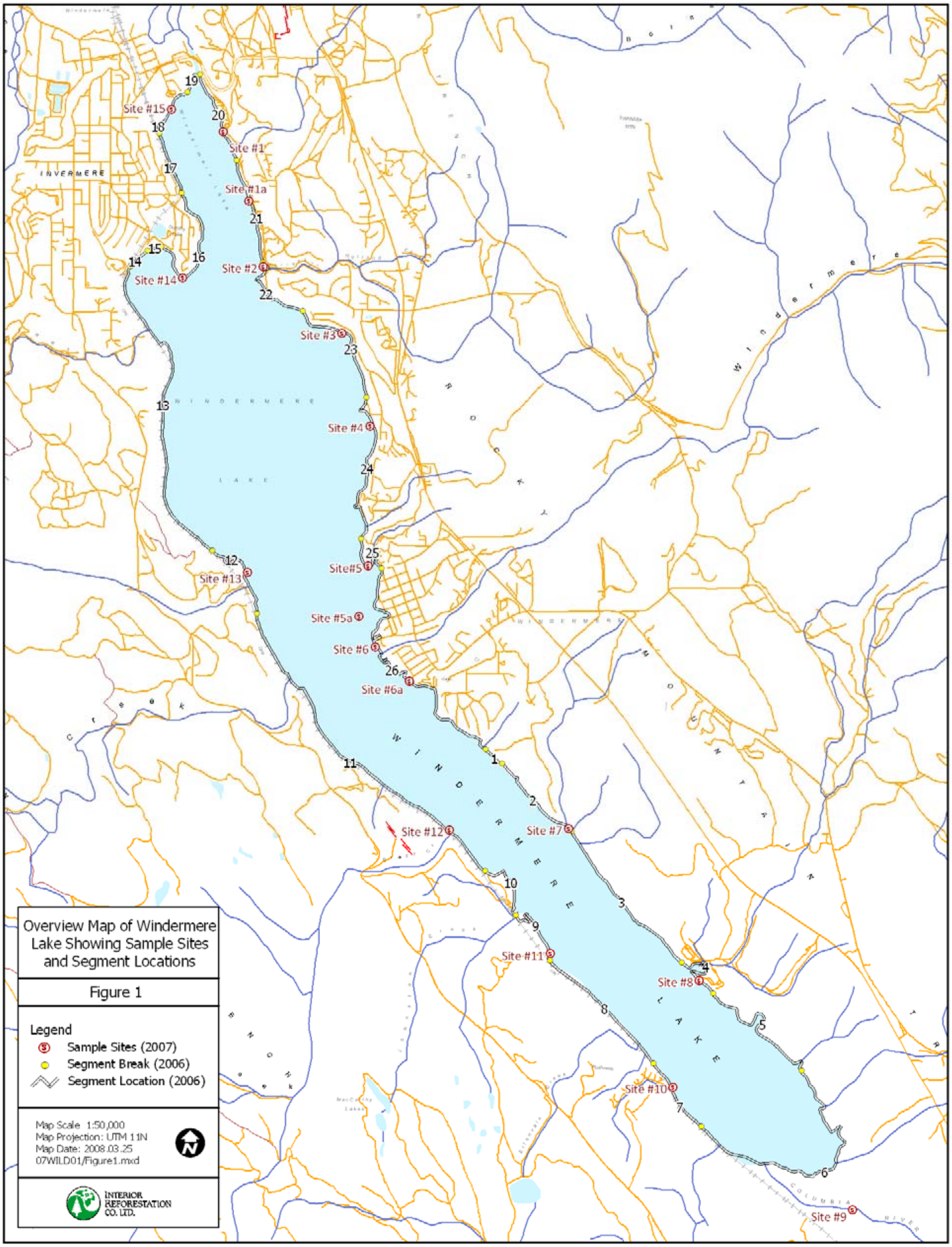


Figure 1. Overview map of Windermere Lake showing 2007 sample sites and 2006 segments.

1.6 Description of the Windermere Lake Watershed

Windermere Lake is located in the Rocky Mountain Trench within the Upper Columbia River Valley. The north and north east shores of Windermere Lake are developed and include the towns of Invermere and Windermere. The west and south-east shores are less developed and their lake habitats are characterized by dense aquatic vegetation. With the exception of Columbia River, Windermere Creek is the largest tributary of Windermere Lake. Several tributaries flow into Windermere Lake, including Windermere Creek and Holland Creek along the western shore; and Goldie, Salter and Brady Creeks along the eastern shore. The Canadian Pacific Railway runs along the western shore of the lake. The CPR has altered the natural connectivity of many of the eastern shore creeks mouths, while at the same time it has protected habitat from development. The upland ecosystem is characterized as being in the Interior Douglas Fir, very dry cool (IDFxk) biogeoclimatic zone, containing pockets of native grasslands and open forest. The lake is an important linkage to the Columbia River and its wetlands complex. The unique biodiversity contained in the area provides important wildlife habitats, in particular for birds and ungulates.

2 Methods

The Okanagan Lake F&W Report (Schleppe and Arsenault 2006) was used as a guide and template for conducting this fish and wildlife assessment for Windermere Lake. Several activities were undertaken including a historical air photo analysis, fisheries assessment, wildlife assessment, habitat indexing, and determination of zones of sensitivity for the foreshore. In general, members of the EKILMP conducted field activities, while Interior Reforestation completed data analysis and report preparation. The methods employed to complete each of these components are described below.

Field Reconnaissance (EKILMP)

Members of the EKILMP conducted the field-sampling component for this study, which included sampling fish, wildlife and aquatic invertebrates along the foreshore. Individuals involved in data collection included Peter Holmes and Kristin Murphy of MoE, and Bruce MacDonald, Tola Coopper and Louise Porto of DFO. Fieldwork was completed during the summer (July 17-19, 2007) and the fall (September 25, 2007) periods.

Since time and funding resources did not allow for all foreshore sites to be sampled, field staff selected representative areas for sampling. A review of the 2007 FIM results for Windermere Lake was completed, and sites were selected in order to review areas from each of the foreshore types and areas with different types and degrees of development. As well, some sites were selected based on their potential for development pressure. In total, 18 sites were assessed, with each of the foreshore types represented, at varying degrees of disturbance. Shore Type and Level of Disturbance were confirmed during the office analysis by Interior Reforestation staff and are detailed further in Section 2.4. Site locations were recorded using a global positioning system (GPS) unit.

2.1 Fish Sampling

Fisheries assessment at each of the foreshore sites was conducted using snorkel, seine and/or minnow trap techniques. Surface observation from (e.g., from the boat shore or dock) were also documented. Table 2 lists the sampling technique(s) utilized at each site and the respective date/season. Overall, the snorkel survey was the main sampling technique utilized. Snorkel surveys were employed at all except one site in the summer and all but five sites in the fall. Seine and minnow trap techniques were utilized when necessitated by habitat conditions. For instance seine and minnow traps were used under silty conditions when visibility was low. Fish measurement data was not collected during summer and fall surveys. The following details were recorded for each site sampled: a description of substrate type, general aquatic vegetation details, air temperatures, water temperatures, numbers of each fish species, life stage for fish, as well as site observations.

The snorkel survey area was intended to be consistent for each of the sites sampled. Generally, the survey ran along 200 m of shoreline and extended approximately 30 m wide into the lake. There was some variation to this, if for example, visibility was low or the key feature area to be sampled was of a different size. The perimeter of Windermere Island for instance (Site 5a) was estimated to be between 200 and 400 m and the Irvine property retaining wall (Site 1a) was only 50 m.

Table 2. **Sampling dates for fisheries assessment of the Windermere Lake foreshore**

SITE	SUMMER				FALL			
	SNORKEL SURVEY	SEINE	MINNOW TRAP	SURFACE OBSERV.	SNORKEL SURVEY	SEINE	MINNOW TRAP	SURFACE OBSERV.
1	19-Jul-07				25-Sep-07			25-Sep-07
1a	19-Jul-07			19-Jul-07	25-Sep-07			25-Sep-07
2	19-Jul-07	19-Jul-07	19-Jul-07		25-Sep-07			25-Sep-07
3	19-Jul-07					26-Sep-07		
4	18-Jul-07					26-Sep-07		
5	18-Jul-07				26-Sep-07			
5a	18-Jul-07		19-Jul-07		26-Sep-07			
6	18-Jul-07				26-Sep-07	26-Sep-07		
6a	18-Jul-07				26-Sep-07			
7		18-Jul-07						
8	18-Jul-07	18-Jul-07			25-Sep-07			
9	18-Jul-07		18-Jul-07		25-Sep-07			
10	17-Jul-07							
11	17-Jul-07	17-Jul-07				25-Sep-07		
12	17-Jul-07				25-Sep-07			
13	17-Jul-07				25-Sep-07			
14	17-Jul-07				25-Sep-07			
15	19-Jul-07	19-Jul-07			25-Sep-07	25-Sep-07		
Air Temp. Range:	19-35 °C				9-19 °C			
Water Temp. Range:	19-25 °C				10-14.5 °C			

The beach seine was 30 m in length. A 5 mm stretch mesh was used to sample an area between 15 and 200 m along the shore. This was done once per site. Distances seined depended on site specific conditions, including obstructions along the shore. Beach seining was conducted after the snorkel survey was completed. Fish were collected from the net, identified to species (where possible), assessed for life stage, counted, and returned to the lake within the same area where they were captured.

Minnow trapping was only used at three sites during the summer and not employed during the fall due to limited survey and sampling time available. Standard baited (e.g., cat food) Gee traps were placed on the lake bottom, and left in place as follows:

- Site 2 – overnight (between 12 and 15 hours)
- Site 5a – as Site 2 above
- Site 9 – 30 minutes

A minimum of two traps were placed at each of the three minnow trap sites. Traps were collected and numbers and life history stage for each species of fish were recorded. Fish in the traps were released back to the lake within the sampling site.

2.2 Aquatic Invertebrate Sampling

Aquatic invertebrates were sampled in unison with the fish and wildlife sampling. A standard sized D-net was placed into the water within the fish sample site and the substrate was disturbed by kicking and vigorous hand rubbing of larger substrates (i.e., large cobble and small boulders) to dislodge invertebrates. For each site, the total area disturbed was approximately 2 m x 2 m, and the duration of the disturbance was 1.5 to 2 minutes. The contents were transferred from the D-net to a white tray and invertebrates were identified by order. Following identification, all of the invertebrates were returned back to the water.

2.3 Wildlife and Rare and Endangered Species Observations

The foreshore wildlife assessment was completed during the July and September field program by Peter Holmes (July) and Kristin Murphy (September). The assessment generally involved walking along the upland side of the foreshore area (approximately 200 m length and 50 m or more in width) at each site where a fisheries assessment was completed. Species presence (particularly bird) and attributes in and around the foreshore that are important to wildlife were recorded. Bird presence was reported using both visual and audio accounts. Photo documentation was also completed.

Office Analysis and Reporting

All analysis and reporting for this project was completed by Interior Reforestation professionals. Raw data from the field assessments was provided to Interior and was used as the basis for this analysis. The information provided in the FIM Report (McPherson and Michel 2007) was also used as a baseline for this project. Segment data and descriptions are examples of information carried over from the FIM report. Interior Reforestation staff consulted with the EKILMP field crew throughout the analysis in order to ensure that the report was consistent with their objectives and field findings. The office analysis and reporting involved completing several activities including: data entry, site descriptions, historical air photo analysis, fish species ecology and life history literature review, fish species abundance reporting and discussion, habitat indexing, determination of zones of sensitivity, and wildlife and rare and endangered species data analysis. GIS mapping was a data presentation tool used for each of these activities.

2.4 Data Entry, Shore Type and Site Descriptions

All fish, aquatic invertebrate and wildlife data was entered into spreadsheets for summary (*See* Appendix A.).

A detailed description was completed for each site assessed during the field component. An important initial task for describing the sites was to accurately identify the Shore Type, as this was not identified during the field program. In the FIM report, Shore Types along the Windermere Lake foreshore were identified by percentage for each Segment using Resource Inventory Committee definitions (Table 2). These FIM designations did not pinpoint Shore Type at the site level required for this analysis. Shore Type was a particularly important parameter to identify since it was used to compare lake habitats along the foreshore for the Okanagan Lake F&W Report and would be used in the same way for this assessment. For instance, it was a basis for comparing fish utilization along the lake in the fish abundance analysis. A Shore Type was attributed to each site using field note details, site photos and consultation with EKILMP field professionals. There was some difficulty with doing this activity in the office, since for some sites two Shore Types were apparent (i.e. vegetated on the shore with gravel beach littoral zone, or wetland at one end with sand beach along the other). Because the Shore Type was important to comparing and discussing different fish habitats around the lake, the most prevalent Shore Type was selected, particularly as it related to fish habitat. For instance, if the shoreline appeared to be gravel beach, but in the lake wetland attributes were prominent, the site was described as a Wetland Shore Type.

Table 3. Predominant shore types as defined by the Resources Inventory Committee (1999) and *Interior Reforestation.

SHORE TYPE	DESCRIPTION	EXTENT OF LAKE FORESHORE
Cliff/Bluff	Adjacent to steeper slopes, usually indicating a steep-sided lake basin or sudden drop-off	15%
Sand Beach	Often associated with alluvial fans or other shoreline deposition areas.	8%
Gravel Beach	Often associated with low gradient foreshore, coves with pockets of riparian vegetation among steeper hillsides or alluvial fans.	7%
Vegetated Shoreline	Characters of undisturbed foreshore with narrow littoral width. Vegetation is commonly shrubs and small trees. Overhanging vegetation occurs to the mean water level.	29%
Low Rocky Shore	Cobble, boulder or bedrock substrate often prevalent along the base of steeper shorelines.	19%
Wetland	Characteristic of wide littoral zones with fine substrates promoting abundant emergent vegetation such as sedges, reeds and cattails.	18%
Creek Mouth*	Associated with the outlet of a creek	5%
Modified*	Site that has been modified along most of its length (e.g. with retaining walls, docks, gabions, boat houses etc.) containing few natural features.	Not calculated

Two new Shore Types were added to those provided in the FIM to further define foreshore habitats assessed. Creek Mouth was a new Shore Type attributed to sites located at the outlets of creeks. At sites where extensive disturbance was reported a 'Modified' tag was attributed to the Shore Type. This was used to differentiate between highly modified and natural or moderately impacted sites. Using this tag a creek mouth with a marina on one side and docks on the other, for instance, would be designated as a Modified Creek Mouth Shore Type; or a low rocky shoreline lined with retaining walls and docks would be a Modified Low Rocky Shore Type. Vegetated shores and wetlands, due to their inherent 'natural character', would become non-existent if highly disturbed. A "Modified" classification was thus assigned to wetlands or vegetated shores if they were even moderately disturbed. The modified tag was only used during the Windermere Lake Fisheries Analysis. The modified tag was not used during the development of the Habitat Index, since disturbance indicators were built into the habitat matrix through specific rankings calculations.

2.5 Historical Air Photo Analysis

1968 and 1988 air photos and 1995 and 2004 orthophotos were analyzed in order to determine changes which have occurred over time along the shoreline. The air photos were scanned and geo-referenced. Only partial coverage (approx. 30% of the lake) was available for the 2004 orthophotos. Comparisons were made between the years reviewed in order to assess the extent of shoreline length disturbed and to identify whether or not there had been any noticeable changes in wetland size. The review of lacustrine wetland habitats was limited to only the larger south end wetlands, since they were the only ones evident in the airphotos.

The shoreline width reviewed extended 50 m upland from the lakeshore. This distance is consistent with that of the Habitat Index Section *(See* Section *2.10*), where the Creek Mouth area extended 50 m upstream from its confluence at the lake, in terms of potential fish habitat. For the air photo analysis, any human induced modification, structure or alteration was considered a disturbance. The total percentage of the shoreline disturbed was calculated for each year and results were compared between the years.

Human induced changes to the lake were considered to varying degrees throughout this report, depending on the objective of the respective section. This historical photo analysis section was most intensive, with any human induced change interpreted as a disturbance. During the measurement of vegetation bandwidth in the Habitat Index, any impervious structure greater than 5 m was considered an alteration (2.10 Habitat Index). Conversely, in order for a site's shore type to be designated as "modified", in Section 2.4 (Data Entry, Shore Type and Site Descriptions), the site had to show a high degree of disturbance along both banks; allowing for a comparison of extreme situations for biological data collected (fish and birds).

2.6 Fish Species Ecology and Life History Literature Review

A literature review on the ecology and life history for each fish species known to inhabit Windermere Lake was completed. This resulted in a one-page (approximate) summary defining important biophysical characteristics of habitats during the different life history stages, for each of the 14 native species and 4 non-native species previously reported in the lake. The Okanagan Lake report (Schleppe and Arsenault 2006) provided life history information for 10 out of 18 of these species. In order to provide cost savings and efficiencies to this project, it was initially intended that all applicable fish species information from the Okanagan F&W report would be generally inserted into the Windermere Lake report. Prior consent was received from EBA (Darryl Arsenault *pers. comm*.) to utilize the summaries. The fish information provided in the Okanagan F&W report, however, was not used to the extent anticipated, because for many species more current or appropriate local information was available. This included studies specific to the Upper Columbia Basin and Windermere Lake as well as the BC specific information provided in the newly published book 'Freshwater Fishes of British Columbia' (McPhail 2007). A review of non-native species was also included in this report, due to their known high incidence in the lake. The non-native species preferences and interactions with native species were discussed, as these details were considered an important component for understanding Windermere Lake's overall health.

According to the FIM report, the fish species that required a literature review and detailed ecology and life history write-up were as follows:

<u>Native species</u>
- bull trout (*Salvelinus confluentus*);
- rainbow trout (*Oncorhynchus mykiss*);
- kokanee (*O.*);
- mountain whitefish (*Prosopium williamsoni*);
- westslope cutthroat trout (*O. clarkii lewisi*);
- burbot (*Lota lota*);
- chiselmouth chub (*Acrocheilus alutaceus*);
- lake chub (*Couesius plumbeus*);
- torrent sculpin (*Cottus rhotheus);*
- peamouth chub (*Mylocheilus caurinus*);
- largescale sucker (*Catostomus macrocheilus*);
- longnose sucker (*C. catostomus*),
- longnose dace (*Rhinichthys cataractae*);
- redside shiner (*Richardsonius balteatus*);
- northern pike minnow (*Ptychocheilus oregonensis*); and
- prickly sculpin (*Cottus asper*).

<u>Non-native species</u>
- eastern brook trout (*S. fontinalis*);
- largemouth bass (*Micropterus salmoides*); and
- pumpkinseed (*Lepomis gibbosus*).

2.7 Fisheries Analysis

The second part of the fish species summary involved discussing Windermere Lake specific data and identifying important habitats and interactions for each species, where possible, utilizing 2007 field assessments and historical accounts. Both quantitative results (e.g., from the 2007 snorkel survey abundance results) as well as qualitative observations (considering results from other 2007 sampling techniques) were utilized. Summer and fall data was analysed and presented separately in order to provide seasonal distinctions in habitat use and populations.

Data was generally not analysed using statistical methods since the sampling program was designed only to allow simple analysis of data, such as presence/absence or calculation of means. In order to conduct statistical analysis, for instance, more replication within habitat unit types would have been necessary. Relative abundance was calculated for each species sampled in order to analyse the use of particular shore types. Relative abundance was only calculated on snorkel survey data, as this was the most consistent sample technique that was utilized at almost all sites. In accordance with the Okanagan Lake F&W Report, relative abundance was calculated using data grouped across similar shore types. For each season all fish from one shore type were pooled and the relative abundance for the particular shore type was calculated. This method assumed that if fish were sampled along a particular shore type, utilization of that shore type would be equal in all similar shore types. Following this assumption, if mountain whitefish had a high abundance in the wetland area sampled, then it was assumed that all wetlands would be equally utilized by mountain whitefish. Relative abundance results were graphed.

When raw data was being considered in this analysis, there were a few additional assumptions made. Where raw data provided numbers that were not absolute (e.g., >200 or 100+), only the whole number (e.g., 200 or 100) was considered for mathematical and graphical purposes. If a range of fish observed were reported (e.g. 25 – 50), the average of the range was used for this analysis. Another assumption was that if the life stage of fish field entry was not recorded, it was assumed that the fish was an adult. This last assumption was supported through communications with DFO (L. Porto pers. comm.) and is identifiable in the raw data spreadsheet as being in red type.

2.8 Aquatic Invertebrate Results

Under this contract, invertebrate sampling data was to be limited to simply transferring the results from a hard-copy to an excel spreadsheet. A summary by Species Grouping by Order of aquatic invertebrates was also presented.

2.9 Wildlife / Sensitive Species and Habitats

Three key activities were completed for the wildlife and sensitive species component of this study. First, all wildlife observations made during the field sampling program were listed, including the bird data, which was the key wildlife information collected for each site. Second, a review of the BC Conservation Data Centre Records was conducted to identify sensitive species potentially in the area; and any sensitive species identified in the field were discussed. Third, all wildlife habitats of significance not included in the ZOS Section, were discussed.

2.10 Habitat Index

Schleppe and Arsenault (2006) estimated the environmental sensitivity or biological value of physical characteristics of the shoreline in the Okanagan Lake F&W Report using a Habitat Index. This involved incorporating physical and biological data into a detailed modeling analysis in order to rank overall values for the segments. For consistency and comparison between lake systems, the approach at Windermere Lake for this activity closely followed that of the Okanagan Lake study. Interior Reforestation made appropriate modifications to the analysis, when necessary, in order to account for attributes of local significance including: species present, site data collected and priorities/input from EKILMP professionals. Schleppe and Arsenault (2006) deserve special recognition for developing this complex matrix and Interior Reforestation is grateful that EBA granted permission for the report to be used on other lakes including Windermere Lake. In order to save time and costs, most of the detailed description of how the Habitat Index activity was completed was taken directly from the Okanagan Lake F&W Report (Schleppe and Arsenault 2006) and inserted here in the Habitat Index methods for Windermere Lake. In this section, all of Schleppe and Arsenault's (2006) method descriptions are presented in bold and italics, while Interior Reforestation's inclusions are provided as normal text.

An index is defined as a numerical scale used to compare variables with one another or some reference number. Thus, an index can be used to categorize or rank variables, such as shoreline segments, to one another to determine their contribution to fish or wildlife habitat. An index was chosen because a variety of physical and biological data has been collected for the Windermere Lake Foreshore during this assessment and other projects (e.g., FIM). ***Thus, there is adequate background information to compare sites. The Habitat Index consists of physical parameters, such as substrate type, shore type, etc. A mathematical relationship that compares these parameters (variables) was used to determine the ranking or environmental sensitivity of a particular shore segment***.

The Habitat Index was constructed using various parameters collected during the FIM of Windermere Lake, data collected during this assessment and literature findings. ***The index was designed in such a way that positive habitat features, such as near shore terrestrial vegetation and shore type, etc, added to the habitat value, while negative habitat features, such as docks, marinas and other high level impacts decreased the habitat value. Index parameters were weighted based upon their importance or overall contribution to aquatic habitat. The same premise for weighting negative habitat parameters was also incorporated into the index. The guiding principle for using positive and negative parameters was to compare shoreline segments to their natural state. Thus, anthropogenic features were all considered to be negative habitat features, whereas natural features were considered to be positive habitat features.***

2.10.1 Habitat Index - Parameters

The Habitat Index was used to estimate the environmental sensitivity or biological value of physical characteristics of the shoreline because these parameters were quantifiable and did not tend to vary as much as biological data. Biological data was incorporated into the index based on known life history information (literature findings) and upon data gathered from fish sampling at the different shore types. Fisheries data for the different shore types were incorporated into one parameter (Shore Type) and a description of how this was done is found in subsequent sections. The physical values of other parameters were mostly obtained from data collected during the FIM for Windermere Lake. The parameters incorporated into the analysis and their respective calculations and weightings followed the Okanagan F&W report methods closely; however some modifications were made to accommodate the specific Windermere Lake environment and data, and these have been noted. The complex analysis that determined weightings for individual shore types, for instance, were reviewed in detail and refined to incorporate the Windermere Lake fish collection data, habitat specificity obtained from the literature review and local rarity ratings. The following section briefly discusses each of the different aquatic habitat parameters that were used to create the Habitat Index with respect to why they contribute or detract from the habitat value of a shore segment. Table VII (Appendix A) summarizes the different physical features that were incorporated into the index, while Table VIII provides a summary of Habitat Index parameter scores for each Windermere Lake segment.

Percentage Natural

The percentage of relatively natural shoreline was collected during the FIM performed in 2007. Natural shorelines have a greater fisheries, wildlife and ecological value because they tend to have fewer anthropogenic disturbances that can reduce the habitat integrity (e.g., docks) and are therefore more environmentally sensitive. Brazner (1994) indicated that fish assemblages were influenced by development in Green Bay in Lake Michigan. Incorporation of a parameter that quantifies the level of disturbance is important because more natural areas likely function better and are more similar to historical ecosystems than highly disturbed shorelines. This parameter was a large component of the index because natural shoreline is indicative of natural habitat, which has the highest environmental sensitivity.

The percentage of foreshore in natural/undisturbed condition was determined for each Segment during the FIM. As Table VII provides, the percentage of natural shoreline for each segment was divided by 100 (to make it a whole number) and this value was multiplied by 10. The model was developed so that a maximum value of 8 could be attained for a segment (Schleppe and Arsenault 2006). Thus a segment that was 100% natural would receive a point score of 8 for this parameter.

Shore Type

Shore Type was mapped during the FIM of Windermere Lake. For this study, Creek Mouth Shore Type was also added to the database because of its importance to fish and fish habitat. Creek Mouths foreshore length was estimated using orthophotos. The Creek Mouth length along the foreshore was defined by its zone of influence on the lake and ranged from 40-90 m depending on the size of the creek/stream. The Shore Type that the Creek Mouth was most likely included in during the FIM was also determined (i.e. Vegetated Shore or Wetland) using the orthophotos and the Creek Mouth length was subtracted from it, so that the overall length for the segment stayed the same. The Griffith report (1994) was used to provide additional background on tributaries (e.g., conditions at the mouth, fish access). The percentage of each shore type along respective segments was recalculated with the inclusion of Creek Mouth lengths. For this study, the Creek Mouth area extended 50 m upstream (downstream for the outlet to Columbia River) from its confluence at the lake when considering potential habitat available to fish. This foreshore width definition of 50 m upland or upstream from the lakeshore is consistent with that of other sections in this report (*See* Section 2.5 Historical Air Photo Analysis). The revised Segment data which includes the Creek Mouth's as a Shore Type will be provided as a separate spreadsheet to EKILMP members for their database.

Determination of Shore Type score and an overall Shore Type score for each segment was an involved process which considered both biological and physical data. ***Shore Type was included as a parameter in the index because it is the only parameter that breaks the shore zone into distinct segments that correspond to a specific area of land. The Shore Type parameter assumes that all shore types would have similar physical features in their natural state and that habitat utilization by the different species is similar in identical shore types (e.g., the use of one sand beach by fish is similar to the use of a different beach in another area). Based upon field observations, this is generally true and therefore applying the described matrix should produce a reliable estimation of the importance of different shore types to different species and their associated life stages.*** Determination of Shore Type values for the Habitat Index involved a complex analysis. Overall, the analysis was conducted using Table V- Fish Species Habitat Matrix and Table VI Determination of Shore Type Score (Appendix A), and the results were fed into the Habitat Index Table VII under Shore Type. The Shore Type analysis incorporated fish collection data, habitat specificity and local rarity to determine the weighting of different shore types for the index. The analysis also involved a differential weighting of different fish life stages. The 5 main steps undertaken in this analysis were as follows:

<u>Step 1. Determining Habitat Specificity</u>

The shore type utilization assessment first required determining **Habitat Specificity** for each native fish species in the lake (Table V). Habitat Specificity was determined by identifying the different shore types utilized during each life history stage (i.e., General Living, Reproduction, Rearing/Nursery and Staging) for each species. Reproduction habitats were areas where adults laid their eggs or spawned. Staging habitats were often the same as Reproduction habitats since they were considered to be the areas where adults gathered just prior to spawning. Rearing/Nursery habitats were areas used by young-of-the-year and juveniles. General Living habitat was defined as that used by adults when they were not in any of the other life history stages. This fish species habitat matrix was created using habitat data collected during the fisheries assessment and published literature findings. For fish species consistent with Windermere Lake, the Okanagan Lake F & W Report was a key source for habitat information, since it reviewed habitat use in a similar but more rigorous sampling approach. Detailed background on habitat utilization for each fish species is found in Appendix C (Fish Species Summaries). ***In the matrix, fish species using different shore types were initially assigned a score of 1 or 0 (relating to presence/absence) for each different life stage.***

<u>Step 2. Determining Habitat Selectivity</u>

Habitat Selectivity was then determined using the Habitat Specificity results for all of the native fish species. This involved counting the total number of shore types used (for all life stages) for a species. This provided the overall extent of shore type utilization for each species. For example, mountain whitefish used 7 shore types for general living, 3 shore types for reproduction, 7 shore types for rearing/nursery and 3 shore types for staging for a total habitat use of 20 (*See* Species Habitat Use column in Table V). Using the Species Habitat Use counts, Habitat Selectivity was determined, with each species fitting into one of the following categories:

- High - if the species was selective, and used few habitats. Species of high habitat selectivity were determined to be bull trout, westslope cutthroat trout, rainbow trout, kokanee, longnose dace and burbot;
- Moderate – if the species was less selective about habitats utilized and used quite a few habitats. Species of moderate habitat selectivity were determined to be torrent sculpin, mountain whitefish, longnose sucker and largescale sucker;
- Generalist– if the species had a low selectivity, using most, if not all of the available shore types throughout its various life history stages. Species determined to be generalists at Windermere Lake were northern pikeminnow, lake chub, peamouth chub and redside shiner.

<u>Step 3. Weighting of Habitat Specificity Scores and Determining Overall Habitat Score</u>

Once Habitat Selectivity was determined, the Habitat Specificity for each species' lifestages was weighted accordingly so that an overall **Habitat Score** could be determined (*See* last row of Table V). ***Reproduction and Rearing/Nursery life stages are highly important, and were weighted higher in the final analysis because of their importance or contribution to fish habitat. For species categorized as having a high specificity, scores in the matrix were assigned a 3 rather than a 1 for Reproduction and Rearing/Nursery life stages. A 2 was assigned for species with moderate habitat specificity for these two categories. Finally, because staging areas often overlap or coincide with reproductive areas, a lower score of 0.5 was assigned to generalist species staging habitat, while high and moderate specificity species were assigned a 1 for staging habitats.***

<u>Step 4. Determining Shore Type Score using Summated Habitat Score and Local Rarity Score</u>

A Total Shore Type score was determined for each Shore Type by adding the respective Shore Type's Habitat Score (summated for all species and life history stages) to the Local Rarity Score *(*Table VI). The **Local Rarity** component was determined using the total length of shoreline for each shore type along the Windermere Lake Foreshore. Respective lengths for each Shore Type were obtained from the FIM report considering the changes made to incorporate Creek Mouths. The shore type with the longest shoreline length was assigned the minimum score (0) and the shore type with the shortest shoreline length was assigned the maximum score (7). Considering this, Creek Mouth Shore Type received a score of 7 because cumulatively it covered the shortest length of the shoreline (1632 m), and Vegetated Shore received a value of 1 because it was found along the greatest extent (10,214 m) of shore line at Windermere Lake. The total Shore Type Score was then ordered from highest to lowest, and the highest shore (Creek Mouth) was assigned a 12, the next highest (Gravel Beach) was assigned a 10, etc. The end result of these biological and physical steps relating to shore type was the determination of a **Score for each Shore Type,** which was used in the Habitat Index model (Table VII).

Step 5. Calculating Shore Type for each Segment

The Shore Type Score was used to calculate a shore type value for each segment in the Habitat Index Model (Table VIII). This was done by multiplying the percentage of all shore types found in a segment by their respective Shore Type Scores and by adding these together in order to determine the **Shore Type Score for each Segment**. The maximum model value for this was 12. Most segments had more than one shore type, so each shore type score for that segment had to be determined and all summated together for that segment.

Additional Shore Type Considerations

Note that the extent of wetlands and their values to fish and wildlife are not appreciably accounted for in the Shore Type rating. At Windermere Lake, Wetlands Shore Types often overlapped with other shore types. Wetlands provide substantial benefits to fish and wildlife not incorporated into the Fish Species Habitat Matrix (i.e. important for primary production). Their value to fish (i.e. for nursery habitat) is expected to be higher than that shown in the Fish Species Matrix. Wetlands were difficult to assess at Windermere Lake since fish could elude observance due to cover features and silty conditions. There was little detail in terms of fish utilization of wetlands in the literature. This may be because wetlands are not common in representative BC lakes sampled, for example, there was 0 % wetland in Okanagan Lake sample area. As a result, wetlands have also been incorporated into the Habitat Index as a separate parameter, which has been described further below.

Substrate Type

Lakebed substrates are extremely important for a variety of reasons. First, species generally deposit eggs onto the lake or streambed substrates and certain species are extremely selective about the substrate types used for egg deposition. Substrates, in combination with wave energy and other factors, also act as rooting areas for aquatic vegetation that are important for providing cover from predators, foraging opportunities for benthic macro-invertebrate, and three-dimensional structure (Randall et al. 1996). Substrate composition data were collected during the FIM and were gathered by estimating the percentage of boulders, cobbles, gravel, fines, and bedrock.

The importance of different substrate types was determined by reviewing life history requirements for the different species. In general, most species use cobble/gravel lake substrates for spawning, while areas of finer substrates tend to be used more for foraging because they contain more aquatic macrophytes. Substrates used for reproduction were considered to be more critical than those used for foraging because spawning areas with suitable substrates are often a limiting factor in the reproduction life stage of different fish species. Data collected during the fisheries assessment, coupled with published species life history data, were used to rank substrates from most important to least. Values attributed to each substrate type were consistent with that utilized by Schleppe and Arsenault (2006). Cobbles were assigned a score of 10, gravels were 8, boulders were 6, fines were 4 and bedrock was 2. These values were multiplied by the percent of the substrate type in each Segment. A total score of 10 was attributed to a Segment based on substrates.

Vegetation Bandwidth

Upland vegetation bandwidth was incorporated into the Windermere Lake Habitat Index model because ***it is an important characteristic that can be used to determine the importance of the shoreline to fish and fish habitat and wildlife habitat. Vegetation contributes to the habitat by providing insect fall for example, that can be an important component of prey items for fish and lake productivity. Vegetation provides a significant amount of nutrients to a system via allocthonous inputs of organic matter through litter fall, large woody debris, etc. Vegetation is also an important factor when determining the value of habitat for wildlife.*** At Windermere Lake, for instance, this parameter incorporates grassland habitats, migration corridors and sensitive species habitats (i.e. badgers). Because vegetation bandwidth assigns a high value to undisturbed areas, it also captures clay bank (or cliff/bluff) habitat which is important to wildlife (i.e. nesting for swallows). ***Thus, shoreline vegetation is an important characteristic that should be considered when ranking the importance of shore segments. This factor has been incorporated into regulatory guidelines (e.g., Riparian Areas Regulation),*** which have been enacted in other regions (e.g., Southern Interior and Lower Mainland).

A mapping analysis of the Windermere Lake foreshore was performed to analyze vegetation bandwidth. ***Vegetation bandwidth was measured every 200 m of shoreline, or for a total of four measurements per segment. In segments smaller than 200 m, two measurements were taken. Vegetation bandwidth was measured to the first impervious structure, such as road or houses.*** The potential vegetation measurements did not treat small paths of less than 5 m, including the railroad tracks (located along the western shoreline) as impervious structures. In accordance with the FIM, it was assumed that although the railway tracks were a disturbance, they currently do not highly impact the vegetation of the overall area. In some ways railroad tracks help to protect the foreshore vegetation by curbing residential development. The vegetation was reviewed to a maximum distance of 50 m upland from the lakeshore. This distance is consistent with that of other parts of this report (e.g., Section 2.5 Historical Air Photo Analysis). ***The average vegetation bandwidth of each segment was used in the Habitat Index and is considered to be representative of the shoreline segment. This analysis was very similar to the Simple Riparian Areas methodology used to determine vegetation potential.***

Littoral Zone

In the Okanagan Lake foreshore assessment the littoral zone was characterized in terms of its depth for each of the segments. Areas >10 m were classified as Shallow; areas 10- 50 m were Moderate and areas >50 m were rated as High. The littoral zone of Windermere Lake is all categorized as Shallow (>10 m), because the lake's average depth is 3.4 m and maximum depth is 6.4 m. As a result, the littoral zone depth is not considered a significant factor for comparing segments at Windermere Lake and was excluded from the Habitat Index. Lacustrine Bay Marshes appropriately replaced this parameter since they provide similar benefits to fish and wildlife, including being important areas for primary productivity.

Wetlands

Wetlands are known to be important to the food chain, rich in biodiversity and extremely valuable areas for fish and wildlife (See 3.6.3 Zones of Sensitivity). Substantial areas along Windermere Lake's shoreline are known to contain wetland habitats. The wetland Shore Type classification in the FIM did not present the full extent of wetlands within Windermere Lake. This may have been because wetlands overlapped with other significant shore types (e.g., occurred at the foot of a cliff/bluff or alongside a vegetated shore or at the outlet of a creek) or because only 'conventional' wetlands that were encompassed by terrestrial habitats were considered. Lakeshore wetlands nonetheless, were identified during a separate assessment conducted by Wildsight (2006). During this assessment, wetlands existing within Windermere Lake were inventoried and their locations were recorded using GPS. Wildsight defined these wetlands as areas containing emergent wetland vegetation (e.g., cattails, rushes and sedges).

According to the Canadian Wetland Classification System (Wetlands Research Centre 1997), the wetlands associated with Windermere Lake foreshore are marshes. There are three key characteristics which suggest this (Wetlands Research Centre 1997):

1) minimal or no peat accumulation (although thin layers of both mineral and organic silt may be present);
2) they are located in periodic or persistent standing water or slow moving surface water which is generally nutrient rich; and
3) they are comprised predominantly of emergent graminoid vegetation such as rushes, reeds, grasses and sedges. Other common plants known to marshes are shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species, and non-vascular plants such as brown mosses, liverworts, and macroscopic algae.

The wetlands located directly in the lake waters along the shoreline, as identified by Wildsight are the focus of this parameter because of their importance to both fish and wildlife. These wetlands are most likely Lacustrine Bay Marshes according to the Canadian Wetland Classification System (Wetlands Research Centre 1997; Figure 2.). Further details on these wetlands as provided by the wetlands Research Centre are as follows:

> Lacustrine Bay Marshes occur along the shores of permanent inland, open water bodies and lakes. They receive their water from a combination of sources including adjacent lakes, rivers and streams entering the lake, surface runoff, and ground water discharge. They are associated with gently sloping offshore zones or shoals of shallow bays of more permanent lakes and merge with deeper water to about 2 m. Lacustrine Bay Marshes often experience water level fluctuations.

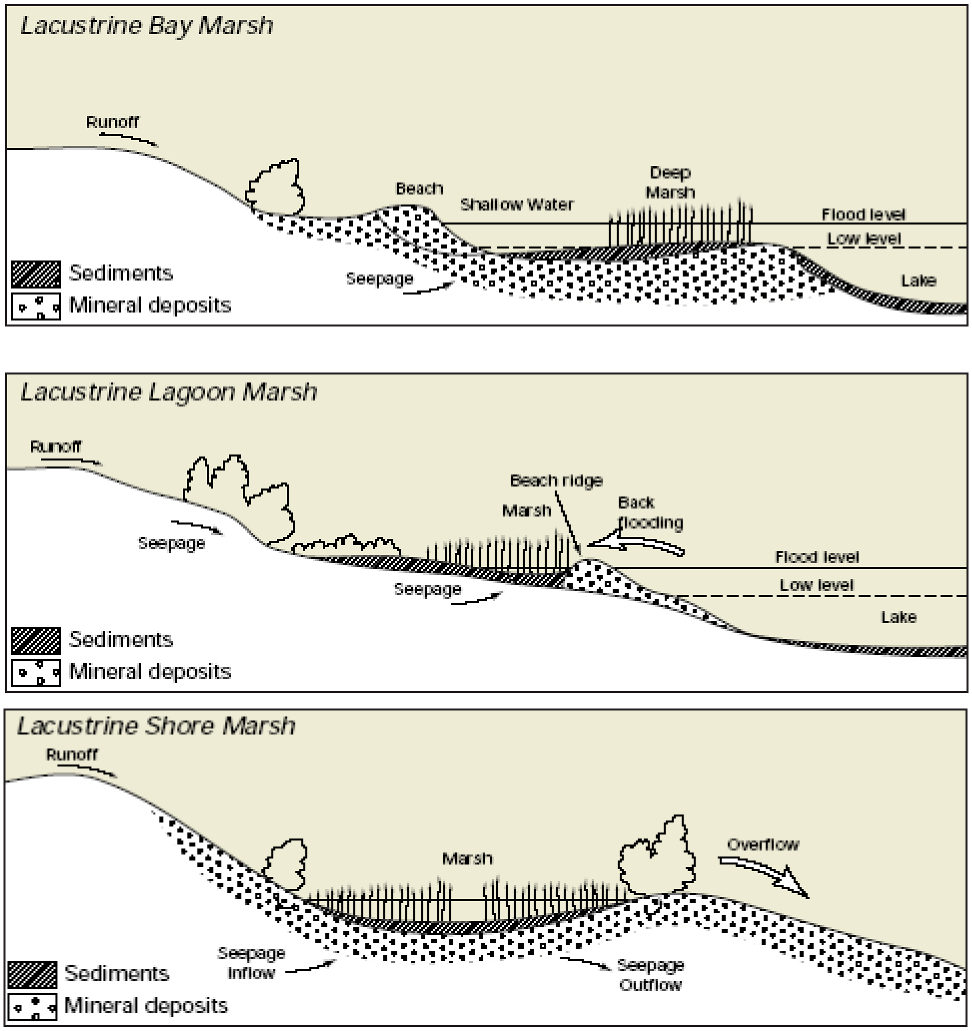


Figure 2. Lacustrine bay marsh according to the *Canadian Wetland Classification System* (Wetlands Research Centre 1997).

The other marshes along the foreshore of Windermere Lake appear to be Lacustrine Lagoon Marshes and Lacustrine Shore Marshes (Figure 2). These marshes also occur on lacustrine soils, but they are separated more from the lake by features such as barrier beaches and bars (Lacustrine Lagoon Marsh), or beach ridges and recession flats (Lacustrine Shore Marsh) (Wetlands Research Centre 1997). The railway which runs along the west side of the lake is considered a type of ridge and the wetlands located behind it would thus be considered lacustrine shore marshes.

Wildsight (2006) identified Windermere Lake's lacustrine bay marshes and these were mapped in the Windermere Lake FIM report (McPherson and Michel 2007). Lacustrine Shore marshes were identified during the 2006 FIM and 2007 fish and wildlife field components and the wetland polygons were updated. These wetland marshes were the basis for this parameter in the Habitat Index. The percentage of marsh wetland for each segment was determined by calculating the extent of wetland along the segment and by dividing this value by the total segment length. This value was multiplied by 7, so that a maximum value of 7 could be attained.

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 nearshore fish assemblages because they eliminate complex habitat features that function as critical prey refuge areas. 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, 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. Retaining walls were thus incorporated into the Habitat Index as a negative influence. The percentage of retaining wall coverage per segment was obtained from the FIM report, which provided data on retaining walls on a lot by lot basis around the lake. The percentage of shoreline with retaining walls was divided by 100, in order to provide a whole number and this was multiplied by -3. With this, the maximum model value was -3.

Docks

The negative effects of docks on fish habitat are controversial. On one hand docks may provide areas of hiding for 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 over-water 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 with increased overwater structures (e.g., docks) and riprap shorelines, and therefore, construction of these structures may affect juvenile migrating salmonids (Piaskowski and Tabor, 2001).

Docks are known to create islands or bottlenecks in lake habitats (J. Bisset pers. comm.). They can modify predator/prey interactions which can cause fundamental shifts in the trophic structure of an ecosystem (J. Bisset pers. comm.).

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 Habitat Index, segments were assigned a score based on the following dock density categories: 0 docks/km = 0 score, 0.1 to 10 docks/km = -1 score, 10.1 to 15 docks/km = -2 score, 15.1 to 20 docks/km = -3 score, and 20.1+ docks/km =-4 score.

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. B. MacDonald (pers. comm.) described that groynes are known to have significant impacts on shoreline processes and fish. They concentrate fish similarly to docks; they disrupt shoreline migration and force juvenile fish out into in deeper waters away from refuge, where they are easily predated upon (B. MacDonald pers. comm.) Groynes also alter shoreline substrates by reducing the natural movement of sediment materials along the shoreline and therefore erosional and depositional processes. ***They also increase the embeddedness of gravels***. ***These structures are considered a Harmful Alteration and Disruption of Fish Habitat (HADD) as defined under the federal Fisheries Act.***

In the Habitat Index, every groyne in a Segment was given a value of -0.5, with a segment obtaining a possible maximum value of -4.

Boat Launches

Boat launches were considered to be a negative parameter within the Habitat Index. 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 Okanagan Lake Habitat Index 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).

Only two boat launches were identified in Windermere Lake during the FIM. The extent (i.e. number of boat ramps/launch) was not covered in the FIM; therefore each boat launch was given the same value of -3 in the Habitat Index. The lake has an additional ‘primitive’ boat launch, located off a dead end road at the end of Ash Street/ Tretheway Rd (J. Bisset and K. MacLeod pers. comm). This launch was also included in the analysis.

Marinas

Marinas are a concentration of boat slips, offering a place of safety to vessels. 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.

Large marinas tend to have breakwaters, which affect lake processes and fish in a similar manner to groynes (B. MacDonald pers. comm.). Breakwaters impede shoreline migration and force juvenile fish to venture into deeper water making them subject to predation (B. MacDonald pers. comm.). The breakwaters further affect wave action, sediment scour, deposition and circulation. Dredging to maintain depth and access for boats is an additional significant impact on the foreshore (B. MacDonald pers. comm.). Other effects of marinas on the natural environment are that they tend to: have homogeneous substrates; have concentrated hydrocarbon levels, altering water quality; provide a continuous disturbance to aquatic vegetation; and re-suspend sediments (J. Bisset pers. comm.).

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 Okanagan Lake study differentiated between large and small marinas. Larger marinas typically have amenities such as fuelling, whereas smaller marinas typically just contain boat moorage. Large marinas also tend to have year round moorage and related activities. All of the marinas at Windermere Lake are seasonal, other than Pete's Marina, which is located outside of the study area at the lake's outlet. Marinas within the study area were identified as being small, medium or large based on an orthophoto review. Large marinas were those that had 50+ berths, medium marinas had 20+ berths, and small marinas had <20 berths. Each marina was given a value based on its size with a large marina valued at -6, medium at -4 and small at -2. The total value was summated for a Segment, with a possible maximum value of 6 given to any one segment.

2.10.2 Habitat Index Ranking Calculation Methodology

The Habitat Index consists of a variety of parameters and each parameter has a range in potential scores based upon the physical properties of each shore segment. For each parameter, the appropriate score for a shore segment was applied based upon the physical characteristics in the database for that segment. Once the scores had been assigned to all parameters, the total habitat values were summated for each segment based upon the scores of the parameters. The total habitat value for each shoreline segment included all positive and all negative index parameters. Results for this are provided in Table VIII in the column "Habitat Index Score with Instream Structures".

Maximum and minimum scores were used to determine the framework for comparison between the different shore segments. The range was determined by subtracting the maximum possible score from the minimum score. The range in possible scores was divided into five even categories. Each different category was calculated and assigned a value of 1 through 5, which corresponded to Very Low, Low, Moderate, High, and Very High respectively. These broad categories are considered to be the Ecological Value of a shore segment and are provided in Ecological Value Column of Table VIII.

The Okanagan Lake Foreshore study (Schleppe and Arsenault 2006) was used as a template for developing the Habitat Index. The Habitat Index was calibrated using data collected at Windermere Lake in 2006 and 2007 specific to this study, historical data collected on Windermere Lake, and literature findings. The model also received the review and input from EKILMP professionals (including MoE, DFO and Wildsight). The Okanagan Lake matrix also went through a rigorous review with these regulatory agencies and was run through numerous iterations, comparing the outcomes of each run to perceived habitat value based upon the fisheries data collected (Schleppe and Arsenault 2006). Schleppe and Arsenault (2006) also made adjustments to the parameter scores following each different run to ensure that items were not overly weighted in the Habitat Index. Negative habitat parameters were constrained to have a potential maximum negative effect of 44% out of the total of a shore segment score. This is consistent with that of Okanagan Lake, which had a potential negative effect of 43%.

2.10.3 Habitat Index – Restoration Areas Analysis

A restoration analysis was completed based upon the Habitat Index. To investigate the potential for restoration, negative instream parameters (including dock density, groynes, retaining walls and marinas) ***were removed from the calibrated index and the index was re-run***. ***The same environmentally sensitive ranking categories were used in this analysis.*** Areas of shoreline that increased in habitat value were considered to be areas where shoreline improvements may result in increased fish habitat value. The restoration analysis ranking results of the Habitat Index are also provided in Table VIII – in the “Habitat Index Score without Instream Structures” and the “Ecological Potential” Columns.

Finally, each shoreline that had potential for habitat improvements was reviewed to determine candidate areas for restoration. Other factors were considered when reviewing shoreline segments for restoration potential (e.g., wetland expansion, ownership, etc.).

2.11 Zones of Sensitivity

Zones of Sensitivity (ZOS) were defined as environmentally sensitive areas that have the potential to be negatively affected by development. By delineating these ZOS for the Windermere Lake foreshore, the OCP objectives of *protecting environmentally sensitive areas*… and …*protecting natural ecosystems unique to the area* could be achieved. Further, the ZOS areas at Winderemere Lake follow the key wildlife habitat policies of the OCP– by being broad and based upon *promoting connectivity and discouraging fragmentation of contiguous ecosystems and ecosystem components to preserve landscape diversity and allow for species use movement and dispersal.*

The ZOS features and their boundaries were determined from a literature review of fish and wildlife species and habitats utilizing the foreshore of Windermere Lake. The OCP environmental policies and input from EKILMP professionals also directed ZOS. The areas along the foreshore of Windermere Lake that will be mapped as ZOS are as follows:

- Wetlands;
- Creek Mouths;
- Native Grasslands;
- Wildlife Habitat and Corridors;
- Gravel/Cobble areas for fish spawning and rearing;
- Biologically Productive Areas; and
- Unimpacted/Natural Areas;

Supporting information including, data, literature findings and professional input for each of the ZOS are provided in the Results Section of this document (Section 0 – Zones of Sensitivity). The intent of the ZOS is to act as a trigger for further investigation if development is proposed in these areas. Shoreline management recommendations for each ZOS are also presented and support policies provided in the OCP.

3 Results

3.1 Site Descriptions

Table 4 lists the Shore Types attributed to each of the Sites where field assessments were undertaken and provides associated foreshore characteristics for each site, including FIM Segment, level of disturbance and general location.

Table 4. Sample site description for Windermere Lake foreshore fish and wildlife field review

Site Number	Foreshore Segment # (FIM Report)	Shore Type	Level of Site Disturbance	Location
1	20	Modified Gravel Beach	High	Downstream of Copper Point intake
1a	21	Modified Low Rocky Shore	High	Irvine retaining wall
2	22	Modified Creek Mouth	High	Holland Creek, Lakeview Meadows / Timber Ridge
3	23	Modified Cliff/Bluff	High	Around corner and upstream of Site 2.
4	24	Modified Sand Beach	High	Before Windermere
5	25	Vegetated Shore	Low	Upstream of Hidden Bay
5a	26	Vegetated Shore	Low	Windermere Island
6	26	Creek Mouth	Low	Windermere Creek and Shadybrook Marina
6a	26	Modified Creek Mouth	High	Jane Creek and Trethewey Marina
7	2	Wetland	Low	Outlet of Cool Spring Creek
8	4	Sand Beach	Moderate	First Nations community upstream of the inlet
9	6	Wetland	Low	Columbia River inlet
10	7	Modified Vegetated Shore	Moderate	Near Rushmere
11	9	Vegetated Shore	Low	Below Sunshine Ranch Park
12	11	Creek Mouth	Moderate	Outlet of Brady Creek
13	12	Creek Mouth	Moderate	Goldie Creek
14	16	Modified Cliff Bluff	High	Fort Point
15	18	Gravel Beach	Moderate	James Chabot Park

A summary of numbers of low-moderate and highly modified sites reviewed for each Shore Type is provided in Table 5. There were no unmodified Cliff/Bluff or unmodified Low Rocky Shore types reviewed in this analysis.

Table 5. Summary of the shore types reviewed and associated degree of modifications.

	NUMBER OF SHORE TYPES REVIEWED						
	Cliff/Bluff	**Creek Mouth**	**Vegetated Shore**	**Sand Beach**	**Gravel Beach**	**Low Rocky Shore**	**Wetland**
Low to Moderately Impacted	0	3	3	1	1	0	2
Extensively Modified	2	2	1	1	1	1	0

Site numbering followed sampling order which started at the north east end of the lake and progressed clockwise around the entire lake. A high proportion of the sites sampled (9/15) were located along the north to mid east end of the lake. The sampling was focused in this area because this is an area experiencing particularly high development pressures. Appendix B provides detailed descriptions and photo documentation for each site according to information collected during the field inspections. The study site locations are also highlighted on the overview map and orthophotos for the lake in Appendix D. Specific details on fish findings are provided in subsequent sections of this study. Terrestrial wildlife and habitat details for these sites were largely derived from comprehensive field summary documents provided by Holmes (2008). Additional wildlife details are provided in Section 2.9 - Wildlife / Sensitive Species and Habitats.

3.2 Historical Air Photo Analysis

The historical air photo analysis included review of 1968 and 1988 air photos, as well as 1995 and 2004 (partial coverage) orthophotos, in order to determine the extent of changes or disturbances which have occurred over time along the shoreline. The shoreline width reviewed extended 50 m upland from the lakeshore. This analysis used photo interpretation to identify disturbed areas which included any human induced modification, structure or alteration. The results of this analysis are provided in Table 6 and have been mapped in Appendix D – Figures I and II. Note that the 1968 air photo mosaic has been provided as the base layer for these maps.

Table 6. Extent of disturbed and natural areas from air photo analysis

Year	Mapped Shoreline Length (m)	Disturbed Shoreline Length (m)	Undisturbed Shoreline Length (m)	% of Shorline Disturbed
1968	35473	21737	13736	61%
1988	35473	25678	9795	72%
1995	35473	26287	9186	74%
2004	14,291	14,107	184	

The results indicate in what general period changes along the lakeshore occurred. They show that much of the foreshore development occurred by 1968, where 61% of the shoreline was evidenced as being disturbed. In the 20 years which followed (by 1988), an additional 11% of the shoreline was disturbed. By 1995 only 2% more of the shoreline was disturbed, extending across at total of 74% of the shoreline. The analysis also revealed that much of the developed area has become more dense with time.

The 2004 orthophotos were partial and only covered the northern end of the lake (approx. 1/3 of the lake). In the area that the 2004 photos covered, the entire foreshore had shown disturbance by 1995, other than one small cliff bluff parcel in Segment 22. This parcel still appeared to be in a natural condition in the 2004 orthophotos. 2004 orthophoto coverage does exist for the rest of the lake, but it has not been processed yet. Once processed and available to the public, it would be of value to complete this analysis.

A bottom sediment core study at Windermere Lake which considered changes to the lake over the past 300 years corroborated these results and also provided further insight as to when accelerated settlement of the area occurred (McDonald 2000). The sediment core study found that water quality began to change around 1950, concurrent with population growth (McDonald 2000). The report also provided an additional detail of interest, that of the total of 1290 lots subdivided on the east side of the lake from 1940 to 1986, 623 (48%) were established between 1947 and 1957. Unfortunately, complete air photos were not available for the lake, dating back before 1968 to portray this.

The areas which remain in a natural condition are predominantly located along the south east border of the lake. This stretch of shoreline runs along the Columbia lake Indian Reserve #3 and is predominantly cliff/bluff type habitat. The other pockets of natural areas are found in either parks (Segment 9) or what appears to be private land parcels (in Segments 12 and 22). The foreshore associated with Windermere Island (approximately 400 m, representing 1% of the total shoreline length) in Segment 26, is one natural area unaccounted for in this analysis. Windermere Island fell outside of the foreshore GIS linework used in the 2007 FIM and to maintain consistency was not included in this report. Its value as a natural area, nonetheless, should not be overlooked.

The review of lacustrine wetland habitats was limited to only the larger south end wetlands, since they were the only major wetlands evident in the airphotos. No noticeable changes in the south end wetlands were evident from this analysis. This is to be expected since little/no development has occurred in this area. It would have been valuable to have air photos showing the extent of wetlands for the lake prior to development, since generally wetlands are absent from the heavily developed areas of the lake.

3.3 Fish Results

Fish surveys were conducted at each of the 18 foreshore sample sites during the summer and fall. Survey techniques involved snorkeling, minnow trapping, seining and through visual observations from the boat/shore. All field data from the fish surveys are provided in Appendix A – Table 1. Detailed life histories for all fish potentially inhabiting Windermere Lake and abundance summaries for each species identified during 2007 surveys are presented in alphabetical order (by common name) in Appendix C. From these summaries, habitat utilization for each species has been synthesized and presented in tabular format in Appendix B - Table V (Fish Species Habitat Matrix).

The literature and the 2007 findings were used to confirm which species are likely to exist in the lake. Overall 9 of the 19 potential fish species historically reported in the lake were observed during the 2007 survey. The literature suggests that a further 7 species, although not observed during the 2007 sampling, may utilize the lake. Three species were determined to no longer likely inhabit the lake. The species breakdown for each of these groups is as follows (*See* Section 2.6 for scientific names):

- During the 2007 surveys, the **native species found** were: bull trout; kokanee, mountain whitefish, sculpin (most likely torrent sculpin*),* largescale sucker, redside shiner and northern pike minnow. The **non-native species observed** were: largemouth bass and pumpkinseeds.
- Species that **could be expected in the lake** based on the literature, although they were not seen or identifiable to species (e.g., field notes documented sucker spp., sculpin spp., cyprinid spp. or salmonid spp.) during this survey include: burbot, longnose dace, longnose sucker, peamouth chub, prickly sculpin, rainbow trout, westslope cutthroat trout.
- Species that have been determined to **not likely be likely present in the lake** based on the literature are: chiselmouth chub, lake chub and eastern brook trout.

As outlined in the Methods (*See* 2.7 Fisheries Analysis), fisheries analysis in this study primarily focused on snorkel survey data, since this was the most consistently applied technique during the study. Table 7, below, has synthesized the 2007 summer and fall snorkel data and provides relative abundance of each species. A breakdown of results by shore type and the total numbers of fish observed is also included.

Table 7. Numbers and relative abundance (%) of fish observed at each shore type during snorkel surveys

Season	Common Name*	Species	Creek Mouth (n=3)	Gravel Beach (n=1)	Sand Beach (n=1)	Vegetated Shore (n=3)	Wetland (n=3)	Modified Cliff Bluff (n=2)	Modified Creek Mouth (n=2)	Modified Gravel Beach (n=1)	Modified Sand Beach (n=1)	Modified Low Rocky Shore (n=1)	Modified Vegetated Shore (n=1)	Total # Fish	Total % of Fish Community by Species
Summer	YOY cyprinid	Unknown	16.7		100.0	1.0			63.6	92.3				**133**	**5.2**
	largemouth bass*	*Micropterus salmoides*	43.3			24.3			17.0		6.9	11.1	0.3	**181**	**7.1**
	largescale sucker	*Catostomus catostomus*				0.4			0.6					**3**	**0.1**
	mountain whitefish	*Prosopium williamsoni*				4.3	100.0							**22**	**0.9**
	Pumpkinseed*	*Lepomis gibbosus*				8.8			0.6					**44**	**1.7**
	redside shiner	*Richardsonius balteatus*	40			61.2		6.7	18.2		86.2	89.0	99.6	**2138**	**84.1**
	sculpin	*Cottus spp.*						86.7			6.9			**15**	**0.6**
	sucker spp.	Unknown						6.7		7.7			0.1	**4**	**0.2**
	salmonid spp	Unknown											0.1	**1**	**0.0**
		Total Community %	**100**		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**		**100**
		Total # of Fish	**60**	**0**	**1**	**490**	**1**	**15**	**165**	**13**	**29**	**9**	**1757**	**2541**	
Season	**Common Name***	**Species**	**Creek Mouth (n=3)**	**Gravel Beach (n=1)**	**Sand Beach (n=1)**	**Vegetated Shore (n=2)**	**Wetland (n=1)**	**Modified Cliff Bluff (n=1)**	**Modified Creek Mouth (n=2)**	**Modified Gravel Beach (n=1)**	**Modified Sand Beach (n=0)**	**Modified Low Rocky Shore (n=1)**	**Modified Vegetated Shore (n=0)**	**Total # Fish**	**Total % of Fish Community by Species**
Fall	bull trout	Salvelinus confluentus							0.1					**2**	**0.2**
	cyprinid	Unknown							0.3					**3**	**0.3**
	kokanee	*Oncorhynchus nerka*				2.6		100.0						**21**	**2.0**
	largemouth bass*	*M. salmoides*				25.6			0.1					**11**	**1.0**
	largescale sucker	*C. catostomus*	100.0			7.7								**4**	**0.4**
	northern pikeminnow	*Ptychocheilus oregonensis*				12.8								**5**	**0.5**
	redside shiner	*R. balteatus*				51.3			99.4					**1020**	**95.7**
		Total Community %	**100**	**0**	**0**	**100**			**100**						**100**
		Total # of Fish	**1**	**0**	**0**	**39**	**0**	**20**	**1006**	**0**	**0**	**0**	**0**	**1066**	

* Denotes non-native fish species to Windermere Lake

Overall, many shore types were found to be utilized during this assessment. The shore types which had the greatest utilization by fish were the Creek Mouth and the Vegetated Shores. Nearly twice as many (42%) more fish were found in the summer than in the fall. In the summer, both the generally intact Creek Mouth and Vegetated Shore areas and their Modified (extensively impacted) counterparts were utilized. Redside shiners were a substantial proportion of the overall fish community in the lake, representing 88% of all fish surveyed during the summer and fall combined.

The results will further be presented under the categories of native sport fish, native coarse fish, and non-native fish.

3.3.1 Native Sport Fish

> *Over-fishing, mining, logging, dams and urban development are all known to have impacted Columbia River fish populations. In addition to direct habitat alteration, development activities have altered water quality and thereby also impacted local fisheries* (Westslope 2001).

Windermere Lake is essentially a widened section of the Columbia River (J. Bisset, pers. comm.) and any species present in the Columbia River are able to migrate into Windermere Lake (Urban Systems 2001). Windermere Lake is known to support a high diversity of fish because of this continuity with the Columbia River. It has been known for some time, that despite the high fish diversity, the total numbers of individual species are generally low in the lake, especially sport fish (Westslope 2001, Urban Systems 2001 and Griffith 1994). 2007 findings are consistent with these earlier accounts. The lack of success of sports fish in the lake has been attributed to many potential factors including: competition and predation by coarse fish, limited availability of spawning and recruitment habitat, improved angler access, overfishing, forest harvesting, exotic fish introductions, urbanization and water temperature increases.

The sport fish potentially in Windermere Lake include the following members of the Salmonidae Family: bull trout, kokanee, mountain whitefish, rainbow trout and westslope cutthroat trout. Burbot, which belongs to the Gadidae (cod) Family, is also a sport fish known in the lake. Eastern brook trout (potentially) and largemouth bass are the two non-native sport fish species in the lake.

Native Sport fish in Windermere Lake are generally fluvial forms, which move from rivers to spawn in tributaries. Adfluvial forms that move from lakes to spawn in tributaries and lacustrine forms, which stay in a lake for all of their life history stages, are generally not expected at Windermere Lake, as a result of the lake's habitat conditions. For instance, the lake is not known to have suitable beach spawning sites (upwelling on gravel beaches) for potential lake spawning sport fish forms (such as kokanee and mountain whitefish) (J. Bisset pers. comm.). More details on the habitat conditions will be provided below. Stream resident forms which rear and spawn in the neighboring streams to the lake, are known (i.e., westslope cutthroat trout and bull trout) (Griffith 1993, Artech 2002); however, they are outside of the scope of this study.

A. Sport Fish Observed During the 2007 Surveys

During the 2007 summer and fall sampling, native sport fish abundance in the lake was found to be low (i.e., bull trout, kokanee and mountain whitefish) or non-existent (burbot, westslope cutthroat trout and rainbow trout). Only two bull trout, which appeared to be migrating to spawning grounds, were observed in the fall, representing 0.2% of the fall fish community. The bull trout were near the Holland Creek mouth. Twenty one adult kokanee, representing 2.0% of the fall fish community, were also observed in the fall (most near Fort

Point), en-route to spawning grounds. An additional 30 migrating kokanee were observed from the boat (and thus not included in the abundance calculation), along the cobble beach near site 1. Mountain whitefish appeared to be utilizing the lake for more of their life history stages than the other native sport fish, during the period of this assessment. Twenty two mountain whitefish were observed during the summer snorkel surveys, representing 0.9% of the summer fish community. Most of the mountain whitefish (20) were young-of-year (YOY), and were found using the reed beds around the Vegetated Shore of Windermere Island (Site 5a). The other mountain whitefish observed during the snorkel survey was of a sub-adult in the Columbia River wetland (Site 9). Not accounted for in the relative abundance estimates, were the fall seine results which captured an additional 20 juvenile mountain whitefish along the Vegetated Shore of Site 11, and 7 juveniles along the Gravel Beach at Site 15.

The literature and data suggest that fluvial forms of these native sport fish species generally use the lake as a migration corridor to gain access to their spawning beds, located in other parts of the Columbia System as well as creeks draining into Windermere Lake. During the migration, the lake's wetlands are believed to be particularly valuable to fish, by providing cover elements and food (B. MacDonald pers. comm.). The main creeks draining into the lake which have been documented as providing spawning habitat and a source of sport fish recruitment to the lake (i.e., rainbow trout, bull trout and/or kokanee) include: Windermere, Salter, Goldie and Abel Creeks (Griffith 1994). Windermere Creek was found to be a particularly important creek for spawning, since it is the largest tributary to the lake, other than the Columbia River (Griffith 1994). Fisheries production in the some of the other smaller tributaries to the lake is likely limited by excessively steep and swift water flows (Griffith 1994).

YOY and juvenile data for sport fish was limited in this study, other than the mountain whitefish findings; however, young fish that emerge from the tributary creeks would typically be expected to move into the lake and rear along the lake margins in the littoral zone. Although high quality rearing habitat is species specific, generally rearing habitat should provide cover from predators and ample forage. For some species such as burbot, course substrates are the cover elements sought; while for other species (mountain whitefish), the vegetated shoreline and/or wetland habitat are more highly utilized. The shoreline wetlands at Windermere Lake provide a particularly valuable ecological function for fish, since they are a source of primary production in the lake (i.e. invertebrate production) (Mitsch and Gosselink 2000). Windermere Lake however, is likely only used for a short period of time by these sport fish, since they prefer cold water habitats. The lake is shallow and as a result gets quite warm during the summer months. The lake does not stratify, whereby a cold-water layer would occur at depth, which could provide refuge during the warm summer months. With rising lake temperatures, the cold-water fish species likely move out of the lake and seek refuge in the cooler waters of the Columbia River, larger basins, or at creek mouth/spring areas (which may increase their vulnerability to predators). Overall, considering the sport fish habitat requirements and life history needs, the key areas of importance for their protection relative to the Windermere Lake foreshore would be spawning habitats in the tributary streams. Maintaining wetlands for rearing habitat and primary production is also considered important. Because of their significance to fish, creek mouths and wetlands have thus been included as ZOS in this study.

Bull Trout

Bull trout deserve special mention because they are considered a sensitive species in BC (blue listed and ranked S3) and globally (G3) (CDC 2008). These rankings indicate that they are considered to be vulnerable. Historically, bull trout were abundant throughout the Columbia River, including Windermere Lake (Westslope 2001). Griffith (1994) reported lake recruiting bull trout in Windermere Creek and Salter Creek. Juveniles have also been observed in the lower reaches of Windermere Creek in 1998 (J. Bisset, pers. comm.). In

Windermere Creek, spawning habitat is limited to the lower reaches (3 km) as a result of an upstream barrier (J. Bisset pers. comm). Considering bull trout habitat requirement and life history needs, the key areas of importance for protection of this species relative to the Windermere Lake foreshore would be spawning habitats in the tributary streams.

B. Sport Fish Not Observed During 2007 Surveys

Burbot

Burbot is a species which has experienced significant declines in the Columbia System, including Windermere Lake (Paragamian et. al. 2000). As a result of these declines, they are considered a species of regional concern in the Columbia River system (McPhail 2007). Protection of this species' habitat at Windermere Lake is thus considered important.

Burbot is a winter spawner and is the one sport fish species suspected to spawn in Windermere Lake. Spawning in the lake is suspected because: 1) burbot are not documented to need upwelling at their spawning lake sites, 2) age 0 juveniles were sampled on the western shore (Taylor 2002), 3) burbot spawning sites occur in relatively shallow water over sand or gravel bottoms (McPhail 2007), and 4) burbot historically spawned in the weed beds at the creek mouths around the lake (Westslope 2001). The physical habitat data for the lake suggests that spawning habitat is not limiting.

Maintaining rearing habitat for burbot is considered important. Taylor (2001) identified the following key habitat requirements rearing and juvenile burbot:

1) cover is an important component to all ages of bubot, even adults;
2) juveniles are highly associated with the interstitial spaces in the substrate, the preferred habitat for age 0 burbot is gravel and cobble substrates along the shoreline;
3) since shelter size increases with body size, older juveniles are associated with larger substrates of cobble and boulder;
4) where aquatic vegetation is utilized, extensively branching species such as bushy pondweed (*Najas flexis*) are preferred;

Further, older fish (2+) tend to move below the thermocline to deeper waters (McPhail 2007). Overall, the literature suggests that course substrates are important rearing habitats for this species. Course substrates however, are generally not common along the Windermere Lake shoreline. Because of this, areas where course substrates are known to exist have been identified and mapped as a ZOS (*See* Section 2.11Zones of Sensitivity).

Taylor (2001) reported that juvenile mortality is not only affected by the availability of cover from predators, but also by the abundance of predators and competitors. Potential fish predators on juvenile burbot could include fish species such as torrent sculpins, pike minnows and trout (Taylor 2001). Large mouth bass as well as birds could also affect juvenile survival along the shoreline of Windermere Lake. More discussion relating to predatory fish in Windermere Lake is provided in Section 3.3.4. If the population levels become too low and below a healthy threshold, successful reestablishment of fish stocks can be difficult (J. Bisset pers. com).

Westslope Cutthroat and Trout Rainbow Trout

Westslope cutthroat trout and rainbow trout are expected to utilize the Windermere Lake and tributary habitat in a similar manner to that described for other sport fish (i.e., kokanee, bull trout). They would use the lake as a migratory corridor to gain access to their tributary spawning grounds. Young fish are expected to move into the lake habitat, to feed and seek refuge. Once water temperatures increase, in the summer, the fish would leave the lake in order to seek out colder water refuge areas in the Columbia System.

Westslope cutthroat trout are a blue-listed in BC, meaning that they are a species of concern vulnerable to human activities or natural events (CDC[1] 2008) and a species of concern by COSEWIC[2] (See Appendix B – Table XI). Only stream resident fish have been found in the Windermere Basin in recent years (Griffith 1994, Artech 2002). The introduction of non-native salmonids, such as brook trout and rainbow trout, has had profound negative effects on this species (McPhail 2007). Competition for food and habitat resources, over-fishing and habitat degradation are additional factors believed to have caused the population declines seen today (McPhail 2007).

Since no rainbow trout were found along the foreshore during this assessment, accounts and habitat limitations for this species as provided by Griffith (1994) will be provided here.

> *Small lake recruiting populations have been reported for Windermere Creek; while Abel and Goldie Creeks have been identified as having possible lake recruiting rainbow trout populations. Although rainbow trout are periodically stocked, it seems likely that suitable recruitment sites may be limiting potential natural production. In almost every tributary sampled (excluding the Columbia River), accessible stream length appeared too steep and swift flowing for the successful spawning of rainbow trout. Furthermore, rearing habitat appeared to be limited for rainbow. Very low survival is also anticipated for fry recruiting back to the lake, due to large numbers of northern pikeminnow (and other potential predators) in the lake*.

3.3.2 Coarse Fish

There is a diversity of coarse fish potentially inhabiting Windermere Lake. Coarse fish potentially found in Windermere Lake fall into the following families:

Native species to the Columbia Basin

- Cyprinidae (minnows and carps): redside shiners, longnose dace, northern pikeminnow, lake chub, peamouth chub;
- Catastomidae (suckers): longnose sucker, largescale sucker;
- Cottidae (sculpins): torrent sculpin, prickly sculpin;

Non-native species to the Columbia Basin

- Centrarchidae (sunfish): pumpkinseed

As Table 5 reveals, during 2007 snorkel surveys, members of the Cyprinidae Family were most highly represented, with redside shiners, northern pikeminnow, and unidentifiable cyprinids found. The largescale sucker, sucker spp. and sculpin spp (most likely torrent sculpin) were also observed during the 2007 sampling. Pumpkinseed fish were the only non-native species found in the lake. Other than redside shiners, all coarse fish species were found in relatively low numbers along the lake's foreshore, representing anywhere from 0.1 – 1.7 % of the total fish community. Only redside shiners, because of their high abundance will be discussed in greater detail here. Since northern pikeminnow is a potential threat to native fish numbers in the lake, it will be discussed in greater detail in Section 3.3.4. Comprehensive results from the literature review and 2007 assessment for all of these species are documented in Appendix C.

[1] British Columbia Conservation Data Centre
[2] Committee on the Status of Endangered Wildlife in Canada.

Redside shiners

Redside shiners, a native fish to the Columbia Basin, were the most abundant species in the lake, making up 84% of the summer and 96% of the fall fish community sampled. This species is likely an important food source in the lake for piscivorous fish (rainbow, cutthroat northern pikeminnow and largemouth bass) and birds. In the fall, grebes and loons were seen feeding on the schools of redside shiners at the outlet of Holland Creek.

3.3.3 Non Native Fish Species

Introductions of non-native fish species have typically been found to be detrimental to indigenous fish populations (Westslope 2001, McPhail 2007). This is because they are often strong competitors for habitats and food, and once introduced, they are hard to get rid of since they are often prolific and typically have fewer predators. They can also be difficult to remove from a system because they are socially and thus politically appealing. The non-native fish are often preferred by anglers since they are a good food source and easy to catch (J. Bisset pers. com.). The two non-native species observed during this study were the largemouth bass and the pumpkinseed fish. The largemouth bass would be considered to be a greater threat to native fish populations since they were more abundant in the lake and as a result of the fact that they are ominivores, that will eat just about anything including fish (McPhail 2007). Because of this largemouth bass will be discussed in further detail.

Largemouth Bass

Largemouth bass, a non-native species in BC, were the one sport fish species which appeared to have relatively high numbers in Windermere Lake. Windermere Lake with its warm water temperatures, soft substrates and extensively vegetated shoreline, provides good habitat for this non-native species. One hundred and eighty one (181) largemouth bass, representing 7.1% of the summer fish community and 11 largemouth bass, representing 1% of the fall fish community were observed during 2007 snorkel surveys. The largemouth bass abundance in the summer was second only to redside shiners which represented 84% of the population. More than half of the observations in the summer were juveniles observed along the Vegetated Shoreline areas. Largemouth bass adults did not seem to be affected by shoreline disturbance since they did not appear to be particular about whether cover was a manmade (docks) or natural (vegetation). Compounding this issue is the fact that the best places to catch largemouth bass are docks and floating manmade structures (J. Bisset, pers. com.).

Largemouth bass (mostly adults) were the most prevalent species in Creek Mouths during the summer (43.3%). They appeared to be associated with the redside shiners, which were the most abundant species sampled. Also during the summer, largemouth bass were second only to redside shiners in the Vegetated Shore and Modified Creek Mouth habitats, with respective abundances of 24.3 % and 16.9 %. Largemouth bass are known to impact native fishes and their population growth once introduced to a system (McPhail 2006). At Windermere Lake, they likely are consuming cyprinids (i.e. redside shiners), since they are abundant and easy prey (J. Bisset pers. com.).

J. Bisset (pers. comm.) provided the following summary relating to exotic species in system:

> *There is essentially no way of eliminating most of the exotics from these systems once they are introduced. At best, you might be able to control population levels, although in a system like Windermere (essentially a widening of the Columbia River, with many accesses/tributaries, we are limited in management opportunities, and likely stuck with the current situation. It becomes increasingly difficult for native species when habitat*

> *becomes degraded, since the changes typically tend to suit invasive species better.*

This provides yet another reason why maintaining the natural habitat conditions is so important to preserve native species assemblages.

3.3.4 Predator Prey Interactions

Fish success is not only affected by the availability of habitat for spawning, rearing, feeding, and hiding from predators, but also by the abundance of predators and competitors. Predatory fish species (piscivores) known in the lake include: northern pikeminnow, largemouth bass and torrent sculpins. The 2007 snorkel surveys results provide the respective summer and fall abundances for these species in the lake:

- sculpin spp (most likely torrent sculpin spp): 0.6% and 0%;
- northern pikeminnow: 0% and 0.5%;
- trout 0%; and,
- largemouth bass: 7.1% and 1.3%.

In 2007, there were additional sightings of these species not included in this dataset, since they were obtained through means other than snorkel survey. These include:

- Northern pikeminnow: 20 (sized 30 - 50 cm.) and over 100 (sized 10 – 30 cm) were observed from the dock at Site 2 near the Holland Creek Mouth.
- Sculpins (likely torrent sculpin): An additional 8 adults were observed at various sites following minnow trap, seine and invertebrate sampling.
- Largemouth bass: a further 14 were observed along the foreshore considering other techniques (dock observations, seine, minnow trap).

Further, during gill net surveys in 1993, Griffith (1994) found that northern pikeminnow, represented 29% of the fish population and was second only to migrating kokanee. Largemouth bass represented a much smaller portion of the population (1%), at the time and location of Griffith's study.

From the data, it appears that both largemouth bass and northern pikeminnow would be the greatest predatory threats in the lake. J. Bisset (pers comm.) described the likely history behind how these species may have taken over as key predators in the lake as follows:

> *Burbot, bull trout, and rainbow trout were likely really important top level predators in Windermere Lake historically. Unfortunately, these populations have been depleted over the years, largely as a result of over-fishing and habitat loss. One of the outcomes from the loss of these top level predators is that species such as the northern pikeminnow and the exotic largemouth bass have experienced explosions in their population levels. These species now appear to control various fish populations. This has been observed with other species such as brook trout in the lakes around Algonquin Park and is an ongoing concern to fisheries management.*

Taylor (2001) specifically detailed impacts of pikeminnow on burbot, by suggesting that reduced cover availability during low water periods, may make juvenile burbot especially vulnerable to predation. This may occur at Windermere Lake since field descriptions indicate, that for many sites, coarse substrates utilized by burbot for cover, were located closer to the shoreline. Under reduced water conditions of late summer and fall, these areas would likely become dewatered. Largemouth bass could also influence this species in a similar manner. The literature also provides that northern pikeminnow and largemouth bass have a tolerance to higher temperature than the other species (e.g. burbot, bull trout and rainbow) (Taylor 2001, McPhail 2007), which could make them more successful in the warm waters of Winermere Lake. Adult pikeminnow and burbot also share similar characteristics of nocturnal feeding (Scott and Crossman 1973).

3.3.5 Lake Outlet Downstream to Athalmer

The section of the Columbia River from the outlet of Windermere Lake downstream to Athalmer (approximately 300 m in length) is known to have valuable fish habitat and culturally significant elements. The shore habitat in this area was not included in the original FIM but was subsequently mapped in June, 2008. Its close proximity and continuity with the lake and its significant cultural and environmental values make it worthy of a brief discussion here.

The outlet of Windermere Lake (downstream of the bridge at Athalmer) provides important Kokanee spawning habitat, with up to 15,000 fish reported in the gravel outcrops (Oliver 1995). Prior to dams being constructed in the lower Columbia River, this site was also known to be an important chinook salmon (*Oncorhynchus tshawytscha*) spawning area (J. Bisset, B. MacDonald and M. Thomas, pers. com.). Maintaining the ecological integrity of this site is important due to existing values but even becomes of critical importance should migration structures for salmon be constructed downstream at the dams in the lower Columbia River.

This area is known to contain an important archaeological site (Salmon Beds Archaeological Site EdQa 121). The 'Salmon Beds Site' was an important First Nations campsite and food processing area (both salmon and ungulates) evidenced to be repeatedly occupied over the last 1000 years (Royal BC Museum 1999). *This site is one of a very few excavated sites in the Upper Columbia basin, and provides a view of a segment of life in the time just before the arrival of white settlement* (Royal BC Museum 1999).

M. Thomas (pers. comm.) provided the following additional background on the cultural and historical significance of the area.

> *The Shuswap Band is adjacent to this site and it is more than likely no accident that it was situated there. The Shuswap people of the Columbia Valley have a deep rooted relationship with the salmon, and salmon are integral to their culture in that it is the basis for worship or ceremony. There are stories of there being so many salmon that you could walk across the river on their backs (in the millions annually). Archeological remains confirm the historical use of the area, with arrow heads, spear points and other lithographic items uncovered. A study was done to determine the species and quantity of salmon that frequented the area. It was determined that chinook, sockeye, and steelhead at least were present historically. Now no salmon exist there except for landlocked sockeye or kokanee, which were re-introduced. The site is also adjacent to the 'old trail' which was used for travel from the north end of the reserve to town.*

J. Bisett (pers. com.) further provided that at their peak, the Columbia has a run of 100-200 million salmon. With their absence in the area, significant loss of genetics and ecological values has occurred.

P. Holmes (pers. com) identified that this site also provides important values for wildlife. It acts as an important migration corridor for ungulates and other species, providing an east/west terrestrial connection. Of utmost importance, this area and a portion of the wetland to the north is ice-free during the winter. This allows access to water for overwintering birds and other species such as river otter. As early migrants of the Pacific Flyway arrive, it provides rare open water habitat during the early spring. Prior to human settlement, the area would have been used extensively by grizzly bear and eagles during the fall spawning of the Chinook salmon.

3.4 Invertebrate Results

Invertebrates are important to the lake's trophic system since they provide one of the first and key links in the food chain for many animals (Mitsch and Gosselink 2000). The invertebrate component for this study was to be limited to simply providing the raw data collected during the summer and fall field sampling. Interior Reforestation did not complete a quantitative analysis or ranking of benthic assemblages on these results.

The field data is provided in Appendix A -Tables III and IV. A simple review of the data was included so that findings could be summarized in an overview manner for the lake. The invertebrate data for Windermere Lake shows that there indeed is a diverse invertebrate assemblage in the lake, with a total of 16 orders collected (Figure 3).

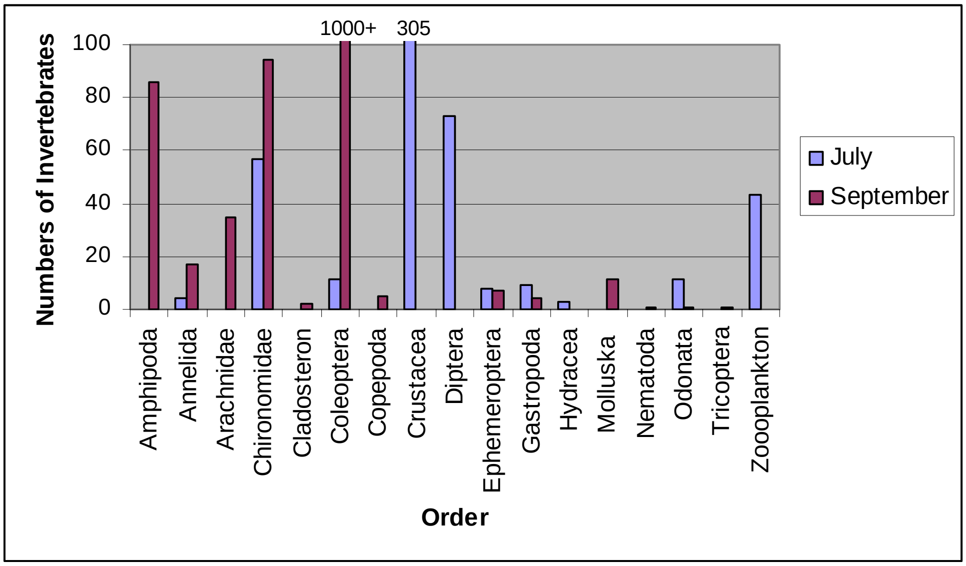


Figure 3. Total numbers of benthic invertebrates by Orders sampled in Windermere Lake during the summer and fall of 2007.

3.5 Wildlife / Sensitive Species and Habitat Results

The foreshore of Windermere Lake is diverse and contains a variety of habitat types for numerous plant and animal species. This study's field assessment involved conducting presence/absence surveys of mainly birds and fish at select sites around the lake during the summer and fall. General wildlife and habitat observations were also made during the field sampling and were provided with the Site Descriptions (Appendix B). The field assessment was conducted over a relatively short time period at each site (approx. ½ hour each). It is thus not considered a rigorous inventory and the absence of species or habitats does not necessarily preclude their existence. For instance, many animal groups (both invertebrate and vertebrate) and no plant groups were considered. Additional study would be required to provide a more complete inventory.

The results of the bird surveys will be provided here in detail. A discussion on sensitive species and habitats will also be included. The fish findings are provided in detail in other parts of this report (Section 3.3 Fish Results and Appendices A and C).

3.5.1 Bird Results

Bird presence/absence was recorded for all sites and was the fundamental species specific wildlife data collected in this study. Appendix A – Table II provides the bird species observed at each site and has segregated the findings into standard bird groupings (e.g.,

ducks/geese, raptors, shore birds etc). A notation of whether the bird species is a migratory or resident form has also been provided. These results are further summarized in
Table **8**, below in order of sites with highest to lowest species diversity.

Table 8. Summary of bird observations during the summer and fall Windermere Lake foreshore assessment

Diver-sity	Site	# of Bird Species	# of Groups Represent-ed	Shore Type	Aquatic Vegetation	General Habitat Conditions/Influences
High	**2**	20	8	Mod. Low Rocky Shore	Submerged and emergent patches	Holland Creek Tributary with good riparian vegetation at mouth; marina on south side and docks/beach area on north
	8	18	9	Sand Beach	Wetland d/s	Large adjacent wetland ecosystem, wildlife trees, shrubs and grassland community
	9	15	9	Wetland	Wetland – emergent / submergent	Extensive Wetland ecosystem (Columbia River near inlet to lake)
Medium	**11**	14	6	Vegetated Shore	Some emergent	Well vegetated shore, 2 wetlands at this site (1 on other side of tracks, 1 to north of fish survey area)
	15	14	8	Gravel Beach	Wetland - Emergent	James Chabot Park with wetland at western end, vegetation at eastern end
	12	13	6	Creek Mouth	Emergent	Outlet of Brady Creek (culvert), wetland habitat on other side of tracks, wildlife trees, clay banks
	10	12	5	Mod. Vegetated Shore	Emergent patches	Wetland on opposite side of tracks, abundant wildlife trees
	13	12	7	Creek Mouth	Emergent and submergent	Goldie Creek outlet; excellent riparian habitat
	7	12	6	Wetland	Wetland - Emergent	Outlet of Cool Spring Creek, undisturbed, grasslands, mature conifers
	6	11	8	Creek Mouth	Emergent with some submergent	Windermere Creek outlet; marina on north end; good riparian habitat
	1	10	6	Mod. Gravel Beach	None	Extensively developed by residential and associated foreshore structures
Low	**5**	8	6	Vegetated Shore	Abundant submerged and emergent	Windermere Cemetery and Hidden Bay area; undeveloped; natural adjacent wetland
	5a	7	6	Vegetated Shore	Submerged	Windermere Island shoreline, natural condition
	3	4	4	Mod. Cliff/Bluff	Minor submerged	Steep, clay banks, with sparse riparian vegetation
	6a	3	2	Mod. Creek Mouth	Emergent and submergent	Jane Creek outlet, marina/breakwater on one side and residential on other (with boat house over creek mouth)
	4	2	2	Mod. Sand Beach	Minor submerged	Highly developed foreshore; residential landscaping
	14	2	2	Mod. Cliff/Bluff	Minor submerged	Little native vegetation evident, extensively stabilized banks (retaining walls)

Bird results were divided into three equal sized groups equating to high diversity (20-15 species; green), medium (14-9 species; blue) and low (8-2 species; yellow). The number of bird groups represented at each site is also included in the results table below in order to provide some to diversity of groups present. Shore Type and a general description of habitat features present for birds are also provided.

In total 57 different species of birds were observed along the foreshore during this assessment. Thirty-one species or 54% of these were migratory species. Even greater numbers of migratory species would be expected during the spring/summer. The bird results indicate that the greatest number of species occurred in sites offering diverse habitat structure, particularly vegetation components (including emergent aquatic vegetation, riparian vegetation associated with creek mouths, wetlands, native grasslands and forest). Site 2, at the Holland Creek outlet, was particularly high even though it has been disturbed, demonstrating the importance of retaining riparian vegetation elements. The large wetlands associated with Sites 8 and 9, located at the south end of the lake, also showed particularly high diversity. Generally, bird diversity was lower at sites that had fewer of these habitat attributes and greater human disturbance such as Sites 4 and 14.

There were some exceptions to these findings. Windermere Cemetery/Hidden Bay area (Site 5) and Windermere Island shoreline (Site 5a) would have been expected to have a higher diversity of species due to the available habitats and the fact that they are generally in an undisturbed condition. The extensively developed residential area (Site 1) would have been expected to be lower in diversity than these two previously mentioned sites (Site 5 and 5a). These results may have been influenced by any number of factors. Sampling intensity, for example, may have varied for these sites. Some species (such as song birds) would be much easier to locate than other more elusive species, and if appropriate time to conduct the survey was not given, some species may have gone unnoticed. Timing, both in terms of time of day and time of year may have influenced results. For instance, a greater proportion of migratory species would be expected during the spring and summer, while resident birds would be present all year round. Birds also tend to be more active during dawn and dusk, particularly when temperatures are high. Lastly, the results above did not differentiate between habitat generalists and specialists. Habitat generalists, such as the American robin, black-capped chickadee and red-breasted nuthatch were found in the more urbanized setting of Site 1; while the undeveloped shoreline areas of Sites 5 and 5a had more habitat specialists such as shorebirds (sandpiper species) and other wetland species (red-necked grebe and common loon). Finally, the numbers of each species were also not recorded, so these findings should thus only be considered an overall indication of birds present.

The CDC sensitive species listing indicates that there are 10 bird species potentially in the area that could be dependant on the aquatic environment provided along the foreshore for breeding (i.e. particularly wetlands and river outlets) (Appendix A -Table XI). These include: Le Conte's sparrow, short-eared owl, American bittern, bobolink, barn swallow, western screech-owl, Lewis's woodpecker, long-billed curlew, and the sharp-tailed grouse (*See* Table XI for more details including scientific names and rankings). The Lewis's woodpecker is one species which has been identified in the area (1994 - 3 males and 3 females were observed south of Goldie Creek, in the *Purshia* grass near scattered snags and live ponderosa pine) (CDC 2008). A spring breeding bird survey would be valuable to conduct, in order to assess the utilization of the area during a critical life history stage.

3.5.2 Sensitive Species and Wildlife Habitats

Several sensitive species potentially inhabiting the Windermere Lake foreshore were identified in the FIM study following a review of the BC Conservation Data Centre (CDC) database (McPherson and Michel 2007). A revised CDC list of sensitive species was provided with this study, because there were several changes that were evident since the

2007 review. Appendix A – Table XI, provides a current listing of the potential species of concern in the IDF Biogeoclimatic Zone of the RDEK. The listing provides that there is one nonvascular plant species, 74 vascular plant species, 8 invertebrate species (all gastropods) and 24 vertebrate species potentially in the area. Of the sensitive vertebrate species, 3 are fish, 12 are birds (all during breeding), 2 are amphibians, 1 is a reptile and 6 are mammals. As the list indicates, nearly 60% of these species are associated with aquatic environments, further indicating that they may potentially be found along the foreshore of Windermere Lake. Although it does not appear that detailed plant and wildlife inventories of sensitive species have been conducted, occurrence reports indicate that 8 of these species have been historically documented in the Windermere Lake area (these have been highlighted in Table XI). During the 2007 field surveys, two sensitive species were observed - bull trout (*Salvelinus confluentus*) and great blue heron (*Ardea heridias herodius*). There was also evidence (excavation) of the American badger (*Taxidea taxus jeffersonii*). The details on the bull trout observations are provided in Appendix C – Fish Species Summaries. The other species will be discussed here.

Sensitive habitats are also known throughout the Windermere Lake foreshore area. Many of the sensitive habitats are discussed under the ZOS component (Section 0) of this report, including wetlands, creek mouths, natural grasslands and wildlife habitat and corridors. This section thus only reviews wildlife tree habitat along the foreshore, since it is an additional known habitats of importance that was not specifically addressed in the ZOS section, but which was noted during field assessments and/or in the OCP (RDEK 2008)

A listing of sensitive animal species, general wildlife observances (other than birds) and wildlife trees observed during both the field components of this assessment and the FIM study are provided in Table 9.

Table 9. Wildlife species and habitat observations according to the 2006 FIM report (segment data) and 2007 Fish and Wildlife Assessment (site data).

Site	Seg-ment	Sensitive Species	Wildlife Use		Wildlife Trees *(>/=5)	
			Site data	Segment data	Site data	Segment data
1	20					X
1a	21					X
2	22	bull trout		Wildlife tracks	X	
4	24					X
5	25		bear & deer tracks			X*
5a	26	great blue heron				X*
6	26	great blue heron				
6a	26		Bear scat, osprey nesting platform			
-	1			Swallow nests & wildlife tracks		
7	2			Swallow nests		X*
-	3					X
8	4		Beaver lodge		X	
-	5					X
9	6	great blue heron	300 scaups (fall)			
10	7	badger (activity)			X	
-	8					X
11	9		ungulate usage	Wildlife trails		X
12	11		Wildlife trails		X	X*
13	12	great blue heron				X*
-	13					X*
-	14					X
15	18		osprey nest			

3.5.2.1 American Badger (Taxidea taxus jeffersonii)

In BC, the American badger is limited to the south central and south east portions of the province, an area which represents the northwest limit of their total distribution (Rahme et al 1995). The badger inhabits mainly open habitats at low elevations (Newhouse and Kinley 2000). The valley bottom habitats where they concentrate their activity are often heavily impacted by human development and forest in-growth (Newhouse and Kinley 2000). Loss of habitat, prey, burrows, mortality from roadkills and shooting has resulted in badger population declines (Newhouse and Kinley 2000). In BC, the American badger is ranked as being critically imperiled (S1), it is also red-listed (endangered), and considered Identified Wildlife under the Forest and Range Practices Act. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) also has identified the badger as being an endangered species and it has subsequently been listed as a Schedule 1 species under the Canadian Species at Risk Act (SARA) (CDC 2008). The SARA designation means that protection and recovery methods have been developed and are to be implemented under Canadian law.

Badgers inhabiting the Rocky Mountain trench of the East Kootenays have been studied using radio telemetry in recent years (Kinley and Newhouse 2005 and Newhouse and Kinley 2000). Windermere Lake, located within the northern most range of their distribution, was found to be important to this species. Figure 4 provides a map showing sitings (between 1968 and 2002; indicated as dark blue points) and tracked movements of the species using radio telemetry (data from 1996-2005; indicated as light blue dots and lines). This data shows that badgers are known to inhabit areas around the entire lake, although they are concentrated along the eastern shore. Badgers are likely taking advantage of the open habitats, which unfortunately include roadsides. Their prey in these areas includes fossorial rodents of open habitats (mainly Columbia ground squirrels) as well as insects, and birds and amphibians inhabiting wetlands (Kinley and Newhouse 2005).

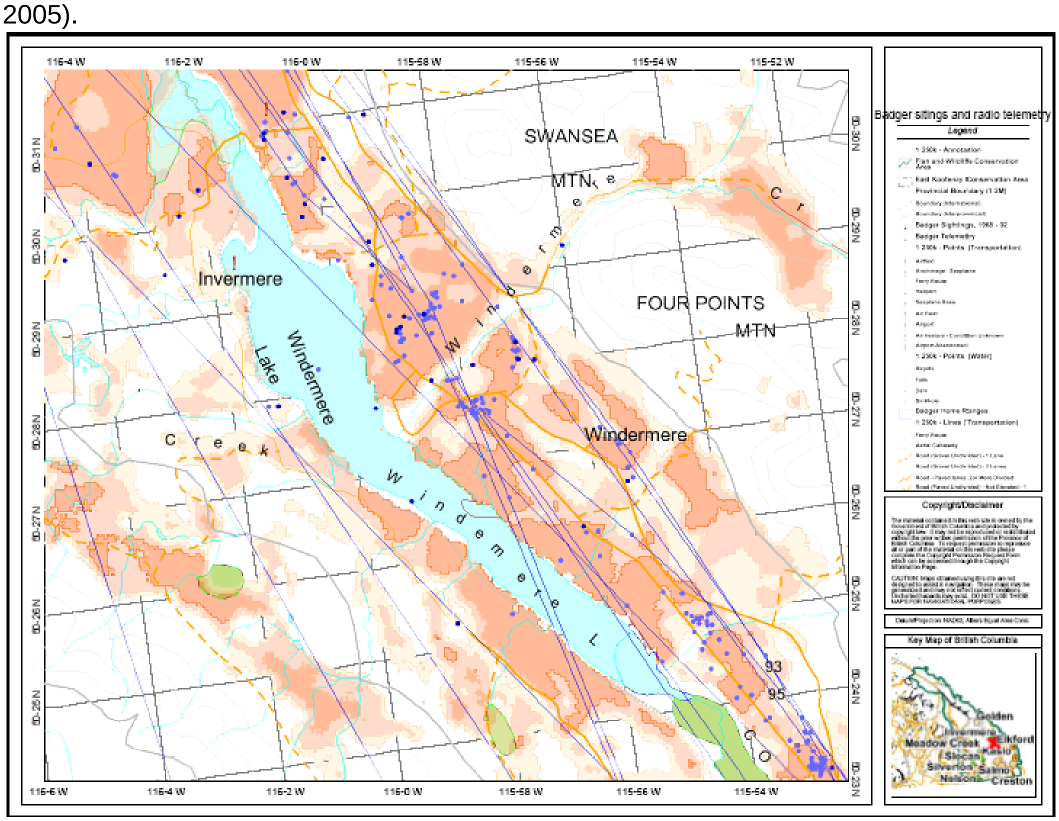


Figure 4. Badger sitings and radio telemetry movements in the proximity of Windermere Lake (Fish and Wildlife Compensation Program 2008)

During this assessment badger excavation was observed in the banks at Site 10, located along the northwest slopes near Rushmere (Figure 5). The Lake Windermere OCP (RDEK 2008) addresses badger habitat specifically under the Section 12.3 Wildlife Habitat and Corridors, by outlining that future land uses should not compromise the integrity of badger habitat. Specific areas have been identified as integral to the movement of the badger along the east side of the lake, namely the linkages provided by the BC Hydro right-of–way, Copper Point Golf Course and Holland Creek drainage. A management policy to protect the badger is that no structures, fences or buildings that would impede the movement of badgers or other wildlife is to be constructed in the OSRT Open Space, Recreation and Trails portion of the Holland Creek drainage south of Lakeview Drive adjacent to The Cottages at Lakeview Meadows (RDEK 2008).

Figure 5. Badger excavation observed in the foreshore habitat of Windermere Lake (Site 10) (photo by P. Holmes July 2007).

3.5.2.2 Great Blue Heron (Ardea heridias herodius)

The great blue heron is provincially ranked as being vulnerable during breeding (S3B); it is considered a blue listed or sensitive/vulnerable species in BC and is an Identified Wildlife Species under the Forest and Range Practices Act (CDC 2008).

The following summary of the great blue heron's habitat and ecology has been provided by Machmer and Steeger (2003), who conducted a breeding inventory and habitat assessment on the great blue heron in the Columbia River Basin. The authors compiled this synopsis using various sources of literature, of only which only one reference per sentence has been provided here for brevity. The original document should be reviewed for more detail.

> *The Great Blue heron is provincially ranked because it is vulnerable to habitat loss and disturbance associated with development in prime breeding and wintering habitats (Gebauer and Moul 2001). In the Interior of BC, herons nest along the margins of lakes, slow-moving rivers, wetlands and sloughs in small to large breeding colonies (Butler 1992). They typically breed and roost in mature black cottonwood (Populus balsamifera) or coniferous stands along lakeshores, on lake islands, in wooded swamps, or other isolated locations near shallow water foraging habitat (Butler 1992). Interior herons eat primarily fish (Machmer 2002), but other prey (e.g., amphibians, reptiles, invertebrates, small mammals and birds) likely also form part of their diet (Butler 1992). As cool weather and freezing conditions approach, some herons from the interior migrate south, while others remain around ice-free watercourses with adequate food supply (Campbell et al. 1990). Valley bottom riparian and wetland*

> *areas in the Columbia Basin represent important breeding and wintering areas for interior herons (Gebauer and Moul 2001). Herons are sensitive to disturbance, particularly during the early stages of nest selection, nest building, pair formation and egg laying (Butler 1992). Although some colonies habituate to non-threatening disturbances (Vos et al. 1985), colony abandonment resulting from nearby human activity has been documented (Forbes et al. 1985)*.

Machmer and Steeger's (2003) inventory identified heron adults at the wetlands to the north and south of Windermere Lake and a possible breeding site at the wetland to the south of the lake. The foreshore of Windermere Lake does appear to also contain valuable habitats for this species as it was observed at four sites during this Fish and Wildlife assessment in 2007. Reported occurrences were at Site 5a-Windermere Island, Site 6-Windermere Creek, Site 9-Columbia River Inlet and Site 13-Goldie Creek (Figure 6). These sites generally showed a low level of site disturbance and they all had emergent/wetland aquatic vegetation. Great blue heron potentially nest in the area and since they (and their habitat) are considered sensitive during nesting, it would be valuable to conduct a breeding bird survey to better understand habitat utilization in the area and potential areas requiring protection.

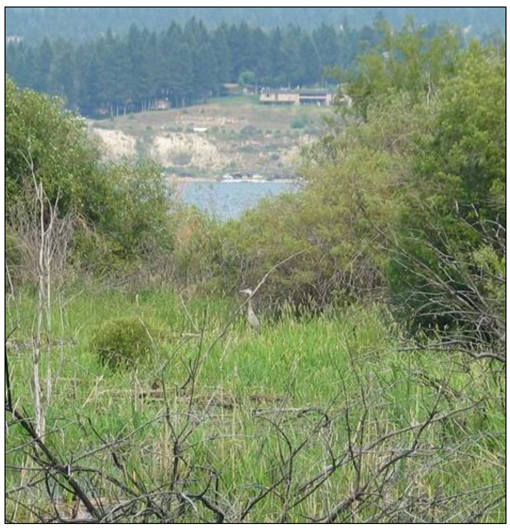


Figure 6. Great blue heron observed in the Wetland area near Goldie Creek (Site 13) photo by P. Holmes July 2007)

3.5.2.3 Wildlife Trees

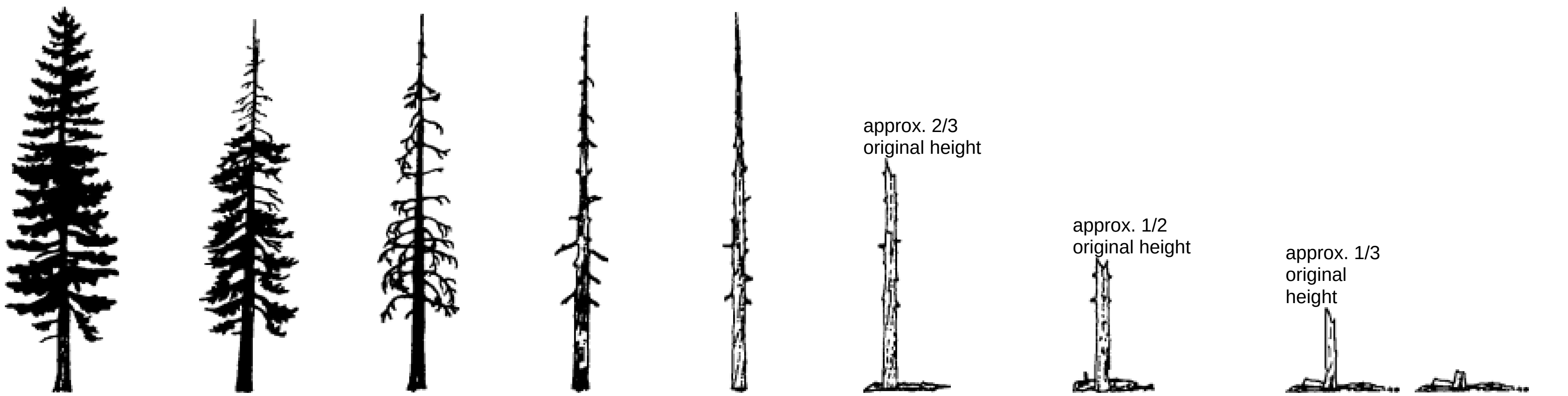
As a veteran tree deteriorates, it can support up to 80 wildlife species, or 15% of the province's birds, mammals and amphibians (Ministry of Forests and Range 2008 and Wildlife Stewardship Program 2006). Wildlife trees provide many kinds of critical habitat including nest cavities and platforms, nurseries, dens, roosts, hunting perches, foraging sites and display stations (Backhouse 1993). Wildlife trees located along the foreshore of Windermere Lake would be expected to be highly utilized since wildlife trees located in riparian, deciduous patches, gullies and ravines are known to be used the most (Backhouse 1993). Many species dependant on wildlife trees are on the provincial red and blue lists as endangered or sensitive/vulnerable species (Backhouse 1993). The Lewis' woodpecker (*Melanerpes lewis*), is one such documented species. In 1998, nests were found in old, decayed or dead paper birch, black cottonwood or Douglas fir that were associated with open burn areas and riparian cottonwood/woodland and golf course areas, along the Columbia River. Loss of this habitat is a concern for many dependant wildlife species and the most effective wildlife management practices is to retain wildlife trees (Wildlife Stewardship Program 2006).

As Table 9 provides, wildlife trees were noted at four of the sites reviewed during the 2007 sampling period. At Site 2, two decay class 3 wildlife trees were reported; at Site 8 a decay class 4 wildlife tree was observed (Figure 7); at Site 10 abundant trembling aspen wildlife trees were observed adjacent to the wetland; and at Site 12 abundant wildlife trees were noted near the outlet of Brady Creek. From 2007 studies (FIM report), riparian snags were also identified in several Segments (i.e., 2, 3, 5, 8, 9, 11, 12, 13, 14, 20, 21, 24, 25, 26), many of which were noted to have 5 or more wildlife trees observed.

Figure 7. Decay class 4 wildlife tree at Site 8 (photo by P. Holmes July 2007)

Wildlife trees provide valuable habitat for many wildlife species. The BC wildlife tree classification is provided in Figure 8. It is recommended that a Wildlife Tree Assessment be completed for the foreshore and that these trees remain protected during development, where safely possible.

Figure 8. British Columbia's wildlife tree classification system (Ministry of Forests and Range 2004)



LIVE		DEAD					DEAD FALLEN	
Decay class		**Hard**			**Spongy**	**Soft**		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Description								
Live/healthy; no decay; tree has valuable habitat characteristics such as large, clustered or gnarled branches, or, thickly moss-covered branches.	**Live/unhealthy;** internal decay or growth deformities (including insect damage, broken tops); dying tree.	**Dead;** needles or twigs may be present; roots sound.	**Dead;** no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable.	**Dead;** most branches/bark absent; some internal decay; roots of larger trees stable.	**Dead;** no branches or bark; sapwood/ heartwood sloughing from upper bole; decay more advanced; lateral roots of larger trees softening; smaller ones unstable.	**Dead;** extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells.	**Debris;** downed trees or stumps.	
Uses and Users								
Nesting (e.g., bald eagle, great blue heron); feeding roosting perching	Nesting/roosting, strong PCEs[1] (woodpecker); SCUs[2]., large-limb and platform nests (osprey); insect feeders.	Nesting/roosting- strong PCEs; SCUs; bats	Nesting/ roosting- PCEs; SCUs; insect feeders	Nesting/ roosting- weak PCEs (nuthatches, chickadees); SCUs; bats; insect feeders	Weaker PCEs; SCUs; insect feeders; salamanders; small mammals; hunting perches	Insect feeders; salamanders; small mammals; hunting perches; occasionally used by week cavity excavators (chickadees)	Insect feeders; salamanders; small mammals; drumming log for grouse; flicker foraging; nutrient source	

[1]PCU=primary cavity excavator. [2]SCU=secondary cavity use. *This classification does not recognize root disease trees specifically; these become unstable at or before death.

3.6 Habitat Index

The Habitat Index was used for two separate analyses. In one analysis, the Habitat Index was used to rank the **Ecological Value** of each foreshore segment. In the other, the Habitat Index was used to determine what the **Ecological Potential** of each segment would be if the in-water structures (e.g., docks, groynes, marinas and boat launches) were removed. The tabular results of the following sections can be found in Appendix A - Table IX and Table X and the mapped results are located in Appendix D Figures III and IV. An overview of the results comparing both analyses is provided in Table 10.

Table 10. Summary of Habitat Index results following ecological value analysis (with in-water structures) and ecological potential analysis (without in-water structures).

Ecological Value	Ecological Value			Ecological Potential		
	Total Number of Segments	Total Shoreline Length (%)	Total Shoreline Length (m)	Total Number of Segments	Total Shoreline Length (%)	Total Shoreline Length (m)
Very High	9	42%	14929	10	52%	18474
High	8	23%	8308	10	28%	9846
Moderate	2	3%	1042	6	20%	7137
Low	4	19%	6697	0	0%	0
Very Low	3	13%	4487	0	0%	0
			35,457			35,457

3.6.1 Habitat Index Ecological Value

Segments ranked by the Habitat Index model ranged from Very High to Very Low. These were determined using a complex matrix that considered physical and biological elements in the area, as well as human induced disturbances. Overall, most of the undeveloped areas of the lake were determined to have important fish and wildlife values of one type or another, whether it was creek mouths, wetland habitats, gravel beach areas or migration corridors. Generally, with increasing disturbance extent, ecological values and ranking went down.

Very High Rankings

The Habitat Index determined that a total of 9 segments or 42% of the Windermere Lake foreshore had a Very High Ecological Value. These typically were found where there was little or no associated urban development and a concentration of important fish and wildlife values. These Very High areas included Segments 2, 3, 5, and 6 in the undeveloped areas along the south east end of the lake; Segments 9, 11, 12 which were also generally undeveloped areas along the western shore; Segment 18 located along the park at the north end of the lake; and Segment 25 a small pocket located half way on the eastern shore (Windermere Cemetery).

A total of 8 segments, covering 23% of the lake, were ranked as having a High Ecological Value. These were found in areas where there was generally a low level of residential development and relatively high ecological values. Segments ranked as High included Segments 4, 7, 8 located at the southern end of the lake; Segments 13, 14, 15, and 17 located along the western perimeter of the lake. Some of the northwest portions of the lake were ranked as high even though they were located in the vicinity of the Invermere Townsite. These Segments generally did not have residences along the immediate foreshore or associated instream structures negatively impacting their rankings.

The two segments that were rated as having a Moderate Ecological Value were Segments 10 (residential area on west side of lake) and Segment 19 (lake outlet). These segments represented 3% of the shoreline length. They have both been modified to some degree which has influenced their value for fish and wildlife. Segment 10 was characterized as having less dense urban development than other areas and development here was set back from the lake edge. The homes were set back because the CPR tracks were positioned between the residential area and the shoreline.

Where urban development was concentrated along the foreshore, segments were determined to be Low and Very Low in their Ecological Value; thereby reducing (or limiting) fish and wildlife habitat values. A total of 7 segments, representing 32% of the shoreline were ranked as Low or Very Low. These were mostly along the north east shore and included most Segments south to the Windermere Townsite. Segment 25 (Hidden Bay area), which was largely undeveloped and appropriately ranked as Very High, was the only Segment north of the Windermere Townsite on the eastern side of the lake to not be ranked as Low or Very Low.

3.6.2 Ecological Potential Index

In-water features including docks, groynes, marinas, boat launches and retaining walls were removed from the Habitat Index model to investigate the difference that restoration would make to the habitat value for each segment. This ranking was mapped as the Ecological Potential. The Ecological Potential analysis revealed that 11.2 km of shoreline could be improved with restoration efforts. In general, running the Habitat Index model without these structures resulted in approximately 9/26 of the foreshore segments moving up at least one ranking. Four of these moved up two rankings, with Segments 21 and 24 increasing from a Very Low to a Moderate ranking, and Segments 22 and 26 increasing from a Low to a High ranking. Other than Segment 13 (which is has a High ecological value), all segments showing potential improvement following restoration were those that currently have Ecological Values as being either Moderate, Low or Very Low. Other than Segment 13, these segments all have associated residential development.

With the removal of in-water features the following increases could be evidenced in term of total shoreline length: a 10% increase (or 3.5 km) of shoreline ranked as Very High, a 5% increase (1.5 km) of shoreline ranked as High, and a 17% increase (or 6.0 km) of shoreline ranked as Moderate. With restoration, 0% of the shoreline could be valued as being Low or Very Low. These segments were mainly located along the south eastern to central eastern shore where residential areas dominate. Three segments located along the western shore would also benefit from restoration, these being Segments 10, 13 and 16.

In terms of improvement by Shore Type, restoration of these segments would benefit all habitat types to some extent. It is not easy to identify which habitat type would benefit the most since each segment is typically represented by more than one shore type. These results indicate that there is a great potential environmental benefit to be had if in-water structures were removed. Some additional opportunities which have not been considered in the Ecological Potential Index include: native plant species revegetation efforts, stabilizing eroding bankslopes, replacing culverts with bridges at tributary crossings, removing wildlife barriers (e.g. fences), re-establishing lakeshore wetland features, removing structures located on the land along the foreshore (e.g., decommissioning roads or railways). These can be accomplished in a cost-effective manner through restrictive covenants, development/planning related policies and with funding/cooperation from a number of groups (J. Bisset pers. com.). Large ecologically significant pieces of land could also be purchased or swapped, using organizations such as the Nature Conservancy of Canada (J. Bisset pers. comm.).

Zones of Sensitivity

Zones of Sensitivity (ZOS) were defined as Environmentally Sensitive Areas that have the potential to be negatively affected by development. The intent of the ZOS is to act as a trigger for further investigation if development is proposed in these areas. ZOS were delineated in order to protect Environmentally Sensitive Areas and natural ecosystems unique to the Windermere Lake foreshore. Protection of the defined ZOS will help achieve the OCP environmental policies which generally outline that water sources and water quality and fish and wildlife habitat should not be compromised by development. The ZOS were also identified in such a manner as to *promote connectivity and discourage fragmentation of contiguous ecosystems and ecosystem components, in order to preserve landscape diversity and allow for species use, movement and dispersal (RDEK 2008).* The habitats determined to be ZOS through this study are as follows:

1. wetlands,
2. creek mouths,
3. native grasslands,
4. wildlife habitat and corridors,
5. gravel/cobble habitat,
6. biologically productive areas, and
7. unimpacted/natural areas.

Some of these habitats overlap, such as native grasslands and wildlife corridors and creek mouths. Each will be individually described in order to outline their environmental importance. All of the ZOS have been mapped and are provided in Appendix D (Figures I-IV). Other than the Natural Areas which are outlined in Figures I and II, all ZOS are depicted (with the HI Rankings) on Figures III and IV. The HI/ZOS maps show some ZOS as individual feature layers (i.e. Gravel/Cobble Substrates and Wetland areas), while others are combined together into one “Key Habitat” layer. The Key Habitat layer includes Wildlife Corridors, Creek Mouths, Native Grasslands and Biologically Productive Areas. Note that the ZOS were delineated independent of shoreline Segments, while the Habitat Index results related directly to calculated segment values.

The extent of potential effects to a ZOS depends on the ZOS type, proposed development type, development intensity and other factors (e.g., increased recreational use). Shoreline management recommendations for each ZOS are presented and these typically correspond with the respective OCP policies. All ZOS should be considered synonymous with Environmentally Sensitive Areas under the OCP, at a minimum. In Environmentally Sensitive Areas, the OCP outlines *that the landowner shall obtain a Development Permit when planning for land alterations*. Development permit guidelines for the protection of the natural environment are described in Section 21.4 of the OCP. Overall, *activities in environmentally sensitive areas are to be conducted in an environmentally sensitive manner that minimizes disruption or alteration of the environmental integrity.* This section of the OCP identifies that the landowner is *to provide several pieces of information such as: watercourses and wetlands; significant areas of native flora and fauna, including any known endangered or vulnerable species; and methods for preserving of dedicating watercourses and protecting fisheries. Additional information may be required, such as a report completed by a professional biologist that provides, for example, more detailed biological information, opportunities for mitigation, areas for conservation, and confirmation of setback distance established within the Regional District floodplain regulations. This is intended to protect valuable fish and wildlife habitat and movement corridors associated with the Lake, its wetlands and creeks and other identified Environmentally Sensitive Areas.* The OCP provides several specific guidelines, in order to help protect these sensitive areas. These guidelines will be referenced under the relevant habitats. Development guidelines and management strategies in the ZOS will be further detailed in the Shoreline Management Guidelines document, which will be developed subsequent to this report’s completion.

3.6.3 Wetlands (Lacustrine Marshes / Aquatic Vegetation)

> *Wetlands are arguably one of the most critical components in maintaining the health of ecosystems for fish, wildlife and humans, but they are the least understood and protected. Wetlands provide a number of important ecological functions ranging from water purifiers and fish nurseries to carbon sinks and wildlife breeding grounds. In the Columbia Basin region there are 41 species of mammals, 108 species of birds, 9 species of amphibians and 4 species of reptiles that are dependent on wetlands for their survival (*FWCP 2008)

The wetlands located along the lake's foreshore were classified as being lacustrine marshes in the Habitat Index (*See* 2.10.1 Wetlands). The marshes located within the lake were identified as being lacustrine bay marshes, while those separated by a land barrier from the lake were either lacustrine lagoon marshes or lacustrine shore marshes according to the Canadian Wetland Classification System (National Wetlands Working Group 1997) (Figure 9). These foreshore wetlands are all considered to be sensitive habitats and have been mapped within a ZOS. Wetlands provide important habitat to many species and perform critical functions to the lake ecosystem as a whole. An overview describing some of their key values for fish and wildlife is provided here.

Figure 9. Important marsh wetlands are found along the foreshore of Windermere Lake, as evidenced by the lacustrine bay marsh at Hidden Bay (Site 5) and the lacustrine shore marsh at Site 10, depicted respectively (photos by P. Holmes, July 2007).

The wetlands at Windermere Lake are significant and important ecological features. Windermere Lake lies within the Columbia River Wetlands Complex, which is known to be one of the longest continuous wetlands in North America (Zimmerman 2004). The Columbia River Wetlands Complex has been provincially, federally and internationally recognized. All wetlands located on crown land, which includes extensive sections of the Columbia River to the north and south of Windermere Lake have been established as a Wildlife Management Area (WMA) under the BC Wildlife Act (Zimmerman 2004 and P. Holmes pers. comm.). These areas have also been chosen as a Ramsar wetland of international significance (Ramsar 2008). The expansive wetland located at the south end of Windermere Lake is included in the WMA. The remaining wetlands along Windemere Lake were not included in with these designations because they are located on or adjacent to private land. At Windermere Lake, the private lands fall under regional or local municipality jurisdiction and land use is generally governed by the OCP bylaw and its policies (K. MacLeod pers. comm.). For effective implementation, both OCP policies and regulatory bylaws that back up the policies are required.

Windermere Lake is contiguous with the Columbia River Wetlands Complex and its wetland habitats hold similar ecological values. Features of the Columbia Wetland Complex were described by Zimmerman (2005) who used Pedology et al (1983) as a main reference. Some key points presented regarding the significance of the Columbia Wetland Complex are as follows:

- support intricate food chains that play a key role in the water cycle;
- are utilized by approximately 216 species of birds and mammals; including vulnerable, endangered or threatened species;
- are the last intact portion of the Pacific Flyway, where during the spring and fall migration periods, tens of thousands of individual birds representing hundreds of species rest and feed in the area;
- are an important spawning, feeding and migration path for 11 indigenous fish species, and;
- reduce the impact of floods by slowing and storing floodwater (i.e. attenuate flows).

Because of their continuity with the Columbia River Wetland complex, the Windermere Lake wetlands are known to provide similar ecological functions. Birds are particularly abundant in the marshes, because of the food richness and the diversity of habitats for nesting and rearing (Mitsch and Gosselink 2000). A diversity of bird species were found during this assessment, with the findings presented in Section 3.5.1 Bird Results. The FIM provided additional historic information on birds in the Windermere Lake wetlands (as documented in Urban Systems 2001). In general, Urban Systems presented that the wetlands are known to provide important nesting and rearing habitat for several duck species, Canada geese, and great blue heron. At least 24 active nesting pairs of osprey are known to inhabit the wetlands, as well as several other birds of prey (including 8 owl species). The older stands of cottonwood are also known to provide important habitat for cavity nesters.

Sensitive or vulnerable blue listed plant species in BC have also been found to be associated with wetland habitat in the Windermere Lake area. These include the water marigold (*Megalodonata beckii* var. *beckii*), stiff-leaved pondweed (*Potamogeton strictifolius*) and Booth's willow (*Salix boothii*) (CDC 2008). Table XI (Appendix A) outlines that there are several (approx. 36) other sensitive plant species that could potentially occur in the area, since they are reported to inhabit palustrine and/or lacustrine environments in the IDF Biogeoclimatic Zone in the RDEK. Plant inventories would be required to confirm presence/absence of these sensitive species.

Wetland habitats are known for their high level of productivity (i.e. invertebrate productivity). Invertebrates are important to the lake's food web since they provide food for many animals including fish, ducks and birds and some mammals (Mitsch and Gosselink 2000). The invertebrate field data results for Windermere Lake (Section 3.4) indicate that there indeed is a diverse invertebrate assemblage in the lake, as evidenced by a total of 16 orders represented. Mitsch and Gosselink (2000) describe that in marshes benthic invertebrates (such as Diptera larvae) are food for fish, frogs and diving birds and that the pupae, which surface and emerge as adults are exploited by surface-feeding birds and fish. Mollusks such as snails are also common and are food for fish species.

The FIM report data indicates that although wetlands are prevalent along approximately 40% of Windermere Lake's margins, they generally only exist along undeveloped stretches of the lake's foreshore, suggesting that they are sensitive to development. Boundaries for the lacustrine bay marshes were determined by Wildsight in 2006 and mapped in the FIM report (McPherson and Michel 2007). The lacustrine shore and lacustrine lagoon marshes (adjacent wetlands) were identified using orthophotos, 2006 and 2007 field data and input from EKILMP habitat professionals. The Windermere Lake OCP recognizes the significance of the Windermere Lake wetlands in terms of their connectivity with the Columbia River wetlands complex and their importance to birds, wildlife and sensitive species (Section 12 Environmental Considerations). Policies relating to wetland management are provided under Section 12.2 Environmentally Sensitive Areas and Section 12.4 Water Resources. These are summarized as follows:

Section 12.2 - Environmentally Sensitive Areas: wetlands are recognized as Environmentally Sensitive Areas and property owners *are encouraged to preserve wetlands, riparian areas, wildlife habitats, native vegetation and trees through consideration of the location of infrastructure and utilities, concentration of development and minimization of site grading*.

An objective of **Section 12.4-Water Resources** is *to support the protection, rehabilitation and enhancement of wetland and riparian areas*. Associated policies are as follows

- *Ecosystem restoration of wetland and riparian areas is encouraged;*
- *Resource extraction and development should not harm fish and wildlife habitat;*
- *A permit from the environmental regulatory agencies is to be obtained if the foreshore is to be altered in the following ways: adding or removing fill; constructing or maintaining retaining walls, banks protection, docks, marinas, boathouses, groynes, breakwaters or other foreshore structures; any activity that may alter, disrupt or destroy fish habitat; removing foreshore vegetation; or other significant works.*

Wetlands are important features in Windermere Lake that should be given greater protection than what is apparent in the OCP. In order to protect their valuable fish and wildlife habitat, we believe that the OCP wording should be stronger to ensure that any proposed wetland alteration (as designated by the ZOS map), does have a development permit completed according to the Section 21 of the OCP. This would require the completion of such tasks as: analysis and identification of endangered or vulnerable flora and fauna species, identification of areas to be altered and areas to remain natural, mitigation of impacts on fish and wildlife values, and establishment of setback distances.

Wetlands are considered islands of biological diversity integral to the ecology and species diversity of the lake. For this reason, it is recommended that buffers or set-backs be established by government agencies to ensure their protection. These established buffers should be adequately sized to provide protection of function and should be regulated and enforced regardless of land status.

3.6.4 Creek Mouths

Creek Mouths are extremely important areas for fish and wildlife. In this study, the Creek Mouths were found to be the most highly used shore types by fish, especially during the critical reproduction (spawning) and rearing stages (*See* 3.3 Fish). The associated riparian areas and their wetlands were found to be highly utilized by birds. The Creek Mouths are also known to be important wildlife access corridors (RDEK 2008).

The Creek Mouth ZOS boundaries were mapped to extend 50 m up the streams. The Creek Mouth ZOS boundaries were also mapped to include their zone of influence along the lake's shoreline, which extended beyond the immediate confluence at the lake. Creek Mouth ZOS are considered to be highly sensitive to alterations because they influence so many fish and wildlife habitat requirements.

Figure 10. Windermere Creek outlet (Site 6), a zone of sensitivity, important for fish and wildlife (Photo by P. Holmes July 2007).

In terms of fish and wildlife values, the OCP addresses Creek Mouths primarily through their riparian habitats in the OCP and these overlap with wildlife corridors. This discussion of management practices at the Creek Mouths will relate to riparian habitats, since wildlife corridors will be discussed in the following section. In the OCP, riparian areas are addressed as Environmentally Sensitive Areas (Section 12.2).

> In this section *property owners are encouraged to protect and conserve the natural riparian vegetation along the creeks*. *Further developments along Windermere Creek are encouraged to dedicate land for conservation and protection purposes.*

Riparian areas are also discussed in the OCP under Water Resources – Section 12.4, with one of the objectives being to *support protection, rehabilitation and enhancement of wetland and riparian areas.* Policies to this regard are to:

- *minimize the level of access impacts by using established trails and avoiding the creation of new access points;*
- *conduct ecosystem restoration where necessary;*
- *retain riparian areas in a natural state throughout development to promote slope stabilization, vegetation retention and preservation of fish and wildlife habitat;*

Most of the creeks draining into Windermere Lake (and their associated riparian areas) are designated as Environmentally Sensitive Areas in the OCP. The exceptions are the creeks entering the lake from the Columbia Lake Indian Reserve # 3 on the south eastern shore and from the District of Invermere on the north western shore. Provincial base maps indicate that there are seven creeks associated with the Indian Reserve (including Cool Spring, Madias and five unnamed creeks) and one creek (Abel Creek) associated with the District of Invermere. These areas have not been included in the OCP because they fall under interjurisdictional management (K. McLeod 2008). However, they provide important habitats for fish and wildlife and have been included in the Habitat Index and mapped as ZOS in this study. The creeks associated with the Indian Reserve are particularly valuable because, for the most part, they remain undisturbed along their length providing important and stable connections to upland habitat and they have large wetlands at their outlets. These creeks have been mapped for this project as ZOS. These areas are all depicted in the Key Habitats layer in the HI/ZOS maps (Appendix D - Figures III and IV). Because of their environmental values and importance to the lake as a whole, OCP environmental policies should be extended to these areas as a minimum.

Alterations of riparian areas identified as Environmentally Sensitive Areas in the OCP would trigger the requirement for a development permit, according to the Section 21 of the OCP. The intent of this is to protect valuable fish and wildlife habitat. The permit could require the completion of such tasks as: *analysis and identification of endangered or vulnerable flora and fauna species, identification of areas to be altered and areas to remain natural, mitigation of impacts on fish and wildlife values, and establishment of setback distances*.

Similarly to wetlands, creek mouths are considered islands of biological diversity integral to the ecology and species diversity of the lake. For this reason, it is recommended that buffers or set-backs be established by government agencies to ensure their protection. These established buffers should be sized to offer adequate protection and should be regulated and enforced regardless of land status. Other jurisdictions in the province have adopted riparian protection mechanisms through the Riparian Area Regulations under the provincial *Fish Protection Act*, or through local government bylaws.

3.6.5 Wildlife Habitat and Corridors

Windermere Lake foreshore provides important habitat for wildlife. Although a thorough inventory was not conducted, evidence of deer, bear, beaver and elk were noted during the 2006 and 2007 field reviews and are summarized in Section 3.5 (Wildlife / Sensitive Species and Habitat Results) and in the Site Descriptions (Appendix B). Foreshore areas are known to be highly productive and diverse, providing important foraging and refuge habitats for wildlife. They also provide a critical link between aquatic and terrestrial ecosystems, both physically and biologically. Maintaining the foreshore and providing unrestricted access to it is thus important. This section includes both wildlife corridors and winter range, since they were presented together in the OCP. ZOS for wildlife corridors and winter range have been determined from the literature, information provided by the EKILMP habitat professionals and the 2008 OCP document for the area.

The OCP addresses Wildlife Habitat and Corridors specifically in Section 12.3. The land use planning objectives of this section of the OCP are to a) *maintain habitat connectivity through undisturbed open space and wildlife corridors to support the movement of various wildlife species,* and b) *to encourage the protection of natural ecosystems unique to the plan area*. Key wildlife habitat and corridors have been mapped as Environmentally Sensitive Areas in the OCP and some require a Development Permit. Details on important wildlife habitat and corridors have been largely obtained from the OCP document, and are as follows:

1. *Development that considers and promotes connectivity of wildlife movement corridors is encouraged.*
2. *The riparian areas of the main creeks in the system are important wildlife corridors linking the upland wildlife habitat to Windermere Lake. Keeping these corridors uninterrupted is essential for wildlife. The creeks which have been specified as important to this regard are: Holland, Windermere, Jane, Johnston, Brady, Salter and Goldie. Windermere Creek is a particularly important wildlife corridor and an essential linkage from the upland wildlife habitat to Lake Windermere.*
3. *The linkages provided by the BC Hydro right-of-way, Copper Point Golf Course and Holland Creek Drainage near the southeast end of the lake are integral to the movement of the badger population* (*See* Section 3.5.2.1). The OCP further states that no *structures, fences or buildings are to be constructed that would impede wildlife movement within the OSRT (Open Space, Recreation and Trails) portion of Holland Creek drainage south of Lakeview Drive adjacent to the Cottages and Lakeview meadows*.
4. *Property owners considering the use of wildlife fencing are encouraged to consider wildlife movement, habitat and access to water when determining fence placement.*
5. Elk depend on equisetum located in riparian areas which are adjacent to the lake. *Future land uses should not compromise the integrity of Class 1 and 2 ungulate winter range, particularly the range located along the southwest facing slopes*. The OCP provides location data on elk winter range (class 1) and bighorn sheep winter range habitat. Although much of the winter range for these species lies in the upland areas, some class 1 elk winter range habitats are located along the foreshore.

As described in previous sections (*See* Creek Mouths), the Columbia Lake Indian Reserve # 3 lands located on the south eastern shore and the District of Invermere on the north western shore were excluded from the OCP due to jurisdictional responsibilities. Wildlife habitats and corridors for these areas were thus not included in the OCP. Important areas for wildlife movement (i.e. badgers) and winter range do however exist in these areas and have been subsequently mapped by MOE. Movement corridors are generally situated along the riparian areas of the creeks. This includes the seven creeks associated with the Indian Reserve (including Cool Spring, Madias and five unnamed creeks) and Abel Creek located in the District of Invermere. The creeks associated with the Indian Reserve are particularly valuable because they are relatively undisturbed and provide uninterrupted movement for wildlife to upland habitats. Almost the entire Columbia lake Indian Reserve # 3 is classified as class 1 and 2 elk winter range.

The Lake outlet downstream to Athalmer also provides important values for wildlife. It acts as an important migration corridor for ungulates and other species, providing an east/west terrestrial connection. Of utmost importance, this area and a portion of the wetland to the north is ice-free during the winter, allowing access to water for overwintering birds and other species such as river otter. As early migrants of the Pacific Flyway arrive, it provides rare open water habitat during the early spring. Prior to human settlement, the area would have been used extensively by grizzly bear and eagles during the fall spawning of the Chinook salmon.

The wildlife habitat and corridors described above have been mapped as ZOS. These areas are all depicted in the Key Habitats layer in the HI/ZOS maps (Appendix D - Figures III and IV). Overall, land uses in these areas should not compromise the integrity of these habitats. Any developments proposed outside of the OCP jurisdiction should follow the similar protocols to that required for OCP Development Permit Areas/Environmentally Sensitive Areas.

3.6.6 Native Grasslands

Grasslands are one of Canada's most endangered ecosystems (FWCP 2008). The Grassland Conservation Council of BC (GCCBC 2008) summarized the significance of BC's grasslands as follows:

> *In BC, grasslands make up less than one percent of the province's area. Much of these grasslands have been altered by livestock grazing, recreational activities, the invasion of non-native invasive plants, and encroaching trees. As grasslands have been lost or altered, so has the habitat for the species that lived there. The grasslands of BC are unique since they are a northern extension of the grasslands of the Great Basin of the Western United States, and thus different from the prairie grasslands found east of the Rocky Mountains. The plants and animals found in BC's grasslands live in the northern limit of their habitat, and they are adapted to survive in harsh climatic conditions. Scientists are now finding that these uniquely adapted species are particularly important in terms of continental and global conservation, which makes BC's grasslands especially important.*

BC's grasslands are home to over 30 percent of the species at risk in the province (GCCBC 2008). Although a sensitive plant species inventory was not conducted under this assessment and does not appear to have been conducted in recent years, sensitive species likely exist in the area. CDC (2008) sensitive species listings (Appendix A – Table XI) indicate that the Windermere Lake area is known to contain several sensitive plant species (i.e., red or blue listed and either provincially designated as critically imperiled (S1), imperiled (S2) or vulnerable (S3)). The plant species historically documented in the Windermere Lake area and associated with grasslands include Hooker's townsendia (*Townsendia hookeri;* red listed, S2), and scarlet globe-mallow (*Sphaeralcea coccinea;* red-listed, S1). In addition to these, there are a further 65 sensitive vascular plant species potentially associated with the grassland areas, (i.e., they are listed as being found in terrestrial habitats in the IDF Biogeoclimatic Zone of the RDEK) (CDC

2008). The Lewis' woodpecker (*Melanerpes lewis*) is an example of a sensitive bird species (red-listed, and breeding sites considered imperiled in BC) also historically documented in the area, which has been reported to be associated with native grassland habitat (CDC 2008). The Lewis' woodpecker occurrence report indicated that in 1994 3 males and 3 females (1 mating pair) were observed in the Sharptail Prairie, south of Goldie Creek. They were utilizing the grassland habitat containing *Purshia* grass, scattered snags and live ponderosa pine (CDC 2008). Grassland habitats are also considered important for other species known in the area including ungulates, particularly for feeding, and badgers, which have been listed as a Schedule 1 species under SARA (CDC 2008). The SARA designation means that protection and recovery methods have been developed and are to be implemented under Canadian law.

Native grasslands are found throughout most of the undeveloped sections of Windermere Lake's foreshore (Figure 11). Native grasslands were identified along the foreshore during field inspections of Sites 7, 11, 12, and in addition in Segments 3, 5, 8 and 13, following a review of the 1995 orthophotos. Further, the FWCP (2008) completed grassland mapping, as part of the Biodiversity Atlas and other initiatives, in order to prioritize specific grassland ecosystems most threatened by human activities. This mapped information should contribute to developing specific conservation and stewardship recommendations for these priority grassland areas.

Figure 11. Native grasslands associated with the foreshore of Windermere Lake, located respectively near Cool Spring Creek (Site 7), and near the outlet of Brady Creek (Site 12) (photos by P. Holmes July 2007).

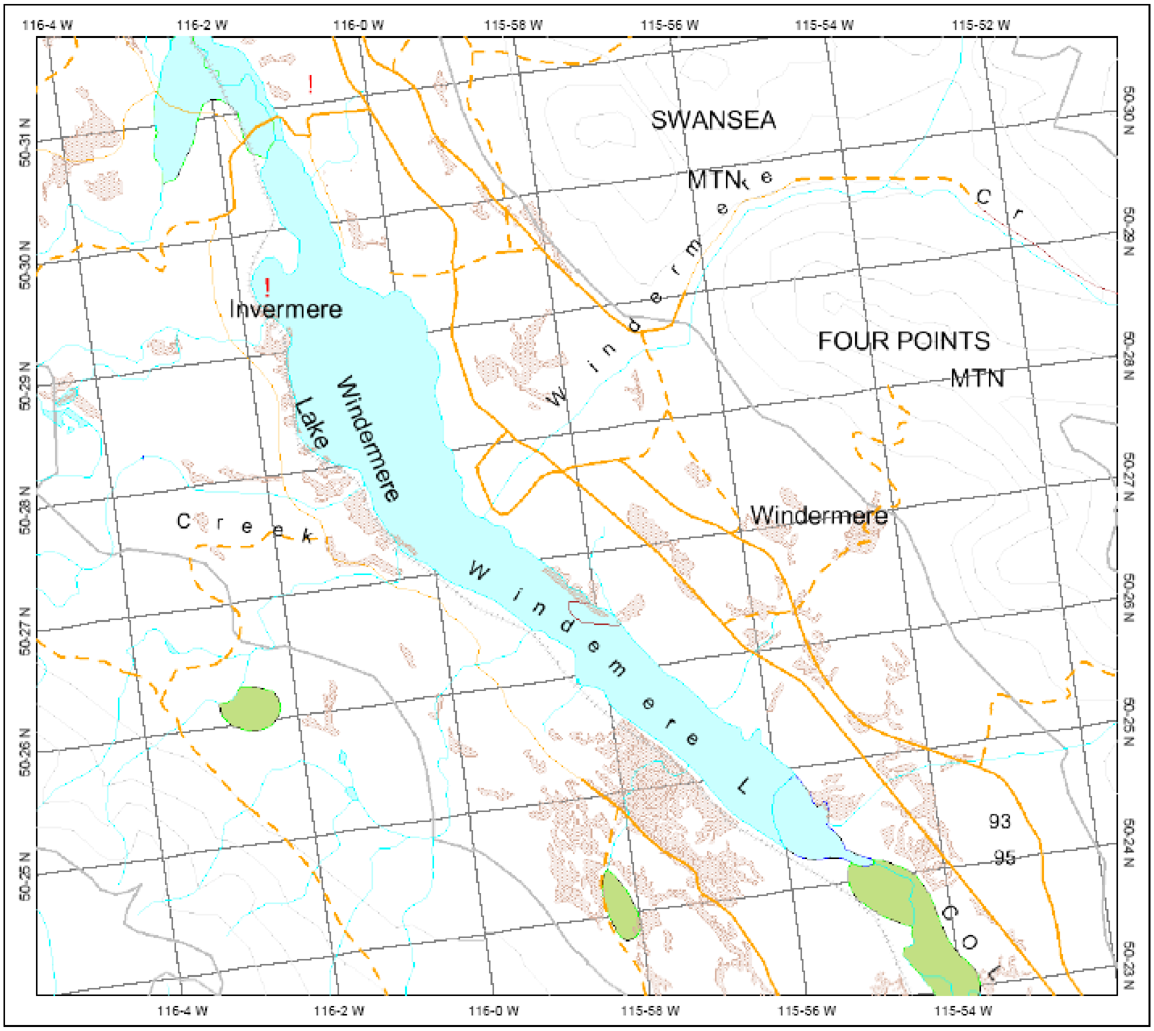


Figure 12. Grassland ecosystems in the Windermere Lake area (shown as light brown polygons), as provided by the Biodiversity Atlas (FWCP 2008)

The native grasslands surrounding Windermere Lake are unique habitats sensitive to development. The OCP refers to grassland habitats under Environmentally Sensitive Areas (Section 12.2), where the natural vegetation between Toby Creek Road and the escarpment is specifically identified as an Environmentally Sensitive Area. The Wildlife Habitat and Corridors Section (Section 12.3) also outlines that vulnerable plant community should be considered at the time of applications for rezoning or OCP amendment.

Key intact grassland communities within the RDEK jurisdiction have been included in the OCP Development Permit Area map. These appear to coincide with the grassland ecosystems map, above, developed by the FWCP (2008). For the ZOS, grasslands in the Indian Reserve and District of Invermere were also included. These grassland polygons were determined by Ministry of Environment using the 2006 and 2007 field findings and the FWCP map above. These areas are all depicted in the Key Habitats layer in the HI/ZOS maps (Appendix D - Figures III and IV). Overall, land uses in these areas should not compromise the integrity of these habitats, especially given the new classification (SARA) of badgers.

Gravel and Cobble Substrates for Fish Habitat

Course substrates including gravels, cobbles and boulders are important for spawning and rearing of many fish species inhabiting Windermere Lake. Species including kokanee, longnose dace, burbot, torrent sculpin and mountain whitefish are known to specifically depend on gravels for spawning (*See* Appendix C – Fish Species Summaries). Burbot, kokanee and longnose dace also depend on course substrates for rearing. Course substrates are not common along the Windermere Lake shoreline. FIM results indicate that fine silt materials are the dominant substrate along nearly half of the shoreline length. The shore types where coarse substrates are typically found are mainly the Gravel Beach and Low Rocky Shore Types and these represent 7% and 18% of the shoreline, respectively

Burbot are considered species of concern, since they have experienced significant population declines in the lake and the region as a whole (Paragamian et al. 2000, Prince 2007). Burbot will be the focus of this ZOS because of their population declines and because recent studies have been completed on them in Windermere Lake. In lakes, burbot are known to spawn in relatively shallow water (1-10 m) over sand or gravel bottoms (McPhail 2007). Studies on burbot at Windemere Lake (Taylor 2002) revealed that age 0 juveniles preferred gravel and cobble substrates along the shoreline and that the highest densities were found in areas with high percentage of cobble (>64 mm to 256 mm) and low fines (<2mm). It is generally known that a silt free environment is important to egg survival for many fish species; these results indicate that for burbot, substrates should also be relatively silt-free during the rearing stages. Taylor (2001) also found that shelter size increases with body size for burbot, and that older juveniles were associated with larger substrates of cobble and boulder.

Based on the above habitat requirements, areas with relatively high percentages of gravel and/or cobble substrates and low percentages of fines (<10%) were identified and mapped as ZOS (Table 11). Table 9 indicates that approximately 33% of the shoreline potentially contains coarse substrates with a low percentage of fines, as represented by Segments 10, 11, 12, 13, 14, 15, 17 and 21. These habitats are found mainly along the western end of the lake. The 2008 site data indicates that there may be additional pockets of suitable spawning/rearing substrates around the lake, as was found at Site 5 (Segment 25), Site 5a (Segment 26) and 1 Site 10 (Segment 7). Percentages of each substrate type, however, were not determined during the 2008 sampling studies.

More thorough sampling in these areas could be completed to delineate areas providing important substrate habitat at the site level, since the Segment results were obtained at a fairly broad scale during the FIM. The ZOS associated with coarse substrates for fish spawning and rearing optimally should be protected from development with appropriate buffers. As a minimum, they should be included as Environmentally Sensitive Areas in the OCP, where a permit would be required for any development that may disturb their integrity.

Table 11. Segments likely to provide spawning/rearing ZOS for burbot, based on substrate composition (low percentage of fines (<10%) and subsequent availability of gravel and cobble substrates) (FIM data)

Segment # and (length)	Shore Type	% natural	% fines	% gravel	% cobble	% boulder
10 (773 m)	85% vegetated, 10% cliff/bluff, 5% wetland	50	10	70	20	0
11 (3868 m)	80% low rocky shore, 10% cliff bluff and vegetated shore	15	0	35	35	30
12 (1090 m)	70% vegetated shore, 15% gravel beach, 10% sand beach, 5% wetland	60	0	15	80	5
13 (3550 m)	80% low rocky, 15% vegetated, 5% wetland	100	0	15	80	5
14 (255 m)	90% gravel beach, 10% vegetates shore	100	0	100	0	0
15 (164 m)	50% gravel beach and 50% sand beach	100	0	50	50	0
17 (696 m)	40% vegetated, 40% low rocky shore, 20% cliff bluff	70	10	60	10	20
21 (1154 m)	50% vegetated shore, 40% gravel beach, 5% low rocky and cliff/bluff shore	0	10	70	10	10

3.6.7 Biologically Productive Areas

Biologically productive areas are sites along the foreshore of Windermere Lake known to contain unique species and/or habitats, which have not already been discussed above. The biologically productive areas identified were the mussel beds observed during 2007 field surveys. These mussel beds were substantially sized and were observed at Sites 12 and 14. The mussels were not identified to species, but were typed generally as Oregon freshwaters. These mussel bed areas are considered significant features along the foreshore and their habitat should be protected during development. These biologically productive areas have been included in the Key Habitat Areas on the ZOS/HI Maps.

3.6.8 Natural Areas

All unimpacted/natural areas identified during the aerial photo analysis were also considered to be ZOS. As the aerial analysis provides, a significant portion of the foreshore has been disturbed (74% evident in 1995). The remaining natural areas provide important intact habitats for fish and wildlife. Efforts should be made to preserve these areas in their natural condition so that they continue to provide their biological functions.

As the air photo analysis revealed (Section 3.2), most of these natural areas are concentrated along the south east half of the lake. This area is known to have a variety of valuable habitats for fish and wildlife, including many of those described above such as wetlands, creek mouths, wildlife corridors and native grasslands. In addition to these areas, a substantial portion of the foreshore contains important cliff/bluff habitat. These features have not yet been discussed.

Cliff/bluff areas are found along much of the southeast perimeter of the lake. These steep clay bank slopes provide a unique physical habitat and distinctive micro-climates. They are thus inhabited by plants and animals that are specially adapted for the area. Bank swallows (*Riparia riparia*) are an example of a species dependant on the cliff/bluffs along Windermere Lake. This bird lives in colonies and builds its nest in the erodible banks near water. The bank location provides protection from ground predators during nesting and close proximity to foraging areas.

The other areas of intact/natural habitat mapped in the air photo analysis (including Windermere Island), also have valuable important habitats and should be maintained.

4 Discussion/Conclusions

Summarizing the fish and wildlife values at Windermere Lake involved reviewing 2006/2007 field results and conducting a literature review for a great many topics. Because of this, some results sections also include discussion components. This section will discuss the effects of previous shoreline modifications, present values/implications for fish and wildlife habitat management and summarize how the results of the Habitat Index and Zones of Sensitivity could be used to prepare the Shoreline Management Guidelines.

4.1 Effects of Previous Shore Zone Modifications

Historical disturbance of the Windermere Lake shoreline was concentrated in areas that are more urbanized now (e.g., northern and northeastern portions). Other studies identified that intensification of foreshore development began in the 1950s (McDonald 2000). Through our study, it is evident that a great extent of the shoreline disturbance, which is currently evident, had occurred by 1968 (the earliest air photos we could obtain); albeit density has increased with time. Shoreline development has resulted in numerous changes including the addition of foreshore buildings, infrastructure (roads and railways) and instream structures (such as marinas, groynes, retaining walls, docks, boat launches and boathouses), as well as other human induced impacts unaccounted here (e.g., recreational and water quality effects). Riparian vegetation disturbance is also a precursor of many of these developments. Until recently, very little strategic shoreline planning or consideration of the potential cumulative impacts appears to have occurred. Although it will be a challenging undertaking, there is a need for a shoreline management plan that balances environmental considerations with the community's social, economic and development needs.

Approximately 74% of the total shoreline has been disturbed to some extent, according to most recent air photos (1995). This represents a variety of shore types and habitats, including sensitive ecosystems including: wetlands, creek mouths, fish spawning and rearing areas, riparian areas, grasslands and wildlife corridor habitats. Although the combined or cumulative effects of this level of development are unknown, this study revealed that the foreshore still has extensive and viable ecological communities present that are worthy of preservation and protection. These natural components have been maintained, for the most part, because residential development has been concentrated (in the north and north eastern sections of the lake). Infrastructure (railway) has limited residential development on the western shoreline and the Indian Reserve jurisdiction has limited development at the south eastern end of the lake, thereby buffering the area from development. In the current real estate market there are great potential monetary benefits to be gained from development and these two factors alone are not expected to always act to protect the foreshore environment. The results of this relatively detailed baseline inventory program, which includes data obtained during the 2006/2007 FIM study, provides a good basis for identifying and valuing areas for conservation and restoration.

4.2 Fish and Wildlife Values

4.2.1 Fish

Overall, Windermere Lake is known to have a wide assemblage of species, of which most occur in relatively low numbers, particularly sport fish. Windermere Lake itself has been reported to provide good spawning, rearing and over wintering habitat; good cover and food sources associated with the high aquatic macrophyte populations; and to have water chemistry that is optimal for fish survival (Urban Systems 2001). However, from the literature review and field results of this study, it appears that several factors may have contributed to negatively influence the native fish assemblages, particularly the sport fish including bull trout and westslope cutthroat trout which are listed/sensitive species and burbot which is a regionally significant species. It is likely that historic over-fishing coupled with habitat changes, including potentially increasing water temperatures, may have influenced the sport fish species in particular (J. Bisset pers. comm.). Sport fish have likely been replaced by other top predators in the system, most notably northern pikeminnow and the exotic largemouth bass. Conditions appear to be quite suitable for these species and have allowed them to thrive. In order to sustain and allow for possible improvement to historic native fish (sport fish) populations, maintaining natural habitat conditions is considered imperative. This includes maintaining a diversity of habitats in the system through protection of the natural foreshore areas. Components identified as important for fish include creek mouths, vegetated shores, shoreline areas with course substrates and wetland habitats.

4.2.2 Wildlife

This study revealed that Windermere Lake is encompassed by an array of ecosystems which are home to a great diversity of wildlife species. Although the lake provides important habitat for a variety of fish species, its biodiversity should be considered its most notable feature. Of particular importance are the wetland habitats which are found along much of its perimeter, both in the lake and adjacent to the lake. The wetlands are an extension of the world renowned Columbia Wetlands, which intricately connect a myriad of plant, invertebrate and vertebrate life as well as provide fundamental physical benefits to the basin and its inhabitants (Zimmerman 2004). The wetlands should not be taken for granted just because they are still found along a considerable extent of shoreline (approximately 50 %). Since it appears that in almost all cases where there is concentrated residential development, there are no wetlands present. Schleppe and Arsenault (2006) also found that wetlands were susceptible to destruction as a result of development along the foreshore of Kelowna in Okanagan Lake, with results indicating that they have been reduced from approximately 21% in 1938 to 2% or less in 2004.

Other important ecosystems associated with the lake's shoreline identified in this study are the native grasslands, wildlife corridors, riparian areas and cliff/bluff habitats. All told, these areas are known to provide habitats to numerous migratory bird species, sensitive species (e.g. American badger and great blue heron), as well as critical year-round habitat for ungulates. Although the habitats have not been fully inventoried, they are expected to be inhabited by numerous other sensitive plant and animal species.

4.2.3 Habitat Index and Zones of Sensitivity

This study reveals that the area still has a significant extent of natural intact and/or ecologically viable ecosystems apparent, as evidenced by the HI and ZOS processes. This is evident despite the facts that much of the lake's foreshore was developed back some 40 years ago and that the area is currently experiencing unprecedented growth levels. The extent of areas ranking as high or very high following the Habitat Index analysis exemplify this. As aforementioned, certain elements have been in place which have helped to make this so, including the Indian Reserve which has limited development, likely due to political as well as the physical nature of the area, and the railway on the western shore which has limited foreshore development. With proper planning, key habitat areas and highly ranked areas (as identified in the HI) can be preserved.

This study has conversely revealed that development does impact the environment, with 32% of the lake currently ranked as Low or Very Low in terms of its Ecological Value. Almost all areas where development has occurred (particularly residential), habitat values have been greatly compromised. There were few historical instances where residential effects only caused modest impacts. Because of this, consideration should be given to using the High (Segment 7 – Rushmere) and moderately ranked (Segment 10 also at south west end), developed areas as templates or reference sites for future developments. Alternatively, if development is expected to continue, it may be optimal to keep it concentrated in existing areas, leaving the remaining High and Very High value areas in their current condition.

The Ecological Potential Analysis has identified that there are opportunities to improve even the most highly impacted areas through removal of shoreline structures. Additional restoration opportunities also exist, which have not been considered in the Ecological Potential Index. These include: revegetation with native plant species, removal of non-native plants, stabilizing eroding bankslopes, replacing culverts with bridges at tributary crossings, removing wildlife barriers (e.g. fences), re-establishing lakeshore wetland features, removing structures located on the land along the foreshore (e.g., decommissioning roads or railways). Due to the sensitive nature of the foreshore, there are also other conservation opportunities which should be implemented in order to maintain quality habitats and water quality. Some examples include: limiting horsepower of water vessels on the lake, particularly near the wetlands; and limiting access by off-road vehicles (e.g., quads and motorbikes) in sensitive areas.

Maintaining the Very High and Highly ranked foreshore habitats and the ZOS in their current naturally functioning condition should be a goal of any future management strategies. This would help ensure that ecological communities remain intact and do not become fragmented and in doing so maintain the lake's fish, wildlife, water quality and aesthetic values. Restoration efforts could be implemented to help achieve these goals. Lake management should also ensure to consider cumulative impacts of small changes along the foreshore.

4.3 Implications for Lake Management and Conservation

Lakes are hierarchically structures with attributes at landscape, watershed, lake-basin and local habitat scales, each contributing to ecosystem function (Kolasa and Pickett 1992). With increasing development of the lakeshore, habitat protection that depends solely on site-specific or individual property regulation will become more biologically insufficient and administratively impractical (Radomski and Goeman 2001). For instance, small-scale scope results in resource degradation because cumulative impacts of each individual (permit) are often not accounted for (Radomski and Goeman 2001). Although conservation approaches at smaller scales have benefits, maintaining functional attributes at these larger scales will help to maintain ecological integrity and functional attributes (Jennings et al. 2003). A comprehensive approach to lake management should include not only in-water and riparian zone management, but should also put appropriate emphasis on maintaining watershed scale processes (Jennings et al. 2003). Management goals should thus attempt to ensure a proper functioning ecosystem, which consists of littoral zones, wetlands, creek mouths, grasslands, riparian areas, cliff/bluffs etc. By maintaining this ecosystem, the needs of fish, waterfowl, benthic invertebrates, ungulates and other wildlife should be protected.

The results from this study are intended to provide direction to the process of developing Shoreline Management Guidelines for Windermere Lake. The Shoreline Management Guidelines will aid future management by highlighting areas where development could be permitted (Green Zones), where development should not be permitted (Red Zones) and where development could only be permitted with restrictions (Yellow Zones). The Shoreline Management Guidelines should be developed in a manner which considers both the HI and the ZOS results together, since these were developed using the most comprehensive data available for the lake and followed scientific and quantitative methods. Because the HI rankings and the ZOS were developed using watershed, landscape and lake-basin levels of fish and wildlife information, the Shoreline Management Guidelines are expected to provide direction for shoreline development at the broad comprehensive scale described by the various authors above.

A lake management goal which should be incorporated into the Shoreline Management Guidelines is that the Ecological Value rankings for the Segments as provided by the Habitat Index should be maintained (or increased). With this approach, the HI model could be rerun when a development plan is reviewed, with segment values recalculated considering all potential structures. Optimally, activities should only be approved if they do not result in a reduced overall score for the segment. This process would thereby reduce the potential and/or track cumulative impacts for a segment. Developers are likely to support this since it could allow a certain extent of development in some natural areas (which are currently ranked as Very High) without changing the rank. In other areas, restoration may be necessary before further development activities could proceed. As a whole, the focus of the Shoreline Management Guidelines should be to protect and promote healthy and aesthetic lake ecosystems.

Residential and recreational development can induce profound changes in natural landscapes through many means. Although physically altering the lake habitat is one potential consequence of development, other pressures include inputs of nutrients and contaminants, human induced alterations to fish species communities through fish introductions and changes to the food webs and through harvest of resident organisms (Jennings et al. 2003). These should all be given consideration by resource managers. Jennings et al. (2003) and Radomski and Goeman (2001) identified additional options for lake management consideration which would discourage actions that cause small losses or alterations to aquatic habitat. These are provided here as suggestions for future management plans:

<u>Jennings et al. (2003)</u>

- maintain intact wetlands;
- use best management practices (e.g., to reduce non-point source run-off and maintain vegetative riparian buffers);
- limit the density of development in the riparian zones through mechanisms such as zoning;

<u>Radomski and Goeman (2001)</u>

- Encourage lake associations and local communities to designate lakes as pesticide free or a natural-landscape lakes;
- Eliminate riparian owner rights to destroy aquatic plants and put in place a regulatory system in which aquatic plant control is allowed only by lake associations or improvement districts;
- Establish shoreline zoning rules which encourage retention of natural habitat on the water's edge as buffer strips in order to maintain natural shoreline characteristics and protect water quality; and
- Implement programs that change the attitudes and behaviors of lakeshore property owners.

As explained by Schleppe and Arsenault, in the Okanagan Lake F&W study (2006), *this study provides some of the data necessary to begin to understand the biological communities of the shoreline and helps define what these communities need to carry out their life processes. More data collection is recommended in order to more completely understand these communities so that managers can prepare better guidelines for their preservation or restoration. This includes understanding more on the species inhabiting the area including plant communities, breeding birds, and spawning fish. The inventories and literature synthesis completed as part of this study provide enough information for managers to begin to effectively set guidelines for development. The inventories provide a general understanding of the fish community, part of the wildlife* *community and relate this understanding to specific shoreline segments (via the HI Ecological Value rating) and Zones of Sensitivity around the lake. Thus, specific management goals or objectives can be established.*

This study has identified that the area from the outlet of Windermere Lake north to Athalmer possesses valuable cultural and environmental values. Although this area lies outside of the scope of this project, it should have an equivalent FIM and fish and wildlife study completed, in order for regulatory agencies to properly assess future development proposals.

4.4 Data and Analysis Limitations

This section relates to potential limitations with the data and analysis and has been obtained from the Okanagan Lake F&W report (Schleppe and Arsenault 2006).

The HI ranks current shoreline conditions based upon a desktop study of known fish life history requirements, a fish and bird inventory, surveys and literature review of wildlife habitat and the physical shoreline characteristics gathered during the FIM (e.g., substrates, level of impact, docks, etc.). ***The index incorporates fish life history habitat requirements, effects of previous development, and uses the current shoreline condition to determine a ranking for a given shoreline segment. Other important habitat values are incorporated into areas identified as ZOS, which are independent of specific shore segments. However, the HI does not provide information about historical effects and it is only as robust as the assumptions contained within it. It appears that identifying and quantifying the specific effects of current or previous development on fisheries, whether it is direct (i.e., loss of habitat) or indirect (i.e., reduction in allochthonous inputs results in poor productivity, which affects fish survival), is difficult because there have been very few large scale studies investigating these questions.*** Coupled with the lack of supporting documentation is the fact that a large portion of research has focused on eastern fish assemblages, which are significantly different than the fish assemblages of Windermere Lake. ***Therefore, using the HI to predict the potential effects of development on fish assemblages is difficult and it is even more difficult to quantify these effects.***

Quantifying previous impacts is very difficult since good historical baseline data does not exist. Fish assemblages are known to vary with time; however, the fisheries inventory that was completed only contains data from one year. Thus, it is false to assume that this one-year of sampling is sufficient to accurately describe the fish assemblage and all ZOS or environmentally sensitive areas. It is for these reasons that the HI safely assumes that previous shore zone impacts are detrimental to aquatic habitat, rather than assuming that these impacts are negligible and that the HI uses presence/absence data rather than actual fish densities or abundances to predict shoreline sensitivity.

5 Recommendations

The following are general recommendations to help regulatory authorities a) identify areas for improvements for future similar studies, b) identify areas that require further assessment at Windermere Lake, and c) prepare the Shoreline Management Guidelines:

Suggestions for Future Similar Studies

1. It would be beneficial to have an individual segment in the FIM study include only one shore type, so that the Segment was representative of a single contiguous habitat feature.
2. The fish sampling regime was a presence/absence evaluation; if quantitative numbers are required, then a more rigorous fish sampling regime should be undertaken.

3. Future assessments, for other lakes, should attempt to select just one shore type at a particular fish sampling site. For instance, Site 8 had both sand beach and wetland components, making it difficult to correlate findings.
4. Consider removing wetland as shore type or re-defining it, particularly if it is prevalent in a particular lake and overlaps with other shore types. Perhaps have wetlands identified as a unique segment parameter within a shore type.
5. Ensure that all areas to be potentially reviewed are included in the overall length of the shoreline segment (including islands).
6. Use GPS to mark locations of sensitive species (badger dens) or habitats (wildlife trees) during field activities.

Further Assessment Needs at Windermere Lake

7. To better understand fish habitat utilization of the lake, surveys should be conducted again in the spring which is a spawning period for many of the identified fish species.
8. Obtain a better understanding of spawning locations for mountain whitefish and burbot, which are fall/winter spawning fish respectively. The historic spawning locations as well as potential shore-spawning areas should be assessed, and once confirmed should be adequately protected.
9. Complete a spring breeding bird survey, in order to assess utilization of the area during a critical life history stage.
10. Conduct inventories of: amphibians, reptiles; invertebrates (including slugs and snails); and vascular plants. Identify locations for species of concern.
11. Conduct a wildlife tree inventory of the shoreline in order to identify trees of significance and cavity nesting locations.
12. The EKILMP is arranging for low elevation, high resolution air photos to be obtained for the lake this summer. Also, the 1994 orthophoto coverage does exist for the rest of the lake, but it has not been processed yet. Once both of these have been processed and available to the public, it would be valuable to update the historical analysis.
13. Identify the current state of the water quality for the lake, link findings to this study and provide recommendations to address any related concerns (i.e. nutrient inputs and contaminants).
14. More detailed sampling of areas providing course substrates for fish spawning and rearing could be completed to more definitively delineate sensitive areas providing important substrate habitat, since the Segment results were obtained at a fairly broad scale during the FIM. The ZOS associated with coarse substrates for fish spawning and rearing optimally should be protected from development with appropriate buffers.
15. Peter – Bruce: any management suggestions that should be noted regarding human induced alterations to fish species communities through fish introductions (Large mouth bass or pumpkinseed fish)?

Shoreline Management Guidelines

16. As a result of the cultural and fisheries sensitivities noted north of the highway bridge (See Section 3.3.5 Lake Outlet Downstream to Athalmer), further development should not proceed until such time that a FIM and Fish and Wildlife study is completed. Field work is scheduled for this summer (2008).

17. An alternative to new marinas such as reissuing of tenure providing on-land storage with concierge service should be promoted, as a matter of policy.

18. No new marinas should be built in shallow areas requiring dredging.

19. EKILMP should play a strong role in encouraging a restoration focus to the heavily developed north east shoreline. This could involve moving back retaining walls when redeveloped, revegetation, etc. Jane Creek is an example of where there are potential restoration opportunities. EKILMP should consider developing a priority list that incorporates the increases in habitat value associated with the restoration and the feasibility (e.g., cost benefit analysis) of restoring the area (adopted from Schleppe and Arsenault 2006).

20. The Shoreline Management Guidelines and/or the Lake Management Plan should: contain a 'how to' section for shoreline residents, refer to legislative triggers (activities that need to be permitted), and reference best management practices and guidelines.

21. Consider updating the OCP to explicitly identify setback distances for environmentally sensitive areas such as wetlands, riparian and the foreshore areas. Follow the Riparian Areas Regulation under the Provincial Fish Protection Act as a minimum.

22. Ensure that ZOS identified in this report but not covered by the OCP be included in future Lake Management planning. This includes the ZOS within the interjurisdictional lands (Indian Reserve and District of Invemere Lands). As a minimum, these areas should be included as Environmentally Sensitive Areas in the OCP, where a permit would be required for any development that may disturb their integrity. Sensitive habitats and species require confidentiality and their locations should only be provided on a need-to know basis.

23. Incorporate the GIS map products from this study into the Community Mapping Network.

24. The EKILMP should develop a Lake Management Plan that incorporates a more regional approach to development of the foreshore. The Lake Management Plan would help all stakeholders and levels of government with regional planning and would work towards identifying the carrying capacity of the Windermere Lake system (adopted from Schleppe and Arsenault 2006).

25. The Ecological Value rankings for the segments as provided by the Habitat Index should be maintained (or increased) with time. The HI model should be rerun when a development plan is reviewed, with segment values recalculated considering all potential structures. Optimally, activities should only be approved if they do not result in a reduced overall score for the segment. This process would thereby reduce the potential and/or track cumulative impacts for a segment.

    Alternatively,

    A monitoring program of the shoreline should be prepared and carried out on a regular basis (e.g., every 5 to 8 years). The program should be used to monitor conditions of the foreshore area. The best way to maintain and monitor changes in data would be to repeat the FIM exercise, but record the small additions to the database made by Interior Reforestation (e.g., new shore segments including creek mouth). Maintaining one database with current and historical data will provide the basis for comparison and work towards goals such as identifying carrying capacities, monitoring habitat restoration efforts, effectiveness of regulatory guidelines, etc. An updated FIM database and HI analysis will been provided and attempts should be made to keep the database current in order to help make decisions regarding large-scale changes along the foreshore or to monitor successes and shortcomings of the Shoreline Management Guidelines (adopted from Schleppe and Arsenault 2006).

26. The foreshore is an important area. However, many of the fish and wildlife species also require streams in proper functioning condition to carry out their life process. A coordinated approach to foreshore and streamside management should be adopted. Some improvements to stream habitats will also improve the habitats found in the foreshore areas. For instance, reducing or treating storm water discharge to streams will improve the water

quality of the stream and along the foreshore and ultimately improve habitats in both (adopted from Schleppe and Arsenault 2006).

27. Designate Windermere Lake as pesticide free or a natural-landscape lake;

28. Consider suggestions made by Jennings et al (2003) to limit the density of development in the riparian zones through mechanisms such as zoning, and by Radomski and Goeman (2001) to eliminate riparian owner rights to destroy aquatic plants and put in place a regulatory system in which aquatic plant control is allowed only by Lake Associations or Improvement Districts (neither of which exist to date at Windermere Lake);

29. Consider changing the styles of development (e.g. nodes, reduce road networks, intensify development only in existing sites etc) (J. Bisset pers. com.).

30. The Lake Management Plan should identify how instream permitting (i.e., construction of structures below the high water mark) will be handled. For instance, have construction of private moorage only require a Provincial permit and not require authorization from the City/RDEK. This agreement could open communication and allow local/regional government to monitor construction of these structures. Agreements could be amended as OCP provisions. Regulating the construction of instream structures is very important in High and Very High ranked habitats and in the ZOS (adopted from Schleppe and Arsenault 2006).

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Appendix A – Tables

TABLE I: FISHERIES FIELD DATA FROM SAMPLING ALONG THE FORESHORE OF WINDERMERE LAKE IN JULY AND SEPTEMBER OF 2007

Site	Segment	Sampling Season	Sampling Date	Predominant Shore Type	Disturbance Level	Substrate Type	Aquatic Vegetation	Air Temp. (°C)	Water Temp.(°C)	Photo No.	Sample Type	Channel Distance (m)	Species	Number of Fish	Life Stage	Fish Comments	General Site Observations
1	20	Fall	25-Sep-07	Modified Gravel Beach	High	silt/small cobbles along shoreline	None	18	14.5	18 & 19 u/s and d/s (fall)	Seen from boat	200	kokanee	30	adults	Kokanee observed from boat rolling at the surface along cobble shoreline just upstream of river inlet (~200m) near boathouses. Test redds in area; some redds may have been started.	
1	20	Fall	25-Sep-07	Modified Gravel Beach	High	silt/small cobbles along shoreline	None	18	14.5	18 & 19 u/s and d/s (fall)	Snorkel	200	none	0			
1	20	Summer	19-Jul-07	Modified Gravel Beach	High	Gravel, cobble and algae at end of site	None	19	23.8	28 d/s	Snorkel	200	cyprinid	12	young of year	6 by overhanging vegetation by retaining wall and 6 over gravel	
1	20	Summer	19-Jul-07	Modified Gravel Beach	High	Gravel, cobble and algae at end of site	None	19	23.8	28 d/s	Snorkel	200	sucker	1	adult	Dead	Developed, retaining walls between boathouses and docks. Downstream of Copper Point Intake.
1a	21	Fall	25-Sep-07	Modified Low Rocky Shore	High	Silt/cobble;boulder retaining wall	None	17	14		Seen from boat		largescale sucker	1	adult	Dead	
1a	21	Fall	25-Sep-07	Modified Low Rocky Shore	High	Silt/cobble;boulder retaining wall	None	17	14		Snorkel	50	none	0			Retaining wall above water level.
1a	21	Summer	19-Jul-07	Modified Low Rocky Shore	High	Boulders	None	19	23.8	29 (retain. wall)	Seen from boat		sculpin	2	adult		
1a	21	Summer	19-Jul-07	Modified Low Rocky Shore	High	Boulders	None	19	23.8	29 (retain. wall)	Snorkel	100	largemouth bass	1	adult	Dock	Irvine retaining wall. Rebuilt retaining wall with fish structures (boudlers) in front of wall.
1a	21	Summer	19-Jul-07	Modified Low Rocky Shore	High	Boulders	None	19	23.8	29 (retain. wall)	Snorkel	100	redside shiner	8	adult	Likely more hiding in rocks	
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock		bull trout	2	30-50 cm		
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock		largemouth bass	2	adult	Asociated with the dock	
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock		largescale sucker	1	adult	Asociated with the dock	
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock		northern pikeminnow	20	30-50 cm		
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock		northern pikeminnow	100+	10-30 cm		
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Observed from dock	200	redside shiner	100+	adult	Very large school actively feeding at the surface.	Bay surrounded by dock (swim area). Greebes and loons feeding on redside shiners.
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Snorkel	200	largemouth bass	1	adult		
2	22	Fall	25-Sep-07	Modified Creek Mouth	High	Sand/silt	Submerged	9	12	1 & 2 u/s and d/s (fall)	Snorkel	200	redside shiner	1000+	adult		
2	22	Summer	19-Jul-07	Modified Creek Mouth	High						Minnow trap		sculpin	1	adult		Trap set at Holland Creek
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel		20	23.7		Seine		None	0	adult		Located at Holland Creek, Lakeview Meadows/Timber Ridge. Swim area/bay surrounded by dock.
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	cyprinid	5	young of year	Assoc. with alluvial fan.	
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	cyprinid	100	young of year	Some uncertainty with species identification.	
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	largemouth bass	18	adult	Using docks or boats; 1 on nest of newly hatched fry.	Marina; swam area with large dock; Holland Creek tributary disturbed; schools of fish observed from dock; entire area full of aquatic vegetation except for swimming area (sand and large gravels).
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	largescale sucker	1	adult	alive	
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	pumpkinseed	1	adult	vegetation	
2	22	Summer	19-Jul-07	Modified Creek Mouth	High	Sand with some large gravel	Submerged and emergent patches	20	23.7	30 /3? u/s and d/s	Snorkel	200	redside shiner	30	adult	20 in vegetation; 10 assoc. with alluvial fan of Holland Creek.	
3	23	Fall	26-Sep-07	Modified Cliff Bluff	Moderate	90% silt, 10% sand, a few cobble	Minor submerged	11	12	3 d/s, 4 u/s, 5 u/s (fall)	Seine	1 X15m	redside shiner	2	adult		
3	23	Fall	26-Sep-07	Modified Cliff Bluff	Moderate	90% silt, 10% sand, a few cobble	Minor submerged	11	12	3 d/s, 4 u/s, 5 u/s (fall)	Seine	1 X15m	sculpin	1	adult	Caught in kick net	
3	23	Fall	26-Sep-07	Modified Cliff Bluff	Moderate	90% silt, 10% sand, a few cobble	Minor submerged	11	12	3 d/s, 4 u/s, 5 u/s (fall)	Seine	1 X15m	sucker	1	young of year		
3	23	Summer	19-Jul-07	Modified Cliff Bluff	Moderate	Sand/gravel	Very small patches of submerged veg.	21	23.76	32 and 33 (u/s & d/s)	Snorkel	200	sculpin	1	adult	under wood	Around corner and downstream from Site 2
3	23	Summer	19-Jul-07	Modified Cliff Bluff	Moderate	Sand/gravel	Very small patches of submerged veg.	21	23.76	32 and 33 (u/s & d/s)	Snorkel	200	sucker	1	young of year	Dead	
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	largemouth bass	3	juvenile		
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	northern pikeminnow	4	juvenile		Seine sample located under overstory (willows). Water level is about 2 m below retaining walls; did not snorkel due to sandy bottom and shallow water.
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	pumpkinseed	1	juvenile		
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	redside shiner	1	juvenile		
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	sculpin	2	juvenile	1 full-bellied	
4	24	Fall	26-Sep-07	Modified Sandy Beach	High	Sand/silt; cobble/gravel near shoreline	Little amount submerged	10	13	6 u/s, 7 d/s (fall)	Seine	200	sucker	2	juvenile		
4	24	Summer	18-Jul-07	Modified Sandy Beach	High	Sand with some gravel	Some deeper Sm and submerged	30		25 u/s	Snorkel	200	largemouth bass	2	adult	1 by overhanging veg and 1 under dock	Located downstream of Windermere. Developed; nothing but retaining walls; some undisturbed overhanging vegetation.
4	24	Summer	18-Jul-07	Modified Sandy Beach	High	Sand with some gravel	Some deeper Sm and submerged	30		25 u/s	Snorkel	200	redside shiner	25	young of year	By overhanging veg	
4	24	Summer	18-Jul-07	Modified Sandy Beach	High	Sand with some gravel	Some deeper Sm and submerged	30		25 u/s	Snorkel	200	sculpin	1	adult	Under rocks	
4	24	Summer	18-Jul-07	Modified Sandy Beach	High	Sand with some gravel	Some deeper Sm and submerged	30		25 u/s	Snorkel	200	sculpin	1	juvenile	Swimming by dock	
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	kokanee	1	adult	off point (beach)	Three habitat types: 1)shallows with silt & submerged vegetation, 2) drop off from beach, 3)deep bay of 3-5 m -dredged? for marina.
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	largemouth bass	10	juvenile	in bay	
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	largescale sucker	1	adult	large	
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	largescale sucker	2	juvenile	subadult	
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	northern pikeminnow	5	adult	off beach	

Site	Segment	Sampling Season	Sampling Date	Predominant Shore Type	Disturbance Level	Substrate Type	Aquatic Vegetation	Air Temp. (°C)	Water Temp.(°C)	Photo No.	Sample Type	Channel Distance (m)	Species	Number of Fish	Life Stage	Fish Comments	General Site Observations
5	25	Fall	26-Sep-07	Vegetated Shore	Low	silt/sand; cobble shoreline & beach	Abundant submerged vegetation	10	13	8 u/s, 9 d/s (fall)	Snorkel	200	redside shiner	20+	adult		
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	largemouth bass	3	adult	All fish at this site were associated with weed beds in the bay	Overhanging riparian in bay. Located upstream of Hidden Bay.
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	largemouth bass	100	juvenile		
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	largescale sucker	2	adults	1 dead	
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	pumpkinseed	2	adults		
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	pumpkinseed	25-50	juvenile		
5	25	Summer	18-Jul-07	Vegetated Shore	Low	Gravel cobble (sands); bog area is all sandy/silt	Emergent	31	25	24 towards bay	Snorkel	200m into Bay	redside shiner	100+	adult		
5a	26	Fall	26-Sep-07	Vegetated Shore	Low	Sand/silt;small cobble/gravel along perimeter of island	Submerged	19	14		Snorkel	whole perimeter of island ~ 400	none	0		No fish observed. Large mussel bed at tip of island.	
5a	26	Summer	19-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged				Minnow Trap		largemouth bass	1	juvenile		
5a	26	Summer	19-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged				Minnow Trap		pumpkinseed	2	juvenile		
5a	26	Summer	19-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged				Minnow Trap		redside shiner	18	adult		
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	largemouth bass	1	adult	Associated with LWD	Undisturbed island by Shadybrook; overhanging vegetation; coarse woody debris; mosquito larvae casings everywhere; dead mussel shells by point of island.
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	largemouth bass	2	juvenile	In submerged vegetation	
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	mountain whitefish	20	young of year	Schools using reed beds	
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	pumpkinseed	3	adult	In submerged vegetation	
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	redside shiner	100	young of year	Schools	
5a	26	Summer	18-Jul-07	Vegetated Shore	Low	Gravels, cobbles and sand	Submerged	27.5	25.04	23	Snorkel	200 - around island	sucker	1	adult	Dead	
6	26	Fall	26-Sep-07	Creek Mouth	Low	clay/sand	Submergent	13	12	10 u/s, 11 d/s (fall)	Seine		largemouth bass	2	juvenile		Dragonfly nymph caught in seine net.
6	26	Fall	26-Sep-07	Creek Mouth	Low	Silt (hydrogen sulphide when disturbed)	Submergent	10	10	10 d/s (fall)	Snorkel	200	largescale sucker	1	adult	largescale sucker observed in Windermere Ck.	Marina frontage dredged; retaining wall frontage/pilings/silt banks.
6	26	Summer	18-Jul-07	Creek Mouth	Low	Silt/clay	Emergent with some submergent	29.5	24	21,22 u/s and d/s	Snorkel	200	largemouth bass	4	adult	In reedbed	Snorkelled around marina & mouth of Windermere Creek; no fish using docks or breakwater;low visibility; minnow trap set off boat for entire snorkel survey with no fish caught; mosquito larvae casing everywhere.
6	26	Summer	18-Jul-07	Creek Mouth	Low	Silt/clay	Emergent with some submergent	29.5	24	21,22 u/s and d/s	Snorkel	200	largemouth bass	20	juvenile	In reedbed	
6	26	Summer	18-Jul-07	Creek Mouth	Low	Silt/clay	Emergent with some submergent	29.5	24	21,22 u/s and d/s	Snorkel	200	redside shiner	15	adult	At mouth of Windermere Creek	
6a	26	Fall	26-Sep-07	Modified Creek Mouth	High	Silt/sand	Submergent	13	11	12 facing marina, 13 u/s, 14 d/s	Snorkel	200	cyprinid	3	juvenile	Couldn't ID	Water level low, difficult to snorkel; went into Jane Ck.
6a	26	Summer	18-Jul-07	Modified Creek Mouth	High	Silt/sand	Emergent and submergent	29.5	24	19,20 u/s and d/s	Snorkel	200	largemouth bass	10	adult	Along breakwall	Jane Creek/Trethaway. Snorkelled at Jane Creek (impacted tributary) and along shore to look at fish structures. No observations of fish in most of area.
7	2	Summer	18-Jul-07	Wetland	Low	Sand and clays	Wetland - emergent	29	24.5	17,18 d/s and u/s	Seine	50	cyprinid	5	young of year		
7	2	Summer	18-Jul-07	Wetland	Low	Sand and clays	Wetland - emergent	29	24.5	17,18 d/s and u/s	Seine	50	largemouth bass	6	juvenile		
7	2	Summer	18-Jul-07	Wetland	Low	Sand and clays	Wetland - emergent	29	24.5	17,18 d/s and u/s	Seine	50	pumpkinseed	4	juvenile		Sample site located downstream of first reedbed. No snorkel survey completed due to high turbidity from clays; seined by tributary?; very slippery.
7	2	Summer	18-Jul-07	Wetland	Low	Sand and clays	Wetland - emergent	29	24.5	17,18 d/s and u/s	Seine	50	redside shiner	1	adult		
8	4	Fall	25-Sep-07	Sand Beach	Moderate	Silt/sand/cobble (in shallows)	reed beds at d/s end	1	10	1 u/s, 2 d/s (fall)	Snorkel	200	None	0		Freshwater clams	Water is lower than in July.
8	4	Summer	18-Jul-07	Sand Beach	Moderate	Sand	Wetland d/s	26	23		Seine		cyprinid	2	young of year		
8	4	Summer	18-Jul-07	Sand Beach	Moderate	Sand (silt) with some gravel	Wetland d/s	22	23	15,16 u/s and d/s	Snorkel	200	cyprinid	1	young of year		Reed beds and docks. Very turbid at downstream end of snorkel site (could not even see hand in front of face)
9	6	Fall	25-Sep-07	Wetland	Moderate	silty and weedy	Changing to emergent vegetation	11	10	3 (fall)	Snorkel		None	0		No snorkel completed outside direct vicinity of boat due to water levels and weed growth.	1 flock of coots
9	6	Summer	18-Jul-07	Wetland	Low	Sand/silt	Reeds	23	29		Minnow trap		none	0		Dropped trap (baited with cat food) off boat, mid channel along edge of reeds ~ 2 m deep. Not left long enough ~30 minutes.	Columbia River Inlet.
9	6	Summer	18-Jul-07	Wetland	Low	Sand/fines	Wetland emergent/ submergent	23	19	13, 14 u/s and d/s	Observed from boat		mountain whitefish	10	juvenile	over sand	More fish likely present but able to avoid snorkeller due to high water level and cover. Mayfly floating on water surface; damselflies; mosquito and larvae casing.
9	6	Summer	18-Jul-07	Wetland	Low	Sand/fines	Wetland emergent/ submergent	23	19	13, 14 u/s and d/s	Snorkel	200	mountain whitefish	1	sub-adult	No parr marks, sub adult?	
10	7	Summer	17-Jul-07	Modified Vegetated	Moderate	Cobble/gravel/fines	Emergent patches - some offshore and along shore	26	21.95	1, 2	Snorkel	200 (15 m out)	largemouth bass	1	adult	Caught by fisherman onsite.	Rushmere; developed with vegetation and wetland. Schools of fish observed in foreshore areas around docks.
10	7	Summer	17-Jul-07	Modified Vegetated	Moderate	Cobble/gravel/fines	Emergent patches - some offshore and along shore	26	21.95	1, 2	Snorkel	200 (15 m out)	largemouth bass	4	adult	2 by emergent vegetation along shore, 1 by dock and 1 over cobble.	
10	7	Summer	17-Jul-07	Modified Vegetated	Moderate	Cobble/gravel/fines	Emergent patches - some offshore and along shore	26	21.95	1, 2	Snorkel	200 (15 m out)	redside shiner	1750	adult		
10	7	Summer	17-Jul-07	Modified Vegetated	Moderate	Cobble/gravel/fines	Emergent patches - some offshore and along shore	26	21.95	1, 2	Snorkel	200 (15 m out)	salmonid	1	young of year		
10	7	Summer	17-Jul-07	Modified Vegetated	Moderate	Cobble/gravel/fines	Emergent patches - some offshore and along shore	26	21.95	1, 2	Snorkel	200 (15 m out)	sucker	1	adult	Dead	
11	9	Fall	25-Sep-07	Vegetated Shore	Low	Sand/silt with band of cobble/gravel along edge of water.	None	13	12	4 u/s, 5 d/s (fall)	Seine	50	mountain whitefish	20	juvenile		No snorkel completed
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Sand beach	None	32	22	3	Seine	20	cyprinid	6	young of year		Area #1 had no fish. Lots of damselfly larvae; poor visibility, all sandy substrate.
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Sand beach	None	32	22	3	Seine	20	redside shiner	1	adult		Park and railway behind shore. Overhanging vegetation, cliff bank and bay.
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Sand beach	None	32	22	3	Seine	20	redside shiner	5	juvenile		Area #2 had really nice overhanging cover right along the shoreline; this was best habitat since substrate is sandy.
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Area #2 with riparian & mostly sand	Lilies and reeds	32	22	4,5,6,7,8	Snorkel	200 along shoreline	cyprinid	5	young of year	At area #2; many unidentified.	Area #3 had aquatic macrophytes in bay area (lilies and reeds) and was ground water fed.
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Area #3 mostly sand with some small cobbles/gravel near edges.	Lilies and reeds	32	22	4,5,6,7,8	Snorkel	200 along shoreline	largemouth bass	13	adult	At area #3	
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Area #2 with riparian & mostly sand	Lilies and reeds	32	22	4,5,6,7,8	Snorkel	200 along shoreline	mountain whitefish	1	adult	At area #2	
11	9	Summer	17-Jul-07	Vegetated Shore	Low	Area #3 mostly sand with some small cobbles/gravel near edges.	Lilies and reeds	32	22	4,5,6,7,8	Snorkel	200 along shoreline	redside shiner	100	adult	At area #3; school	

Site	Segment	Sampling Season	Sampling Date	Predominant Shore Type	Disturbance Level	Substrate Type	Aquatic Vegetation	Air Temp. (°C)	Water Temp.(°C)	Photo No.	Sample Type	Channel Distance (m)	Species	Number of Fish	Life Stage	Fish Comments	General Site Observations
12	11	Fall	25-Sep-07	Creek Mouth	Moderate	Silt-few cobble/gravel substrates along shoreline	emergent /submergent	12	11	6 u/s, 7 d/s (fall)	Snorkel	200	None	0			Fresh water clams
12	11	Summer	17-Jul-07	Creek Mouth	Moderate	Cobble gravel / silty sand by vegetation.	Emergent by shore / submergent	33	25.24	9,10 u/s and d/s	Snorkel	200 near shore	largemouth bass	2	adult	1 by Brady Ck. culvert (start of snorkel), and 1 by emergent wetland veg. (end of snorkel).	Brady Creek - culvert outlet to lake. CP Rail influence. Low visibility. Beds of mussles (Oregon freshwaters)
13	12	Fall	25-Sep-07	Creek Mouth	Moderate	Silt-few cobble/gravel substrates along shoreline	Emergent	18	12	10 u/s, 11 d/s (fall)	Snorkel	200	None	0		Lots of fresh water mussels.	Water is lower than July sampling. Salter Ck. has channel in soft lake substrates & flows into the lake.
13	12	Summer	17-Jul-07	Creek Mouth	Moderate	Silt-few cobble/gravel substrates along shoreline	Reeds / submergent	35	23.9	11, 12	Snorkel	200	cyprinid	10	young of year		
13	12	Summer	17-Jul-07	Creek Mouth	Moderate	Silt-few cobble/gravel substrates along shoreline	Reeds / submergent	35	23.9	11, 12	Snorkel	200	redside shiner	9	adult	6 at rock rip rap; 3 at LWD	Salter Creek outlet - had very cold water. There was low visibility and the water was turbid due to windy conditions on the lake.
14	16	Fall	25-Sep-07	Modified Cliff Bluff	High	Silt-few cobble/gravel substrates along shoreline	None	15	14	12 u/s, 13 d/s (fall)	Snorkel	200	kokanee	20	adult	Mature in spawning colouration swimming along shore	No fish associated with structures (boat docks etc.). Mussels further along west side.
14	16	Summer	17-Jul-07	Modified Cliff Bluff	High	Silt-few cobble/gravel substrates along shoreline	Minimal / scattered submerged	35	24.5	13,14? (said 11, 12)	Snorkel	200	redside shiner	1	juvenile		
14	16	Summer	17-Jul-07	Modified Cliff Bluff	High	Silt-few cobble/gravel substrates along shoreline	Minimal / scattered submerged	35	24.5	13,14? (said 11, 12)	Snorkel	200	sculpin	12	under large cobble	No fish using the retaining walls or docks	Fort Point - retaining walls, docks and boathouses. Low visibility due to high wave action. Mosquito larvae casing were visible in the water column. There was high silt levels on the rocks.
15	18	Fall	25-Sep-07	Gravel beach	Moderate	Silt-few cobble/gravel substrates along shoreline	emergent	18	14.5		Seine		mountain whitefish	7	juvenile		
15	18	Fall	25-Sep-07	Gravel beach	Moderate	Silt-few cobble/gravel substrates along shoreline	emergent	18	14.5		Seine		sculpin	2	adult	Torrent Sculpin	
15	18	Fall	25-Sep-07	Gravel beach	Moderate	Silt-few cobble/gravel substrates along shoreline	emergent	18	14.5	14 u/s, 15 d/s	Snorkel	200	None	0			
15	18	Summer	19-Jul-07	Gravel beach	Moderate	Silt-few cobble/gravel substrates along shoreline	wetland	19	23		Seine	50	None	0			
15	18	Summer	19-Jul-07	Gravel beach	Moderate	Silt-few cobble/gravel substrates along shoreline	wetland	19	23	26 (west), 27 (east)	Snorkel	200 (park and beach)	none	0			James Chabot Park, near oultlet of lake.

	TABLE II. BIRD FIELD DATA DURING SAMPLING ALONG THE WINDERMERE LAKE FORESHORE (JULY 17-19 & SEPT 25-26 2007)																		
Group	**Common Name[1]**	***Scientific Name***	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 5a**	**Site 6**	**Site 6a**	**Site 7**	**Site 8**	**Site 9**	**Site 10**	**Site 11**	**Site 12**	**Site 13**	**Site 14**	**Site 15**
Chikadees	Black-capped Chickadee	*Parus atricapillus*	X	X					X		X	X				X	X		
Ducks/Geese	American Widgeon*	*Anas Americana*										X				X			
Ducks/Geese	Bufflehead	*Bucephala albeola*										X		X					
Ducks/Geese	Canada Goose*	*Branta Canadensis*							X				X				X		
Ducks/Geese	Common Loon*	*Gavia immer*		X				X											
Ducks/Geese	Common Merganser*	*Mergus merganser*		X	X				X					X					
Ducks/Geese	Eared Grebe*	*Podiceps nigricollis*												X					
Ducks/Geese	Horned Grebe*	*Podiceps auritus*	X																
Ducks/Geese	Mallard*	*Anas platyrhynchos*		X			X		X			X		X		X	X		
Ducks/Geese	Red-necked Grebe*	*Podiceps grisegena*		X			X	X			X		X		X	X			
Ducks/Geese	Scaup spp.*	*Aythya spp.*														X			
Ducks/Geese	Western Grebe*	*Aechmophorus occidentalis*											X						
Gruiforms	American Coot*	*Fulica Americana*											X						
Gulls/Terns/Skimmers	Glaucous-winged Gull	*Larus glaucescens*							X			X							
Gulls/Terns/Skimmers	Gull spp.	*Larus spp.*		X					X							X			X
Kingfishers	Belted Kingfisher	*Ceryle alcyon*		X								X	X		X	X			X
Passerines	American Robin	*Turdus migratorius*	X	X		X			X			X			X		X	X	X
Passerines	Bank Swallow	*Riparia riparia*	X	X	X		X			X	X			X	X	X			
Passerines	Brewer's Blackbird	*Euphagus cyanocephalus*										X							X
Passerines	Cedar Waxwing*	*Bombycilla cedrorum*									X	X							
Passerines	Common Yellowthroat*	*Geothlypis trichas*											X						
Passerines	Dark-eyed Junco*	*Junco hyemalis*													X		X		
Passerines	Hermit Thrush*	*Catharus guttatus*											X						
Passerines	Orange-crowned Warbler*	*Vermivora celata*														X			
Passerines	Pine Siskin	*Carduelis pinus*		X												X	X		X
Passerines	Pygmy Nuthatch	*Sitta pygmaea*										X							
Passerines	Red-breasted Nuthatch	*Sitta Canadensis*	X	X							X	X					X		
Passerines	Red-winged Blackbird	*Agelaius phoeniceus*										X		X	X	X			X
Passerines	Ruby-crowned Kinglet *	*Regulus calendula*		X											X				
Passerines	Song Sparrow*	*Melospiza melodia*	X	X				X			X		X		X				X
Passerines	Sparrow spp.												X	X					
Passerines	Warbler spp.*			X								X							
Passerines	Western Meadowlark*	*Sturnella neglecta*												X		X			
Passerines	Wilson's Warbler	*Wilsonia pusilla*											X		X				
Passerines	Yellow Warbler	*Dendroica petechia*												X					
Pelecaniforms	Great Blue Heron	*Ardea Heridias*						X	X				X				X		
Raptors	American Kestrel*	*Falco sparverius*			X														
Raptors	Bald Eagle	*Haliaeetus leucocephalus*									X	X			X				
Raptors	Hawk spp.	*Buteo spp*															X		
Raptors	Northern Harrier*	*Cicus cyaneus*									X	X							X

Group	Common Name[1]	*Scientific Name*	Site 1	Site 2	Site 3	Site 4	Site 5	Site 5a	Site 6	Site 6a	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15
Raptors	Osprey*	*Pandion haliaeteus*	X	X			X	X	X		X		X	X	X				X
Shore birds	Common Snipe*	*Gallinago gallinago*											X						
Shore birds	Sandpiper spp.*						X												
Shore birds	Spotted Sandpiper*	*Actistis macularia*						X											X
Shore birds	unidentified shorebirds								X										
Shrikes/Vireos	American Crow	*Corvus brachyrhynchos*	X	X	X	X	X			X	X							X	X
Shrikes/Vireos	Black-billed Magpie	*Pica pica*		X			X										X		
Shrikes/Vireos	Common Raven	*Corvus corax*									X								X
Shrikes/Vireos	Vireo spp.*	*Vireo spp.*								X		X							
Shrikes/Vireos	Warbling Vireo*	*Vireo gilvus*		X															
Tyrant Flycatchers	Alder Flycatcher*	*Epidomnax alnorum*										X							
Tyrant Flycatchers	Eastern Kingbird*	*Tyrannus tyrannus*												X	X				X
Tyrant Flycatchers	Willow Flycatcher*	*Epidonax traillii*						X			X		X		X				
Woodpeckers	Downy Woodpecker	*Picoides pubescens*	X	X					X			X							
Woodpeckers	Hairy Woodpecker	*Picoides villosus*															X		
Woodpeckers	Northern Flicker	*Colaptes auratus*		X			X						X	X	X	X	X		X
Woodpeckers	Pileated Woodpecker	*Dryocopus pileatus*	X																
Total Numbers of Species Observed			**10**	**20**	**4**	**2**	**8**	**7**	**11**	**3**	**12**	**18**	**15**	**12**	**14**	**13**	**12**	**2**	**14**

[1] Migratory Status in BC - an astrix * following common the name denotes a migratory species; while no symbol indicates resident species.

TABLE III: AQUATIC INVERTEBRATE SAMPLING ALONG THE WINDERMERE LAKE FORESHORE (JULY 17-19, 2007)

Site	Number	Order	Family	Common Name	Comments
1	3	Diptera	Chironomidae		
1	3	Trichoptera		caddisfly	with wood casings
2	1	Diptera	Chironomidae		
2	1	Zooplankton	Copopoda		red circle guy
2	2	Zooplankton		Daphnia	
2	1	Odonata		Damselfly	nymph
3	1	Crustacea	Amphipoda	scud	
3	1	Zoooplankton	Copopoda		
3	1	Annelida	Oligochaeta	mosquito	larvae case
3	2	Diptera			
3	1	Zooplankton		Daphnia	
3	2	Zooplankton spp.			
5	6	Crustacea	Amphipoda	scud	
5	4	Diptera	Chironomidae		
5	3	Diptera	Dixidae		
5	4	Arachnida	Hydracorina	water mite	
5	3	Odonata			
5	6	Ephemeroptera		mayfly	
5	2	Trichoptera			
6	100+	Crustacea	Amphipoda	scud	multiple species and age classes
6	15+	Diptera	Chironomidae		
6	5	Odonata		damsel and dragonf	nymphs
6	1	Trichoptera		caddisfly	
6	1	Coleoptera		water boatman	
7	14	Crustacea	Amphipoda	scud	
7	22	Diptera	Chironomidae		
7	2	Zooplankton	Copopoda		
7	7	Odonata		damselfly - dragonfly	
7	3	Ephemeroptera		mayfly	
7	2	Gastropoda			
7	1	Coleoptera			
8	6	Diptera	Chironomidae		
8	100+	Crustacea	Copopoda		
8	2	Odonata		damselfly	larvae
8	1	Coleoptera			
8	1	Diptera		blackfly	larvae
9					no sampling conducted; silty substrates
10	17	Crustacea	Amphipoda	scud	
10	4	Diptera	Chironomidae		
10	4	Crustacea	Copoda		
10	2	Arachida	Hydracarina	mite	
10	1	Annelida	Ologochaeta	aquatic earthworm	
10	20	Odonata		Damselfly	adult
10	2	Coleoptera		water boatman	
11	1	Crustacea	Amphipoda	scud	
11	4	Diptera	Chironomidae		
11	1	Coleoptera		water boatman	
12	2	Crustacea	Amphipoda	scud	

Site	Number	Order	Family	Common Name	Comments
12	2	Diptera	Chironomidae		
12	60+	Crustacea	Copoda		
12	1	Arachnida	Hydracarina	mite	
12	1	Annelida	Oligochaeta	aquatic earthworm	
12	1			leach	
12	5	Odonata		damselfly	nymph
12	1	Diptera		blackfly	
12	3	Trichoptera		caddisfly	1 stone, 2 in wood casing
12	3	Gastropoda		snail-coiled conch	
12	1	Coleoptera		not boatman	
12	2	Coleoptera			juvenile
12	1	Ephemeroptera		mayfly	
13	1	Diptera	Chironomidae	chironomid	
13	1	Annelida	Oligochaeta	aquatic earthworm	
13	1	Coleoptera		water boatman	
13	1	Ephemeroptera		mayfly	
13	1	Diptera		blackfly	larvae
14	1	Diptera	Chironomidae		
14	4	Diptera	Simulidae	blackfly	casings
14	3	Ephemeroptera		mayfly	casings
14	3	Coleoptera		mites	
15	13	Diptera	Chironomidae		mite
15	20		Copopoda		
15	1	Arachnida	Hydracea		
15	2	Coleoptera		water boatman	
15	1	Crustacea		scud	
15	3	Tricoptera			wood case

TABLE IV: AQUATIC INVERTEBRATE SAMPLING ALONG THE WINDERMERE LAKE FORESHORE (SEPT 25-26, 2007)

Site	Number	Order	Family	Common Name	Comments
1	1	Amphipoda		scud	
1	>50	Arachnidae		mites	
1	1	Chironomidae			
1	2	Copepoda			
1	1	Gastropoda		snail	
1	1	Oligochaete			
2	7	Amphipoda		scuds	
2	>20	Arachnidae		mites	
2	>50	Chironomidae			
2	1	Oligochaeta		worm	
3	1	Amphipoda		scuds	
3	10	Arachnidae		mites	
3	>1000	Coleoptera		water boatmen	caught in seine net
3	3	Oligochaeta			
4	2	Amphipoda		scuds	
5	10	Amphipoda		scuds	
5	1	Arachnidae		mites	
5	3	Chironomidae		bloodworm	
5	1	Tricoptera			casings
6	20	Amphipoda		scuds	
6	10	Chironomidae			
7	>40	Amphipoda		scuds	
7	>40	Arachnidae		mites	
7	4	Ephemeroptera		mayfly	
7	11	Molluska	Crustaceae	snails	
8	1	Cladosteron		buzyminer	
8	2	Crustacea	Amphipoda	scud	
8	1	Nematoda		roundworm	
10	1	Cladosteron		Bosmina?	
10	3	Crustacea	Amphipoda	scud	
10	3	Oligochaete		aquatic worm	
11	3	Amphipoda		scud	
12	6	Amphipoda		scud	
13	25	Amphipoda		scud	
13	7	Chironomidae			
13	3	Copepoda			
13	2	Ephemeroptera		mayfly	
13	1	Ephemeroptera		stonefly	
13	?	Molluska			in water
13	1	Odonata		dragonfly	in air
13	5	Oligochaete		worm	
14	6	Amphipoda		scuds	
14	3	Gastropoda		snail	
14	5	Oligochaetes			
15	1			scud	

Table V. Fish Species Habitat Matrix for Native Fish Assemblage along the Foreshore of Windermere Lake

Code	Common Name	Scientific Name	HABITAT SPECIFICITY[1]																												Species Habitat Use	HABITAT SELECTIVITY[2]
			GENERAL LIVING							REPRODUCTION							REARING-NURSERY							STAGING								
			Shore Type							Shore Type							Shore Type							Shore Type								
			CRK	CL/BL	GB	SB	LRS	VS	WTLD	CRK	CL/BL	GB	SB	LRS	VS	WTLD	CRK	CL/BL	GB	SB	LRS	VS	WTLD	CRK	CL/BL	GB	SB	LRS	VS	WTLD		
	bull trout	*Salvelinus confluentus*		1			1			3							3							1							5	HIGH
	westslope cutthroat trout	*Oncorhynchus clarki lewisi*		1			1			3							3							1							5	HIGH
	rainbow trout	*Oncorhynchus mykiss*	1	1			1			3							3		3	3			3	1							9	HIGH
	kokanee	*Onchorhynchus nerka*		1			1			3		3		3			3		3		3			1		1		1			11	HIGH
	longnose dace	*Rhinichthys cataractae*	1		1		1	1		3		3		3			2		3		3	3		1		1		1			14	HIGH
	burbot	*Lota lota*		1			1			3		3	3		3		3		3	3		3	3	1		1	1			1	15	HIGH
	torrent sculpin	*Cottus rhotheus*	1	1	1	1	1	1		2		2		2			2		2	2	2			1		1	1	1			17	MODERATE
	mountain whitefish	*Prosopium williamsoni*	1	1	1	1	1	1	1	2		2		2			2	2	2	2	2	2	2	1		1		1			20	MODERATE
	longnose sucker	*Catostomus catostomus*	1	1	1	1	1	1	1	2							2	2	2	2	2	2	2	1	1	1	1	1	1	1	22	MODERATE
	largescale sucker	*Catostomus macrocheilus*	1	1	1	1	1	1	1	2							2	2	2	2	2	2	2	1	1	1	1	1	1	1	22	MODERATE
	northern pike minnow	*Ptychocheilus oregonensis*	1	1	1	1	1	1	1	1		1		1			1	1	1	1	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	GENERALIST
	lake chub	*Couesius plumbeus*	1	1	1	1	1	1	1	1		1	1	1	1		1	1		1		1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	GENERALIST
	peamouth chub	*Mylocheilus caurinus*	1	1	1	1	1	1	1	1		1	1	1	1		1	1	1	1	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	26	GENERALIST
	redside shiner	*Richardsonius balteatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	28	GENERALIST
Habitat Score			10	13	9	8	14	9	7	30	1	17	6	14	6	1	29	10	23	18	17	16	16	12	4	9	6	8	4	5		

1. Habitat use data was obtained from presence/absence data at Windermere Lake and from the literature.
2. Low, moderate and generalist rankings are based on number of habitat types used.

Table VI. Determination of Shore Type Score

Code	Shore Type	Total Shore Length (m)	Local Rarity	Summated Habitat Score	Total Shore Type Score	Shore Type Score
CRK	Creek Mouth	1636.1	7	81	88	12
GB	Gravel Beach	2630.6	6	58	64	10
LRS	Low Rocky Shore	6618.0	2	53	55	8
SB	Sand Beach	2726.8	5	38	43	6
VS	Vegetated Shore	10203.8	1	35	36	4
CL/BL	Cliff Bluff	5321.1	4	28	32	2
WTLD	Wetland	6320.8	3	29	32	2
		35457.2				

Table VII. Habitat Index Parameters, Weightings and Calculation Method

Parameter Type	Parameter	Parameter Description[1]	Calculation	Maximum Model Value	Minimum Model Value	Model Weight (% of Total)
General	% Natural	% of Natural Shoreline Remaining	(% Natural Shoreline / 100) * 10	8	0	18.2%
Fish	Shore Type	Creek Mouth (12), Gravel Beach (10), Low Rocky Shoreline (8), Sand Beach (6), Vegetated Shoreline (4), Cliff/Bluff (2), Wetland (2)	% Shore Type * Shore Type Score for all shore types for a segment	12	2	27.3%
	Substrate Type	Cobble (10), Gravel (8), Boulder (6), Fines (4), Bedrock (2)	% Substrate Type * Substrate Score	10	2	22.7%
Wildlife	Vegetation Bandwidth	Greater than 50m (7), Between 0 to 50m = [Average Width / 50m] * 7	Assigned Score based upon the Vegetation Width for a segment	7	0	15.9%
	Wetland	% of Segment Length with Identified Wetlands	(Extent of Wetland/Segment Length) * 7	7	0	15.9%
Human Induced	Retaining Walls	% of Shoreline with Retaining Walls	(% Retaining Wall / 100) * -3	-3	0	-6.8%
	Dock Density	# Docks/km: 0 (0), 0.1-10 (-1), 10.1-15 (-2), 15.1-20 (-3), 20.1+ (-4)	Assigned Score based upon the # Docks per km for a segment	-4	0	-9.1%
	Groynes	Every Groynes (-0.5)	# of Groynes * -0.5	-4.0	0	-9.1%
	Boat Launch	Every Boat Launch (-3)	# of Boat Launches * -3	-3	0	-6.8%
	Marina	Small Marina (-2), Medium Marina (-4), Large Marina (-6)	Assigned Score based on Size and Presence of Marinas	-6	0	-13.6%

[1] Numbers in brackets (x) represent the scores for a particular item or parameter.

TableVIII. Summary of Habitat Index (H.I.) Parameter Scores by Segment

Segment Number	Segment Length	% Natural	Shore Type	Substrate Type	Vegetation Bandwidth	Wetland Extent	Retaining Walls	Dock Density	Groynes	Boat Launch	Marina	H.I. Score w/ Instream Structures	Ecological Value	H.I. Score w/o Instream Structures	Ecological Potential
1	239.0	8.0	2.0	4	7.0	0.8	0.0	0	0.0	0	0	21.8	High	21.8	High
2	1095.6	8.0	2.8	4	7.0	7.0	0.0	0	0.0	0	0	28.8	Very High	28.8	Very High
3	1877.5	8.0	3.2	4	7.0	6.5	0.0	0	0.0	0	0	28.7	Very High	28.7	Very High
4	953.7	5.0	5.4	4.4	4.1	5.3	-0.3	-1	0.0	0	0	22.9	High	24.2	High
5	1747.7	8.0	2.8	4	7.0	6.4	0.0	0	0.0	0	0	28.2	Very High	28.2	Very High
6	3094.8	8.0	4.0	4	7.0	7.0	0.0	0	0.0	0	0	30.0	Very High	30.0	Very High
7	865.2	0.0	4.0	4	6.4	6.7	0.0	-1	0.0	0	0	20.1	High	21.1	High
8	1584.6	0.0	3.4	7	7.0	6.6	0.0	0	0.0	0	0	24.0	High	24.0	High
9	892.2	8.0	4.4	7.6	7.0	2.4	0.0	0	0.0	0	0	29.4	Very High	29.4	Very High
10	773.4	5.0	3.7	8	4.7	2.5	-1.4	-2	0.0	-3	0	17.5	Moderate	24.0	High
11	3868.3	1.5	7.4	8.1	7.0	5.3	0.0	-1	0.0	0	0	28.3	Very High	29.3	Very High
12	1090.5	6.0	5.0	9.5	6.3	6.4	-0.4	0	-0.5	-3	0	29.3	Very High	33.2	Very High
13	3550.2	0.0	7.2	9.5	6.9	0.8	-0.1	-1	0.0	0	0	23.3	High	24.4	Very High
14	255.7	0.0	9.4	8	5.6	0.0	-3.0	-1	0.0	0	0	19.0	High	23.0	High
15	163.8	0.0	8.0	9	4.2	0.0	0.0	0	0.0	0	0	21.2	High	21.2	High
16	1539.5	0.0	3.8	7	3.0	0.0	-2.5	-4	-2.0	0	-4	1.3	Very Low	13.8	Moderate
17	696.2	3.0	5.2	7.4	4.6	0.3	0.0	-1	-0.5	0	0	19.0	High	20.5	High
18	593.7	4.0	7.5	9	5.4	3.7	-0.2	-1	0.0	0	0	28.5	Very High	29.6	Very High
19	268.4	0.0	6.0	5.2	5.6	0.0	0.0	0	0.0	0	0	16.8	Moderate	16.8	Moderate
20	1054.1	0.0	6.0	7.3	2.2	0.0	-1.9	-4	-2.0	0	0	7.7	Low	15.5	Moderate
21	1153.7	0.0	6.5	7.6	2.0	0.0	-2.7	-4	-4.0	0	0	5.3	Very Low	16.1	Moderate
22	940.5	5.0	3.6	6	5.0	0.7	-1.8	-1	-0.5	0	-6	11.0	Low	20.3	High
23	1328.2	2.5	4.2	6	3.9	0.0	-1.5	-2	-1.0	0	-2	10.1	Low	16.6	Moderate
24	1793.6	0.5	4.1	5	3.4	0.8	-1.7	-1	-0.5	0	-6	4.5	Very Low	13.8	Moderate
25	663.4	8.0	5.3	6	4.2	4.5	0.0	0	0.0	0	-2	26.1	Very High	28.1	Very High
26	3373.9	3.0	5.7	6.2	4.9	2.0	-0.8	-1	-3.0	-3	-6	8.1	Low	21.8	High
Max Value		8	12	10	7	7	-3	-4	-4	-3	-6	44			
Min Value		0	4	2	1	0	0	0	0	0	0				
Model Weight %		18.2%	27.3%	22.7%	15.9%	15.9%	-6.8%	-9.1%	-9.1%	-6.8%	-13.6%				
Total						*100.0%*					*-45.5%*				

Table IX. Ecological Value Results Summary for Shore Types with Instream Structures (Docks, Groynes, Retaining Walls and Marinas)

Ecological Value	Total Number of Segments	Total Shoreline Length (m)	Total Shoreline Length (%)	Shoreline Length by Shore Type													
				Creek Mouth		Gravel Beach		Low Rocky Shoreline		Sand Beach		Vegetated Shoreline		Cliff/Bluff		Wetland	
				Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total
Very High	9	14924	42%	1187	8%	650	4%	3095	21%	376	3%	2680	18%	2801	19%	4135	28%
High	8	8308	23%	166	2%	360	4%	3466	42%	559	7%	1557	19%	987	12%	1214	15%
Moderate	2	1042	3%	62	6%	0	0%	0	0%	0	0%	864	83%	77	7%	39	4%
Low	4	6697	19%	216	3%	1160	17%	0	0%	1433	21%	1980	30%	1065	16%	843	13%
Very Low	3	4487	13%	0	0%	461	10%	58	1%	359	8%	3128	70%	391	9%	90	2%
Total	26	35457	100%	1631	5%	2631	7%	6618	19%	2727	8%	10209	29%	5321	15%	6321	18%

Table X. Ecological Potential Results Summary for Shore Types with all Instream Structures Removed (Docks, Groynes, Retaining Walls and Marinas Removed)

Ecological Value	Total Number of Segments	Total Shoreline Length (m)	Total Shoreline Length (%)	Shoreline Length by Shore Type													
				Creek Mouth		Gravel Beach		Low Rocky Shoreline		Sand Beach		Vegetated Shoreline		Cliff/Bluff		Wetland	
				Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total	Length (m)	% of Total
Very High	10	18474	52%	1258	7%	650	4%	5864	32%	376	2%	3213	17%	2801	15%	4313	23%
High	10	9846	28%	311	3%	1203	12%	696	7%	1422	14%	2498	25%	1797	18%	1919	19%
Moderate	6	7137	20%	62	1%	778	11%	58	1%	929	13%	4499	63%	723	10%	90	1%
Low	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Very Low	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total	26	35457	100%	1631	5%	2631	7%	6618	19%	2727	8%	10209	29%	5321	15%	6321	18%

Table XI - Plant and Animal Species of Concern in the Interior Douglas Fir Biogeoclimatic Zone of the Regional District of East Kootenay (CDC 2008)										
Scientific Name*	**English Name**	**Global Rank**	**Prov Rank**	**COSEWIC**	**BC Status**	**Identified Wildlife in BC**	**SARA**	**Class (English)**	**Habitat Type**	**Breeding Bird**
Invertebrate										
Anguispira kochi	Banded Tigersnail	G5	S3		Blue			gastropods	TERRESTRIAL	
Cryptomastix mullani	Coeur d'Alene Oregonian	G4	S3S5		Blue			gastropods	TERRESTRIAL	
Gastrocopta holzingeri	Lambda Snaggletooth	G5	S3?		Blue			gastropods	TERRESTRIAL	
Hemphillia camelus	Pale Jumping-slug	G4	S3		Blue			gastropods	TERRESTRIAL	
Magnipelta mycophaga	Magnum Mantleslug	G3	S2S3		Blue			gastropods	TERRESTRIAL	
Oreohelix strigosa	Rocky Mountainsnail	G5	S3S4		Blue			gastropods	TERRESTRIAL	
Oreohelix subrudis	Subalpine Mountainsnail	G5	S3S4		Blue			gastropods	TERRESTRIAL	
Vallonia cyclophorella	Silky Vallonia	G5	S3		Blue			gastropods	TERRESTRIAL	
Nonvascular Plant										
Pterygoneurum kozlovii	alkaline wing-nerved moss	G2G3	S2	T (Nov 2004)	Red		1			
Vascular Plant										
Adiantum capillus-veneris	southern maiden-hair	G5	S1	E (May 2000)	Red		1	ferns	RIVERINE;TERRESTRIAL	
Agoseris lackschewitzii	pink agoseris	G4	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Anemone canadensis	Canada anemone	G5	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Apocynum x *floribundum*	western dogbane	GNA	S2S3		Blue			dicots	TERRESTRIAL	
Arabidopsis salsuginea	saltwater cress	G4G5	S1		Red			dicots	TERRESTRIAL	
Arnica chamissonis ssp. *incana*	meadow arnica	G5T3T5	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Artemisia ludoviciana var. *incompta*	western mugwort	G5T3T5	S2S3		Blue			dicots	TERRESTRIAL	
Aster ascendens	long-leaved aster	G5	S1S3		Red			dicots	TERRESTRIAL	
Atriplex argentea ssp. *argentea*	silvery orache	G5T5	S1		Red			dicots	TERRESTRIAL	
Botrychium ascendens	upswept moonwort	G2G3	S2		Red				PALUSTRINE;TERRESTRIAL	
Botrychium simplex	least moonwort	G5	S2S3		Blue				PALUSTRINE;RIVERINE;TERRESTRIAL	
Bouteloua gracilis	blue grama	G5	S2		Red			monocots	TERRESTRIAL	
Calamagrostis montanensis	plains reedgrass	G5	S3		Blue			monocots	TERRESTRIAL	
Carex crawei	Crawe's sedge	G5	S1		Red			monocots	PALUSTRINE;TERRESTRIAL	
Carex geyeri	elk sedge	G5	S3		Blue			monocots	TERRESTRIAL	
Carex rostrata	swollen beaked sedge	G5	S2S3		Blue			monocots	PALUSTRINE	
Carex sychnocephala	many-headed sedge	G4	S3		Blue			monocots	LACUSTRINE;PALUSTRINE;TERRESTRIAL	

Scientific Name*	English Name	Global Rank	Prov Rank	COSEWIC	BC Status	Identified Wildlife in BC	SARA	Class (English)	Habitat Type	Breeding Bird
Castilleja cusickii	Cusick's paintbrush	G4G5	S1		Red			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Castilleja minor ssp. *minor*	annual paintbrush	G5T5	S1		Red			dicots	LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	
Cirsium scariosum	elk thistle	G5	S1S3		Red			dicots	TERRESTRIAL	
Cryptantha ambigua	obscure cryptantha	G4	S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Delphinium bicolor ssp. *bicolor*	Montana larkspur	G4G5T4T5	S2S3		Blue			dicots	TERRESTRIAL	
Eleocharis elliptica	Slender spike-rush	G5	S2S3		Blue			monocots	LACUSTRINE;PALUSTRINE	
Eleocharis rostellata	beaked spike-rush	G5	S2S3		Blue			monocots	ESTUARINE;LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	
Epilobium glaberrimum ssp. *fastigiatum*	smooth willowherb	G5T4T5	S2S3		Blue			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Epipactis gigantea	giant helleborine	G4	S2S3	SC (May 1998)	Blue		3	monocots		
Gaura coccinea	scarlet gaura	G5	S1		Red			dicots	TERRESTRIAL	
Gayophytum racemosum	racemed groundsmoke	G5	S1		Red			dicots	TERRESTRIAL	
Gayophytum ramosissimum	hairstem groundsmoke	G5	S1		Red			dicots	TERRESTRIAL	
Gentiana affinis	prairie gentian	G5	S2S3		Blue			dicots	TERRESTRIAL	
Glycyrrhiza lepidota	wild licorice	G5	S2		Red			dicots	LACUSTRINE;PALUSTRINE;TERRESTRIAL	
Hedeoma hispida	mock-pennyroyal	G5	S1		Red			dicots	TERRESTRIAL	
Helianthus nuttallii* var. *nuttallii	**Nuttall's sunflower**	**G5T5**	**S1**		**Red**			**dicots**	**PALUSTRINE;TERRESTRIAL**	
Heterocodon rariflorum	heterocodon	G5	S3		Blue			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Hypericum scouleri ssp. *nortoniae*	western St. John's-wort	G5T3T5	S2S3		Blue			dicots	LACUSTRINE;PALUSTRINE;TERRESTRIAL	
Impatiens ecalcarata	spurless touch-me-not	G3G4	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Isoetes howellii	Howell's quillwort	G4G5	S1		Red			quillworts	LACUSTRINE;PALUSTRINE	
Lathyrus bijugatus	pinewood peavine	G4	S1		Red			dicots	TERRESTRIAL	
Linanthus septentrionalis	northern linanthus	G5	S3		Blue			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Lomatium sandbergii	Sandberg's desert-parsley	G4	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Lomatium triternatum ssp. *platycarpum*	nine-leaved desert-parsley	G5T3T5	S2		Red			dicots	TERRESTRIAL	
Lupinus arbustus ssp. *neolaxiflorus*	spurred lupine	G5T1T3	SH		Red			dicots	TERRESTRIAL	
Lupinus arbustus ssp. *pseudoparviflorus*	Montana lupine	G5T2T3	S1		Red			dicots	TERRESTRIAL	

Scientific Name*	English Name	Global Rank	Prov Rank	COSEWIC	BC Status	Identified Wildlife in BC	SARA	Class (English)	Habitat Type	Breeding Bird
Lupinus bingenensis var. *subsaccatus*	Suksdorf's lupine	G4G5TNR	S2		Red			dicots	TERRESTRIAL	
Megalodonta beckii* var. *beckii	**water marigold**	**G4G5T4T5**	**S3**		**Blue**			**dicots**	**LACUSTRINE;PALUSTRINE;RIVERINE**	
Melica spectabilis	purple oniongrass	G5	S2S3		Blue			monocots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Mimulus breviflorus	short-flowered monkey-flower	G4	S1		Red			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Muhlenbergia andina	foxtail muhly	G4	S1		Red			monocots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Muhlenbergia glomerata	marsh muhly	G5	S3		Blue			monocots	LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	
Orobanche corymbosa ssp. *mutabilis*	flat-topped broomrape	G4T3?	S3		Blue			dicots	TERRESTRIAL	
Orobanche ludoviciana ssp. *ludoviciana*	Suksdorf's broomrape	G5T5	S1		Red			dicots	TERRESTRIAL	
Pellaea gastonyi	Gastony's cliff-brake	G2G3	S2S3		Blue			ferns	TERRESTRIAL	
Physaria didymocarpa var. *didymocarpa*	common twinpod	G5T4	S2S3		Blue			dicots	TERRESTRIAL	
Plantago eriopoda	**alkali plantain**	**G5**	**S1**		**Red**			**dicots**	**PALUSTRINE;RIVERINE;TERRESTRIAL**	
Polemonium elegans	elegant Jacob's-ladder	G4	S2S3		Blue			dicots	TERRESTRIAL	
Polygonum engelmannii	Engelmann's knotweed	G3G5	S2S3		Blue			dicots	TERRESTRIAL	
Potamogeton strictifolius	**stiff-leaved pondweed**	**G5**	**S2S3**		**Blue**			**monocots**	**LACUSTRINE**	
Potentilla diversifolia var. *perdissecta*	diverse-leaved cinquefoil	G5T4	S2S3		Blue			dicots	TERRESTRIAL	
Potentilla nivea var. *pentaphylla*	five-leaved cinquefoil	G5T4	S2S3		Blue			dicots	TERRESTRIAL	
Salix boothii	**Booth's willow**	**G5**	**S2S3**		**Blue**			**dicots**	**LACUSTRINE;PALUSTRINE;TERRESTRIAL**	
Schizachyrium scoparium	little bluestem	G5	S1		Red			monocots	RIVERINE;TERRESTRIAL	
Scirpus pallidus	pale bulrush	G5	S1		Red			monocots	PALUSTRINE;RIVERINE;TERRESTRIAL	
Scolochloa festucacea	rivergrass	G5	S2		Red			monocots	LACUSTRINE;PALUSTRINE;TERRESTRIAL	
Silene drummondii var. *drummondii*	Drummond's campion	G5T5	S3		Blue			dicots	TERRESTRIAL	
Sphaeralcea coccinea	scarlet globe-mallow	G5?	S1		Red			dicots	TERRESTRIAL	
Sphenopholis intermedia	slender wedgegrass	G5	S3		Blue			monocots	LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	
Sporobolus compositus var. *compositus*	rough dropseed	G5T5	S3		Blue			monocots	PALUSTRINE;TERRESTRIAL	
Stellaria obtusa	blunt-sepaled starwort	G5	S2S3		Blue			dicots	PALUSTRINE;RIVERINE;TERRESTRIAL	

Scientific Name*	English Name	Global Rank	Prov Rank	COSEWIC	BC Status	Identified Wildlife in BC	SARA	Class (English)	Habitat Type	Breeding Bird
Stuckenia vaginata	sheathing pondweed	G5	S2S3		Blue			monocots	LACUSTRINE;RIVERINE	
Thalictrum dasycarpum	purple meadowrue	G5	S2S3		Blue			dicots	PALUSTRINE;TERRESTRIAL	
Thermopsis rhombifolia	prairie golden bean	G5	S1		Red			dicots	TERRESTRIAL	
Townsendia hookeri	**Hooker's townsendia**	**G5**	**S2**		**Red**			**dicots**	**TERRESTRIAL**	
Trichophorum pumilum	dwarf clubrush	G5	S2S3		Blue			monocots	LACUSTRINE;PALUSTRINE;TERRESTRIAL	
Veronica catenata	pink water speedwell	G5	S1		Red			dicots	LACUSTRINE;PALUSTRINE;RIVERINE	
Vertebrate Animal										
Acrocheilus alutaceus	Chiselmouth	G5	S3S4	NAR (May 2003)	Blue			ray-finned fishes	LACUSTRINE;RIVERINE	
Ammodramus leconteii	Le Conte's Sparrow	G4	S3S4B		Blue			birds	PALUSTRINE;TERRESTRIAL	Y
Ardea herodias herodias	Great Blue heron, *herodias* subspecies	G5T5	S3B,S4N		Blue	Y (Jun 2006)		birds	ESTUARINE;LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	Y
Ascaphus montanus	Rocky Mountain Tailed Frog	G4	S2	E (May 2000)	Red	Y (May 2004)	1	amphibians	PALUSTRINE;RIVERINE;TERRESTRIAL	
Asio flammeus	Short-eared Owl	G5	S3B,S2N	SC (Mar 2008)	Blue	Y (May 2004)	3	birds	ESTUARINE;PALUSTRINE;TERRESTRIAL	Y
Botaurus lentiginosus	American Bittern	G4	S3B		Blue			birds	ESTUARINE;PALUSTRINE	Y
Chrysemys picta pop. 2	Western Painted Turtle - Intermountain - Rocky Mountain Population	G5TNR	S2S3	SC (Apr 2006)	Blue		1	turtles	PALUSTRINE;RIVERINE	
Corynorhinus townsendii	Townsend's Big-eared Bat	G4	S3		Blue			mammals	PALUSTRINE;SUBTERRANEAN;TERRESTRIAL	
Dolichonyx oryzivorus	Bobolink	G5	S3B		Blue			birds	PALUSTRINE;TERRESTRIAL	Y
Gulo gulo luscus	Wolverine, *luscus* subspecies	G4T4	S3	SC (May 2003)	Blue	Y (May 2004)		mammals	TERRESTRIAL	
Hirundo rustica	Barn Swallow	G5	S3S4B		Blue			birds	ESTUARINE;LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	Y
Martes pennanti	Fisher	G5	S2S3		Blue	Y (Jun 2006)		mammals	PALUSTRINE;TERRESTRIAL	
Megascops kennicottii macfarlanei	Western Screech-Owl, *macfarlanei* subspecies	G5T4	S1	E (May 2002)	Red	Y (May 2004)	1	birds	PALUSTRINE;TERRESTRIAL	Y
Melanerpes lewis	**Lewis's Woodpecker**	**G4**	**S2B**	**SC (Nov 2001)**	**Red**	**Y (May 2004)**	**1**	**birds**	**PALUSTRINE;TERRESTRIAL**	**Y**
Numenius americanus	Long-billed Curlew	G5	S3B	SC (Nov 2002)	Blue	Y (May 2004)	1	birds	ESTUARINE;PALUSTRINE;TERRESTRIAL	Y
Oncorhynchus clarkii lewisi	Cutthroat Trout, *lewisi* subspecies	G4T3	S3	SC (Nov 2006)	Blue	Y (Jun 2006)		ray-finned fishes	LACUSTRINE;RIVERINE	
Otus flammeolus	Flammulated Owl	G4	S3S4B	SC (Nov 2001)	Blue	Y (May 2004)	1	birds	TERRESTRIAL	Y

Scientific Name*	English Name	Global Rank	Prov Rank	COSEWIC	BC Status	Identified Wildlife in BC	SARA	Class (English)	Habitat Type	Breeding Bird
Ovis canadensis	Bighorn Sheep	G4	S2S3		Blue	Y (Jun 2006)		mammals	PALUSTRINE;TERRESTRIAL	
Rana pipiens	Northern Leopard Frog	G5	S1	E (May 2000)	Red	Y (May 2004)	1	amphibians	LACUSTRINE;PALUSTRINE;RIVERINE;TERRESTRIAL	
Salvelinus confluentus	Bull Trout	G3	S3		Blue	Y (Jun 2006)		ray-finned fishes	LACUSTRINE;RIVERINE	
Sphyrapicus thyroideus nataliae	Williamson's sapsucker, *nataliae* subspecies	G5TU	S1S2B	E (May 2005)	Red	Y (Jun 2006)	1	birds	TERRESTRIAL	Y
Taxidea taxus	**Badger**	**G5**	**S1**	**E (May 2000)**	**Red**	**Y (May 2004)**	**1**	**mammals**	**TERRESTRIAL**	
Tympanuchus phasianellus columbianus	Sharp-tailed Grouse, *columbianus* subspecies	G4T3	S2S3		Blue	Y (Jun 2006)		birds	PALUSTRINE;TERRESTRIAL	Y
Ursus arctos	Grizzly Bear	G4	S3	SC (May 2002)	Blue	Y (May 2004)		mammals	PALUSTRINE;RIVERINE;TERRESTRIAL	

Global Rank:	**Provincial Rank:**	**COSEWIC (Committee on the Status of Endangered Wildlife in Canada)**	**BC Status**	**SARA (Canada Species at Risk Act)**
GX = Presumed Extinct	SX = Presumed Extirpated	E = Endangered	Red=Extripated, Endangered or Threatened	Schedule 1 = Species recognized under the Act
GH = Possibly Extinct	SH = Possibly Extirpated	SC = Special Concern	Blue=Species of special concern; vulnerable.	Schedules 2 & 3 = COSEWIC Species Under Review
G1 = Critically Imperiled	S1 = Critically Imperiled	NAR = Not at Risk		
G2 = Imperiled	S2 = Imperiled			
G3 = Vulnerable	S3 = Vulnerable			
G4 = Apparently Secure	S4 = Apparently Secure			
G5 = Secure	S5 = Secure			
	B = Breeding			
	N = Non Breeding			
	Z = Moving - diffuse, usually moving population			

* All highlighted species have been identified in the Windermere Lake Area (in accordance with CDC Mapped Occurrence Records, May 2008)

Appendix B – Site Descriptions

Appendix B- Site Descriptions

Detailed descriptions and photo documentation for each site according to information collected during the field inspections. The study site locations are also highlighted on the overview map and orthophotos for the lake in Appendix D. Terrestrial wildlife and habitat details for these sites were largely obtained from a comprehensive field summary document provided by Holmes (2008).

Site 1 (FIM Segment #20)

Site 1 is located at the north east end of Windermere Lake, downstream of the water intake for the Copper Point Golf Course. The lake bed substrates along this site were a mix of gravels and cobbles along with silt/algae. No aquatic vegetation was present. This site has been extensively developed and disturbed along most of its length by retaining wall, dock, gabion and boat house structures. Most of these foreshore structures were built below the high water mark. This site has been typed as **Modified Gravel Beach** (Figure 1).

Figure 1. Modified gravel beach shore along Site 1, showing respective upstream and downstream views of fish sample area (photos by L. Porto, Sept 25 2007).

Site 1a (FIM Segment # 21)

Site 1a is located along a property that had an extensively disturbed foreshore (Figure 2). Some improvements, however, have been implemented along the shoreline here. The retaining wall was situated below the high water level and fish structures (boulders) were placed in front of the wall to improve fish habitat. The instream substrate type was mainly boulders, with silt and cobbles evident deeper off the shore. The foreshore length of this site was approximately 75 m. There was no aquatic vegetation at this site. This site was classified as a **Modified Low Rocky Shore Type**.

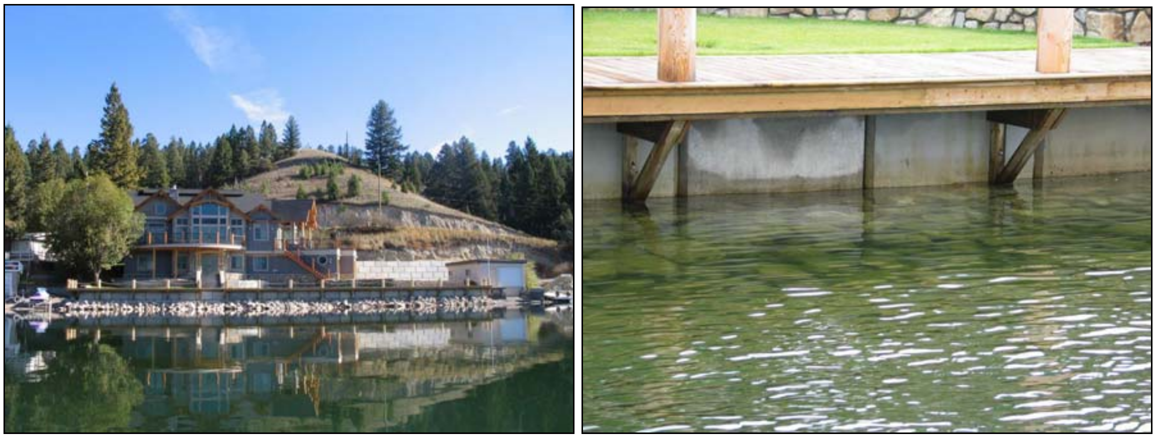

Figure 2. Site 1a showing retaining wall with fish habitat structures (photos respectively by H. Leschied and P. Holmes July 2007).

Site 2 (FIM Segment #22)

Site 2 is located at the Holland Creek tributary outlet. The fish survey area extended beyond the outlet to include the marina on the south side and the swim area surrounded by an extensive dock on the north side. The substrate for the area was silt/sand with some large gravel (in the swim area). Other than the swim area, the site was full of submerged aquatic vegetation. The foreshore has been typed as **Modified Creek Mouth**, due to the fact that there were substantial anthropogenic structures on both sides of the Creek outlet (Figure 3).

Figure 3. Site 2, showing respective upstream and downstream views of fish sample area (photos by L. Porto, September 26 2007).

In terms of riparian vegetation, the outlet of Holland Creek appeared to be in good condition with development generally situated away from the stream edge (Figure 4). The vegetation along the north side of the creek was particularly healthy, due to the presence of a fence which offered protection. The south side was manicured with lawn and a road. Two decay class 3 wildlife trees (Douglas fir) were observed at the mouth of Holland Creek. An additional wildlife observance was of a dog attempting to capture a muskrat (*Ondatra zibethicus*).

Figure 4. Respective photos of vegetation at the outlet of Holland Creek and fence protecting vegetation on north side of Holland Creek (Photo by P. Holmes, July 2007)

Site 3 (FIM Segment #23)

The Shore Type for Site 3 is **Modified Cliff/Bluff** Shore Type, due to the steep, clay banks of the area and extent of impact of development and the road (Figure 5). The riparian vegetation was sparse resulting in continuous erosion. Black cottonwood (*populous balsameifera* spp. *Tichocarpa*) and willow (*Salix* spp.) were present and attempting to re-establish. A community picnic site has also been established here. Some rehabilitation to stabilize the slopes and manage water runoff has been attempted. This involved planting trees and shrubs and placing a rock drain at the base of a section of the cliff. The banks at the southern end of the site were less disturbed and were utilized by nesting Bank Swallows (*Riparia riparia*).

Figure 5. Site 3, showing respective views of development in the north and Bank Swallow nests in the south (Photos by P. Holmes, July 2007).

In the lake, substrates were composed of mostly silt and sand with some gravel and cobble (Figure 6). There were small patches of submerged vegetation.

Figure 6. Site 3 showing respective upstream and downstream views of fish sample area (photos by L. Porto, Sept 26 2007).

Site 4 (FIM Segment #24)

Site 4 is located just north of Windermere. This site had a highly developed foreshore with extensive retaining wall coverage (Figure 7). The foreshore substrate type was mostly sand with some gravel near the shore. There was only a small amount of submerged aquatic vegetation in this area. The Shore Type has thus been classified as **Modified Sandy Beach**. One property provided a good example of maintaining vegetative cover even though the retaining wall was situated below the high water mark (Figure 8).

Figure 7. Overview of Site 4 (photo by P. Holmes, July, 2007)

Figure 8. Site 4, showing respective upstream and downstream views of fish sample area (photos by L. Porto, September 26 2007).

Site 5 (FIM Segment #25)

This site is located along the Windermere Cemetery and Hidden Bay. It is known to be the least developed shoreline and the highest productive point on the northeast side of Windermere Lake. Because of these predominant features, the Shore Type for this site was classified as **Vegetated Shore** (Figure 9). The site had a natural adjacent wetland along the point of land below the cemetery. These types of wetlands provide important habitat for nesting birds, invertebrates and natal grounds for numerous species. The Douglas fir trees adjacent to the wetlands are also known to provide important perching sites for Osprey (*pandion haliaeteus*) and other raptors. Additional wildlife accounts were of bear and deer tracks which were observed during the July field review. The water level in the wetland was still up during the fall inspection despite lower lake levels.

Figure 9. Site 5 respectively showing Hidden Bay and wetland habitat (with transition between grassland, riparian and foreshore habitats) (Photo by P. Holmes, July 2007).

In the lake, the foreshore habitat consisted of silt/sand with a cobble shoreline and beach. The area has abundant submerged vegetation. There were three habitat types covered in the snorkel survey of this area including 1) shallows with silt and submerged vegetation; 2) drop off from beach; and 3) deep bay of 3-5 m, which appeared dredged for the small (<10 boats), primitive marina. Figure 10 depicts the fish sample area.

Figure 10. Site 5, showing respective upstream and downstream views of fish sample area (photos do not depict the Hidden Bay area, which is to the left of the first photo) (photos by L. Porto, September 26 2007).

Site 5a (FIM Segment #26)

This site is located along the foreshore of Windermere Island (Figure 11). The island was in a natural condition, providing good nesting, rearing, perching and foraging habitat for waterfowl and associated species. It was observed that black cottonwood (*Populus balsamifera* spp. *Tichocarpa*) has been protected from the beaver with poultry netting. Overhanging vegetation was available for fish species. The lake substrates were a mix of gravels, cobbles and sand. Submerged aquatic vegetation was found along the foreshore. This site has been classified as **Vegetated Shore Type**.

Figure 11. Site 5a, showing respective views of Windermere Island from afar (photo by P. Holmes) and south side wetland area (photo by H. Leschied).

Site 6 (FIM Segment #26)

Site 6 is located at the outlet of Windermere Creek. The riparian area was intact, providing good habitat, except for a well used trail on the northern bank. The foreshore however, was quite modified with an adjacent marina (approx. 20 m downstream of the site) and a large manicured lawn. The marina has greatly modified the shoreline of the creek mouth with structures such as docks, breakwater, dredged frontage and pilings. The lake substrates were silt and clay, with submergent aquatic vegetation present. Overall, the Windermere Creek outlet has been classified as **Creek Mouth Shore Type** (Figure 12). This site could have been tagged as a

“Modified” shoreline, due to the marina’s presence (approx. 20 m upstream). This site was not labeled as Modified, because it still retained some natural characteristics (directly at the mouth and along the upstream shoreline).

Figure 12. Site 6, showing respective views of Windermere Creek outlet (photo by P. Holmes July, 2007) and downstream marina (photo by L. Porto, September 26 2007).

During the snorkel survey (summer), all fish at this site were observed in Windermere Creek or the reed bed. No fish were found to be using the docks or breakwater, albeit visibility was low. A minnow trap was set off the boat for the duration of the snorkel and no fish were caught.

Site 6a (FIM Segment #26)

Site 6a is located at the outlet of Jane Creek, a highly disturbed site, which was classified as **Modified Creek Mouth Shore Type (**Figure 13). A boat house has been built over top of the creek with concrete footing creating a fish barrier. The site may have been dredged to maintain entrance to the boat house. An osprey nesting pole has been erected on the foreshore. A floating breakwater and berm (Trethaway Beach) has been planted with shrub species to promote fish and wildlife habitat and was in place to protect the downstream marina. Bear scat was observed along the foreshore.

Figure 13. Site 6a, showing respective views of Jane Creek outlet with boathouse and downstream breakwater and marina (photos by L. Porto, September 26 2007).

Snorkel surveys were conducted both at the outlet of Jane Creek and along the shoreline fish structures. The water level was low in the fall making it difficult to snorkel at Jane Creek. Although some fish (10 largemouth bass) were observed along the break wall, no fish were observed through most of the area. The substrate type is silt/sand, and the site has both emergent and submergent aquatic vegetation.

Site 7 (FIM Segment #2)

This site is located at the outlet of Cool Spring Creek, which is an undisturbed ephemeral creek with wetland features in its lower section (Figure 14). There was excellent riparian habitat associated with Cool Spring Creek with typical species such as spruce species (*Picea* spp.), cattatil (*Typha latifolia*), cow parsnip (*Heracleum lanatum*) and scrub birch (*Betula glandulosa* var. *glandulosa)*. The undeveloped grasslands and mature conifers in upland area were also in good condition. Large clay bank to the south of the outlet were unstable due to wave action and as a result, did not provide suitable nesting for Bank Swallows. Large reed beds were situated offshore.

Figure 14. Site 7, showing respective views of upland grasslands and unstable clay bank (photos by P. Holmes, July 2007).

The fish sampling site was located downstream of the first reed bed. The lake substrates were sand and clays. The area contained wetland emergent vegetation. No snorkel surveys were conducted here due to high turbidity from clays; although a seine was conducted in the vicinity of the tributary. Although this site contained qualities of several shore types (i.e., wetland, cliff/bluff and creek mouth and vegetated shore), it has been identified as a **Wetland Shore Type**, based on this being the most prominent feature for fish (Figure 15).

Figure 15. Fish sampling area at the outlet of Cool Spring Creek (photos by P. Holmes, July 2007).

Site 8 (FIM Segment #4)

This site is moderately disturbed by a resort which surrounds an excellent wetland ecosystem adjacent to the lake (Figure 16). Adjacent to the wetland there is an abundance of conifers and shrub species (north aspect) and grassland communities which have been impacted by human development (south aspect). Wildlife trees and shrubs provide important food and nesting sites for bird species. A beaver lodge was also noted here.

Figure 16. View of wetland located downstream of Site 8 and upland features (photo by P. Holmes, July 2007)

Fish assessments at this site incorporated wetland (reed beds) at the downstream end and sand beach with docks at the upstream end. The substrate was mainly sand and silt with some gravel and cobbles in the shallows. The waters at the downstream end were very turbid during the summer snorkel survey and a seine was thus completed. Defining the Shore Type at this site was difficult, due to the prominence of both wetland and sand beach features. It was decided that this site was **Sand Beach Shore Type** based on the fact that more sand beach area appeared to be covered during the fish surveys (Figure 17).

Figure 17. Site 8, showing respective views of upstream and downstream ends of snorkel survey (photos by L. Porto, September 25 2007).

Site 9 (FIM Segment #6)

Site 9 is located in the wetland habitat of the Columbia River inlet, at the south end of Windermere Lake and was relatively undisturbed during the surveys (Figure 18). This site had emergent (e.g. reeds) and submergent vegetation. The substrate was classified as sand and silts. Field accounts identified that fish may have eluded snorkel observance due to high water and cover. A minnow trap was set, but no fish were caught. This was assumed to be the result of the trap being set for too short of a period of time (approx. 30 minutes). A flock of more than 300 scaups were observed during the fall sample. Overall this site was classified as **Wetland Shore Type**, due to the prominence of the wetland feature in this part of the river.

Figure 18. Site 9, showing respective views of extensive wetland complex at the Columbia River Inlet (photo by H. Leschied),

Site 10 (FIM Segment #7)

Site 10 is located on the south western shore of the lake, near Rushmere. This site showed moderate disturbance, mostly relating to the railway. The railway itself which runs along the foreshore of most of the west side of the lake is an interesting modification. Its presence both impacts the foreshore and protects it (by limiting residential development). This site had an important wetland feature situated on the opposite side of the railway tracks (Figure 19). The wetland is fed by an unnamed creek, which does not have a culvert connecting it to the lake (Griffith 1994). There was an abundance of wildlife trees (trembling aspen) adjacent to this wetland with future recruitment of conifers and deciduous apparent. Some vegetation was also present on the lakeshore side, although growth was limited by the railroad tracks. This site had evidence of badger activity.

Figure 20. Site 10, showing respective views of adjacent wetland and associated shrub and tree species (photos by P. Holmes, July 2007).

The lake substrate consisted of cobbles, gravels and fine substrates. There were patches of emergent aquatic vegetation throughout. This site was difficult to classify since it contained more than one type of habitat feature (e.g., gravel, wetland, vegetated). It was determined that the site would be classified as a **Modified Vegetated Shore Type** (Figure 21). This site could have been a modified wetland; however, very little in the way of wetland features exist in the lake, since the railway track is a barrier to flows from the small upstream tributary. Consideration was also given to classifying this site as gravel beach shore type, but when the FIM results were reviewed, this Segment was not reported to have any gravel beach shore types. Thus, in order to conduct comparative analysis (including AHI) using FIM data, it was identified as a Modified Vegetated Shore.

Figure 21. Fish sampling area at Site 10 (photos respectively by P. Holmes, July 2007 and L. Porto, September 25 2007).

Site 11 (FIM Segment #9)

Site 11 is located adjacent to Sunshine Ranch Provincial Park. The railroad at this site is set back from the shoreline providing good examples of natural plant communities and morphological conditions (Figure 22). Other than a sandy bank which was disturbed from human recreation activities (e.g., sunbathing and boating) (Figure 23), this site was relatively undisturbed. The railroad runs adjacent to the shoreline at the southern end of the site but still provided a good example of vegetation growth between it and the lake. The shoreline north of the beach area provided an excellent example of natural foreshore vegetation. There was also a wetland located at north end of the site and an adjacent wetland created by the establishment of the railroad. The upland bench exhibited a healthy native grassland with species such as junegrass (*Koeleria macrantha*) and blubunch wheatgrass (*Agropyron spicatum*), although some non-native species such as western goatsbeard (*Tragopogon dubius*) have invaded the site. This area is known to have extensive ungulate usage.

Figure 22. Overview of Site 11 showing plant communities (photos by P. Holmes, July 2007).

Figure 23. Site 11, showing respective views of disturbed sandy bank and native grassland habitat on upland bench (photos by P. Holmes, July 2007).

Snorkel and seine surveys were conducted over the following three different habitat types in this site: 1) a sandy beach area with no vegetation, 2) an area with overhanging riparian vegetation, aquatic vegetation and sandy substrate, and 3) a ground water fed area with mostly sand substrate and aquatic macrophytes (lilies and reeds). Like some of the other sites, it was difficult to classify this shore because of the diversity of habitat it encompassed (e.g. cliff/bank, wetland, sand beach and vegetated shore). Because the FIM identified that 100% of this Segment was Vegetated Shore, this site was classified as being **Vegetated Shore Type** (Figure 24).

Figure 24. Vegetated Shore Type at Site 11, showing respective upstream and downstream views of fish sample area (photos by L. Porto, September 25 2007).

Site 12 (FIM Segment #11)

Site 12 is located at the outlet of Brady Creek and has thus been classified as a **Creek Mouth Shore Type (**Figure 25**)**. This site has been moderately - highly disturbed as a result of the culvert which directs Brady Creek flows to the lake, the railway running adjacent to the lake (and bisecting a wetland), as well as some structures (retaining walls and docks) erected on the beach at the north end (Figure 26). This is another site which could have been tagged as being **"Modified"**. In terms of fish habitat, it appeared that there were some natural features intact, including vegetation along much of the shore and wetland features, which is why it was not tagged as 'Modified' for the fish distribution component of this assessment. In terms of wildlife, this site provided valuable features including wetland habitat, abundant high quality wildlife trees, clay banks, an ecotone example of grassland adjacent to the wetland and abundant wildlife trails. The lake substrates were silts near the vegetation and cobble / gravel away from the vegetation and along the shore. The site had both emergent and submergent aquatic vegetation.

Figure 25. Photos of Site 12, showing respective views of lake shore and wetland on opposite side of railway (photos by P. Holmes, July 2007).

Figure 26. Creek Mouth Shore Type at Site 12 (Brady Creek), showing respective views of upstream and downstream snorkel survey areas (photos by L. Porto, September 25 2007).

Site 13 (FIM Segment #12)

Site 13 is also typed as a **Creek Mouth Shore Type** since it is located at the outlet of Goldie Creek. The railroad is set-back some from the lake here, which has helped the alluvial fan function well and provide excellent riparian habitat. The alluvial fan is composed of aspen and cottonwood stands; while higher densities of spruce occur inland from the railroad.

Figure 27. Wetland habitat associated with Goldie Creek (photos by P. Holmes, July 2007)

Substrates here were mainly silt, with some cobble/gravel along the shore. Emergent (reeds) and submergent aquatic vegetation was also present. During the summer fish assessment, Salter Creek outlet was noted as having particularly cold water. Visibility was also low due to tubidity caused by windy conditions (Figure 28).

Figure 28. Creek Mouth Shore Type at Goldie Creek outlet, showing respective views of upstream and downstream ends of snorkel survey areas (photos by L. Porto, September 25 2007).

Site 14 (FIM Segment #16)

Site 14 is located at Fort Point. This site shows extensive urban development with no natural vegetation communities remaining (Figure 29 and Figure 30). It is a very exposed site, with higher banks. In order to provide foreshore bank protection, severe measures using 'hard' techniques have been employed. Some of these modifications appeared to be failing. There was an abundance of the invasive species Baby's Breath (*Gypsophila paniculata*) along the shore.

The substrates at this site were mainly silt, with a few cobbles and gravel along the shoreline. Aquatic vegetation was minimal and scattered as submerged vegetation. This site was classified as a **Modified Cliff/Bluff Shore Type**. This classification was given based on analysis of photos and lake habitat features. FIM report data was also used to classify this site, which identified that this Segment as a whole had only vegetated shore or cliff/bluff shore type. It showed aspect of each, with its vegetated rolling hills. Because the banks at the beach were relatively steep, (as evidenced by extensive retaining walls) the Modified Cliff/Bluff Shore Type was chosen.

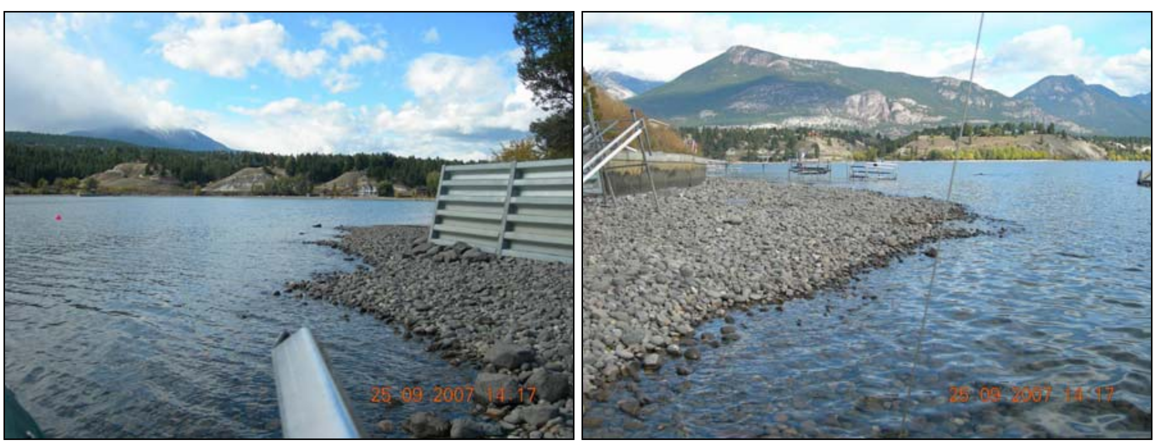

Figure 29. Site 14, showing respective views of upstream and downstream ends of snorkel survey areas (photos by L. Porto, September 25 2007).

Figure 30. Modified Cliff / Bluff Shore Type shown at Fort Point (photos by P. Holmes, July 2007).

Site 15 (FIM Segment #18)

Site 15 is located at James Chabot Provincial Park, situated near the outlet of Windermere Lake. This site contains a popular beach that receives high human usage during summer months, resulting in extensive foreshore disturbance. The nesting platform for osprey located in parking lot was occupied. The wetland located at the western portion of the park appeared to be functioning properly despite adjacent development (Figure 31). This development is currently under construction and is being built on fill which was placed in the wetland approximately 9 years ago. Overhanging vegetation along north-eastern portion of the site was relatively undisturbed and provided important habitat.

Figure 31. Photos showing respective wetland features located at the west end of this site and foreshore vegetation along the north east part of this site (photos by P. Holmes, July 2007)

Both a snorkel survey and a beach seine were conducted at this site. At the survey locations, substrates were described as mainly silt in wetland areas, with cobble and gravel along the shoreline (Figure 32). Emergent and wetland aquatic vegetation were also in the lake. This site was difficult to classify, because like others it had more than one characteristic along its foreshore length and because characteristics in the lake were different than from what appeared on the shore. Disturbance may have also greatly altered it from its natural state. For this site, it was decided that the **Gravel Beach Shore Type** designation was most suitable. This was based on the photos for the area and on the fact that the FIM report identified much (45%) of this Segment as gravel beach.

Figure 32. Site 15, showing respective views of upstream and downstream ends of survey areas (photos by L. Porto, September 25 2008).

Appendix C – Fish Species Summaries

BULL TROUT *(Salvelinus confluentus)*

Ecology and Life History

Bull trout is a member of the Salmonidae Family and is a trout-like char (McPhail 2007). The species' range extends from Northern California north to the Yukon River and east to western Alberta and Montana (Cannings and Ptolemy 1998). In BC, bull trout are known to coexist and hybridize with dolly varden (*S. malma*) (McPhail 2007). Although there has been debate on whether bull trout and dolly varden are separate or individual species, they are currently recognized as separate species (McPhail 2007). Bull trout are used as an indicator species of ecosystem health because they are widely distributed in BC and known to be sensitive to habitat changes (Cannings and Ptolemy 1998). Distribution and abundance are strongly influenced by channel and hydrologic stability, substrate composition, cover, temperature and the maintenance of migration corridors (Cannings and Ptolemy 1998). Population declines for this species has resulted in it being ranked as vulnerable, both globally (G3) and provincially (blue-listed, S3) (Cannings and Ptolemy 1998, CDC 2008).

Bull trout are a cold water species, uncommon at temperatures above 15 ^{o}C (Cannings and Ptolemy 1998, McPhail 2007). Bull trout are unique in that they can inhabit high gradient areas (up to 30%) where other game species would not be found (Cannings and Ptolemy 1998). In the Interior of BC, three life-history patterns are common for the bull trout: 1) a riverine form that lives as an adult in large river systems and migrates to small tributaries to spawn; 2) an adfluvial form that resides as an adult in lakes and migrates to tributaries to spawn; and 3) a stream - resident form that lives in small rivers and streams (McPhail 2007, Cannings and Ptolemy 1998). This synopsis, with Windermere Lake as the focus, will generally summarize details relating to the adfluvial form.

In adfluvial populations in southern BC, sexual maturity is reached when the males are about 5+ years and females are about 6+ years (McPhail 2007). Spawning occurs in the fall, and for ad/fluvial forms, is preceded by a migration into smaller rivers in late August (McPhail 2007). Bull trout can be extremely sensitive about spawning sites, often utilizing small very high gradient tributary streams and groundwater seepage channels (Cannings and Ptolemy 1998). The following features are often also important requirements for spawning: clean gravel and cobble substrates, adjacent cover elements (deep pools or cutbanks, log jams, and overhanging bushes) (Cannings and Ptolemy 1998). Spawning typically takes place when water temperatures drop below 9 ^{o}C (McPhail 2007, Cannings and Ptolemy 1998). Optimal incubation temperature is from 2 ^{o}C to 4 ^{o}C (Cannings and Ptolemy 1998). Fry emerge in the spring and move into low velocity areas such as backwaters or sidechannels, typically with ample overhead cover, where they stay until the fall (Cannings and Ptolemy 1998). Juveniles feed primarily on the nymphs and larvae of aquatic insects (McPhail 2007). For adfluvial populations in southern BC, fry typically migrate to their lake in the second or third summers of growth, once they have reached an approximate fork length of 200 mm (McPhail 2007).

Once in the lake, juveniles are thought to move to deeper water (McPhail 2007). Adults are piscivorous, preying on trout, whitefish, kokanee, arctic grayling, suckers, minnows and sculpins. By day adults tend to inhabit deeper water, while at night, they move into shallower water (e.g., littoral zones) (McPhail 2007).

Windermere Lake System

Although bull trout are widely distributed throughout the Upper Columbia River system (McPhail and Carveth 1993), abundance in Windermere Lake is low. Only two adult bull trout were observed in Windermere Lake during the 2007 foreshore sampling completed for this study. The bull trout were observed in the fall, from the dock that surrounds a swim area at Site 2 (Segment 22), near the Holland Creek outlet. The site was classified as a Modified Creek Mouth Shore

Type. Considering their size (300 – 500 mm), and the season, the bull trout were likely migrating to a spawning stream and/or taking advantage of available food source at this site (plentitude of redside shiners also present). These bull trout represented 0.2% of the total fall population of fish for the study area and 0.1% of the fish found in the Modified Creek Shore Type in the fall.

Historically, bull trout were known to be abundant throughout the Columbia River and associated lakes, including Windermere Lake; however angling opportunities are no longer favourable in these areas (Westslope 2001). There were only a few historical accounts of bull trout in Windermere Lake found in the literature. Lake recruiting bull trout have been reported in Windermere Creek and Salter Creek, tributaries to Windermere Lake during 1993 sampling (Griffith 1994). MoE (2008) Fisheries Inventory Summary System (FISS) indicates an adfluvial bull trout capture in 1983, and non-specified bull trout forms in 1977 and 1994 (1 fish assumed each). Interior Reforestation also captured juvenile bull trout in the lower portions of Windermere Creek in the summer of 1998 (J. Bisset pers. comm.). Windermere Creek spawning habitat is limited to the lower reaches (approx. 3 km), as a result of a potential barrier at the Scandia gravel pit (old concrete dam) (J. Bisset pers. comm.). The upper reaches of Windermere Creek may also be a little small for adfluvial bull trout (J. Bisset pers. comm.). Bull trout also likely spawn in other proximal and larger tributaries such as Dutch Creek, Spillimacheen and areas in the Columbia River (J. Bisset pers. comm.).

According to their life-history bull trout would be expected in the deep cool water during the summer, and Windermere Lake's warm water temperatures would likely be too high to for this species. During July 2007 sampling, for example, temperatures ranged from 19-25 °C, values which are higher than the 15 °C preference identified by Cannings and Ptolemy (1998) and McPhail (2007). Cold-water refuge during the summer is not encountered at depth in Windermere Lake, as water quality sampling shows that the lake, due to its shallow nature (6.4 m maximum and 3.4 m mean) does not become stratified (Griffith 1994). Fall temperatures at Windermere Lake which ranged from 10 – 14.5 °C during 2007 sampling, were however favorable for this species. Griffith (1994) provides that there just might be very few adult bull trout in the system and that low numbers do not relate to tributary habitat conditions since accessible stream habitat is not fully exploited. This is typical for bull trout, since they are known to be extremely sensitive about spawning sites, with some populations observed selecting one small area and ignoring other apparently suitable habitats (Cannings and Ptolemy 1998).

Known causes of risk to bull trout that could be associated with Windermere Lake include: improved angler access, over fishing, forest harvesting, habitat loss, exotic fish introductions (brook trout and related hybridization), hydroelectric impoundments, urbanization and water temperature increases (Hass 1998). Considering bull trout habitat requirements and life history needs, the key areas of importance for protection of this species relative to the Windermere Lake foreshore would be spawning habitats in the tributary streams, namely Windermere Creek and Salter Creek.

When completing the Fish Species Habitat Matrix for the Habitat Index, bull trout had low habitat use of Windermere Lake Foreshore. Based on the literature and the assessment findings, the Creek Mouths were the only areas selected for habitat use for staging/spawning and rearing. Cliff/Bluff and Low Rocky Shore Types were included for adult general living since these areas potentially provide deeper refuge habitat. More rigorous sampling may provide further insight to this species' habitat utilization along the foreshore. Bull trout were rated as high for Habitat Selectivity based on the fact that they are very selective about their habitats.

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PERSONAL COMMUNICATIONS

Bisset J. 2008. Senior Aquatics Biologist, Interior Reforestation Co. Ltd. Cranbrook British Columbia.

BURBOT *(Lota lota)*

Ecology and Life History

Burbot are the only truly freshwater member of the Gadidae (cod) Family (Nelson 1994). The fishes' range occurs circumpolar, from North America through Eurasia, southward to about 40 ^{o}N (Scott and Crossman 1973). There has been some debate about the distinction of European and North American burbot as separate species because the life histories and morphological traits are somewhat regional (McPhail 1997). Recent molecular analysis indicates that there is one species of burbot, and that there are at least two subspecies (McPhail 2007). Although Burbot are widespread and abundant throughout much of BC, they are considered a species of regional concern in the Columbia River system due to marked declines in their numbers (McPhail 2007). Columbia Lake, located at the headwaters of the Columbia River, has been the focus of several burbot studies. The findings for Columbia Lake are particularly relevant to this project, since Columbia Lake is located only 20 km upstream of Windermere Lake on the Columbia River. The key habitat requirements observed from the Columbia Lake studies will be referenced as much as possible.

Burbot are a cool-water fish that seldom occur in lakes or rivers exceeding 18 ^{o}C (McPhail 2007). Adult burbot are benthic, inhabiting waters greater than 2 m deep (McPhail 2007). Columbia Lake burbot typically become sexually mature following 4 growing seasons (Arndt and Hutchinson 2000). Burbot spawn in lakes and streams, typically under the ice in the winter or early spring (early February in Columbia Lake), when water temperatures range from 0 ^{o}C to 5 ^{o}C (McPhail 2007). In lakes, spawning occurs in relatively shallow water (1.0 – 10.0 m) over sand or gravel bottoms (McPhail 2007). Eggs are released into the water column and sink slowly to the substrates below (Scott and Crossman 1973), where they incubate for 30 to 60 days (McPhail 2007).

Studies on newly hatched larvae from Columbia Lake identify that larvae remain sedentary on the substrate for at least 5 days, at which point they start a unique behavior of spiraling up towards the surface and sinking to the bottom (McPhail 2007). This 'wriggling' continues for about a week, after which larvae become free-swimming and begin feeding (McPhail 2007). Once the larvae grow to be 30-40 mm, they become benthic and nocturnal, inhabiting nearshore areas (less than 2 m deep) (McPhail 2007). For the remainder of the burbot's life, they hide during the day and are strongly associated with the bottom (McPhail 2007). Cover is particularly important to all ages of burbot, even adults (Taylor 2001). At Columbia Lake, juvenile burbot are strongly associated with interstitial spaces in the substrate (Taylor 2001). The preferred habitat for age 0 burbot is gravel and cobble substrates along the shoreline (Taylor 2001). Since shelter size tends to increase with increasing body size, older juveniles are associated with larger substrates of cobble and boulders (Taylor 2001). Where aquatic vegetation is utilized, extensively branching species such as bushy pondweed (*Najas flexis*) are preferred (Taylor 2001). Older juveniles (2 +, >200 m) stay below the thermocline in the summer (McPhail 2007). At Columbia Lake, burbot larger than 390 mm, representing an age between 2 and 3, generally move to deeper waters and no longer inhabit the shoreline (Taylor 2001). However, Bisset et al (2001) did find some adults in less than 1 m of water in various seasons in Columbia Lake. J. Bisset (pers. comm.) further added that in Columbia Lake, which is a relatively shallow lake that does not stratify in the summer (as a result of depths and wind), adult burbot likely move out during the summer following the kokanee and move back into the lake in the fall / winter.

Food preferences increase in size with increasing body size, starting at small phytoplankton and rotifers for newly hatched larvae, and shifting to bottom organisms (e.g., amphipods) once the burbot become larger and benthic (McPhail 2007). Adult fish are primarily piscivores, preying on a variety of fish species including trout, suckers, minnow and sculpins (McPhail 2007). Burbot can live up to 20 years and reach lengths of 700 mm (McPhail 2007). The largest reported burbot caught in BC (15.44 kg) was caught in Windermere Lake near the mouth of Windermere Creek in 1923 (McPhail and Paragamian 2000). Adults are nocturnal (Westslope 2001).

Windermere Lake System

There have been significant declines in burbot populations in areas of the Kootenay Region of southeast BC (Paragamian et al. 2000), including Windermere Lake. It is hypothesized that high water temperatures (>25 ^{o}C) and habitat loss are the main factors limiting burbot growth and survival in Windermere Lake (C. Spense pers. comm.). J. Bisset (pers. comm.) supported this and provided that burbot declines in the lake can also likely be attributed to the combined influences of: overfishing, non-native species interactions changing the predator/prey dynamics and habitat degradation. No burbot were found along the Windermere shoreline during the 2007 summer and fall surveys. It is likely that that burbot were not sampled during this study because their populations are at such low levels that they may not be prevalent, even in optimal habitats (J. Bisset pers. comm.). The Columbia Lake and Windermere Lake burbot populations are considered to be linked and in Columbia Lake burbot are just starting to recover (J. Bisset pers. comm.). There are however, some historic accounts of burbot in the lake including that of adults (e.g., MoE 2008, Prince 2007, Arndt 2001) and juveniles (e.g., MoE 2008, Taylor 2002). Juvenile burbot were also found in Windermere Creek in 1998 (J. Bisset pers. comm.).

The foreshore of Windermere Lake is known to provide juvenile burbot habitat. Taylor (2002) used electrofishing (to a one metre depth) to sample juvenile burbot along the western shoreline, in late August of 2002, where nearshore surface temperatures were 19.5 – 21 °C. Taylor's (2002) findings revealed that the mean density of age 0 burbot was 4.5/100 m and of age-1 burbot was 0.6/100 m. Taylor (2002) found that age 0 burbot juveniles had the highest densities in areas with high percentage of cobble (>64 mm to 256 mm) and low fines (<2mm) (Taylor 2002). Taylor (2002) compared the 2002 results with that of previous sampling he completed in mid August of 1998 and identified that for most sites the densities had decreased with time.

It is a possibility that burbot were not found during the 2007 sampling because their optimal habitat was not sampled. Field data suggests that Sites 1, 4, 5, 5a and 10 would have been the most likely to provide juvenile burbot habitat, based on their substrate type (i.e. presence of gravel and cobble). This cannot be confirmed with the information available, because substrate sizes and percentage compositions (i.e., fines) were not calculated. The sampling techniques chosen (mainly snorkel) may also have been ineffective in locating burbot, as the species are known to have a strong association with hiding in the interstitial spaces.

Juvenile mortality is affected not only by the availability of cover from predators, but also by the abundance of predators and competitors (Taylor 2001). Predators may be an issue at Windermere Lake. Taylor (2001) reported that potential fish predators in the lake include torrent sculpins, northern pikeminnows and trout. Largemouth bass are also likely a predator. From the 2007 snorkel surveys results it was found that these species' summer and fall abundances in the lake were as follows: sculpin spp. 0.6% summer and 0% fall, northern pikeminnow 0% summer and 0.47% fall, trout 0% and largemouth bass 7.1% summer and 1.3% fall. Although these predatory species represented only a small proportion of the total fish community observed during snorkel surveys, adult forms of these species could have eluded snorkel observance; this may have occurred with northern pikeminnow in particular. Burbot were a really important top level predator in Windermere Lake historically; the influence of several, large, piscivorous fish in high numbers, competing with the historic piscivores (bull trout, burbot and rainbow) is an ongoing concern to fisheries management (J. Bisset pers. comm.).

Twenty northern pikeminnow (sized 30 - 50 cm.) and over 100 (sized 10 – 30 cm) were observed from the dock at Site 2 near the Holland Creek Mouth, which were not included in the abundance calculations because they were not observed during the snorkel surveys. From gill net surveys conducted by Griffith (1994) northern pikeminnow were the second most abundant species in the lake, only to kokanee who were migrating through to their spawning grounds. Adult pikeminnow and burbot species share similar characteristics of large size, piscivory and nocturnal feeding (Scott and Crossman 1973). Pikeminnow also have a tolerance to higher temperature than burbot. As Taylor (2001) describes, an increase in pikeminnows could increase predation on juvenile burbot and reduced cover availability during low water periods, which may make juvenile burbot especially vulnerable to predation. Burbot could be susceptible at Windermere Lake, since field descriptions indicate that for many sites coarse substrates were located closer to the shoreline. Under reduced water conditions of late summer and fall, these areas would likely become dewatered.

O age burbot prefer temperatures around 21 ^{o}C, while older juveniles and adults prefer cooler water between 10-12 ^{o}C (Ferguson 1958). This cool water preference would likely cause Windermere Lake burbot to seek out deeper waters in the summer. Taylor reported that decreased habitat complexity at depth in Columbia Lake could result in increased predation (Taylor 2001). This may be an issue at Windermere Lake as well.

Westslope (2001) provided historical accounts, going back to the 1930's, of spawning burbot being extremely abundant throughout the Columbia System. Winter ice fishing accounts for Windermere Lake revealed that anglers would spear burbot through holes in the ice in mid February at Goldie Creek and Windermere Creek (Westslope 2001). Spawning burbot apparently arrived in the hundreds to the weed beds at the creek mouths and other areas of the lake with macrophytes (Westslope 2001). Another example of the burbot's abundance was documented in the 1930's, where it was reported that large fish (burbot) observed in the shallow water at the mouth of Windermere Creek were stunned when the thin ice was hit with the blunt side of an axe; and that the fish would then be retrieved from a hole chopped in the ice (Westslope 2001). By the 1950's and 1960's the upper Columbia River Burbot fishery became well known to commercial operations (Westlope 2001). Little historical information exists on juvenile distribution in the lake, although they were reported at the mouth of Windermere Creek (Westslope 2001). This literature review did not provide and recent information on burbot spawning locations in Windermere Lake or its tributaries. The historic spawning locations as well as potential shore-spawning areas should be assessed, and once confirmed should be adequately protected. In terms of protecting foreshore habitat for juvenile burbot, as the literature for Windermere Lake indicates, areas providing cover particularly larger substrates such as cobbles and boulders and larger species of branching aquatic vegetation should be maintained.

When completing the Fish Species Habitat Matrix for the Habitat Index, burbot were rated as High for Habitat Selectivity based on the fact that they are very selective about their habitat needs and they are regionally significant. Results from a similar but more rigorous sampling along the foreshore of Okanagan Lake (Schleppe and Arsenault 2006) were generally used to define Habitat Specificity; although wetlands were also included for staging areas at Windermere Lake, based on historical accounts.

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CHISELMOUTH CHUB *(Acrocheilus alutaceus)*

Ecology and Life History

The chiselmouth is a member of the Cyprinidae Family, which includes minnows and carps (McPhail 2007). This species is endemic to the Columbia River, occurring only in the Columbia River system and adjacent drainages that received their fauna from the Columbia River (McPhail 2007). Chiselmouth inhabit arid interior regions and occur in BC, Idaho, Nevada, Oregon and Washington (McPhail 2007). The Chiselmouth is considered a species at risk in BC (Provincially ranked S3S4 and blue-listed) (CDC 2008).

Except for one record of its presence in Windermere Lake (Carl et al. 1959), chiselmouth are absent from the Upper Columbia River system (McPhail 2007). Other fisheries assessments including those completed by Radridge (1998), Griffith (1994), RL&L (1993) and BC Ministry of Environment (1958), have not found any specimens in the Windermere Lake. The most recent study by Radridge (1998), which attempted to assess the status of chiselmouth populations in Windermere Lake and adjacent waters, concluded that the original account may have been a misidentification, or that the population may have declined to very low levels becoming extirpated. McPhail (2007) corroborated this conclusion, stating that the original record was 'suspect'. As such, chiselmouth will not be a species that is discussed further in this report.

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EASTERN BROOK TROUT *(Salvenlinus fontinales)*

Ecology and Life History

Brook trout belong to the Salmonidae Family. Brook trout are an eastern North American species, which have been introduced to BC waters from domesticated hatchery stocks (McPhail 2007). Brook trout were introduced to BC in the 1920s and are now established throughout the province (McPhail 2007). Stocking reports for Windermere Lake indicate that the lake was stocked with 6,000, 20,000 and 100,000 of this sport fish in 1923, 1924 and 1925 respectively (MoE 2008). Although brook trout were introduced in BC over 80 years ago, little is known about their biology in the province; as such, documented life history and ecology information relates to native species in eastern North America (McPhail 2007).

Brook trout can pose a threat to native salmonids in BC. They are known to hybridize with two native char species – dolly varden and bull trout. Brook trout also are known to occupy similar habitats to that of native trout and char (McPhail 2007) and to compete with native species for food and space (Gunckel et al 2002). All of these influences are concerning as they can lead to displacement of native species.

Windermere Lake System

The fish distribution query for Windermere Lake (Fish Inventory Summary System - MoE 2008) identified that there have been hatchery produced brook trout in Windermere Lake. Other than this one account and the stocking reports referenced above from the 1920's, no further evidence of brook trout in the lake was found. No brook trout were reported at Windermere Lake during the 2007 summer and fall foreshore sampling, or during the 1993 reconnaissance survey conducted by Griffith (1994). Although Griffith (1994) did find brook trout associated with tributaries to Windermere Lake (i.e., Brady Creek, Goldie Creek, Abel Creek and Unnamed Creek #1), they were identified as being clearly stream resident. A review of the Individual Fish Data Reports for Windermere Lake also shows no records of brook trout captured during seine (1976, 1975) and gill net sampling (1993, 1976, 1975, 1958) (MoE 2008). Brook trout may be absent from Windermere Lake because of their intolerance to high temperatures. They are likely located in the cooler tributaries, near river/creek outlets and areas of groundwater upwelling. Due to their apparent absence in Windermere Lake and the fact that they are not a native species to the lake, eastern brook trout will not be discussed in further detail in this study.

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KOKANEE *(Oncorhynchus nerka)*

Ecology and Life History

Kokanee is a member of the Salmonidae family. Kokanee is the freshwater resident form of the anadromous pacific sockeye salmon. Kokanee have both a migratory form (potadramous) where they migrate from lakes to tributaries to spawn and a lacustrine form which spawn along lake shores. Sockeye and kokanee are widely distributed along the North America (from California to Alaska) and Asia (from Japan to Russia) Pacific Coast (Scott and Crossman 1973). Post-glacially, sockeye colonized most west flowing rivers in BC (McPhail 2007). Before the construction of the Grand-Coulee dam, they even reached Windermere and Columbia Lake (Fulton 1970).

Kokanee typically spawn in streams or along lakeshores in the fall when water temperatures fall below 12 ^{o}C (McPhail 2007). Spawning sites with sub-gravel flow are preferred including shallow riffles, outlets of lakes, or upwelling areas on beaches (Parsons and Hebert 1988). Spawning sites in rivers are dependant on water velocity and female size, with gravel diameters ranging from 1 to 2.5 cm, water velocities ranging from 0.15 m/s to 0.85 m/s and depths ranging from 6 to 37 cm (McPhail 2007). In lakes, spawning substrate size is variable (up to cobble size), with depths usually being less than 10 m (McPhail 2007). Typically kokanee juveniles rear in lakes (McPhail 2007). Kokanee fry will often spend the first month in the warmer shallows of the littoral zone foraging on a variety of limnetic and benthic prey (e.g., chironomid larva and pupae, copepods and cladocerans) (McPhail 2007). Fry usually move offshore by midsummer, where they forage primarily on crustacean zooplankton and chironomids (Northcote and Lorz and 1966). Adults also live in offshore habitats of lakes (McPhail 2007). Both juveniles and adults undergo vertical diel migrations, where in stratified lakes, they typically feed in the food rich middle and upper strata of lakes at dawn and dusk, and migrate to the lower cooler depths during the day (Levy 1990). In BC, kokanee typically reach sexual maturity at the end of their third (2+) or fourth (3+) summer (McPhail 2007). Kokanee are a very important prey species for top level native predators including bull trout, burbot and rainbow (J. Bisset pers. comm.).

Windermere Lake System

Although kokanee are not listed as a rare or endangered species, MoE has identified spawning areas as critical habitat and spawning channels as extremely important in the Rocky Mountain Forest District (Chirico 2005). The Columbia River and its tributaries provide very important kokanee spawning habitat (Manson 2006, Oliver 1995). The Upper Columbia River has had annual kokanee spawner enumerations completed since 1995 (Manson 2006). The 1995 enumeration in the Upper Columbia River revealed the mainstem Columbia River at Fairmont (located approximately 20 km upstream of Windermere Lake) as being one of the areas with the greatest concentrations of spawning kokanee, with 250,000 fish counted (Oliver 1995). During the 1995 assessment, Windermere Creek was identified as being the most important tributary to Windermere Lake for kokanee spawning, containing pockets of spawning habitat in its lower 500 m, which were utilized by 1500 fish (Oliver 1995). Griffith (1994) also identified the lower reach (1.5 km) of Windermere Creek as an important kokanee spawning area, which is dominated by swift flowing riffle habitat over cobble and gravel substrates. Griffith (1994) identified that thousands of spawners were evident at the time of investigation; however he noted that rearing habitat appeared to be extremely limited, with little available cover and fast flowing waters over riffles. Goldie Creek, also a tributary to Windermere Lake had some spawning habitat identified in its lower reach (200 m), with less than 50 fish observed (Oliver 1995). The outlet of Windermere Lake (downstream of the bridge at Athalmer) was also assessed to provide habitat (up to 15,000 fish) in the gravel outcrops (Oliver 1995). Although kokanee is a native fish of Windermere Lake hatchery stocks of kokanee were released into Windermere Lake in 1983, 1982, 1948, 1947, 1946, 1945, 1944, 1943, and 1942 (MoE 2008)

In total, considering all survey types, 51 adult kokanee were observed during the fall of 2007 for this project. At Site 1 (Modified Gravel Beach), 30 of these adults were observed from the boat rolling at the surface along the cobble shoreline just upstream (200m) of the unnamed creek inlet (located at the northeast corner of the lake). There was some evidence of redd development at this site. The rest of the kokanee were observed during snorkel surveys and findings will thus be described in detail. None of the kokanee observed were associated with manmade structures such as boat docks. As well, no kokanee were obtained through seine or minnow trap efforts, none were observed during the summer and no juvenile kokanee were sampled.

During snorkel surveys, 20 mature adults in spawning colouration were observed swimming along the Modified Cliff/Bluff at Site 14 (Fort Point) and one was seen along the Vegetated Shore at Site 5. These snorkel accounts represented 2.6% of the fish community in Vegetated Shore areas and 100% of the fish in the Modified Cliff/Bluff area (Figure 1). Overall, kokanee represented only a small percentage (1.97%) of the total fish community, during fall snorkel surveys.

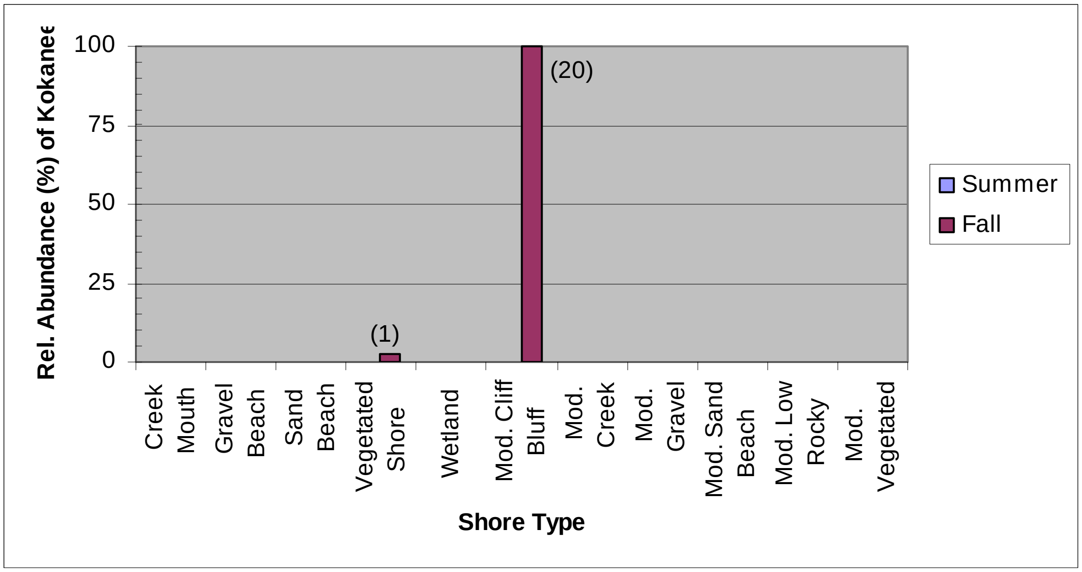

Figure 1. Relative abundance (%) and numbers (in parentheses) of adult kokanee observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore.

Because kokanee were observed building redds at Site 1, it appears that shoreline spawning may occur to some extent along Windermere Lake's foreshore. Lakeshore spawning habitat is not expected to be substantial, since appropriate gravel beach / upwelling areas are limited (J. Bisset pers. comm.). Specific areas where juveniles prefer to rear in Windermere Lake were not determined from this study and the literature only provides a generic description (e.g., littoral zone). Windermere Lake is not expected to provide habitat beyond the early juvenile stages since it lacks the typical cold and deep lake features sought by adult kokanee. J. Bisset (pers. comm.) provided the following additional details on the likely kokanee life history at Windermere Lake which helps to explain the sampling results: "*Young-of-the-year likely stay in their natal streams until early-mid June when they move into the lake. Once in the lake, juveniles move into the shoreline areas where they may initially use a variety of shoreline habitats. They would remain here for only a short period, since the lake water temperatures rise rapidly through the summer. By midsummer, if they have not already moved offshore, juveniles would tend to be associated with deeper and colder water areas such as Cliff/Bluff or Low Rocky Shore areas. Adults likely move out of Windermere Lake to downstream areas such as Revelstoke and return to their natal stream only to spawn.*"

Due to the regional significance of spawning areas, all kokanee spawning habitat associated with Windermere Lake and its tributaries should be mapped and considered sensitive habitat. When completing the Fish Species Habitat Matrix for the Habitat Index, kokanee were rated as high for Habitat Selectivity based on the fact that they are very selective about their habitat needs. Results from a similar but more rigorous sampling along the foreshore of Okanagan Lake were generally used to define Habitat Specificity (Schleppe and Arsenault 2006). Creek Mouths were added as reproduction habitat, and cliff bluffs were excluded because they generally have little gravel in Windermere Lake (McPherson and Michel 2007). Rearing habitat was limited to spawning areas, in accordance with Okanagan Lake findings (Schleppe and Arsenault 2006).

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LAKE CHUB *(Couesius plumbeus)* and PEAMOUTH CHUB (*Mylocheilus caurinus*)

Ecology and Life History

Lake chub and peamouth chub both belong to the Cyprinidae (minnow) Family. In this Windermere Lake study, most of the minnows found were young-of-the-year (YOY) and were not identified to species. Since both of these cyprinid species have been documented in the lake, the life histories of each will be presented together.

The discussion relating to these species' life history and ecology has been summarized using the comprehensive details provided by McPhail (2007). Lake chub are a moderate sized minnow (adults typically less than 120 mm FL), while peamouth chub are considered a large minnow (adults reach lengths over 250 mm). In southern BC, the lake chub is often confused with the juvenile peamouth chub. Lake chub are found throughout North America; whereas peamouth chub are Columbia endemic, restricted to the Columbia River system and drainages that received their fauna from the Columbia River. Both species are known to hybridize with other cyprinids, possibly adding to the difficulty in distinguishing them to species. Both species can inhabit a range of waters from rivers to small streams and lakes. Details pertaining to lakes will be the focus of this summary.

Both species are spring spawners having similar spawning threshold water temperatures of around 9 °C. Lake chub spawn in both flowing and standing waters and do not appear to be selective about substrate type, whereas peamouth chub typically spawn in flowing waters over clean gravel substrates. Although some lacustrine populations of peamouth chub spawn in lakes over gravel beaches, most spawn in inlet or outlet streams within close proximity to the lake. For both species, the spawning process involves several males crowding against a single female and vibrating until a few eggs are released. This activity is repeated several times over the course of the spawning period. Newly hatched fry are about the same size for both species (6 mm and 7 mm for lake chub and peamouth chub respectively). By the end of the first growing season (early November) lake chub have an average fork length of about 30 mm, while peamouth are larger, reaching lengths of 35-60 mm.

YOY lake chub concentrate within 1 m of shore in water less than 1 m deep, where the substrates are fine (such as sands, organic litter and fine gravel), and prefer areas with vegetative cover. As summer progresses, YOY lake chub form schools moving further out from the shore (2-3 m). By October, they join the juvenile population. In the spring, juveniles (1+) and adults tend to stay close to the bottom throughout the littoral zone. By summer they move closer to shore, where by day, they remain in the shallows in schools seeking shelter from predators amongst vegetation (branches of fallen trees). During the night, individual adults often occur at the surface 50 m or more offshore. In the absence of submerged cover, adults form dense schools and move slowly through the littoral zone. Lake chub's diet consists primarily of benthic organisms (amphipods, chironomid larvae, oligochaetes and some plant material), although they are known to take terrestrial insects and the fry of smaller fish. Lake chub are unique in that they are known to forage over a wide range of temperatures (1.5 – 25 °C) and have populations in unusual (i.e. hot spring) environments.

Peamouth chub YOY also school in shallow littoral areas during the summer. They are known to often school with redside shiners and pikeminnow. The YOY exhibit a diel migration, schooling in the shallows during the day and dispersing into deeper water at night. As with lake chub, juvenile peamouth chub also move in schools in slightly deeper littoral areas. Adult peamouth chub are known to associate with the bottom at depths over 20m during the winter. Following spring spawning, in the summer peamouth chub exhibit a reverse daily migration, where they inhabit the depths offshore in the morning and move to the inshore surface waters in the evening. Young of the year peamouth chub consume a variety of prey organisms, which in lakes, mainly includes planktonic crustaceans and chironomid pupae. Prey size increases with increasing peamouth chub size. Lacustrine adults generally forage in both the littoral and limnetic zones, mostly on species in the water column.

Windermere Lake System

Only one reference to lake chub inhabiting Windermere Lake was found during the literature review. This was in a Lake Management Strategy completed by Urban Systems (2001), which obtained data from the Kootenay River Diversion Environmental Impact Resource Atlas (Thurber Consultants, year unknown). The Urban Systems (2001) report identified lake chub at both the north and south end wetlands of the Columbia River and on the central west side of the lake. Peamouth chub accounts were more prevalent, with references by Griffith (1994) following gill net sampling and in the MoE (2008) database, which outlined seine and gill net capture in 1958, 1977, 1993 and 1994.

During 2007 foreshore fish surveys (which included seine and snorkel surveys), cyprinids were identified in 8 out of 18 sites assessed. Other than three juveniles captured in the fall, all cyprinids were sampled during the summer and were YOY. Figure 1 shows cyprinid habitat foreshore utilization from snorkel survey results. The greatest numbers of cyprinids (105 fish) were associated with the alluvial fan at the Modified Creek Mouth at Holland Creek (Site 2). The relatively high number of YOY fish at this location suggests that the Holland Creek outlet may be a spawning site for these species. Snorkel survey results also indicate that the YOY cyprinids were dispersed in only small numbers along the other shore type habitats (including Creek Mouth, Vegetated and Modified Gravel Beach). The site details for these occurrences indicate that most cyprinids were associated with areas having finer substrates of silt and sand. Seine results complimented the snorkel findings by also catching small numbers of cyprinids (2-6) at the Vegetated Shore and Sand Beach Sites (Sites 8 and 11).

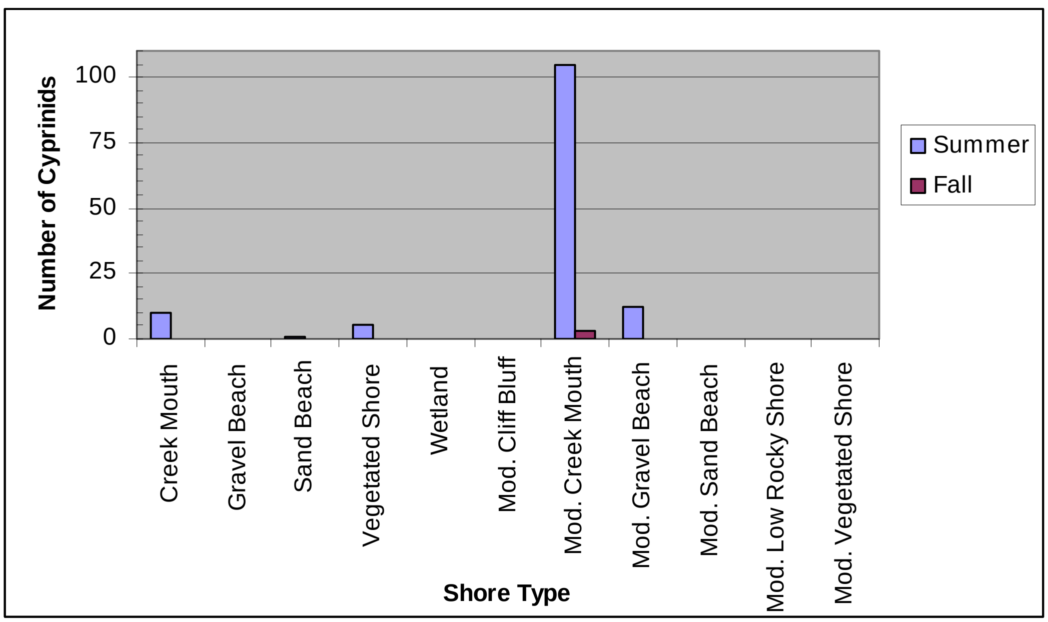

Figure 1. Numbers of YOY (summer) and juvenile (fall) cyprinids observed snorkel surveys at the different shore types along the Windermere Lake Foreshore.

Overall 136 cyprinids were observed during snorkel surveys, which made up 5.23% and 0.28% of the fish community sampled in the summer and fall, respectively. The abundance of cyprinids along the different shore types relative to other species (Figure 2), suggests that YOY cyprinids dominate in Sand Beach areas (100% -although the data is represented by only one fish), Modified Gravel Beach areas (92%) and Modified Creek Mouth areas (64%).

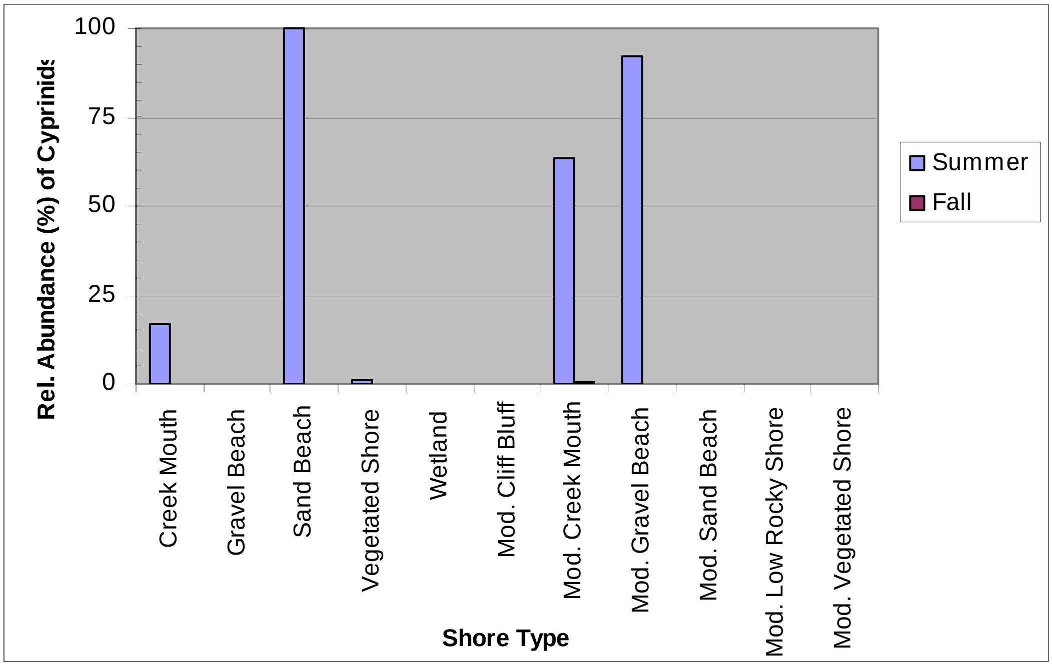

Figure 2. Relative abundance of cyprinids (summer are YOY and fall are juveniles) observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore.

The foreshore of Windermere Lake appears to be important to cyprinids, particularly during the YOY life-history stage. It would be valuable to conduct surveys during the spring to identify spawning locations at Windermere Lake and to conduct more rigorous assessments to understand juvenile and adult populations. Spring sampling was completed during a similar study conducted along the Kelowna waterfront in Okanagan Lake (Schleppe and Arsenault 2006). Okanagan Lake results revealed that peamouth chub spawned in a variety of shorelines between May and June; while juveniles were strongly associated with shallow, well vegetated sites, although they also used artificial cover (including docks). Adult peamouth chub in Okanagan Lake were generally more abundant in deeper sites with fine substrates and aquatic vegetation (Schleppe and Arsenault 2006). In general, peamouth chub at Okanagan Lake were not affected by in water structures or foreshore development to the same extent as more sensitive fish species (e.g., kokanee), and they occupied most habitat types without any limiting factors apparent (Schleppe and Arsenault 2006) . This was not as apparent at Windermere Lake, and it is not known whether it is a factor of less vigorous sampling or fewer peamouth chub experiencing constraints.

For the purposes of the developing the Habitat Matrix associated with this study, peamouth chub habitat specificity generally followed that which was provided in the Kelowna study, other than that Cliff/Bluff habitats were excluded from potential spawning areas. This is because at Windermere Lake fine substrates are associated with Cliff/Bluff habitats (McPherson and Michel 2007). Lake chub were not included in the Okanagan Lake study; however, habitat utilization was assumed to be similar to peamouth chub, other than that course substrate areas (Gravel Beach and Low Rocky Shores) were excluded from rearing habitat in accordance with the literature.

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LARGEMOUTH BASS *(Micropterus salmoides)*

Ecology and Life History

Largemouth bass belong to the Centrarchidae Family. It is an introduced species in British Columbia (BC), originating from eastern North America. In BC largemouth bass occur in lakes and ponds in the upper Columbia and Kootenay drainage systems and the lower Fraser Valley (McPhail 2007). The upper Columbia populations (Columbia and Windermere Lakes) appear to be the result of an 'unsanctioned introduction' made in the 1950s or 1960s (Griffith 1994a). This species' life history and ecology discussion is a summary of that provided by McPhail (2007), who obtained information from both native range accounts (Heidlinger 1975), and from local information provided in a study of introduced fishes in the Creston Valley Wildlife Management Area (Duck Lake) Forbes 1989.

Largemouth bass spawn in the spring when water temperatures rise above 15 °C. In Duck Lake, spawning occurs between May 20 and June 24 at water temperatures ranging from 20 °C to 23 °C. The male selects the spawning site, which tends to be at a water depth of 1 m or less (average depth of 73.5 cm at Duck Lake) and typically near wood cover (stumps or logs). The nests are saucer shaped depressions that are guarded by the males. The incubation period is dependant upon temperature and can range from about 13 days at 10 °C to 3 days at 28 °C. The fry are initially transparent and 3-4 mm in length. The yolk is absorbed after about 10 days and the pale green fry rise out of the nest in a dense swarm. During the day, schools of fry are loosely aggregated, whereas at night they become inactive and form dense groupings associated with submerged cover. After about a month (or a size of 25-30 mm), the male no longer guards the fry and the fry disperse into the shallow, calm, often vegetated lake margins.

Largemouth bass are known for their voracious appetites and rapid growth. Initially young fish forage on zooplankton and as they grow add insects to their diet. Once they reach about 40-80 mm, which occurs by the end of their first growing season, they shift to eating mainly fish. Although fish are the primary food source of adult largemouth bass, they are omnivores eating just about anything including: frogs, baby ducks, macro-invertebrates, their own young and crayfish (J. Bisset pers. comm.). Peak feeding period is in the morning and evening. Growth is steady until they reach sexual maturity, occurring at 3 or 4 years in males and 4 or 5 years in females. Males are known to grow slower with large fish typically being females (J. Bisset pers. comm.).

In BC, most of the lakes containing largemouth bass are shallow, warm-water lakes. Adults are associated with soft substrates in areas with dense beds of emergent and submerged vegetation. They remain in the shallow water during rising summer temperatures, but become nocturnal at temperatures above 27 °C. They move into deeper waters during the fall when temperatures decrease, where they continue to feed and remain moderately active through the winter. In the spring, they return to the shallows and resume feeding before spawning. Juvenile utilize similar habitats as adults; although in the summer they form small schools and remain closer to the shore than the solitary adults. Adults are typically found around structures both natural (e.g., floating lily pads and large woody debris) and manmade (particularly docks) (J. Bisset pers. comm.). Largemouth bass are known to 'wreak havoc' with native fishes and their population growth once introduced to a system (McPhail 2007).

Windermere Lake System

Windermere Lake with its warm water temperatures, soft substrates and extent of aquatic vegetation provides good habitat for largemouth bass. Little historical information was available on largemouth bass in the lake, other than accounts following gill net sampling in September 1993 (Griffith 1994b). Griffith found that this species was only a small proportion of the overall population (1.3%) and small proportion of the sport fish community (2.6%).

During 2007 summer and fall surveys, a total of 206 largemouth bass were observed considering all survey methods. Most of these accounts (192/206), however, were during snorkel surveys. During the snorkel surveys, 181 largemouth bass were observed during the summer, while the remaining 11 were seen during the fall (Figure 1). The seasonal differences in the observed numbers were most likely due to water temperatures in the littoral areas, which ranged from 19 to 25 °C and 10 to 14.5 °C respectively. The largemouth bass likely moved into the deeper waters during September to take advantage of more stable temperatures (L. Porto pers. comm.). Largemouth bass were observed in 10 out of 18 sites sampled representing a variety of shore types (6 out of 11 Shore Types). Visibility was low during snorkel surveys at a few of these sites with no fish observed at all, so there may have been largemouth bass in practically every site sampled (L. Porto pers. comm.). During the summer snorkel survey, the greatest numbers were found along the Vegetated Shore Type habitat (119 fish) followed by the Modified Creek Mouth (28) and Creek Mouth (26) areas.

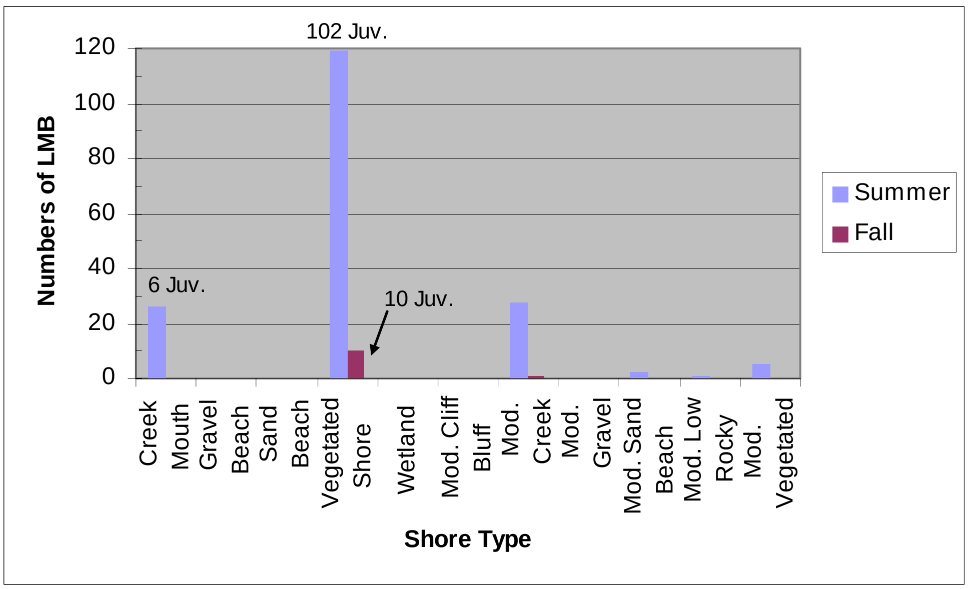

Figure 1. Numbers of largemouth bass observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore. All observances were adults unless noted as juveniles (juv.).

Most of the largemouth bass in the Vegetated Shore and Creek Mouth areas in the summer were juveniles (with 85% and 77% juveniles, respectively in these two shore types). The rest of the summer snorkel observances were adults. In the fall, most of the largemouth bass that were observed were associated with Vegetated Sites. In these Vegetated Sites, all of the largemouth bass were juveniles. Overall, adults were often found utilizing modified structures such as boats, docks and retaining walls, where they were observed guarding a territory (L. Porto pers. comm.). Most juveniles were in warm, vegetated bays; a few adults were here as well, most likely feeding on the abundant small fish (L. Porto pers. comm.). They also appeared to be associated with redside shiners around the docks at Site 2 (B. MacDonald pers. comm.)

Largemouth bass observed during snorkel surveys made up 7.1% and 1.3% of the respective summer and fall fish community. Figure 2 depicts this species' abundance at the various Shore Types. This figure reveals that largemouth bass were the most prevalent species in Creek Mouths during the summer (43.3%). Also during the summer, largemouth bass were second only to redside shiners in the Vegetated Shore and Modified Creek Mouth habitats, with respective abundances of 24.3 % and 16.9 %. It would be interesting to determine whether there was a connection between these two species. In a similar study conducted along the Okanagan Lake foreshore (Schleppe and Arsenault 2006) the stomach contents of fish were also investigated. Largemouth bass were not considered in the Okanagan Lake study, but diet studies to determine what largemouth bass are feeding on in Windermere Lake would be valuable. Largemouth bass quite often get blamed for eating a lot of juvenile trout, however it may be that they consume more cyprinids since they are more abundant and easier to catch (J. Bisset pers. comm.). Due to their prevalence, largemouth bass are likely impacting native fish population at Windermere Lake.

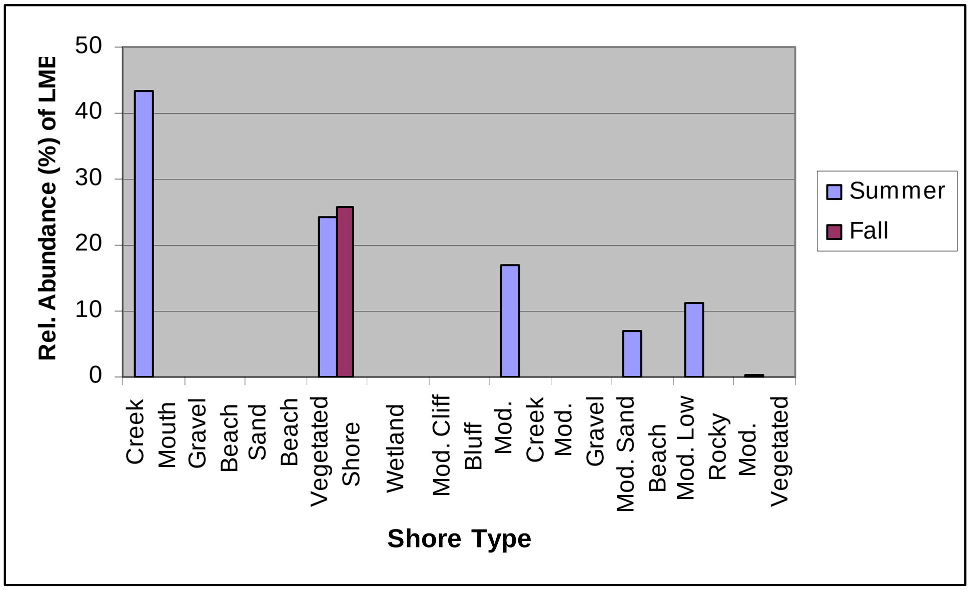

Figure 2. Relative abundance of largemouth bass observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore.

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LONGNOSE DACE *(Rhinichthys cataractae)*

Ecology and Life History

The longnose dace is a member of the Cyprinid family (minnows and carps). The longnose dace is endemic to North America (McPhail 2007). It has the widest geographic distribution of all indigenous minnows, ranging from the Atlantic to the Pacific coast and from the Arctic to Northern Mexico (McPhail 2007). McPhail (2007) was the key source of information used to describe the ecology and life history of this species and unless otherwise noted is the reference for the text. McPhail provides that while some information is available on fluvial populations of longnose dace in the British Columbia (BC), little has been published on lacustrine populations in BC. He states however, that data from lakes in eastern Canada suggest that the life history of lacustrine populations is similar to fluvial populations.

Longnose dace begin spawning in the spring (May to June) when temperatures rise above 10 °C. They spawn on depressions made in riffle area over course gravels, following a complex courtship. Spawning in lake habitats occurs in cobble boulder substrates (Schleppe and Arsenault 2006). At some sites within the Columbia system, spawning may occur in two pulses. Incubation time for the eggs is dependant on temperature, but usually occurs within a week. Young-of-the-year (YOY) reach 20-35 mm FL by the end of their first growing season and reach sexual maturity at the end of their second summer. YOY inhabit quiet waters, typically close to the shore where there is cover (Brazo et al 1978). YOY forage during the day, in mid-water and substrate areas. They mainly consume chironomid larvae, algae, diatoms and sometimes plankton.

Juveniles and adults mainly forage at night (Culp 1989). The adult's diet consists primarily of larvae of aquatic insects, snails, oligochaetes (worms) and pea clams. Longnose dace are believed to use their barbells to locate food. Riverine juveniles are bottom dwellers seeking both slow moving and moderate current areas. Longnose dace adults are adapted to fast water and in lakes they are commonly found in area areas with sufficient fetch to create wave swept cobble beaches.

Windermere Lake System

No longnose dace were observed during any of the 2007 surveys. This species was referenced as inhabiting the north end of Windermere Lake at the outlet in the Lake Management Strategy completed by Urban Systems (2001), who obtained their data from the Kootenay River Diversion Environmental Impact Resource Atlas (Thurber Consultants, year unknown). No accounts were found through a review of Ministry of Environment Fish Inventory Summary System database.

Spring, summer and fall sampling was completed during a similar study conducted along the Kelowna waterfront in Okanagan Lake, with respective relative abundances determined to be 2.2%, 2.93% and 0.52% (Schleppe and Arsenault 2006). The Okanagan Lake surveys for this species were obtained mostly from beach seine techniques, and revealed that young-of-the-year and juvenile fish were associated with similar habitats to adults. Schleppe and Arsenault (2006) also found that both adults and juveniles were associated with Creek Mouths or with wave-washed cobble/boulder substrate areas. Longnose dace displayed some red colouration during spawning but were not as brilliantly coloured as redside shiners. Temperatures during spring sampling were 14 to 17 °C which were within the typical spawning ranges for the species. Typical substrates within the spawning area were 30% gravel with ample cobble or boulders. Generally spawners were sampled in approximately 1 m of water on wave-washed shorelines in areas with larger littoral shelves (10-30 m). Because spawning habitats of this species was limiting at Okanagan Lake and because they comprised a small percentage of the nearshore community, they were considered important to the foreshore and classified as moderate in terms of habitat selectivity in the Habitat Matrix (Schleppe and Arsenault 2006).

At Windermere Lake, because of their absence, longnose dace are considered important. For this assessment, it was uncertain whether sampling rigour/technique or habitat conditions resulted in longnose dace absence during surveys. For the Habitat Index associated with this study, habitat specificity as determined for Okanagan Lake (Schleppe and Arsenault 2006) was utilized, other than the fact that Cliff/Bluff habitat was removed as potential habitat at all lifestages, since at Windermere Lake, course substrates are generally not associated with these areas (McPherson and Michel 2007).

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LONGNOSE SUCKER (*Catastomus catostomus*) and LARGESCALE SUCKER (*Catostomus macrocheilus*)

Ecology and Life History

The longnose sucker and the largescale sucker both belong to the Family Catostomidae, which includes all suckers. The longnose sucker has a wider distribution and is found in both North America and Asia (McPhail 2007). In North America its range extends south from Colorado and Maryland north to the Arctic, while in Asia it is limited to a few drainages in eastern Siberia (McPhail 2007). The largescale sucker however, is endemic to western North America, ranging from the Nass and Peace rivers in the north to the Columbia River in the south (McPhail 2007). Both of these species are common in lakes and rivers of British Columbia (McPhail 2007). Although these two species are distinct, they will be discussed together because both species have similar life histories, occupy similar habitats and their ranges overlap. McPhail (2007) has provided the most current and comprehensive summary on these species, and as such has been the reference for this description unless otherwise noted.

Longnose suckers are known to be the first suckers to spawn, migrating to their spawning grounds shortly after ice-out when water temperatures reach 5 ^{o}C. Longnose suckers usually spawn in streams over gravel substrates (0.5-10.0 cm in diam) and moderate currents (0.30-0.45 m/s), although they are also known to spawn in shallow (often <20 cm) water along lakeshores. Egg development rate is temperature dependant and will hatch in about 11 days at 10°C. The fry remain in the gravel for 1 to 2 weeks after hatching. In BC, the largest that adult longnose suckers typically grow is 500 mm FL. The mouth of the young longnose suckers is initially in a terminal position, and while it is in this forward facing position, in lakes the fry typically eat plankton (Daphnia, Cyclops and Bosmina). Once the mouth changes to a ventral position, the diet shifts to benthic prey. This includes chironomid larvae and ostracods for fry and larger insects such as chironomid pupae, trichopteran and plecopteran larvae for juveniles and adults. In lakes newly emerged longnose sucker fry stay close to the shore near cover (vegetative or wood), and are associated with soft substrates. As they grow, the fry move through the shallow littoral area in loose schools, over the soft substrates. Juveniles remain in shallow areas close to the shore. Lake dwelling adults are known to be habitat generalists and solitary. Adults forage inshore during the night but usually remain below the thermocline during the day.

Largescale suckers are known to be abundant throughout the Columbia drainage. Lake data suggests that they prefer warmer water systems over colder systems. They spawn slightly later than longnose suckers, usually when stream temperatures reach about 8 °C. Interior populations are known to start spawning in late May and peak in June, usually at temperatures approaching 15 °C. The largescale sucker also is known to spawn in flowing water and lakes. In rivers they spawn in riffles adjacent to areas of slower water, while in lakes they too select shallow water (<20 cm) over course material (fine gravel to cobbles). Development of the eggs is temperature dependant and takes 20 days at 10 °C. Typically adults will not grow larger than 600 mm. Development of the mouth is the same as that described for the longnose sucker and food preferences are similar. Periphyton however, is reported as a dominant food during the juvenile and sub-adult periods. Adults are also described as being versatile and exploitive not only foraging on the bottom, but also on the surface of plankton, and easting seasonally abundant foods such as fish eggs and larvae in the spring and filamentous algae in the winter (Duable 1986).

Largescale suckers are known to undergo seasonal and diel migrations in lakes. Fry in Nicola Lake have been reported to be abundant in shallow areas over rock and gravels in July and shift to open sand areas in August. They were also reported to avoid heavily vegetated areas. The fry also made diurnal movements of being onshore at dawn to offshore at dusk. A vertical distribution shift associated with the development of the mouth was also described. Juvenile largescale suckers forage in similar but deeper areas than fry in lakes. Little is known about adult seasonal and diurnal shifts in British Columbia lakes. In the Columbia River, adults are known to move inshore at night and offshore during the day (Dauble 1986). In the summer they are found both above and below the thermocline, and have been documented foraging over the mud-silt lake bottom at depths over 100 m. Adults are relatively sedentary.

Windermere Lake System

Largescale suckers were documented in Windermere Lake in 1975 (MoE 2008) and both largescale and longnose suckers were reported during seine surveys in 1993 (Griffith 1994). During the 2007 snorkel and seine surveys a total of 15 suckers were observed. Nine of these were identified to be largescale sucker species. For the purposes of this assessment, because numbers were so low, findings for all suckers will be grouped together as sucker species, with the understanding that many were largescale suckers.

Although low in numbers, suckers were found in 9 out of the 18 sites sampled representing a variety of shore types. In order to review results for YOY and juveniles, both seine and snorkel survey results will be initially considered. Only two YOY were observed (unknown spp.) and these were along the Modified Cliff Bluff at Site 3. This suggests that shoreline spawning may have occurred in the vicinity or that they may have colonized this area following their stream hatch. Two juveniles each were observed during the fall at the Modified Sandy Beach of Site 4 (unknown spp.) and Vegetated Shore habitat of Site 5 (largescale sucker), where they were associated with vegetative cover. The remaining 10 suckers were adults, with 7 being identified as the largescale species.

In all, 7 suckers were observed during summer snorkel surveys and 4 were observed during fall surveys (Figure 1). Suckers were found in both natural and modified shore types around the lake. Most of the suckers (3 each for summer and fall) were found along the Vegetated Shores at Site 5 and 5a Hidden Bay and Windermere Island. Unfortunately, 5 of the summer occurrences plus an additional fall observance (seen from the boat) were dead. All of these were adults other than one YOY. The cause of death is unknown. The mortalities could have been caused by anglers, since they tend to kill suckers and throw them away when they catch them (J. Bisset pers. comm.). Osprey or other avian predators, may also been dropped the fish (J. Bisset pers. comm.). In early seasons (spring and summer), high mortalities of suckers, bullheads, and other cyprinids are not uncommon; they often occur as a result of a combination of spawning stress and rapid temperature changes causing shock as daytime heating in early spring can really increase water temperatures (J. Bisset pers. comm.). Dead fish amongst other species were not reported.

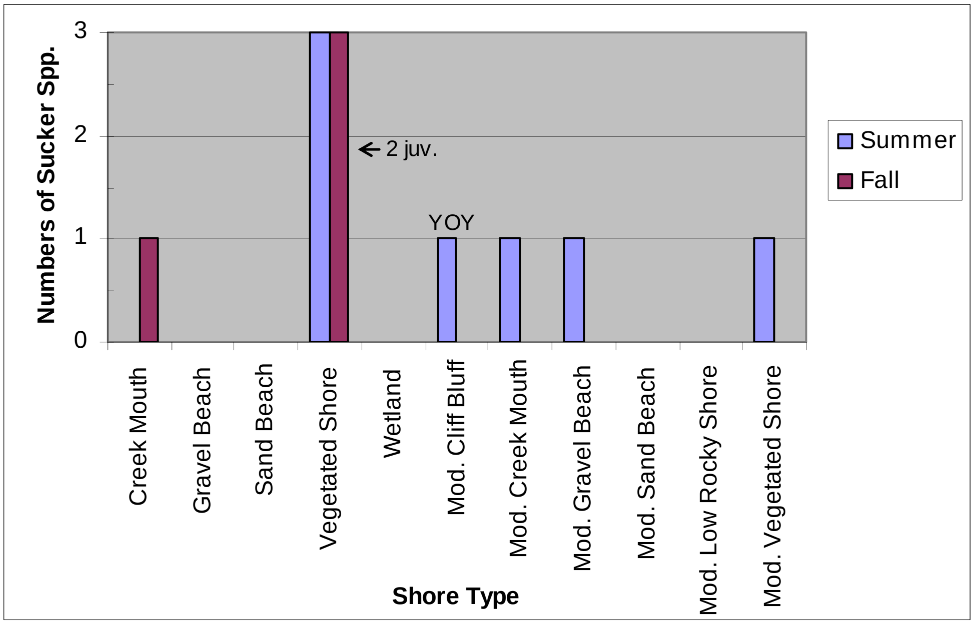

Figure 1. Numbers of sucker spp observed during snorkel surveys at the different shore types along the Windermere Lake foreshore (unless noted all observances were adults).

Suckers accounted for only a small proportion of the total fish community (0.3% in the summer and 0.4% in the fall) during foreshore snorkel surveys. Figure 2 displays the abundance of suckers at each of the shore types, relative to other species found during snorkel surveys. The one sucker found in the Creek Mouth during the fall, represented 100% of the fish community. The suckers observed at the other shore types represented less than 8% of the fish community each.

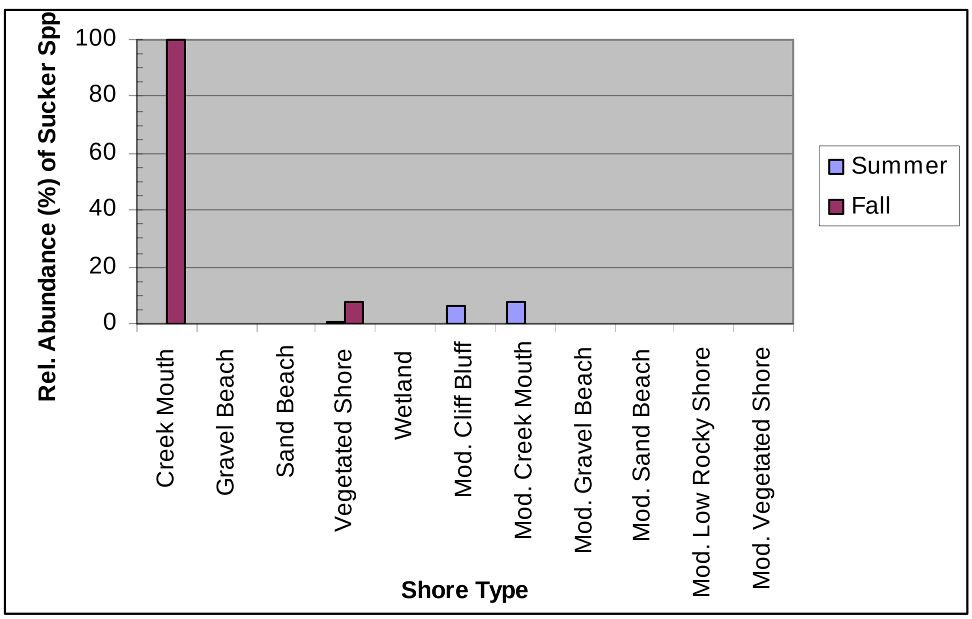

Figure 2. Relative abundance of sucker spp. observed during snorkel surveys at the different shore types along the Windermere Lake foreshore.

During the similar study along the Okanagan Lake foreshore, more rigorous sampling (seine and gill net) provided much additional insight to the life history of these species (Schleppe and Arsenault 2006). Key findings from the Okanagan Lake study are summarized as follows:

- the largescale sucker was more common than the longnose sucker in the shallow nearshore areas, most likely because the longnose sucker occupies deepwater habitats;
- spawning for largescale suckers was reported to have likely began in late March and continued through to early June ceasing when temperatures reached 15 °C;
- out migration of spawned longnose suckers was apparent in mid to late June from streams;
- YOY suckers were believed to reside within streams, which are the most common spawning areas for both species;
- YOY presence along the foreshore however, indicated that some shoreline spawning likely occurred;
- juveniles were associated with shallow vegetated areas; and
- some species appeared to have morphological characteristics of both species, which may have been a result of hybridization.

At Windermere Lake, both largescale and longnose suckers are important native species. Longnose suckers were not identified to species during the 2007 survey and largescale suckers were found only in very low numbers with high mortality over a range of habitats. The specific habitat requirements for the Fish Habitat Matrix were outlined generally as provided by Schleppe and Arsenault (2006) for the Okanagan Lake study, following their more rigorous assessments. Cliff/bluff habitat was added as a potential shore type for rearing/nursery for both species because of the YOY findings during this assessment. Cliff/bluff and Low Rocky Shores were also added for general living and staging for the longnose sucker based on the literature, which indicates that they are generalists and utlilize deep water areas. Further sampling would be required to confirm habitat utilization and overall contribution of these species to the fish populations at Windermere Lake.

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MOUNTAIN WHITEFISH *(Prosopium williamsoni)*

Ecology and Life History

The mountain whitefish is a member of the Salmonidae family. The fish is an exclusively North American Species and in British Columbia (BC) is primarily only found in the interior regions (McPhail 2007). This species is typically associated with fast water in small, turbid pools, or cold, deep lakes (MoEa 2008). McPhail (2007) has provided a current and comprehensive summary on this species and has used Northcote and Ennis (1989) as a key reference. This life history has been developed from McPhail (2007) and should be referenced as such, unless otherwise noted.

Mountain whitefish are known to have three different life history types in BC. They can inhabit lakes (lacustrine form), rivers (riverine form) or move between lakes and rivers (adfluvial form). This summary will focus on the lacustrine and adfluvial forms. Mountain whitefish typically spawn in flowing waters over gravel. They are only known to spawn in a few lakes in BC (e.g., Kootenay Lake, Chehalis Lake and likely Gantahaz Lake). Spawning in flowing water usually occurs at the lower end of riffles or near the upper end of pools. In lakes, spawning typically occurs in upwelling areas. No nest is prepared. Mountain whitefish spawn in the fall or early winter, when water temperatures drop below 10 °C. In BC spawning usually occurs in October or November, but in the Columbia system is known to occur as late a January or February. Eggs incubate over the winter and fry emerge in spring or early summer. Upon emergence, fry drift downstream and move into shallow, slow moving areas. In lakes the fry stay close to the shore in shallow water (< 50 cm) over fine gravel or sand substrates. Fry grow rapidly over the first four years. In lakes, they feed on plankton; while in streams they feed on the smallest life-history stages (i.e. instars) of aquatic insects.

Juveniles also remain in shallow (< 2 m) inshore habitats throughout the spring and summer. They typically remain over sand and coarse gravel substrates. In lakes, adult mountain whitefish usually occur at depths less than 20 m. Adult habitats seasonally change with the changes in water temperatures. In Koocanusa Reservoir, adults remain in the shallows during the spring and move to deeper water as summer progresses. They then return to the littoral zone again in the fall and once they have spawned, move back to the deep water to over winter (Chisholm et al. 1989). In lakes, adults and sub-adults are primarily bottom feeders consuming plankton, snails, surface insects, and sometimes young fish.

Windermere Lake System

Mountain whitefish are known to inhabit Windermere Lake. Winter creel surveys between 1995 and 1997 documented that mountain whitefish utilize the lake during the winter (Arndt 2001). Gill net sampling results from the fall of 1993 indicated that mountain whitefish made up 5% of the fish community of Windermere Lake (Griffith 1994). MoEb (2007) also reported this species during seine surveys in 1975.

During 2007 foreshore sampling, considering all sampling techniques, there were 39 mountain whitefish observations in Windermere Lake. Boat, seine and snorkel observations will be initially reviewed, in order to provide possible insight to general habitat utilization by life-history stage since snorkel surveys alone provided limited data. During the summer, 20 YOY were observed using the reed beds along the Vegetated Shores of Site 5a, 10 juveniles and 1 sub-adult were observed over the sand in the Wetlands at the Columbia River outlet (Site 9) and 1 adult was observed along the Vegetated Shore of Site 11. During fall seines, 20 additional juveniles were captured at Site 11, as well as 7 juveniles along the Gravel Beach Shore of Site 15. Although mountain whitefish were observed in only 4 out of 18 sample sites, it was possible that there were more fish present. At Site 9 it was noted that high water and cover likely allowed fish to avoid snorkel observation.

Snorkel survey results for mountain whitefish are depicted in Figure 1. The summer snorkel survey results indicate that the 21 fish (mostly YOY) contributed to 4.3% of the fish community in the Vegetated Shore area and the 1 sub-adult in the Columbia River Wetland contributed to 100% of the Wetland fish community. There were no whitefish observed during fall snorkel surveys. Considering all snorkel survey results and fish species observed, mountain whitefish represented 0.9% of the summer community for Windermere Lake and 0% of the fall community.

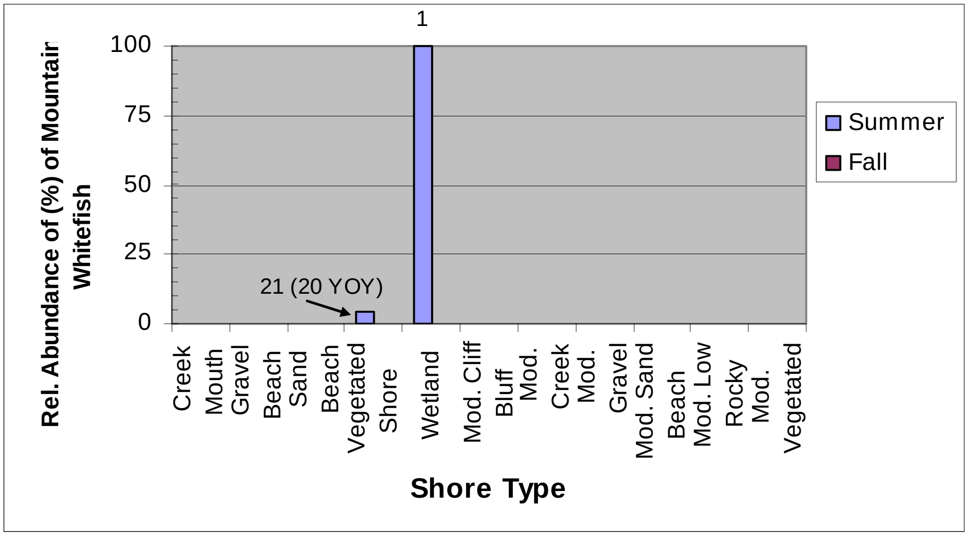

Figure 1. Relative abundance and total numbers (as side notes) of mountain whitefish (adults unless otherwise noted) observed during snorkel surveys at the different shore types along the Windermere Lake foreshore.

From the findings, it is uncertain where Windermere Lake mountain whitefish spawn. The presence of YOY indicates that they may spawn in the lake by Windermere Island, or in the nearest stream which is Windermere Creek. The spread of juveniles around the lake suggests that there may be more than one spawning location. They may also colonize through drift/displacement from the upper Columbia River (J. Bisset pers. comm.). The YOY and juveniles generally appeared to be utilizing vegetative cover. Adult mountain whitefish were likely associated with cooler habitats (i.e. Columbia River) during the summer sample. Adults may have been absent during the fall, because they had not yet returned to the foreshore from their summer habitat. According to the literature, during the spring following the spawn, mountain whitefish adults likely remain in the shallows utilizing a variety of habitats to feed until temperatures become too high. It would be valuable to obtain further information on the habitat utilization of this species in Windermere Lake, particularly during the winter spawn and spring periods.

In a similar but more rigorous study of the foreshore of Okanagan Lake, mountain whitefish were found to spawn along the waterfront where the substrates were composed of some boulders, a large percentage of cobbles (60%) as well as gravel (25%) (Schleppe and Arsenault 2006). It is thus likely that they spawn in more lakes than the limited number indicated in the literature, and that they may potentially spawn in Windermere Lake. In Okanagan Lake, adult mountain whitefish were typically associated with deeper, cooler water habitats, such as Cliff/Bluff, Low Rocky Shoreline and Gravel Beach shoreline types. For completing Windermere Lake's Habitat Index, rearing/nursery habitats were adopted from the Okanagan study. Creek Mouth habitats were added as a likely reproductive area; however Cliff/Bluff habitats were removed, since they generally do not contain course substrates at Windermere Lake. Wetlands were added to the general living habitat category, based on the literature and observations at Windermere Lake.

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PERSONAL COMMUNICATIONS

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NORTHERN PIKEMINNOW *(Ptychocheilus oregonensis)*

Ecology and Life History

Northern pikeminnows, belongs to the Cyprinidae Family and was previously known as northern squawfish or Columbia River dace. It is a Columbia endemic species, restricted to the Columbia River system and adjacent drainages that received their fish fauna from the Columbia River (McPhail 2007). It is found throughout the interior of British Columbia primarily in lakes and large slow-moving rivers (McPhail 2007). This species is the largest native minnow in British Columbia; adults often exceed 300mm FL. McPhail (2007) has provided the most current and comprehensive summary on this species, and as such has been the reference for this description unless otherwise noted.

Northern pikeminnow spawn in the spring once water temperatures reach a threshold of 12 °C. Spawning typically occurs in inlet streams, within the first few hundred metres of the lake, on either the first or second riffle above the lake. Spawning conditions require water velocities of <0.4 m/s and a sand-free substrate of gravel and cobbles (Beamesderfer 1992). Spawning is also known to occur in lakes. The eggs hatch within 6 days at 18°C. Young of year (YOY) northern pikeminnow consume a variety of both benthic and surface prey including: cladocerans, copepods, ostracods and chironomid larvae and pupae. Prey size gets larger as the pikeminnow grows. Once the pikeminnows reaches a length of 100-125 mm, they begin to consume fish (Olney 1975) and above 300 mm they are mainly piscivorous, although they will eat other suitable sized creatures (including crayfish, frogs, toads and small rodents). Adults forage during the day (Chisholm 1975).

In the summer YOY and juveniles prefer lake margin habitat in shallow waters (<0.30 m) close to cover (usually weeds) and are typically in mixed schools with other cyprinids (Miura 1962). By fall, juveniles move offshore to deeper water. Adults are often found cruising through the littoral zone about 1 m above the lake bottom on the offshore side of weed beds. During the winter, northern pikeminnow move to deeper water, where they are not as oriented to the bottom.

McPhail (2007) wrote that '*in British Columbia the northern pikeminnow is not a conservation concern; although it is a persecuted species'*. It is typically an unpopular species with anglers and fisheries professionals because it is a '*superbly adapted piscivore'*. The highly predatory nature of these fish has resulted in numerous attempts to limit their numbers, through programs such as the Northern Pikeminnow Management Program on the lower Columbia River (Beamesderfer et al 1996). McPhail maintains that this predator has a role in the natural balance of northwestern aquatic ecosystems, and should not be persecuted.

Windermere Lake System

There are historical accounts of northern pikeminnow in Windermere Lake, with Ministry of Environment's Fish Inventory Summary System (FISS) identifying this species presence in 1958 and providing gill net results from 1975, 1976 and 1993 (MoE 2007). Gill netting during the fall of 1993, indicated large numbers (127) of northern pikeminnow, contributing to 29% of the fish community (Griffith 1994).

Overall northern pikeminnow were not very prevalent in Windermere Lake during the 2007 summer and fall sampling. Considering all sampling techniques, 129 were reported over a total of three Sites. Northern pikeminnow were only sampled during the fall. The results of all sampling techniques will be initially discussed since only five fish were observed during snorkel surveys. Four juveniles were captured during seine surveys along the Modified Sandy Beach of Site 4. This site was under the cover of a large overhanging willow. The Modified Creek Mouth (Holland Creek) of Site 2 had the most pikeminnow. Here, 20 adults (30-50 cm) and 100+ juveniles (10-30 cm) were observed from the dock.

During snorkel surveys, only one Site (Site 5) had northern pikeminnow occurrence. Five adults were observed during the fall along the Vegetated Shores of Site 5. This observance calculates to a relative abundance of 12.8% for northern pikeminnow in the Vegetated Shore habitats and to 0.5% of the overall lake community observed during the fall. Abundance was 0% in the summer.

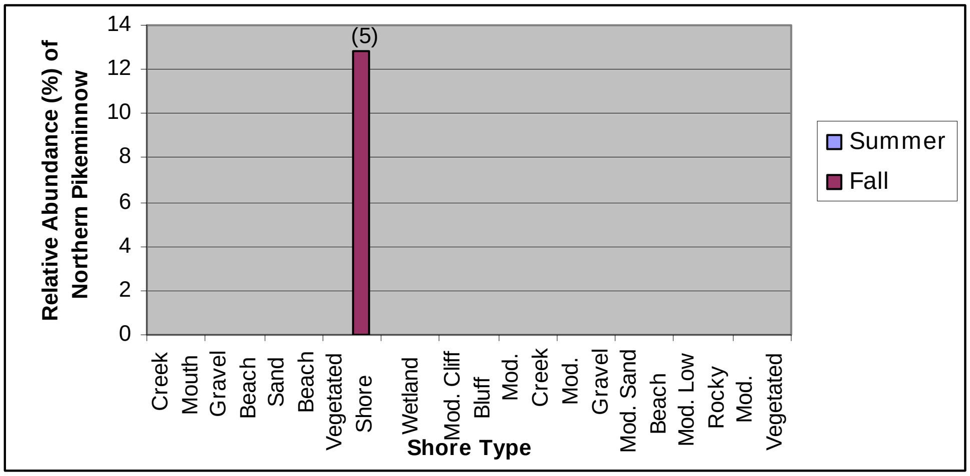

Figure 1. Relative abundance and total numbers (in parentheses) of northern pikeminnow (adults) observed during snorkel surveys at the different shore types along the Windermere Lake foreshore.

During a similar but more intensive sampling study (using beach seines and gill nets) along the foreshore of Okanagan Lake, adult pikeminnow were found to be more abundant in deeper sites than in shallow sites and were sampled more often along rockier shorelines (Schleppe and Arsenault 2006). Juveniles were often associated with adults, but tended to be closer to the shoreline. Similar to that found at Windermere Lake, juveniles in Okanagan Lake were associated with natural structures (e.g., aquatic vegetation) and artificial structure (e.g., docks). Spawning was also reviewed during the Okanagan study (Schleppe and Arsenault 2006). Based on presence of ripe males, it was surmised that all shorelines with sufficient cobbles and gravels were likely used for spawning. The spawning season likely occurred between May and mid July with a peak in June at Okanagan Lake. In general, in Okanagan Lake, northern pikeminnow were not found to be affected by in-water structures or development to the same extent as more sensitive fish species (e.g., kokanee). In preparing the Fish Habitat Matrix for the Habitat Index, habitat specificity for northern pikeminnow at Windermere Lake was generally assumed to be similar to that of Okanagan Lake. The only difference was that Cliff/Bluff shorelines were excluded for reproductive habitat since they lack course substrates at Windermere Lake (McPherson and Michel 2007).

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PUMPKINSEED *(Lepomis gibbosus)*

Ecology and Life History

The pumpkinseed is a member of the Centrarchidae Family (sunfishes). It is native to eastern North America and has been introduced in western North America and other parts of the world. This small, colourful fish is usually associated with clear, quiet water (ponds small lakes, low gradient streams and sloughs) (McPhail 2007). McPhail (2007) has provided the most current and comprehensive summary on this species, and as such has been the primary source for this description. McPhail's local life-history accounts were obtained from a study of introduced fishes in the Creston Valley Wildlife Management Area (CVWMA) (Forbes 1989).

Pumpkinseeds initiate spawning activity in the spring when water temperatures reach 15 °C and continue spawning until water temperatures reach about 25 °C. In the CVWMA, this corresponds with a period from mid-May until early August (Forbes 1989). Males prepare a 'spawning-pit' in the sand or gravel substrate, near or in aquatic vegetation, in shallow water (< 1m). The male diligently defends the nest (Colgan and Brown 1988) and once hatched, guards the fry for about a week. Interestingly, males are known to catch the fry in their mouth and return them to the nest if they stray during this period. Initially the young-of-the year move to open water where they feed on plankton. They move back to the littoral areas where they typically remain throughout their juvenile and adults life-history stages.

The diet of pumkinseeds is variable, depending on several factors such as age, prey availability, habitat, season and presence of other fish. Pumkinseed adults usually prefer warm littoral areas with dense vegetation, where there is an abundance of snails or aquatic insects for feeding upon. An open water (limnetic) form that feeds on plankton is also known to occur in some circumstances in their native range (Robinson et al 1993) and may occur in British Columbia (McPhail 2007). In BC pumkinseeds can grow as large as 15 cm TL and live to be up to 5 years of age.

This species is considered a pest, since it competes with native species. It is continually spreading to new areas throughout British Columbia.

Windermere Lake System

The only historical reference to pumpkinseed fish in Windermere Lake was found in Griffith (1994). During floating and sinking gill net surveys data suggests that this species made up 0% and 2% of the fish population captured respectively (Griffith 1994). During 2007 surveys, a total of 54 pumpkinseed fish were observed, when all survey techniques are considered. All fish, except one (at the Modified Sand Beach of Site 4) were observed during the summer. Seven of these fish were observed using techniques other than snorkel survey (seine and minnow trap). These other occurrences were juveniles in Modified Sand Beach areas (Site 4), Vegetated Shores (Site 5A and Wetland habitats (Site 7). Snorkel observances will be discussed separately, since they are the basis for relative abundance comparison around the lake.

Snorkel survey results reveal that pumpkinseed fish made up 1.7% (summer) and 0% (fall) of the total fish community sampled in Windermere Lake. Figure 1 reveals the shore types where these species were observed in terms of total numbers and relative abundance. Most (38) were juveniles found along the Vegetated Shore at Windermere Cemetery/Hidden Bay (Site 5). The rest were adults dispersed in small numbers at Windermere Cemetery/Hidden Bay, Windermere Island (Site 5a, Vegetated Shore) and at Holland Creek (Site 2, Modified Creek Mouth).

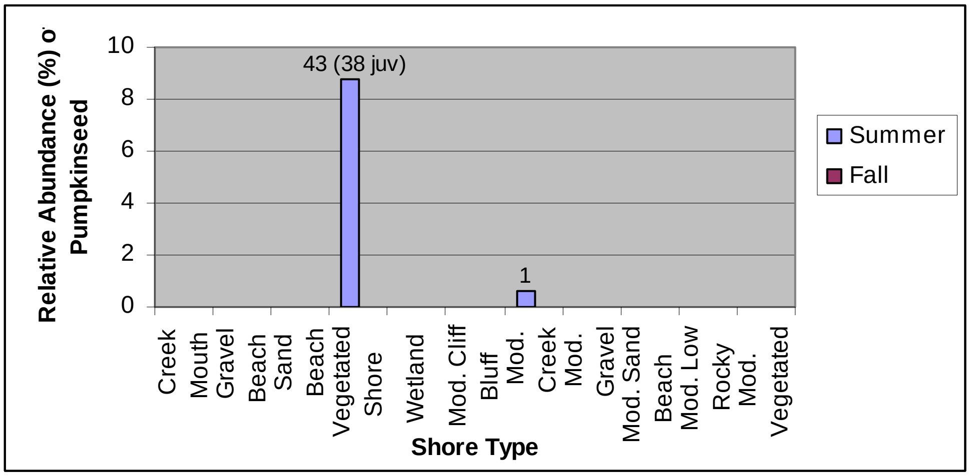

Figure 1. Relative abundance and total numbers (in parentheses) of pumpkinseed fish (adults, unless otherwise identified) observed during snorkel surveys at the different shore types along the Windermere Lake foreshore.

From this data, it is difficult to identify the extent of impact that the pumpkinseed fish may be having on native populations. In the habitats where they were found, their overall abundance was higher than that of many other native fish. During the summer in Vegetated Shores, for example, they were the third most abundant species following redside shiners and largemouth bass; other fish present were mountain whitefish, largescale suckers and cyprinids. Given their higher numbers, largemouth bass are likely more of a concern for native fish populations in Windermere Lake.

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RAINBOW TROUT (*Oncorhynchus mykiss*)

Ecology and Life History

The rainbow trout is a member of the Salmonidae family. They are native to North America and northeastern Siberia but have been introduced to cool waters around the world (McPhail 2007). In British Columbia, there are two forms of rainbow trout, the freshwater resident and the anadromous (steelhead) population. The focus of this report will be the freshwater resident form, which in itself is known to have an extremely variable life history with populations that differ in size, colour, habitats, migratory behavior, run timing and reproductive characteristics (McPhail 2007). This synopsis will focus on populations utilizing lake habitats in at least one of their lifestages. This will include the adfluvial form that moves from lakes to spawn in tributaries and the lacustrine form that remains in their natal lake throughout their life. McPhail (2007) has provided the most current and comprehensive summary on this species, and as such has been the main reference for this description unless otherwise noted. McPhail (2007) provides that his information on this species has largely been obtained from the following key sources: Busby et al 1996, Lynott et al 1995, Smith 1991, Wydoski and Whitney 2003; however several other individual sources are referenced throughout.

Rainbow trout spawn in the spring when temperatures reach 8 – 15 °C, which corresponds to late April to July depending on latitude and altitude. Although most rainbow spawn in flowing water, a few introduced populations spawn on gravel beaches in lakes. Optimal spawning habitat is a factor of fish size, but typically occurs in water velocities of 0.30 – 0.90 m/s at depths of 0.15 – 2.5 m (Raleigh et al 1984). Females select the spawning locations, preferring sites with subgravel flow such as the tail outs of pools immediately above riffles or upwelling sites. Spawning site preparation and egg fertilization are involved processes that are well documented, which will not be discussed here. At hatching, alevins range from 11 to 13 mm TL: and the fry are about 12 - 18 mm TL when they emerge from the gravel. The size and age at maturity vary between systems and life histories, with fish typically maturing between 3 to 5 years and males usually maturing at least a year before females.

The diet varies with size, season, time of day and population. In lakes, fry forage on bottom organisms (amphipods, snails and the nymphs of aquatic insects) and water-column organisms (especially chironomid pupae and cladocerans). Typically lacustrine adults are insectivores, with similar diets to juveniles, only the prey will be larger and more adult insects will be taken. The diet of adults remains variable and is influenced by prey abundance and presence of other fish species. Large rainbow trout (> 400 mm) in large lakes, for instance, often are piscivores, especially when kokanee are present (Keeley et al 2005). Understanding diet of rainbow trout in systems becomes further complicated as a result of stocking programs, which may transfer fish-eating strains (i.e. Girrards) to areas which have historically only had insectivorous populations (J. Bisset pers. comm.).

Generally rainbow trout are cold-water species with a preferred temperature between 7 °C and 18 °C (Raleigh et al 1984) and an upper lethal temperature of 27 °C (Lee and Rinne 1980). Adfluvial fry typically migrate to their lake late in their first summer or in early fall, although fry spawned in some outlet and headwater streams will not move to the lake until the following spring. Once in the lake, fry remain in shallow water, typically about 2-5 m offshore (Wurtsbaugh et al 1975). During the day, they are often associated with cover (cobble, boulders and woody debris); and they emerge to forage at night. Juveniles tend to stay inshore during the winter and early spring, and in some lakes, they more offshore during the late spring and summer (Beauchamp 1990). By day, juveniles are associated with cover (i.e., cobble and boulder substrates or woody debris), while at night, they forage over sand and gravel substrates (Tabor and Wutsbaugh 1991). In small lakes, adults will use all parts of the lake but are often associated with cover (large wood debris) in the lower littoral zone. Adults tend to become more active near dawn and most active at dusk.

Windermere Lake System

The rainbow trout is a native fish to Windermere Lake (McPhail and Carveth 1994), although the lake has been stocked regularly between the years of 1917 and 1994 with multiple strains (MoE 2008). Small lake recruiting populations have been reported for Windermere Creek; while Abel Creek and Goldie Creek have been identified as having possible lake recruiting rainbow trout (Griffith 1994). During a gill net survey, Griffith (1994) did not catch any rainbow trout within the lake. Griffith reported that although rainbow trout are periodically stocked, suitable recruitment sites may be limiting potential natural production. This is due, in part, to accessible stream length being excessively steep and swift flowing for the successful spawning of rainbow trout, for almost all tributaries to the lake (excluding the Columbia River) (Griffith 1994). Rearing habitat also tends to be limited for rainbow (Griffith 1994). As well, very low survival was anticipated for fry recruiting back to the lake, as a result of large numbers of potential predators (e.g., pikeminnow, burbot) in the lake (Griffith 1994).

No rainbow trout were observed during the 2007 fish assessment in Windermere Lake. This is likely a result of unsuitable conditions described above by Griffith (1994). During this assessment July water temperatures ranged between 19 and 25 °C. These levels would have exceeded optimal conditions and approached lethal levels in places. As a result, any rainbow trout in the lake would have likely sought cooler habitat including upstream or downstream reaches in the Columbia River or areas of groundwater upwelling. Juveniles are expected to feed along the foreshore at the water's edge until the temperatures rise (J. Bisset pers. comm.). Anecdotal reports suggest that rainbow trout are occasionally angled in Windermere Lake early in the spring (April to June) before water temperatures rise (J. Bisset pers. comm.).

Schleppe and Arsenault (2006) conducted a similar but more rigorous study along the foreshore of Okanagan Lake. The potential foreshore habitat that was determined at Okanagan Lake was utilized for this species when developing the Fish Habitat Matrix and the subsequent Habitat Index. The only differences were that at Windermere Lake, Creek Mouth Habitat was added for potential reproduction and general living was limited to Cliff/Bluff and Low Rocky Shore which would potentially provide deeper and cooler habitats.

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REDSIDE SHINER *(Richardsonius balteatus)*

Ecology and Life History

Redside shiners belong to the Cyprinidae (minnow) family. They are another Columbia endemic species and in British Columbia are mainly found in interior water's (McPhail 2007). Redside shiners inhabit streams, rivers, ponds, lakes and reservoirs. Information relating to those inhabiting lake habitats (the lacustrine form) will be the focus of this synopsis. McPhail (2007) has provided the most current and comprehensive summary on this species, and as such has been the main reference for this description. McPhail's (2007) synopsis was largely developed using Lindsey and Northcote (1963) and Crossman (1959), unless otherwise noted.

Redside shiners spawn in the spring, when water temperatures reach about 10 ^{o}C. This ranges from April to early June depending on location in the province. Spawning usually occurs in flowing water over clean gravel substrates, with some populations also spawning in lakes. The lacustrine populations typically spawn in inlet or outlet streams associated with the lakes; and stay relatively close to the lake (within a few hundred metres of the lake on the first or second riffle above the lake). This species broadcast spawns with no nest made. At 18°C the eggs take about 5 days to hatch. After about 10 days in the stream, fry migrate to lake at night.

In the summer, young-of-the-year (YOY) inhabit shallow water (usually less than 1 m) along the lake and stream margins, often amongst aquatic vegetation. They are typically associated with mixed schools of young peamouth chub and northern pikeminnow (Miura 1962). The YOY consume a variety of prey organisms from both the bottom and the water surface (including cladocerans, copepods, ostracods and chironomid larvae and pupae). Juveniles venture a bit further from shore than YOY, but generally remain in loose schools along the lake margins. The juveniles are often associated with the outer margins of weed beds.

As the redside shiners grow, their prey size increases. Adults will feed throughout the water column, eating mainly nymphs and pupae of aquatic insects and adult terrestrial insects, as well as cladocerans, copepods, mollusks and eggs and fry of fish (including their own species). In the summer adults '*cruise*' the littoral zone during the day, remaining in waters greater than 4 m deep. Adults forage in small groups that are in constant motion, and have been described as '*aggressively pushing into weed beds, checking out items on the bottom, and darting to the surface'*. They move offshore in the evening. Given the wide range of prey items and habitats, it is no surprise that redside shiners do well when introduced into new waterbodies (M. Robinson pers. comm.). The upper lethal temperature for this species has been calculated as 25 °C (Scott and Crossman 1973). Redside shiners are considered a small minnow, with a fork length typically less than 200 m.

McPhail (2007) provided that redside shiners are probably the most abundant minnow in the BC interior. They are generally not a conservation issue, other than in the lower Fraser Valley, where once abundant populations in sloughs and shallow lakes, have now disappeared (McPhail 2007). It is suspected that largemouth bass have contributed to their demise in these systems (McPhail 2007).

Windermere Lake System

There are only a few historical accounts of redside shiners in Windermere Lake, including that of gill net assessment in 1993 (Griffith 1994) and seine results from 1975 (MoE 2008). Redside shiners were the most abundant and widespread species found during 2007 assessments. Considering the results of all sampling techniques combined, they were found in 12 out of 18 Sites reviewed, representing all natural and modified foreshore habitat types other than Sand Beach (Site 8) and Modified Gravel Beach (Site 1).

From snorkel survey results, redside shiners represented 84% and 96% of the summer and fall fish communities, respectively. In the summer, they were particularly abundant along the Vegetated Shoreline areas, both Modified (1750 were seen at Site 10) and natural (100 each were observed at Sites 5, 5a and 11) (Figure 1). During the fall, particularly high numbers (1000+) were seen at the Modified Creek Mouth at Site 2 (Holland Creek). For most of these accounts life history stage was not identified. However YOY were specifically identified along the Modified Sandy Beach of Site 4 (25 fish) and the Vegetated Shores of Site 5a/Windermere Island (100 fish).

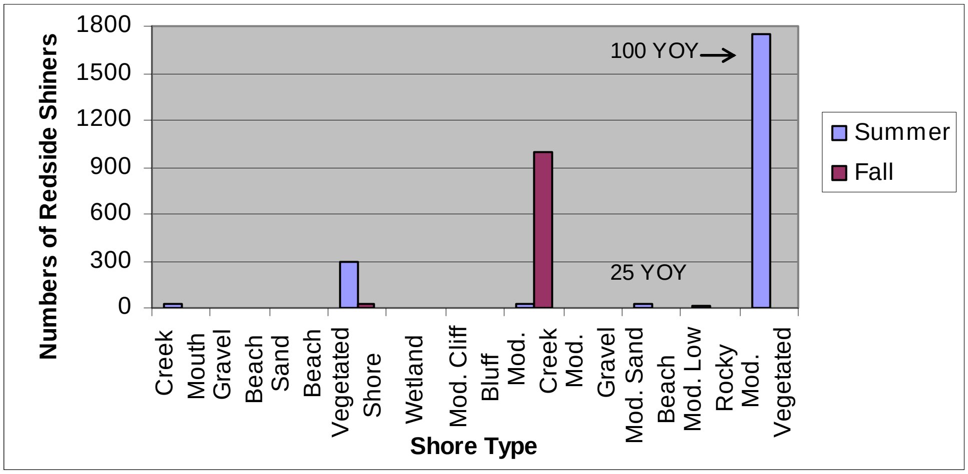

Figure 1. Numbers of redside shiners (adults unless otherwise noted) observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore.

Relative abundance is in accordance with the high numbers seen (Figure 2). In the summer, redside shiners comprised more than 80% of the population along the Modified Sand Beach, Modified Low Rocky Shore and Modified Vegetated Shore areas. In the fall, they made up greater than 80% of the population in the Modified Creek Mouth areas. They were also considered very abundant along other shore types such as Vegetated Shoreline (representing 61% and 51% of the summer and fall populations respectively) and the Creek Mouth areas (with 40% abundance in the summer).

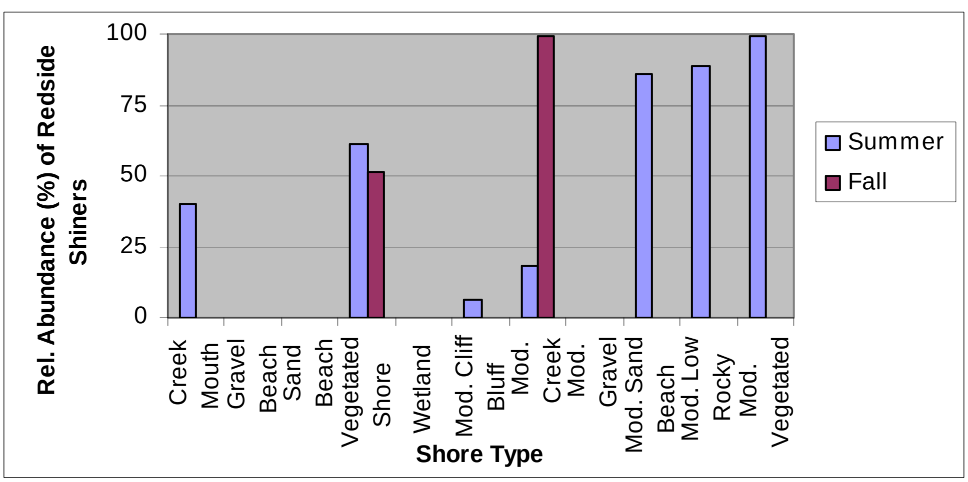

Figure 2. Relative abundance of redside shiners observed during snorkel surveys at the different shore types along the Windermere Lake foreshore.

Redside shiners are known to be an important food source for a variety of fishes including rainbow trout, cutthroat trout and pikeminnow (Scott and Crossman 1973); and given their abundance, this is likely the case at Windermere Lake. They are also known to be an important food source to many fish-eating waterfowl, such as mergansers and loons, as well as other small mammals including mink (Scott and Crossman 1973). Predation was observed at Windermere Lake, with grebes and loons feeding on the fish at the outlet of Holland Creek in the fall.

Windermere Lake redside shiner data was consistent with that of a similar study conducted at Okanagan Lake (Schleppe and Arsenault 2006). The Okanagan Lake study further confirmed that fish appeared to congregate around both artificial and natural structure. Spawning surveys during the Okanagan Lake study indicated that this species spawns from May through June, utilizing any shoreline having cobble, gravel or vegetation present for egg deposition. In accordance with Okanagan Lake findings, redside shiners are considered a generalist and habitat at Windermere Lake does not appear to be a limiting factor, as a result of the wide range of habitats where fish were sampled. The Habitat Specificity for this species, as outlined in the Fish Species Habitat Matrix reflects these findings by identifying habitat usage in all shore types for all life-stages.

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TORRENT SCULPIN *(Cottus rhotheus*) and
PRICKLY SCULPIN *(Cottus asper)*

Ecology and Life History

Sculpins were not identified to species during 2007 foreshore sampling. Therefore, occurrences could either have been torrent or prickly sculpins, since both species were documented in Windermere Lake according to the Fish Inventory Summary System (FISS - MoE 2008). In FISS, torrent sculpins were reported in 1975 (beach seine) and 1976 (gill net) and prickly sculpins were identified in 1977. The ecology and life history of both species was thus reviewed. It is more likely however, that the sculpin reports in Windermere Lake were that of the torrent sculpin species, since the literature suggests that the prickly sculpin is not present in Windermere Lake and is only located in the lower Columbia below barriers (McPhail 2007, McPhail and Carveth 1994).

The torrent and prickly sculpin belong to the Cottidae family. The torrent sculpin is endemic to the Columbia, occurring within the Columbia system from its estuary to its headwaters. The prickly sculpin is more widespread, ranging throughout western North America, particularly along the coast. These species inhabit both flowing waters and lake environments. This study will focus on details pertaining to the lake (or lacustrine) form of these species. McPhail (2007) has provided the most current and comprehensive summary on these species, and as such has been the main reference for this description. McPhail's (2007) synopsis of the lake form of the torrent sculpin was largely derived from observations in Columbia Lake, while background on the prickly sculpin has mainly come from coastal records.

In Columbia Lake, torrent sculpins spawn shortly after ice-out, which is typically in mid-April. However, they are known to spawn as late as June (16°C) in flowing waters. The prickly sculpin is similar, spawning during the spring from April to late June (6 °C – 16 °C). Like most freshwater sculpins, males excavate a nest under a rock or a flat piece of wood (described for prickly sculpin only). Once the female deposits the eggs, the male guards the nest until they hatch. Incubation period is temperature dependant. Once hatched, torrent sculpin larvae remain in the gravel for about two weeks. Tow samples in Columbia Lake (mid-May) found larvae associated with coarse gravel substrates. The larvae of both species are initially planktonic, feeding on microplankton until they develop into small sculpins. Fry for both species are known to inhabit weedy, vegetated and shallow habitats.

Once they transform from larvae to fry, torrent sculpins primarily feed on chironomid larvae. Copepods, ostracods and amphipods are also included in their diet (Northcote 1954). Prickly sculpin fry are similar, with reports of them feeding on plankton and aquatic insect larvae (Northcote 1954). They initially prefer prey from the water column, but benthic prey becomes the dominant source as they grow. Juvenile and adults of both species are mainly insectivorous preying on nymphs and larvae of aquatic insects. Adults of both species are known however, to be '*moderate piscovores*' including small minnows (particularly redside shiners and northern pikeminnow), suckers and sculpins in their diet (McPhail 2007 and Scott and Crossman 1973). Torrent sculpin adults have been observed burying themselves in the sand and ambushing these small, fish during the day.

Torrent sculpin adults in Columbia Lake are known to inhabit shallow waters (< 1 m deep) on gravel beaches. Adult prickly sculpins also inhabit littoral areas, especially areas where there is cover such as cobbles, boulders or woody debris interspersed among sandy patches. Juveniles of both species occupy similar habitats to adults, only preferring shallower areas (<30 cm deep reported for torrent sculpins). Both species forage at night. A key distinction for these species is that the prickly sculpin (YOY to adults) is known to move to open water/offshore to feed.

Windermere Lake System

Considering all survey techniques, a total of 22 sculpins were observed during the 2007 surveys. Sculpins were found in 6 out of 18 sample sites, which in the summer included Modified Creek Mouth (Site 2;), Modified Low Rocky Shore (Site 1a), Modified Cliff/Bluff (Sites 3 and 14) and Modified Sandy Beach (Site 4); and in the fall included Modified Cliff/Bluff (Site 3), Modified Sandy Beach (Site 4) and Gravel Beach (Site 15). All sculpins were adults, other than one juvenile sampled in the summer and two in the fall at the Modified Sandy Beach (Site 4). Two sculpins identified along the Gravel Beach habitat were the only two identified to species, as torrent sculpins.

Sculpins were only observed in the summer during snorkel surveys. Snorkel survey results suggest that sculpins made up 0.6% of the total fish community sampled. Sculpins represented 86% of the fish community in the Modified Cliff/Bluff habitat, and 7 % in the Modified Sandy Beach Habitat during the summer (Figure 1). Most (12) of these sculpins were observed along the Modified Cliff/Bluff at Site 14. The sculpins here were found under the large cobble and were not using the retaining walls or docks. At least a small amount of coarse substrates was available at nearly all sites where the sculpins were found.

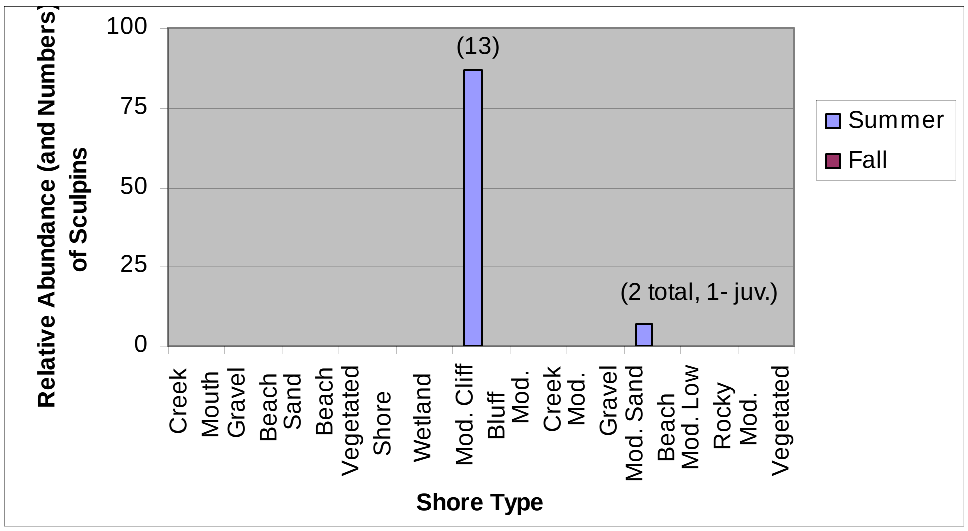

Figure 1. Relative abundance (%) and in parentheses numbers of sculpin spp. observed during snorkel surveys at the different shore types along the Windermere Lake Foreshore (unless other wise noted all observances were adults).

The torrent sculpin was included in Habitat Index because it is the native sculpin species to Windermere Lake. During a similar study along Okanagan Lake, Schleppe and Arsenault (2006) provided a graphical summary of sculpin species distribution; however, they did not provide a summary write-up to indicate which species were considered. A review of FISS records for Okanagan Lake indicates the presence of prickly and slimy sculpins species; not torrent sculpins. Because of this, habitat specificity in the Habitat Index for the torrent sculpin was determined using the literature and 2007 findings at Windermere Lake, not those provided for Okanagan Lake. It was decided that the Windermere Lake cyprinid spp. findings could be utilized even though they may have included the non-native prickly sculpin species, because both species share similar foreshore habitats. Generally reproduction for the torrent sculpin was anticipated to occur in areas with course substrates, and as they mature this species is expected to colonize adjacent habitats that contain at least some course materials.

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WESTSLOPE CUTTHROAT TROUT *(Oncorhynchus clarkii lewisi)*

Ecology and Life History

The westslope cutthroat trout is a member of the Salmonidae Family. In British Columbia (BC), it is a blue-listed meaning that it is a species of special concern vulnerable to human activities or natural events (CDC[1] 2008). This species is also identified as a "species of special concern" by COSEWIC[2]. The range of this regionally significant sport fish includes most of the upper Columbia drainage system and disjunct populations in Oregon, Washington and southwestern Alberta (McPhail 2007). In BC, this species is generally found along the western slopes of the Rocky Mountains in the southeast part of the province (McPhail 2007). They require cool, well-oxygenated water (CDC 2008) that are nutrient poor (Liknes and Graham 1988). This species has three main life-history forms: a migratory form that moves from lakes to spawn in tributaries (adfluvial), a fluvial form that moves from large rivers into tributaries to spawn, and a stream resident form which typically rears and spawns over a small geographic area (M. Robinson pers. comm., McPhail 2007). In situations where there is no tributary access, lake resident (lacustrine) forms have been documented. These lacustrine populations complete their entire life-cycle within a lake (M. Robinson pers. comm., McPhail 2007). This review will focus on populations utilizing lake habitats in at least one of their lifestages. McPhail (2007) has provided the most current and comprehensive summary on this species, and as such has been the main reference for this description. McPhail's (2007) synopsis was largely derived from Liknes and Graham (1988), with other contributing authors noted.

Westslope cutthroat trout typically spawn in the spring from early May to late June. Adfluvial populations usually spawn in tributary streams or lake outlets, while lacustine populations are known to spawn on gravel beaches (Carl and Stelfox 1989). Adfluvial and fluvial populations stage at the mouths of tributary streams and enter during the peak in the hydrograph (Schmetterling 2001). Females select the nest site, which in streams is usually upstream of the tail-out of glides (Schmetterling 2001). Spawning gravel size, water velocities, gradient and water depth vary depending on the population and on the female fish size. In the Flathead River and its tributaries, redd sites had water velocities of 0.3-0.4 m/s, depths of 15 – 20 cm and fine gravel substrates (2-50mm diameter) (Shepard et al 1984).

In adfluvial populations, fry typically migrate to the lake from their natal stream in their second or third summer. Some fry however, have been found to migrate to the lake in their first summer (Chisholm et al 1989). These fry remained in the shallow littoral areas until the fall. Juvenile habitat changes during the day and with the seasons (Bonneau and Scarnecchia 1998). In the summer, juveniles in streams move to deeper water (mean depth 36 cm) during the day and return to the shallows (mean depth 29 cm) at night. In the fall and winter, juveniles are nocturnal, feeding at night and seeking cover during the day under woody debris or among large gravel and cobble (Bonneau and Scarnecchia 1998). Westslope cutthroat trout gradually shift from littoral habitat to open waters as they grow.

Habitat use by adult westslope cutthroat trout is known to vary with the seasons, time of day and life history type. Populations in large rivers, such as the Columbia River, often make major migrations (>200 km) between spawning sites, summer foraging sites and overwintering sites (Schmetterling 2001, Shepard et al 1984). Little is known about adult habitat use in lakes other than that they are associated with near-surface waters except for in the summer when temperatures rise above 20°C (Shepard et al 1984). Westslope cutthroat trout are primarily inectivores. In lakes and large rivers, winged insects are typical prey, and in some lakes zooplankton is also important to their diet.

McPhail (2007) describes that the introduction of non-native salmonids such as brook trout and rainbow trout have had profound negative effects on this species. Throughout their native range,

[1] British Columbia Conservation Data Centre
[2] Committee on the Status of Endangered Wildlife in Canada

the most imminent threat to pure populations is hybridization with introduced rainbow trout (Robinson 2007, Rubidge and Taylor 2005, 2004; Rubidge et al 2001). Following these introductions, competition for food and habitat resources has also negatively affected this species. Over-fishing and habitat degradation are additional factors believed to have caused the population declines seen today.

Windermere Lake System

Cutthroat trout were historically more abundant in the tributary creeks and lakes of the Columbia River than the mainstem river (Westslope 2001). More recent accounts show that pure populations have commonly been reduced to existing in small headwater tributaries, typically above barriers (Robinson 2007). Historic accounts of westslope cutthroat trout in Windermere Lake are limited. The Fish Inventory Summary System (FISS) identified that 5000 hatchery fry were stocked in the lake in 1952 and that the wild adfluvial form was observed in 1983 (MoE 2008). No specific data on the adfluvial fish was reported in the FISS records or found in the literature. During sampling in September and October of 1993, Griffith (1994) found westslope cutthroat trout to be abundant in Reach 3 of Windermere Creek. This reach is located 3 km upstream of the lake and is characterized by relatively steep (4%) fast flowing riffle habitat and large bed materials (60% cobble/boulder) (Griffith 1994). The cutthroat were mature (236 mm), clearly indicating that they were stream residents (Griffith 1994). Artech (2002) found cutthroat trout in Reach #1 of North Windermere Creek; this upper Windermere Creek population is also believed to be a stream resident stock, genetically isolated from migration by downstream barriers (Artech 2002). Stream resident cutthroat were also found in Brady Creek (Reach #2 and #3), approximately 1 km upstream of the lake.

Lake foreshore habitat utilization for westslope cutthroat trout is expected to be similar to that of bull trout, another cold water salmonid. According to their life-history accounts, if spawning occurred in the tributaries, fry would utilize the shallow littoral area of the lake in the fall (if they moved in from their natal stream) and juveniles and adults would seek out deep cool waters during the summer. Windermere Lake's summer water temperatures are likely too high for this species. During July 2007 sampling, for example, temperatures ranged from 19-25 °C. These values meet or exceed the 20 °C preference identified by Shepard et al (1984). Cold-water refuge is not encountered at depth in Windermere Lake, since the lake is shallow (6.4 m maximum and 3.4 m mean) and does not become stratified (Griffith 1994).

When completing the Fish Species Habitat Matrix for the Habitat Index, westslope cutthroat trout were rated as high for Habitat Selectivity based on the fact that they are a listed -species and an important sport fish. In terms of their Habitat Specificity, they are expected to have low habitat use of Windermere Lake Foreshore. Based on the literature, the Creek Mouths were the only potential areas selected for habitat use for staging/spawning and rearing. Cliff/Bluff and Low Rocky Shore Types were included for adult general living since these areas provide deeper refuge habitat. More rigorous sampling may provide further insight to this species' habitat utilization along the foreshore.

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Appendix D- Hard Copy of Maps

Figure I & II – Historical Air Photo Analysis (Shoreline Description for the North and South Ends of Windermere Lake, respectively)

Figure III and IV - Habitat Index and ZOS (for the North and South Ends of Windermere Lake, respectively)

Appendix E - Digital Copy of Maps