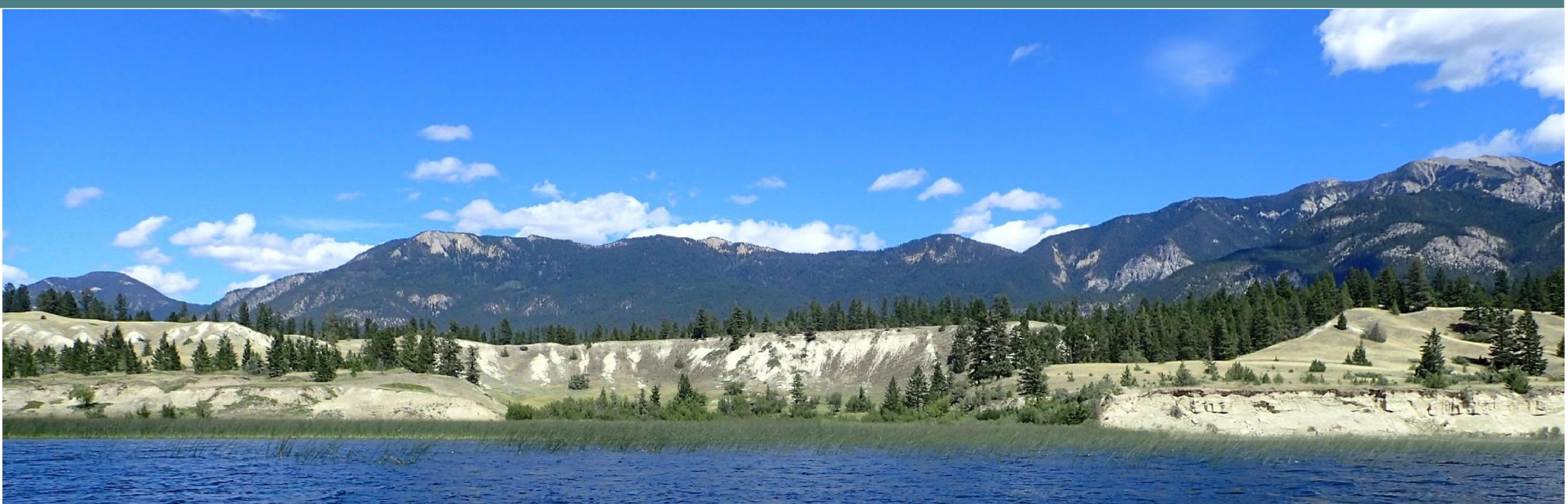
Windermere Lake
Foreshore Integrated Management Planning



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Living Lakes Canada and Project Partners

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LIVING LAKES CANADA MISSION STATEMENT

Living Lakes Canada is a non-profit society that facilitates collaboration in education, monitoring, restoration and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands and watersheds. Our mandate is to help Canadians understand, adapt and mitigate the impacts of climate change to water quality and quantity, biodiversity and healthy human communities through grassroots water stewardship activities. Living Lakes Canada bridges the gap between science and action to foster and normalize citizen- based water stewardship.

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The results contained in this report are based upon data collected during a single season inventory. Biological and lake systems respond differently both in space and time. For this reason, the assumptions contained within the text are based upon field results, previously published material on the subject, and air photo interpretation. The material in this report attempts to account for some of the variability between years and in space by using safe assumptions and a conservative approach. Data in this assessment was not analyzed statistically and no inferences about statistical significance are made if the word significant is used. Use of or reliance upon biological conclusions made in this report are the responsibility of the party using the information. Neither the authors of this report (Ecoscape Environmental Consultants Ltd. or Lotic Environmental Ltd.), or Living Lakes Canada (or project partners) are liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected, analyzed, and presented.

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EXECUTIVE SUMMARY

Living Lakes Canada (LLC) is part of a global network that facilitates collaboration in education, monitoring, restoration and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands and watersheds. Declines in lakeshore conditions are occurring globally, and LLC funded this shoreline mapping project through DFO's Canada Nature Fund for Aquatic Species at Risk Program to help aid better long-term lakeshore planning in the Kootenay region of British Columbia (BC).

The desire to live and recreate in the Kootenay Region of BC, combined with the generally positive economic climate, has resulted in rapid population growth and urban development. This growth has increased the value of most property, and in particular waterfront property for full time residency or seasonally for recreational purposes. As a result, commercial and residential development pressures have increased along lake foreshores, with a greater number of resorts, condominium complexes, and single-family homes proposed and built. Coupled with this, a general increase in affluence among a larger population, has put further pressures on lakefront habitats.

Windermere Lake is located in the southern interior of BC in the Rocky Mountain Trench. The lake is located near the Columbia River headwaters. The two largest communities are the District of Invermere and the community of Windermere. Windermere Lake has seen a high demand for secondary recreational and investment properties. These developments inevitably impact the natural foreshore environment through removal of riparian and aquatic vegetation, and installation of modifications such as marinas, groynes, retaining walls, and docks. Unfortunately, these impacts can diminish the natural values that draw people to live and recreate along the foreshore in the first place. Ultimately, the goal is to maintain a balance between anthropogenic and natural values to the benefit of all residents and species that rely upon the lake.

Foreshore Integrated Management Planning (FIMP) is a framework intended to help governments, landowners, and nonprofit organizations understand lake foreshore habitat values and the potential ecological risks from proposed shore altering activities. The resulting information is used to help make decisions regarding foreshore development and conservation. The methods used are standardized to provide a consistent framework for assessing proposed shoreline development. One of the many benefits of the standardized process is that if data from previous surveys are available, the rate of loss of natural shoreline can be determined. Understanding the rate of loss is important to better manage natural resource values along the foreshore (or shoreline). The FIMP methods have been developed to provide a habitat overview for all stakeholders, recognizing that the budgets available are finite. These data are primarily intended to aid land use planning, and they may not identify site specific habitats of importance. Detailed assessments and planning are an integral part of the urban development process and must be incorporated at later phases of project planning, as necessitated by any existing legislation or permitting processes required.

The key objective of this study was to update the original FIMP that was conducted in 2006 on Lake Windermere and to document changes that have occurred over the 14-year period since the last survey. The following three standard FIMP steps were completed during this study (Schleppe et al. 2020):

1. Foreshore Inventory and Mapping (FIM) was the first step conducted and involved the collection of standardized field data from a boat viewing the shoreline. These data were supplemented with other available ecological datasets originating from a variety of sources (e.g., Species at Risk Management Plans, BC Conservation Data Center, Official Community Plans, etc.). The foreshore was defined as the area from the deeper edge of the littoral region of the lake (i.e., where the start of pelagic region begins) to an area up to 50 m past the high water mark (HWM) into the upland/riparian zone. Within this area, field technicians counted, catalogued and described the following: land use (e.g., residential development), modifications (e.g., retaining walls, docks, marinas), and biophysical attributes (e.g., shoreline vegetation cover, substrates, large woody debris, and aquatic vegetation).
2. Shoreline habitat sensitivities were determined using a ranking index called the Foreshore Habitat Sensitivity Index (FHSI). The index uses the FIM and other data to rank shoreline value in a cost effective method to approximate shoreline habitat values for fish, wildlife and ecosystems, based on field surveys and other existing information available (including assessments, inventories and professional opinions). The index is intended to act as a "flagging" tool to identify areas of the greatest ecological sensitivity to change from urbanization. As part of the FHSI, the most sensitive habitats were identified as Zones of Sensitivity (ZOS).
3. The Foreshore Development Guide (FDG) was prepared to identify risks posed by different shore altering activities, to inform land use decisions. The FDG is intended to help mitigate or reduce the potential for negative effects to sensitive habitats owing to urban developments and identify areas for conservation (e.g., ZOS).

Overall, the FIM identified that 43% (16,191 m) of the shoreline was in a natural condition, while the remaining 57% (21,208 m) was considered disturbed. The natural areas were mostly present along undeveloped Indian Reserve lands at the south east end of the lake, while the area with greatest disturbance occurred within the District of Invermere. Since 2006, the percentage of disturbed shoreline increased by approximately 1% across the entire lake shoreline, representing a loss of approximately 369 m of natural habitat. The observed changes occurred through incremental losses at a small scale, often associated with clearing of small natural areas on private property. While these changes individually may not seem significant, continued losses would add up over time, with the potential to result in landscape-level changes to the surrounding ecosystem.

The FHSI identified numerous important and high value areas around Windermere Lake. Most of the criteria from the original study were included. However, a higher level of detail went into defining and evaluating shoreline segments in this update. Nine ZOS were identified, and these were habitats supporting: fish (Kokanee spawning, native mussels, Burbot spawning/rearing), wildlife (avian bank nesting), waterfowl (aquatic vegetation nesting, and migration corridors), and ecosystems (grasslands, wildlife connectivity, and wetlands).

The FHSI identified that 30% of the foreshore habitat on Windermere Lake had a Very High Ecological Rank, and 23% of the shoreline had a High Rank, which translated to approximately 11,270 m and 8,751m of shoreline respectively. These areas were represented predominantly by wetlands along the shore, stream confluences, and locations where important habitat features such as spawning or waterfowl migration were identified.

Moderate ranked habitat accounted for 30% or 11,261 m of the shoreline. Moderate value segments occurred in locations that had fewer overlapping ZOS's or were areas with important ZOS that were impacted by development. These areas were represented by all shore types and were more prevalent in areas of multi family, single family, or urban parkland developments.

Areas or Low and Very Low Ecological Rank occurred along 17% (or 6,118m) of shoreline. These areas occurred predominantly where there was increased development intensity, such as multi family areas. This was expected, as areas with more intense development often lose many of the habitat values that were originally present. This highlights the importance of protecting natural areas in any development process. Overall, habitat value has decreased over time in these areas, and many developments did not appear to be planned in a way to avoid potential impacts to fish and wildlife.

Recommendations have been presented to help all levels of government utilize these findings and move towards more sustainable urban development practices. Recommendations were categorized by type, and include measures to address cumulative impacts, restoration, and other planning related needs. The FDG is presented under separate cover and presents recommendations and tools to aid in identification and planning so high value environments and ZOS are conserved during development.

ACRONYMS

Post 2020 FIMP Methods Update	Pre 2020 FIMHP Methods Update (only if changed)	Acronym
CDC		Conservation Data Center
DFO		Fisheries and Oceans Canada
CMN		Community Mapping Network
EKILMP		East Kootenay Integrated Lake Management Partnership
FDG	SMG	Foreshore Development Guide / Shoreline Management Guidelines Documents
FHSI	AHI	Foreshore Habitat Sensitivity Index / Aquatic Habitat Index
FHSI Category		Foreshore Habitat Sensitivity Index Category
FHSI Criteria or Criterion		Foreshore Habitat Sensitivity Index Criteria
FHSI Ecological Rank		Foreshore Habitat Sensitivity Index Ecological Rank or output
FIM		Foreshore Inventory and Mapping
FIMP	SHIM	Foreshore Integrated Management Planning / Sensitive Habitat Inventory and Mapping
FNLRORD		Provincial Ministry of Forests, Lands, Natural Resource Operations and Rural Development'
GIS		Geographic Information Systems
GPS		Geographic Positioning System
HWM		High Water Mark
LLC		Living Lakes Canada
TEK		Traditional Ecological Knowledge
ZOS		Zone of Sensitivity

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1.0 INTRODUCTION

Living Lakes Canada (LLC) is part of a global network of over 120 non-governmental organizations that facilitates collaboration in education, monitoring, restoration and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands and watersheds. LLC has a mandate to help Canadians understand, adapt, and mitigate the impacts of climate change on water quality and quantity, biodiversity and healthy human communities through grassroots water stewardship activities. LLC helps bridge the gap between science and action to foster and normalize citizen- based water stewardship. Declines in lakeshore conditions are occurring globally, and LLC funded this shoreline mapping project through DFO's Canada Nature Fund for Aquatic Species at Risk Program to help aid better long term lakeshore planning in the Kootenay region of British Columbia (BC).

LLC has contracted the team of Ecoscape Environmental Consultants Ltd. (Ecoscape) and Lotic Environmental Ltd (Lotic Environmental) to complete Foreshore Integrated Management Planning (FIMP), to update previous mapping completed on Windermere Lake in the East Kootenay Region of British Columbia (BC) (the Project). The Project involved using the recently revised FIMP methods (Schleppe et al. 2020).

1.1 Study Area

Windermere Lake is located in the southern interior of BC, in the Rocky Mountain Trench. The lake is located near the Columbia River headwaters and is simply a widening of the Columbia River rather than a 'true lake" (Urban Systems 2001). Key physical characteristics for the lake are summarized in Table 1. The two largest nearby communities are the District of Invermere and the community of Windermere, located at the north end and mid-east ends of the lake, respectively.

Table 1: Summary of Lake Windermere Characteristics (Urban Systems 2001).

Parameter	Value
Volume	55.19×10^6 m^3
Surface area	1610 ha
Littoral Area	1530 ha
Drainage	1340 km^2
Maximum Depth	6.4 m
Mean Depth	3.4 m
Length	17.7 km
Average Width	1.1 km

1.2 Foreshore Significance and Development Pressures

The desire to live and recreate in the Kootenay region of BC, combined with the generally positive economic climate in BC and Alberta, has resulted in rapid population growth and development. This growth has increased the value of all property, and in particular waterfront property for recreational or permanent residences. As a result, commercial and residential development pressures have increased along lake foreshores, with a greater number of resorts, condominium complexes, and single-family homes proposed and built. At Windermere Lake specifically, there has been a high demand for secondary recreational and investment properties. These developments inevitably impact the natural foreshore (or shoreline) environment through removal of riparian and aquatic vegetation, and construction of modifications such as marinas, groynes, retaining walls, and docks. Unfortunately, these impacts can diminish the natural values that draw people to live and recreate along the foreshore in the first place. Ultimately, the goal is to maintain a balance between anthropogenic and natural values to the benefit of all residents and species that rely upon the lake.

The foreshore is ecologically significant because it is the transitional ecological community between aquatic and terrestrial habitats. It provides a high diversity of habitat for fish and wildlife and provides many beneficial ecological functions. Shoreline habitats include aquatic vegetation, deep and shallow lake edges, stream mouths, wetlands, riparian vegetation, grasslands. Ecological functions in these habitats include but are not limited to providing forage, nesting and rearing areas for aquatic and terrestrial fauna; buffering the watercourse from contaminants; and maintaining bank stability (e.g., DFO 1992). Even though there are several legislative mechanisms in place to help protect the foreshore (e.g., Federal *Fisheries Act*, Local Government Official Community Plans, etc.), anthropogenic pressures often result in both small and large incremental losses leading to habitat fragmentation and degradation. These impacts reduce the ability of a lake to provide habitat necessary for fish, wildlife, and ecosystems to sustain populations.

As a result of the ongoing urban development pressures and evidence of degradation, Foreshore Inventory and Mapping[1] (FIM) was implemented in BC, starting in 2004 by the Community Mapping Network and Regional District Central Okanagan (see Schleppe et al. (2019) for summary of methodological development). In 2020, the methods were updated, and the assessment framework was renamed Foreshore Integrated Management Planning or "FIMP". Although the name has changed, the primary objective of the FIMP process remains to identify environmental values of importance and provide land-use planning guidelines to reduce impacts on high value

[1] Foreshore Inventory and Mapping and the Aquatic Habitat Index (AHI) were commonly referred to as Sensitive Habitat Inventory and Mapping or SHIM in the Kootenays. While these projects are commonly referred to as SHIM, they should not be interchanged with Sensitive Habitat Inventory and Mapping projects that are undertaken on small streams. While names are often used interchangeably, this document will rely upon and utilize the new accepted terms and definitions as required, despite the common use of the word SHIM.

areas. The science-based methods were developed with input from all levels of government (Federal, Provincial, regional, and municipal), First Nations, lake stewardship groups and professional consultants. As a result, the outputs including those specific to Windermere Lake have received support from these groups and have been relied upon during development planning.

1.3 Foreshore Integrated Management Planning Framework

FIMP is intended to help governments, landowners, and nonprofit organizations understand lake foreshore habitat values and the potential ecological risks from proposed shore altering activities (Schleppe et al. 2020). The outputs are used to help make decisions regarding foreshore development and conservation. The methods are standardized to provide a consistent framework for shoreline development reviews. One of the many benefits of the standardized process is that if data from previous surveys are available, the rate of loss of natural shoreline can be determined. Understanding rates of loss is important to better manage the shoreline. The methods have been developed to provide an overview of ecological values of the shoreline, recognizing that budgets available are usually finite. These data and analytical results are primarily intended to aid land use planning, and they may not identify site specific habitats of importance. Detailed assessments and planning are integral for individual developments planned and must be incorporated as necessitated by regulatory requirements, conservation strategies, etc.

The FIMP process follows three general steps (Schleppe et al. 2020):

1. Shoreline inventory and mapping is conducted following the Foreshore Inventory and Mapping (FIM) protocols. FIM consists of collection of standardized field data which is supplemented with the inclusion of available ecological datasets originating for a variety of sources (e.g., Species at Risk Management Plans, Official Community Plans, etc.).
2. Shoreline habitat sensitivities are determined using a ranking index called the Foreshore Habitat Sensitivity Index (FHSI). The index is a simple, cost effective method to approximate shoreline values collected from numerous datasets and is developed using assessments, inventories and professional opinions. The index is intended to act as a "flagging" tool to identify areas of greatest sensitivity to change from urbanization. The index was formerly called the Aquatic Habitat Index (AHI).
3. The Foreshore Development Guide (FDG) is prepared to identify risks posed by different shore altering activities, to inform land use decisions. The FDG is intended to help mitigate or reduce the potential for negative effects to sensitive habitats owing to urban developments.

1.4 FIMP Value During Regulatory Reviews

Windermere Lake is managed by numerous local, regional, Provincial, and Federal agencies. Each governing agency acts as the approving authority for different land use activities that may impact the shoreline. For instance, local and regional agencies and

First Nations generally approve land use activities on properties within their boundaries. The Province manages all areas in and around lake (or stream) side water bodies. The Federal government is responsible for managing fish and their habitats, species at risk, and navigation.

Table 2. Summary of governing agencies for Windermere Lake shoreline.

Level	Agency	Applicable Legislation
Local	District of Invermere	Official Community Plan and associated Bylaws
Regional	Regional District of East Kootenay	Official Community Plan and associated Bylaws
Provincial	Ministry of Forests, Lands, Natural Resource Operations and Rural Development & Ministry of Environment and Climate Change Strategy	*Water Sustainability Act, Streamside Protection Act,* BC Parks
Federal	Department of Fisheries and Oceans (DFO)	*Federal Fisheries Act, Species At Risk Act, Navigation Protection Act*
First Nation	Ktunaxa Nation and Shuswap Indian Band	Official Community Plan and associated Bylaws and/or

Foreshore development and other related undertakings are governed by several federal, provincial, regional and municipal regulatory requirements (e.g., acts, regulations, bylaws and policies). The FDG provides regulators with a clear, consistent, and coordinated management strategy to protect shoreline environmental values, which can be used during the development review process. Key regulatory requirements triggered by foreshore development and undertakings are summarized below, while a full listing of other potential requirements is provided in the FDG (Schleppe and Mcpherson 2021). Despite current and historic regulatory requirements, there are still documented impacts resulting from shoreline urbanization, inferring that more stringent requirements to maintain ecological values are required.

For projects near fish bearing waterbodies, the Federal *Fisheries Act* requires Project Reviews to ensure works or undertaking adjacent to or within watercourses do not result in the harmful alteration, disruption or destruction of fish habitat (HADD). Where a HADD is necessary, an Authorization from DFO is required that clearly demonstrates that Avoidance, Mitigation and appropriate Compensation or Offsetting measures are in place.

In BC, the foreshore is defined as the land between the high and low water mark. This area is considered Crown Land (in almost all cases, with a few rare exceptions) and includes the permanently wetted lake area (Province of BC 2021a). Crown Land falls under provincial jurisdiction, and the public retains the right to access it even if the upland is privately owned. Provincial authorization is required for any developments (e.g., installation of docks or retaining walls below, at, or near the high water mark [HWM]) on Crown Land. This includes but is not limited to obtaining *BC Lands Act* leases/licenses to occupy the land and / or obtaining BC *Water Sustainability Act* Approval or Notification for Works in and About A Stream. The *BC Lands Act* also governs private land, where upland property ownership abuts the Natural Boundary or more commonly the Present Natural Boundary (PNB). The Land Act defines PNB as:

> *"The visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself."*

First Nation referrals are part of the environmental application review process, with environmental protection usually being a very important component of their review. Consequently, various First Nations have also reported using the FIMP reports to support their review of proposed projects. This includes the Ktunaxa Nation Council for Windermere Lake development application referrals.

Local governments around Windermere Lake have authority to make local land use decisions, typically governed through bylaws, policies and a Official Community Plans (OCP). Most of Windermere Lake is within the jurisdiction of the Regional District of East Kootenay (RDEK), with development governed by the Windermere Official Community Plan (OCP; RDEK 2019). Under the current OCP, all areas designated as "Red" or "Orange" zones in the original Shoreline Management Guidelines (East Kootenay Integrated Lake Management Partnership [EKILMP] et al. 2009) are within a Development Permit Area (DPA). These "Red" areas were previously identified as a Key Habitat Area (essentially synonymous with ZOS – see next section) that overlapped with Very High and High value shoreline areas, and "Orange" areas were areas with ZOS alone. The DPA extends 30 m into the lake from the natural boundary. The intent of the DPA is (RDEK 2019):

> *To ensure that activities within and along the shoreline are undertaken in a manner that minimizes the disruption or alteration of the natural ecosystems that creates fish and wildlife habitat and maximizes the opportunity for restoration and enhancement. The intent is not to preclude all development in DPAs, but to provide notice that these portions of the shoreline provide unique characteristics that warrant special review and consideration, and to ensure appropriate mitigation or protection measures are prescribed where identified by a Qualified Environmental Professional (QEP).*

The District of Invermere OCP has categorized the foreshore into four water zones: 1) Residential, 2) Group Moorage, 3) Institutional, and 4) Commercial (District of Invermere 2002). Each zone has permitted uses with docks, swimming platforms, mooring buoys, launch ramps, moorage and boat lifts essentially acceptable in all zones. The commercial zone also allows for marinas. In each zone district regulations are specified for these structures (e.g., size, number per parcel, minimal distances from property line and other structures etc). Generally, environmental protection in the municipality defers to the federal and provincial governments.

1.5 Original Windermere Lake Foreshore Assessment

Sensitive Habitat Inventory and Mapping (SHIM) was previously completed at Windermere Lake using and early version of the FIM database and a study on Okanagan Lake that developed the concept of a shoreline habitat index (Schleppe and Arsenault 2006). The original Windermere study was prepared in three reports: Foreshore Inventory and Mapping (FIM; McPherson and Michel 2007), Fish and Wildlife Assessment (McPherson and Hlushak 2008), and Shoreline Management Guidelines (EKILMP et al. 2009). Key findings from these original shoreline studies are summarized here.

The FIM identified that railway, residential, private recreational, parks and commercial uses impacted over half of the foreshore (McPherson and Michel 2007). Anthropogenic alterations in these areas included riparian vegetation removal and foreshore modifications (including retaining walls, docks, groynes, boat houses, marinas and boat launches). Retaining walls were prevalent along substantial portions of the residential and private recreational areas, with nearly half built below the HWM. A historical air photo analysis revealed that by 1968 approximately 61% of the shoreline had been disturbed, and by 1995 an additional 13% of the shoreline was disturbed, with disturbance including any human induced modification, structure or alteration.

The fish and wildlife assessment report provided insight to species usage along the foreshore (McPherson and Hlushak 2008). The fish sampling program surveyed 18 shoreline sites in various habitats around the lake in both the summer and fall seasons. The most abundant species were Redside Shiners (8 % of all catches) and Largemouth Bass (5 %, a non-native species). Sport fish abundance was low and included Bull Trout (0.06 %), Mountain Whitefish (1.2 %), and Kokanee (0.6 %). Burbot and Westslope Cutthroat Trout were not observed. However, these sport fish were expected to use the lake as a migration corridor to access spawning grounds.

The lake outlet downstream to Athalmer was identified as particularly important area for fish because of the Kokanee spawning beds amongst other fisheries value present. Historically, prior to establishment of dams downstream in the Columbia System, Chinook Salmon also spawned in this location, and there is vision to see them return again in the future. Given these values, the lake outlet was identified to be a culturally significant area (e.g., by the Shuswap Indian Band). The outlet was formally classified as an important archaeological area (referenced as Salmon beds Archaeological Site EdQa 121), given its use as a campsite and food processing area for First Nations for over the last 1000 years (Royal BC Museum 1999).

Wildlife surveys identified 57 species of birds, of which 54% were migratory species. The highest diversity of birds was at sites with undisturbed vegetated habitat structure (i.e., emergent aquatic vegetation, riparian vegetation, wetlands, native grasslands and forest). Wildlife trees were an additional ecologically important habitat noted at several locations around the lake.

The fish and wildlife assessment divided the 35.6 km of shoreline into 26 segments. Over half of the shoreline was found to be of Very High or High value. Highest value habitat was in undeveloped areas, or where disturbances were set-back from the shoreline. Residential areas tended to have the highest level of impact, reducing overall habitat function and value. Specific ZOS identified were wetlands/riparian areas, creek mouths, native grasslands, wildlife habitat (i.e., cliff bluff areas) and wildlife corridors, gravel/cobble habitat (i.e., burbot habitat), biologically productive areas (i.e., mussel beds), and unimpacted natural areas. Of these ZOS, all but gravel/cobble habitat and wetlands/riparian were designated as Key Habitats Areas, which greatly influenced the Shoreline Management Guidelines (EKILMP 2009).

In the Shoreline Management Guidelines, Key Habitat Areas were generally recommended to be conserved. Very High and High ecological values shoreline areas were identified to have development limited to low risk activities, and the remaining areas of Moderate to Very Low ecological value were considered to be areas where development would best be concentrated. An activity risk table identified development activities that were both suitable and not suitable in these respective colour zones, including if a species at risk was present or not. A decision-making flow chart was provided, summarizing the regulatory review process for high and low risk projects. Guideline development involved input from federal, provincial and local government; First Nations; and non-government/stewardship groups. It was a testament that this collaboration resulted in the guidelines being incorporated fully under the RDEK OCP.

1.6 Objectives

The key objective of this study is to update the original Windermere Lake FIMP assessment (and related report) that was completed in 2006 to document any potential changes that have might have occurred over this 14-year period. This update will be used to assess the status of the foreshore, to compare changes in natural shoreline over time, and to identify any trends that might need consideration into the future. The resulting information will be considered a tool to help inform environmental reviews, policies, and standards. It is hoped that these new data and reports can be incorporated into local, regional, Provincial, and Federal policy and guidelines, where appropriate, to promote evidence-based land use and planning decisions.

In meeting this objective, the objectives of the original study (FIMP) will also be met (McPherson and Hlushak 2008):

1. Provide an overview of foreshore habitat condition on the lake that will include but be not limited to an inventory of biophysical values, land use, anthropogenic alterations, and sensitive habitats.
2. Obtain a spatially accurate digital video of the shoreline, to be made available through GIS.
3. Develop an accessible GIS database of the foreshore ecological values.
4. Collect information that will aid in prioritizing high value areas for protection.
5. Integrate information with upland development planning to help provide broader ecosystem protection.

2.0 METHODS

For this Project, Windermere Lake was re-assessed using the recently revised FIMP methods FIMP (Schleppe et al. 2020). The FIMP involved completing the three components: FIM, FHSI, and FDG. Since the lake was previously assessed, past results were included here to provide an understanding of any changes that have occurred over the 14-year time period since the last assessment. To align the original data set with the new standards with as much accuracy as possible, important and detailed quality assurance/quality control (QA/QC) procedures were completed, such as photo comparisons between the original survey and this survey wherever feasible. This process is described below.

The Ecoscape/Lotic Environmental Project Team was carefully selected to include professionals with direct experience conducting FIM, FHSI, and FDG on other similar projects in the province (all team members), as well as on Windermere Lake (Sherri McPherson). The team was comprised of:

- Ecoscape
  - Jason Schleppe as Lead Biologist (M.Sc., R.P.Bio.)
  - Robert Wagner as the GIS Specialist (B.Sc.)
  - Scott McGill as a Project Biologist (B.Sc.)
  - Luke Crevier as a Data Analyst (M.Sc. candidate)
- Lotic Environmental
  - Sherri McPherson as Lead Biologist (B.Sc. R.P.Bio.)
  - Tegan Arnett as Project Biologist (B.Sc., R.P.Bio.)

2.1 Foreshore Inventory and Mapping (FIM) Methods

Foreshore Inventory and Mapping methods were used to delineate, inventory and map foreshore habitats. The foreshore was defined as the area from the deeper edge of the littoral region of the lake (i.e., where the start of pelagic region begins) to an area up to 50 m past beyond the HWM into the upland/riparian zone. Within this area, through completion of the FIM, field technicians counted, catalogued and described the following: land use (e.g., residential development), modifications (e.g., retaining walls, docks, marinas), and biophysical attributes (e.g., shoreline vegetation cover, substrates, large woody debris and aquatic vegetation). The FIM was completed in a four-step process, as identified below:

2.1.1 Step 1 Pre-Field Assessment

The FIM field database was prepared by first converting the original database into the revised database available in the new FIMP methods (Schleppe et al. 2020). This was done by identifying data fields that were collected using similar methods in the original FIM database and merging these with applicable data fields in the revised database. Attribute data requiring additional field consideration to ensure consistency between the former and current data collection were identified.

This original FIM geographical information system (GIS) dataset was converted using GIS 'R' software to script a "rule set". The following rules were applied:

1. Data fields attributes in the 2006 FIM database were matched with the most similar field in the FIM 2020 database. The matched fields were then updated to the most common nomenclature.
2. Fields that were not sampled during the original event were left as either NA's or were estimated using photos, aerial imagery, or other methods.
3. Field data notes in the original database were left in the comments field and / or GIS meta-data, to allow users to understand what fields were added in the second FIM and which fields were completed using estimation or other tools. This field database was used for field inventory.

Important GIS mapping layers from the original FIM database that were to be updated were identified and transferred to the field maps. These data were used to help identify specific field data mapping requirements. Associated filed data mapping protocols were developed (e.g., for FHSI or ZOS).

Other background information was mapped, including the following data layers:

1. The Provincial and Federal GIS registries were searched for Species and Ecological Communities at Risk and Critical Habitat data. A review was conducted for other high value habitats potentially present (i.e., grasslands and wildlife habitat areas). Mapped occurrences were loaded on to field maps.
2. Local government data was obtained, including zoning, cadastral (including government and non-government organization [NGO] conservation areas), Official Community Plan Development Permit areas, and any recent aerial imagery. These data were used to help understand the key land use designations, inform the field surveys (e.g., segment brakes), and inform conservation recommendations.
3. The retaining wall and historical air photo GIS data presented in the original assessment were obtained from the Regional District of East Kootenay and incorporated as possible.
4. The Columbia River Wetlands have been the focus of extensive bird survey work by stewardship groups. This included work through the Columbia Wetlands Waterbird Survey (2015 - present), the Columbia Wetlands Marsh Bird Monitoring Project (2016 - present), and the Columbia Valley Swallow Project (2020 - present). We reached out to the coordinator (R. Darvill pers. comm) to provide relevant data. Nesting locations for Bank Swallows, a threatened species under the Species at Risk Act (SARA 2017), and other general bird use information was provided.

The original segment breaks were reviewed for potential updates. The most recent cadastral and land use data was used to verify land parcel information and help confirm land use categories. From this office exercise, there were no significant land use changes evident, inferring that there were no preliminary segment break changes required.

Finally, all pertinent data were loaded onto the most recent aerial imagery, and these were used as the field maps. All relevant spatial field data identified was also loaded onto the iPad for reference.

2.1.2 Step 2 Field Assessment

The FIM field assessment was conducted by boat on August 19 – 22, 2020 using an 18 foot aluminum hulled vessel. A crew of five was aboard the boat throughout the assessment: Jason Schleppe and Scott McGill (Ecoscape), Sherri McPherson and Tegan Arnett (Lotic Environmental), and Basil Stevens (Shuswap Indian Band). Bruce MacDonald (LLC) also joined for one the first day as an observer to complete various method calibration exercises.

The updated database was used for field collection of FIM data. During this step, field data were collected as follows:

1. Using a laptop computer, data were entered electronically into the MS Excel FIM database field forms. The field forms contained the original FIM data to allow review and evaluation of both years simultaneously.
2. Biophysical and habitat attribute data were collected in accordance with the FIMP methods. (Schleppe et al. 2020). All mandatory data were collected, as well as other important but non-mandatory data (e.g., overhanging vegetation, large woody debris, and modifications).
3. In addition to inputting counts and estimates of shoreline modifications in the FIM database, select modifications were spatially mapped. IPads were used to spatially mark collected data using ArcGIS collector. Retaining walls and erosion control (riprap) were mapped as lines; while docks, groins, boat launches (excluding those associated with boat houses) were mapped as points.
4. Fish, wildlife and ecological habitat surveys were conducted, with the results mapped as polygons, lines, or points. This information was used to inform the FHSI and ZOS analysis. This involved mapping the following:
    a. Polygons: emergent vegetation (submergent, floating, and emergent)/backwaters or wetlands, bank nesting habitat, approximate full extent of mussel beds, spawning habitat (gravel beds), and reptile/amphibian migration areas.
    b. Points: overhanging vegetation, mussels, den/burrows, wildlife trees.
5. All mapping was done directly onto an iPad, which was then loaded in GIS and spatially adjusted and proofed using photos and available aerial imagery.
6. In 2020, select attribute data were collected differently from the original SHIM. These differences were as follows:
    a. Retaining walls: retaining walls were mapped to allow for a comparison with the retaining wall assessment provided in the original SHIM. However, only the retaining walls in close proximity to the HWM were counted. Retaining walls upslope were not included, nor were those that had no direct impact on the foreshore (e.g., where mature trees were in front of wall that was setback approximately 10 m from the HWM).
    b. Boat launches: all boat launches, including private gravel launches leading out of the boathouses were counted. The original SHIM only counted the public launch sites. These launches were split into two categories based on whether they were gravel or concrete and mapped using the iPad. Sometimes large concrete slabs or similar were also counted. Although they were not a "boat launch", the quantity of concrete was similar in form and function that this was deemed the most equivalent FIM attribute feature to map the data as. For example, the photo below shows a concrete slab that would be considered a boat launch, regardless of actual use.

c. Boat rack/lifts: when two jet skis were connected, they were counted as one. We mention this as it was not specified in the methods.

7. The original FIM segment breaks were confirmed and updated, where necessary. Some segment breaks were updated by splitting the original segment further or spatially adjusting them to the new approximate HWM digitized during this mapping exercise. Segments were split to identify high value habitats, typically embedded within a more urban area. In one instance, a new segment was created for a small island that was previously mentioned in the data but not mapped. Other examples were that some marina segments were split out from adjacent areas with a different land use and different level of disturbance. When a segment was split, the original end points were maintained so that the neighboring segments would not be affected. This was important to support the comparative analysis with the original FIM.

8. Geo-referenced still photographs were taken to characterize each shoreline segment and its attributes. These photos, where possible, were spatially referenced with the previous photos from 2006, and were used extensively to QA/QC the 2006 data to ensure rates of change calculated were as accurate as possible against 2020 data.

2.1.3 Step 3 Video Documentation

Video documentation was conducted to assist in classifying land use and features, and to detect change over time. A shoreline video was collected on September 30, 2020, from a boat by a crew of two (Scott McGill and Brad Mason). An 18 ft. commercial boat was used. The weather conditions during the survey were dry, clear and calm, which aided data collection.

The video was recorded within 50 m from the shoreline. The video was filmed using a an ipad and was merged with a file for the “path taken” using GPS. Features of the camera were: a lens shroud to protect from direct sunlight, a polarized lens, a tripod, and hard drive storage media.

Video processing involved running the video through an image stabilizer and applying text to identify the segment number. The time, boat speed, geo-reference (latitude and longitude coordinates), and compass direction (boat's travel direction) were also shown on the video. The output was provided in MP4 format, to work with any standard viewing software.

The following is a stepwise summary of video collection:

1. Created georeferenced maps showing segments, orthophoto, and landmarks to allow the video field crew to determine location of Segment Breaks
2. Created a video for each segment to reduce file size, and to make finding a location of interest easier (instead of scanning one large video).
3. Georeferenced maps were uploaded into iPads to allow the video field crew to see their location on the map.
4. GPS tracks were recorded in sync with the video recording so the start/stop of GPS track was recorded synonymous with the video start/stop.
5. All video and GPS tracks were downloaded post field work, and these were processed on a computer at the office as follows:.
    a. Video editing software was used to stabilize the video due to wave action/boat movement.
    b. Metrics were derived from the GPS track data including date, time, speed, direction, and GPS coordinates.
    c. The metrics were synchronized with the videos.
    d. Metrics were graphically displayed on the exported video.

2.1.4 Step 4 Reporting and Data Analysis

The FIM database was first reviewed and corrected for QA/QC purposes. This involved:

1. Verifying that both the original and new FIM databases were copied over properly. This step was done to ensure the estimates of change between the assessments were accurate as possible.
2. Where segments were split, the original data were also split accordingly, through a detailed review of the original photos and air photos. Field review was also part of the process, where assessors considered whether structures or features were “new” or not to aid in ensuring data consistency. For each FIM database attribute, particularly the modifications, data were assigned based upon the best estimate from the review. It is noted that perfection in interpretation was difficult, and while all attempts for accuracy have been made, errors may still occur resulting from many factors.
3. Air photo analysis was conducted to revise the approximate HWM of Windermere Lake. Recent images and vegetation queues were used to determine the approximate location. Data collected during the field surveys on the iPads were also considered, to help identify the edge of emergent vegetation for example. Results were mapped in GIS. The approximate HWM and location of this line formed the basis for all FIM segments and subsequent analysis of shore length. As a result, the original FIM spatial database was moved to this

location so that shoreline lengths for each segment were comparable for analytical purposes. Additionally, previous segment breaks were adjusted accordingly in the 2006 and 2020 FIM databases. ed as part of this project (see next).

Results of the FIM survey were then analyzed using R Programing Software (R Core Team 2021) and were presented in a series of tables and graphs to describe the overall shoreline condition. Rates of change in key metrics, such as the quantity of natural and disturbed shoreline, were compared at a lake wide scale.

2.2 Foreshore Habitat Sensitivity Index (FHSI)

In order to develop the FHSI, an additional detailed literature review was conducted to further describe foreshore values identified during the FIM office and field activities. This information was specifically used to confirm the applicable Windermere Lake ZOS and inform the FHSI process. For example, where kokanee spawning had been identified in the original FIMP, recent spawning enumeration data was sought to confirm the current status. Similarly, the status of previously reported regionally sensitive species (i.e., Burbot) were confirmed through discussions with provincial fisheries staff. The results of this review were used to support criterion used in the FHSI and to evaluate their weightings. The results were also used to support and strengthen the FDG recommendations. Modification criteria were also included in the FHSI. Foreshore Habitat Sensitivity Index methods were used to rank approximate relative shoreline values based on the data available from the FIM, other inventories, and professional judgement. Ultimately, the FHSI identified areas of greatest sensitivity to change from foreshore development or areas where risks to important ZOS of habitat features may occur if development proceeded.

2.2.1 Step 1 Preliminary Review of Original 2006 FHSI

The 2006 FHSI categories and criterion and their weightings were reviewed to determine if they could be carried over and used as-is with the new 2020 data (i.e., to identify if they were still accurate and relevant). During the review, it was determined that although the original data were relevant, the FHSI should be updated using the new methods and to allow incorporation of new data collected or identified as relevant during the FIM. Further, this would also allow for the inclusion of First Nations Traditional Ecological Knowledge (TEK) data.

Key habitat areas (as outlined in the Introduction is synonymous with current ZOS in 2020 mapping), from local government planning (RDEK OCP) that were derived from the original Windermere Lake studies were obtained and incorporated in GIS data. These data were carried forward into the revised methods wherever possible (refer to Section 2.2.2 for FHSI criterion development and Section 4.1 for criterion used in FHSI). A quick review revealed that while many of the criterion used in the 2006 FHSI calculation could reasonably be carried over to the 2020 FHSI, a number of others could be added to reflect additional data collected. The inclusion of these additional criteria accounted for least some of the potential differences anticipated between the 2006 and 2020 Ecological Ranking results (see Section 0 for a discussion).

2.2.2 Step 2 FHSI Criteria and ZOS development

The FHSI involved first deciding which FIM attributes, ZOS and modifications to consider as criteria and then properly considering the weightings to apply. Data may be available in numerous forms and can be considered or incorporated in the FHSI in numerous ways. Care was taken to include criteria that both supported a broad range of important habitats, while avoiding duplication of a habitat value. For instance, the overlap of wetlands values (from the FIM) and waterfowl values (from other data sources) were considered, with care to not overly weight either. This step is important to ensure the influence of any given criterion was estimated correctly and did not overly leverage the resultant FHSI rank.

In accordance with the methods, when developing the FHSI, each selected criterion was categorized into the different habitat categories. Each categorized criterion was weighted to assess the influence of each category. Data from the original FIMP were used to help determine the initial weightings of criteria within a category. This step was done to help ensure consistency with the original index.

Applicable criterion also had to have data available for the entire lake. Otherwise, shoreline segments where data were missing (of no fault of their own) would be at a disadvantage (assuming these data were assigned a positive FHSI weighting). Similarly, data were not to be uniformly distributed across all FIM lakeshore segments, unless they had some type of variation in density (i.e., high, moderate, low, or a more continuous dataset such as nesting density for example). Data that covered the entire shoreline, such as the American Badger data (from the Conservation Data Centre) were not included because they were applicable as "Present" across the entire lakeshore. If this were included, all segments would receive an identical FHSI score (irrespective of the assigned weighting) and the criterion would not help differentiate areas of low or high habitat value.

To determine which data were "applicable" to a segment, polygons covering the entire study area around the lakeshore to approximately 500 m away were created for each segment. The center of the lake was used to split between shores, and in general, orthogonal offsets from the 500 m buffer from the HWM were used. The spatial mesh of polygons created was manually adjusted for some segments where the scripted GIS offsets did not make sense. This spatial mesh was created for the lake to assign the spatial data used for criterion in the FHSI for each segment. By creating a spatial mesh, habitat data that was in a polygon adjacent to the lakeshore but was important was captured. During the FHSI, if scripted polygons captured by the spatial mesh were deemed not relevant, they were removed from the analysis manually during calibration. Only a few alterations were made and these occurred typically when a buffer from a criterion such as a Rare and Endangered occurrence polygon (which is inclusive of its own buffer) spatially overlapped only a small portion of a segment, around the fringe of the 500 m offset from the HWM. Other examples included ensuring that data were appropriate to a specific segment, such as waterfowl criterion that were removed from long segments of predominantly railway.

Zones of Sensitivity were developed for data that warranted specific additional consideration beyond just the resultant FHSI Ecological Rankings. For each ZOS, reference to relevant data was provided as determined during the preliminary desktop review, field portion of FIM, or detailed post field literature review. These ZOS are, at minimum, a flagging tool to help call attention to areas of high importance for fish and wildlife. Ultimately, ZOS should be conserved. If more detailed data becomes available, the ZOS spatial boundaries can be amended to improve spatial accuracy.

2.2.3 Step 3 FHSI Calibration

Calibration of the FHSI is an iterative process of reviewing the results (e.g., Ecological Ranks that are assigned to shoreline segments) in light of the assigned weightings. The calibration considers the influence of weighting for all habitat categories and individual criterion both within the category and compared to all criteria in the FHSI. The objective is to assign weightings that are representative of observed habitat values and reflective of the shoreline ecological values present for each FIM segment, considering all fish and wildlife data available.

The FHSI was calibrated by preparing a suite of R scripts. For the first iteration of the index, each habitat category was weighted considering the original Windermere Lake surveys, the summary of methods, the FIMP methods, and quality of data available. The purpose of these iterations was to determine the sensitivity of each criterion and category in the FHSI analysis. While these results were visualized on maps to help quickly assess results and influence of the criteria in the FHSI, each iteration has not been presented here.

Histograms of shoreline scores tended to clump into discrete groups. This pattern was expected, where similar shoreline segments and habitats tended to group because values overlapped. With each iteration of the index, several small database QA/QC corrections were made. Manual manipulations of spatial buffers used to identify the FHSI criteria were considered to ensure that the presence/absence data used in the FHSI did not overestimate shoreline value in longer lake segments. The final determination of the "break" used to differentiate segments (e.g., rank score between Very High and High) considered the location on the lake, length of segment, field observations, professional opinion, reference literature, and the values within the identified ZOS.

Data from the original FIM project were used to help determine the initial weightings of criteria within a category. This step was done to help ensure consistency with the original index (where it made sense to do so). To assess the influence of each category, the following additional iterations of the index were run to visualize the influence of each factor spatially on maps for each segment:

1. Every criterion in the index was weighted equally; the methods indicate *this is a good starting point* that is an unbiased analysis that should be considered.
2. A series of iterations where each habitat category was given a low, moderate, and high weight (relative to the others) was done to assess the influence of each habitat category in the FHSI. During this calibration step, the FIM category of criteria were kept constant at 30% for the FIM category. This allowed assessment of the influence of each larger habitat category (such as Fish or Wildlife), and the criterion within each category, where the habitat categories were considered to a greater extent than the FIM attributes.
3. A series of iterations were done where FIM habitat attributes were weighted with a low, moderate, and high weight within the FHSI. Habitat categories were given equal weights that were lower relatively speaking. During these iterations, the individual FIM criterion were also ranked with a range of low, moderate, and high value, with focus on shore type, foreshore and littoral substrates, and riparian condition.
4. Individual criterion within each habitat category were also varied in each of the iterations above to assess the spatial influence of individual criterion.
5. Modifications were also given a high weight (relative to the others), to assess their influence on the FHSI results.

Results were evaluated spatially and in a series of figures (see Section 4.3 for an example of data considered in each iteration). Throughout the FHSI calibration process, QA/QC occurred to ensure that the final deliverable was as accurate as possible. For example, the criteria that applied to a segment using the spatial mesh were evaluated, and in some cases, were manually adjusted because they were over representing the values in a segment because the values were not likely present.

The last phase of FHSI calibration involved scrutiny of the categories, criteria, and weightings by other professionals. The FHSI analysis was refined once a consensus was reached (i.e., the Ecological Ranks assigned to different shoreline segments were appropriate).

2.2.4 Step 3 Reporting, Data Analysis and map production

Results were analyzed and presented in a series of graphs, tables, and figures to describe the overall shoreline condition. The maps summarized the FIM inventory data, and included categories and criteria used in the development of the FHSI. A map set depicting the FHSI Ecological Ranks, including spatial habitat data, was provided to portray the FHSI results. These map sets and associated mapping deliverables are available in GIS and can be integrated in to any planning or permit process easily because they provide a framework for considering the variety of different values around a lake.

2.3 Foreshore Development Guide (FDG)

The FDG report was prepared in accordance with the FIMP methods (Schleppe et al. 2020) and the FDG template (McPherson and Schleppe 2020). The FDG was prepared according to the following stepwise process:

STEP 1: The FDG map was prepared using the FHSI outputs. The map depicted the pertinent fish and wildlife information needed to guide development planning. This included: a) The FHSI Ecological Ranking for each segment (ranging from very high to very low) as colour zones; and, b) the ZOS's.

STEP 2: For each colour zone and ZOS, a summary and general recommendations were provided. Information on habitat sensitivity, anthropogenic disturbance risks, acceptable activities, and conservation recommendations were included.

STEP 3: The Activity Risk Matrix (ARM) identifies the level of risk of typical activities for each colour zone and ZOS. The ARM and associated recommendations from the FDG template were updated, as necessary.

STEP 4: The table outlining the typical regulatory requirements for each activity listed in the ARM was reviewed and updated, as necessary. Additional tools provided in the FDG template were also reviewed and updated as necessary, including the list of federal, provincial and local environmental legislation, and the Best Management Practices (BMP) list.

STEP 5: All GIS, habitat, and fisheries data were finalized into appropriate databases and provided as a final deliverable. The ARC GIS files for linking data to the database were also provided. This step ensured that the colour palettes used, and links for integration into GIS platforms was consistent.

2.4 Traditional Ecological Knowledge (TEK)

First Nation TEK can contribute to a broader understanding of existing ecological values. The FIMP framework was updated with a proposed process for obtaining and including First Nations TEK into FIMP Projects (Schleppe et al. 2020).

Our project team reached out to local First Nations and requested participation in field data collection and/or inclusion of First Nations TEK data. The Ktunaxa Nation Council, Shuswap Indian Band, and Akisqnuk First Nations were contacted in late July. The Shuswap Indian Band expressed their interest and participated in both the field data collection (Basil Stevens – see Section 2.1.2), and provided TEK data. The other First Nations contacted did not have the capacity to participate.

Basil Stevens was a valuable member of the field team. He assisted with photography and counts of shoreline modifications observed. Basil also provided a summary of his observations on change around the lake, as he grew up recreating on the lake, and was able to recall how it had changed in his life. This helped better understand how and where changes had occurred and how it may have affected fish and wildlife.

The Shuswap Indian Band provided TEK point observations (i.e., geospatial data in the form of points or polygons) with accompanying fish and wildlife metadata (e.g., details such a Kokanee spawning locations or other wildlife, ecosystem, or habitat related data descriptions). Overall, there was a high degree of overlap with the First Nations TEK provided and the data available in the scientific literature. Consequently, additional unique FHSI categories, criteria, or ZOS were not required to incorporate the TEK provided. Since the specific areas and information provided by the Shuswap Indian band were already captured in the body of information previously obtained via desktop review and through the FIM survey the information was considered supporting data.

It is noted that TEK data did not overlap perfectly in all cases because sufficient detail was not provided regarding spatial accuracy. Also, we were bound by a data use agreement that included a confidentiality clause. Thus, data were best used to consider as support for existing criterion in cases of overlap.

3.0 FORESHORE INVENTORY AND MAPPING RESULTS

The total length of the Windermere Lake shoreline was determined to be 37,400 m. This estimate varied slightly from the estimate used in the 2006 FIM survey. Potential differences between length estimates between years would be attributed to using this newer approximation of the HWM. Further, an island located along the foreshore was separated into an independent segment, rather than a continuation of the exterior shoreline, increasing the length of the shoreline in the spatial GIS dataset.

The foreshore was divided into 40 contiguous segments. Segments 12, 20, 24, 25, 26 were split into differing numbers of sub-segments in this inventory, increasing the total number when compared to the 2006 survey. This was done to better describe unique habitat values that were evident. The FIM database with all data collected by segment is best viewed electronically and has not been provided because it is hard to interpret in tabular format. FIM maps showing segment location and key segment information are provided in Appendix A.

3.1 Summary of Shoreline Disturbance

Overall, 43% (16,186 m) of the shoreline was in a natural condition, while the remaining 57% (21,214 m) was considered disturbed (i.e., areas that had any sign of being altered) (Figure 1). The natural areas were mostly present along undeveloped Indian Reserve lands at the south east end of the lake, while the area with greatest disturbance was within the District of Invermere. Since 2006, the percent disturbed increased by 1%, representing a loss of approximately 369 m of natural habitat in the 14-year time span since the first survey was completed. This comparison of change is quite accurate relative to these studies but may vary with other published reports[2]. The

[2] Different methods of estimating disturbance may result in small differences in the quantity of disturbed shoreline when compared with other reports. Further, since the total length of shoreline was amended in this assessment, a slight difference from the past FIMP may also occur.

observed changes occurred through incremental losses at a small scale, often associated with clearing of small natural areas on private property. While these changes individually may not seem significant, continued losses would add up over time, with the potential to result in changes to the surrounding ecosystem. It is hard to identify the point where the ecosystem would reach an undesirable tipping point.

In 2006, there were subdivided lots that had not yet been developed. However, in 2020 additional disturbances were observed in these areas as a result of recent development or full built out. Finally, other small disturbances were observed in locations where older buildings were demolished and reconstructed.

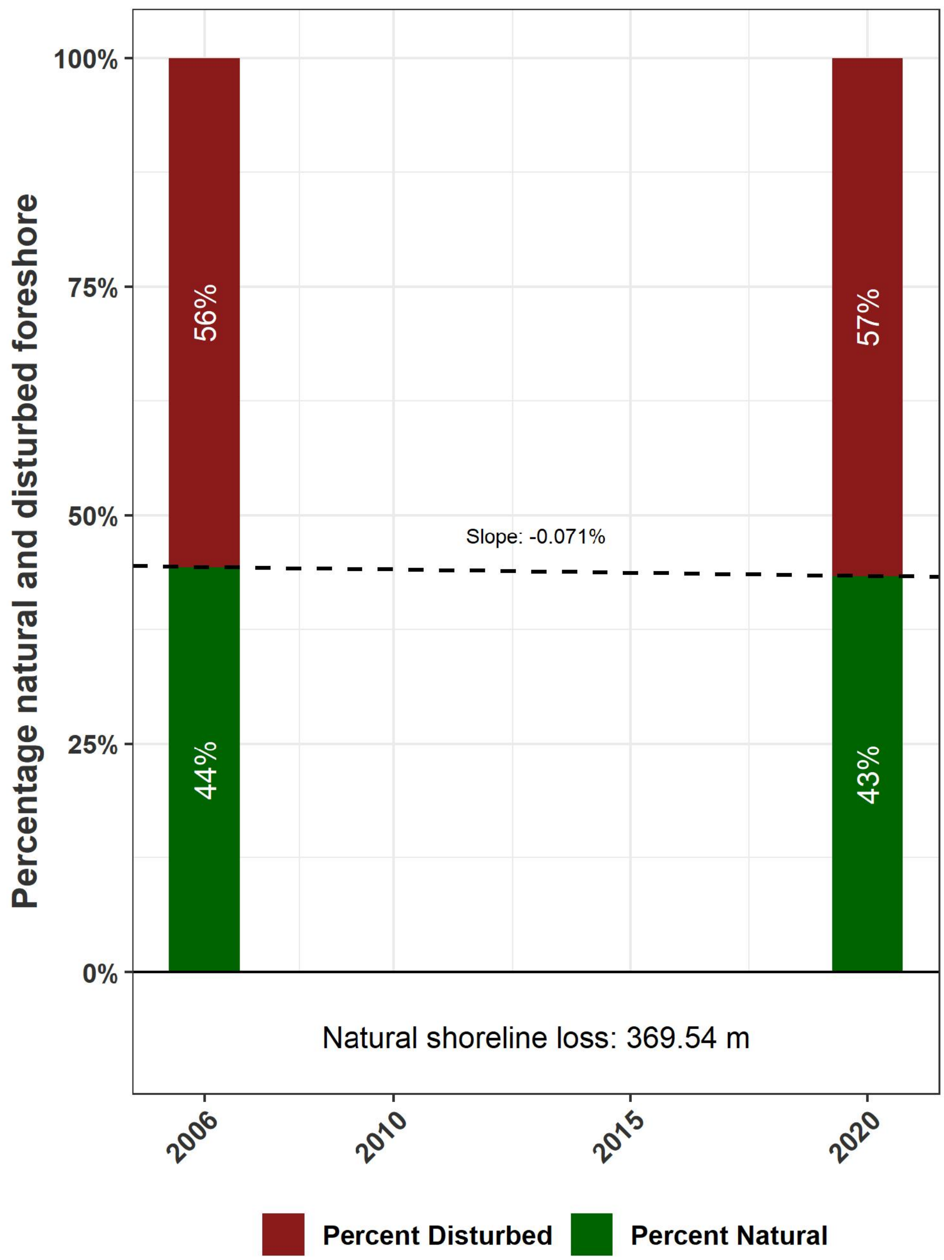

Figure 1. Summary of lake wide shoreline disturbance

3.2 Summary of Land Use Disturbances

Land use types were summarized in order of prevalence in Table 3. The extent of natural and disturbed habitat was consistent for most land uses between 2006 and 2020. The exceptions were single-family residential and urban park land uses, which both exhibited increased disturbance between the two study years.

Table 3. Foreshore land uses and percent natural in 2006 and 2020.

Land use	Total length (m)	% Natural 2006	2020
Commercial	1284	48%	48%
Institution	560	99%	99%
Multi Family	703	5%	5%
Natural Area	5464	100%	100%
Rural	4665	85%	85%
Single Family	11174	25%	22%
Transportation	11803	21%	21%
Urban Park	1747	40%	34%
Commercial	1284	48%	48%

Transportation was the most prevalent land use, extending along 32% of the foreshore. The railroad along the west shore of the lake was the key transportation type present. The railway was noted to have isolated several wetland and small stream systems, which were mapped as backwater wetlands. While they were no longer as functionally connected to the lake, they still provide important and high value habitats.

The single-family land use occurred along 30% of the foreshore and was the second most predominant land use type observed. This was primarily lakefront homes concentrated at the north end (Invermere) and north east half of the lake. Shorelines in areas of single-family land use were 77% disturbed in 2020, which is typical of other lakes in the region and across BC (see Schleppe et al. 2019). The single-family land use had a natural habitat loss of 2% or 274 m over the 14 year period shown in Figure 4. This appeared to be from small incremental losses, usually in the form of removal of patches of vegetation in riparian areas (see example photos). This small rate of change was expected because there have been no new substantial changes in land use, such as a subdivision or resort development. The biggest disturbances to shoreline areas usually occur in processes of shoreline densification, for example where a land use changes from Rural or Natural Area (or similar) to a more urban land use like single-family development, or when large areas of land are cleared for agriculture as on Okanagan Lake (Schleppe and Plewes 2016). None of these processes had occurred at Windermere Lake in recent years. The small incremental changes seen on Windermere Lake resulted in a rate of loss of 0.18% on a lake wide scale (see slope of line in Figure 4). This rate was similar to Okanagan Lake, which has experienced a 0.2% loss per year (Schleppe and Plewes 2016).

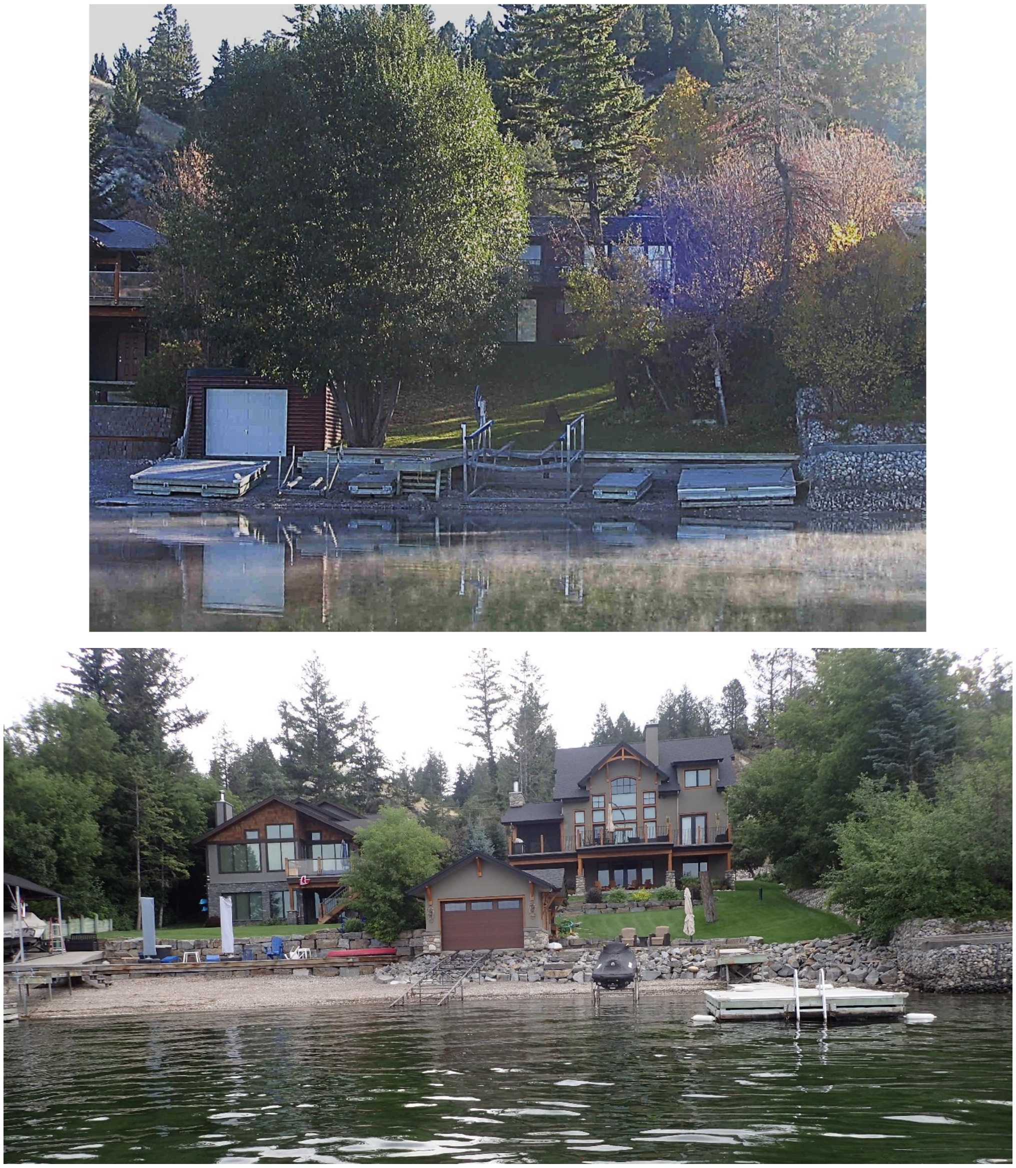

Figure 2. **Example of incremental riparian loss from 2006 (top) to 2020 (bottom)**

While no new subdivisions were observed, there were several lakefront homes that had been recently constructed, re-built, or substantially renovated (Figure 3) On these more urban lots, there was very little shoreline restoration observed as part of a reconstruction process. The incremental, slow losses of riparian habitat can only be balanced with appropriate commitment to incremental shoreline restoration, otherwise, ongoing losses will occur and only a few remnant patches will remain over time on these urbanized lots.

Figure 3. **Examples of new construction where little riparian enhancement is possible or where works were occurring below the HWM.**

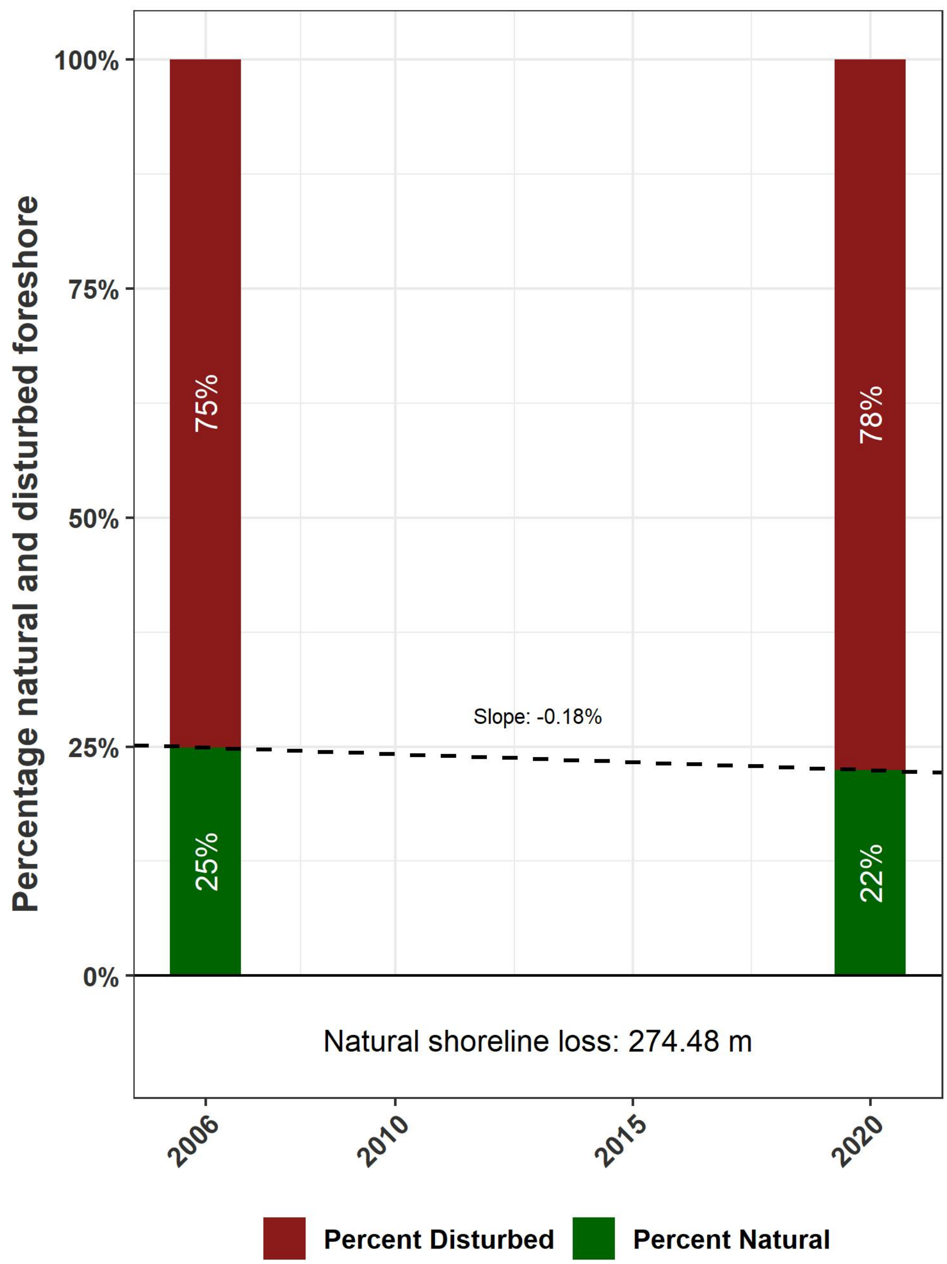

Figure 4. Shoreline disturbance in areas of single-family land use.

The natural area land use comprised 15% of the foreshore. This land use was primarily the Columbia Lake Indian Reserve Number 3, also known as the Akisqnuk First Nation Indian Reserve, which extends along the south eastern half of the lake. Windermere Lake Provincial Park (formerly known as Sunshine Ranch) was also included in this land use. This provincial park is a large day-use park with no facilities, that protects one of the last remaining tracts of native grassland and riparian habitats along the western shores of Windermere Lake (BC Parks 2020). The Columbia Wetlands Wildlife

Management Area (WMA) is another conservation area and is present at the southern end of the lake. The WMA contains high value habitat for fish and wildlife and is described in detail in Section 4.0.

Rural lands comprised 12% of the foreshore and were typically single-family dwellings on larger acreages. These areas were concentrated on the west shore. The land appeared to primarily be used for low intensity agriculture (crops production), and in many cases was in a fairly natural state.

Urban parks were present along 5% of the foreshore and were nestled amongst single family developments. These parks included: Kinsmen Beach Municipal Park and James Chabot Provincial Park in Invermere, and the Windermere Public Beach. There was a 6% (95 m) loss of habitat evident in these areas in Figure 5. Most change was due to loss of riparian and emergent vegetation near boat launches and in areas of buoys or shoreline mooring. Tracking the emergent vegetation losses with a high level of accuracy was not possible using these datasets. Since vegetation has an annual cycle, losses would need to be determined using more accurate mapping techniques. It is highly suspected that the ongoing, intensive recreational use and moorage along the shoreline will continue to impact these important emergent vegetation areas, through slow and incremental losses.

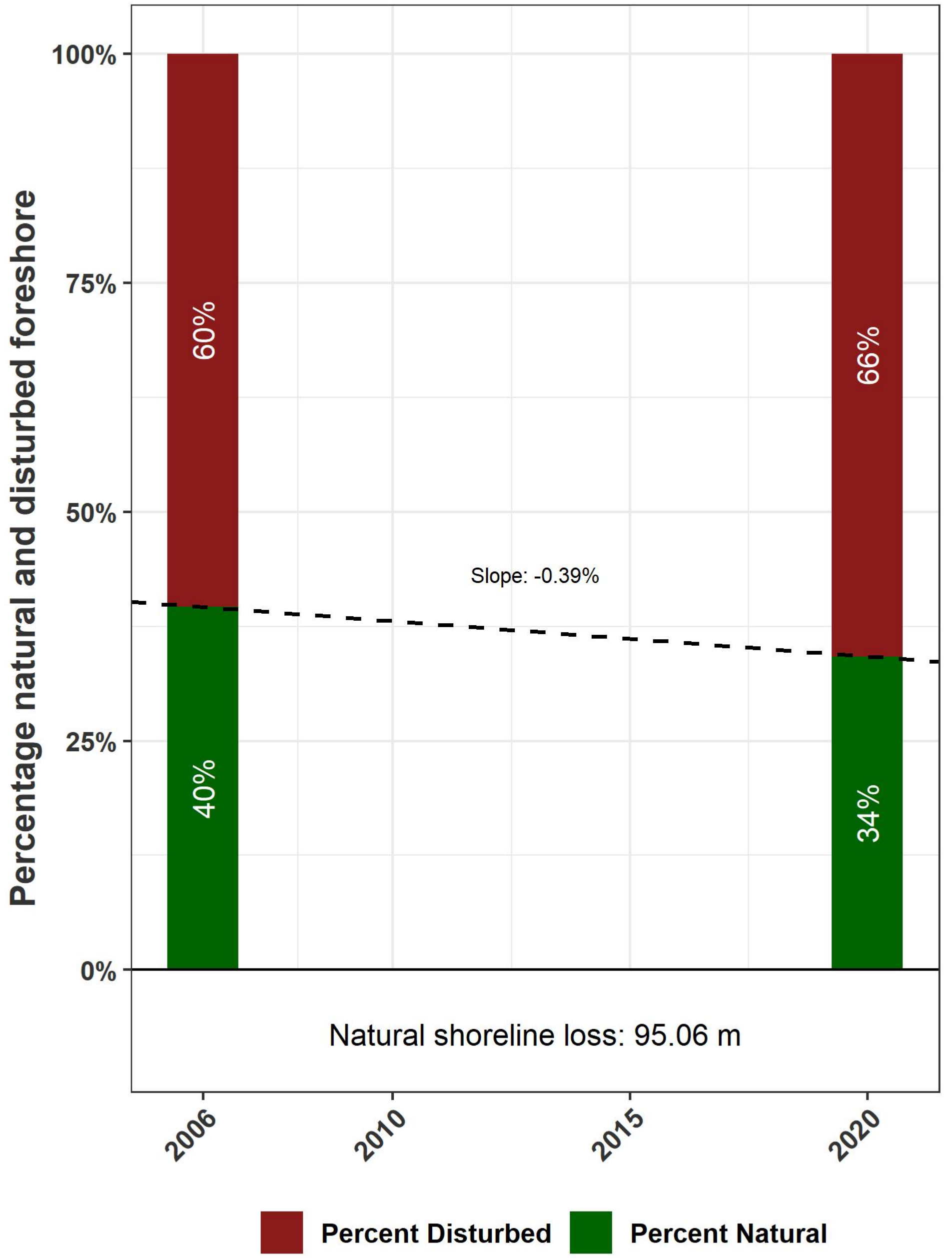

Figure 5. Shoreline disturbance in areas of urban park land use.

The remaining land uses combined accounted for just under 10% of the foreshore. Multi-family and institutional land uses (representing 2% each) and commercial (3%) were present in Invermere.

3.3 Summary of Disturbance along Different Shore Types

The extent of disturbance was consistent for most shore types between the two years of study (Table 4). The exceptions were gravel beach and stream mouth, which both exhibited habitat losses between 2006 and 2020. Each shore type is summarized below in order of prevalence. Losses in stream mouth areas are expected to have a particularly high level of habitat related impact because these areas often occur in the highest value areas along the shoreline.

Table 4. Shore type and percent natural in 2006 and 2020.

Shore Type	Total length (m)	% Natural	
		2006	2020
Cliff/Bluff	5716	94%	94%
Gravel Beach	19598	16%	14%
Sand Beach	2271	30%	30%
Stream Mouth	996	55%	54%
Wetland	8820	77%	77%

Gravel beach was the most prevalent shore type, comprising 52% of the foreshore. However, gravel beach had the lowest amount of natural habitat remaining (14% in 2020; Figure 6). Since 2006, an additional 2% (367m) of this shore type was assessed to be disturbed. This was approximately a loss of 0.14% per year, which was comparable to Okanagan Lake which had a loss of 0.11% per year (Schleppe and Plewes, 2016). Gravel beach areas often have high levels of disturbance because they are associated with low lying areas that are easily accessible for land development and transportation corridor areas. Disturbances were attributed to incremental losses of small patches of native riparian (e.g., large coniferous trees such as Interior Douglas Fir) and emergent vegetation, and often occurred where land was developed for new construction or where reconstruction of existing residences occurred.

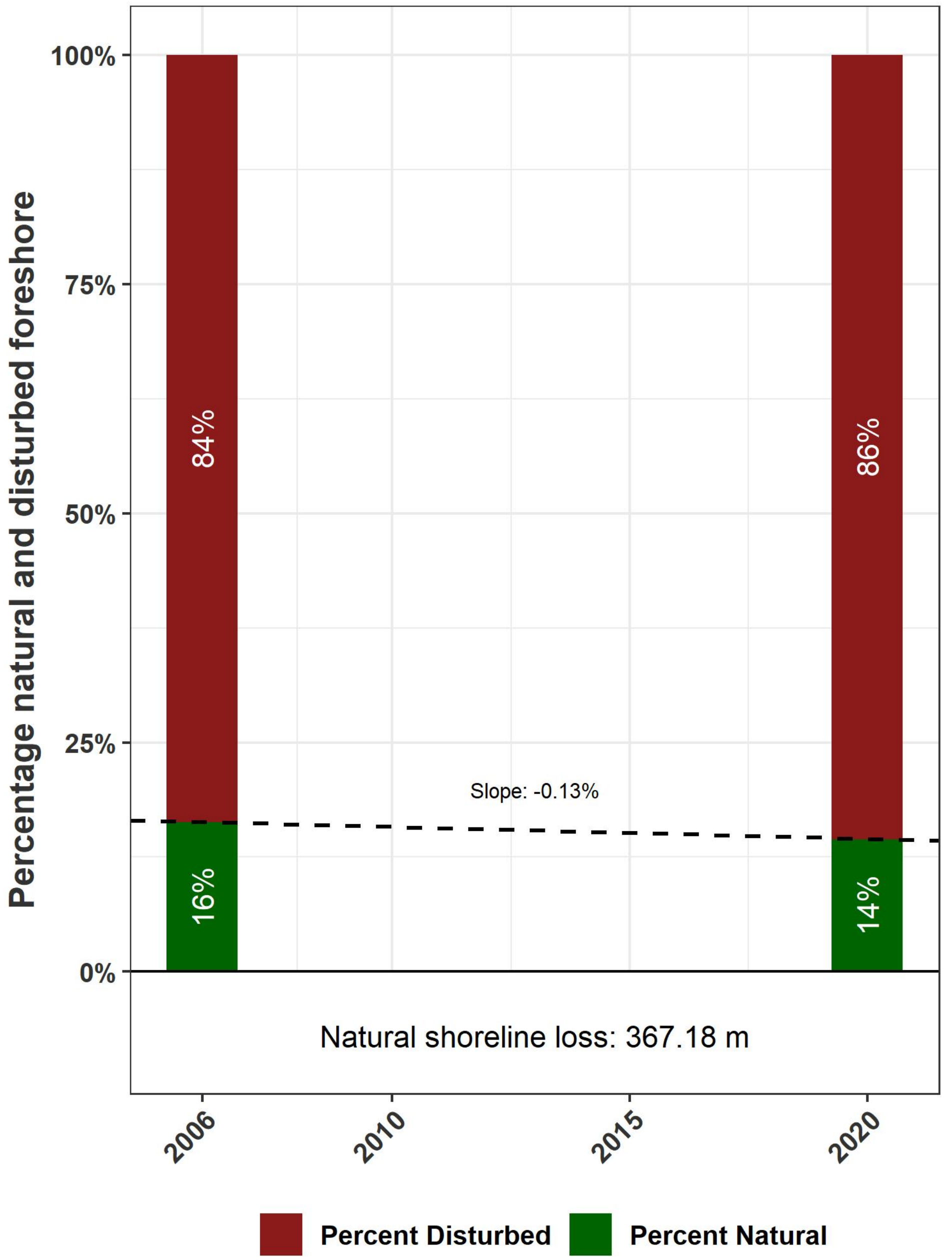

Figure 6. Shoreline disturbance in areas of gravel beach shore type.

Wetland shores comprised 24% of the shoreline. A large extent (77%) of these habitats remained in a natural condition, with no additional disturbance evident since 2006. These are high value fish and wildlife habitats and their continued preservation is considered important. The only observable impacts were mostly associated with mooring buoys placed impacting emergent vegetation.

Cliff/bluff shore type represented 15% of the foreshore. This shore type was largely intact, with 94% of the shoreline remaining in a natural condition. No new disturbances were evident since the 2006 inventory. This shore type was intact because of the challenges with construction in a steep environment. Cliff/bluffs were also largely within Indian Reservation land, which comprised a vast extent of the east side of the lake that was almost entirely undeveloped. Others area along the west side of the lake were protected in a sense by the railway, which likely made it more desirable to construct dwellings set further back.

Sand beach shore type was present along 7% of the lake. A high percentage of this shore type (70%) was disturbed, which was unchanged since 2006. Similarly to the gravel beach shore types, the disturbances were attributed to this shore type being present in easy to develop low elevation areas.

Stream confluences or mouths were present along the smallest extent of the foreshore (3% or 996 m). A large extent (46%) of this shore type has been disturbed, with 1% losses or approximately 2 m since 2006. Much of the historic disturbance observed was attributed to railway culvert installations; and development and modifications adjacent to the lake outlet, areas along Windermere Creek confluence, and two other smaller streams. Similar to other areas, losses observed were slow and incremental.

Maintaining and restoring stream mouth areas is considered important, both for fish and wildlife, similar to wetlands and other areas of high biodiversity and habitat value. Further, there is often additional benefits related to flood management and protection or property and infrastructure.

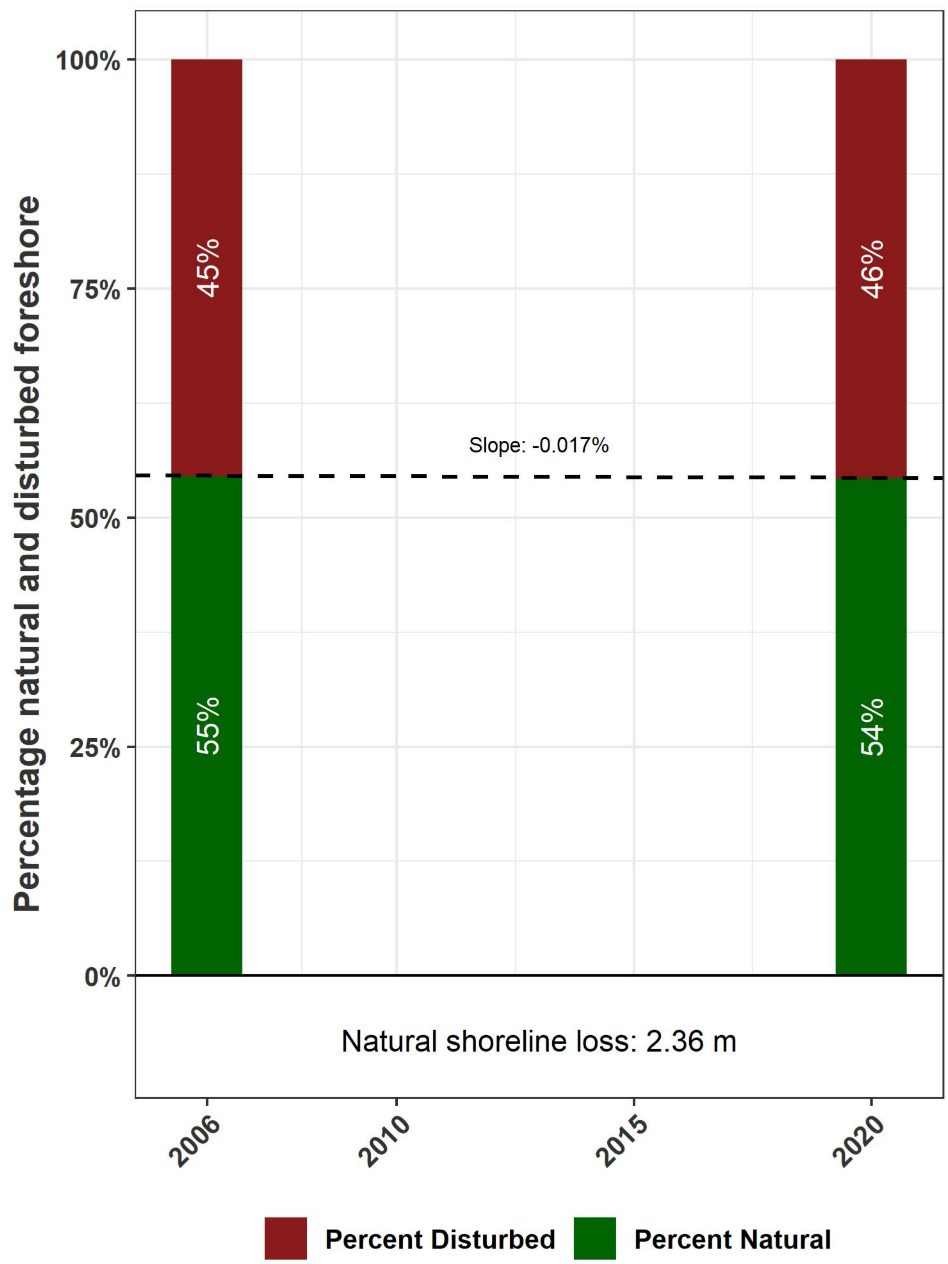

Figure 7. Shoreline disturbance in areas of stream mouth shore type.

3.4 Summary of Anthropogenic Modifications

There were several types of foreshore modifications present along the Windermere Lake shoreline (Figure 8). Since 2006, most of the modification counts increased in number. Observations attributed to modifications were:

- Docks were the most abundant modification. In 2020 there were 275 docks, representing a 35% increase since 2006. This was commensurate with the small, ongoing incremental changes observed in natural areas, as use and ongoing urbanization of the shoreline occurred. It is noted that count variation between years is probable, but this difference would be insufficient to account for the increase observed.

- There were 250 retaining walls in 2020, which was a 28% increase from 2006. Although verifying this number with explicit accuracy was challenging, an increase in quantity of retaining walls was observed, corresponding with other observed small and incremental changes along the shoreline.
- There were 101 boat houses, which represented a 17% increase since 2006. The observed increase revealed that ongoing incremental change continued to occur in urban zoned areas.

- There were 87 groynes observed in 2020, an increase of 58%. As above, the reconciliation of previous counts with historic ones was challenging, but it was suspected that more were present along the shoreline than in 2006.

- There were only 5 swim floats in 2006, and their numbers increased to 70 in 2020. This change was partially attributed to time of year of assessments, but also to the increased use of smaller, floating swim platforms that were more readily available for purchase. Similar to above, the specific numbers were less relevant than the observed increase.

- Marine rails and dock groyne data were not collected in 2006. In 2020, a total of 57 and 10 were observed, respectively (see example dock groyne below). At least some of the marine rails observed in 2020 appeared to have been old and/or associated with other structures (boat houses), and many were thus present for some time likely as far back as 2006.

- The number of boat launches also increased between 2006 than 2020. Concrete boat launches increased from 14 to 34, and gravel launches increased from 1 to 8. Most of these differences were likely due to the fact that counts in 2020 included small boat launches from boat houses on private properties. A reconciliation with appropriate Crown Land licenses or tenures was not undertaken, but it was assumed that appropriate rights to space were not obtained prior to construction, for this or most other modifications. Simple removal of concrete boat launches would easily restore lakebed disturbance in many areas. For instance, if 15 launches were removed, and each was 2 m wide and 3 m long, a total of 90 m^2 of lakebed habitat would be restored.
- The number of marinas remained unchanged, at 17.

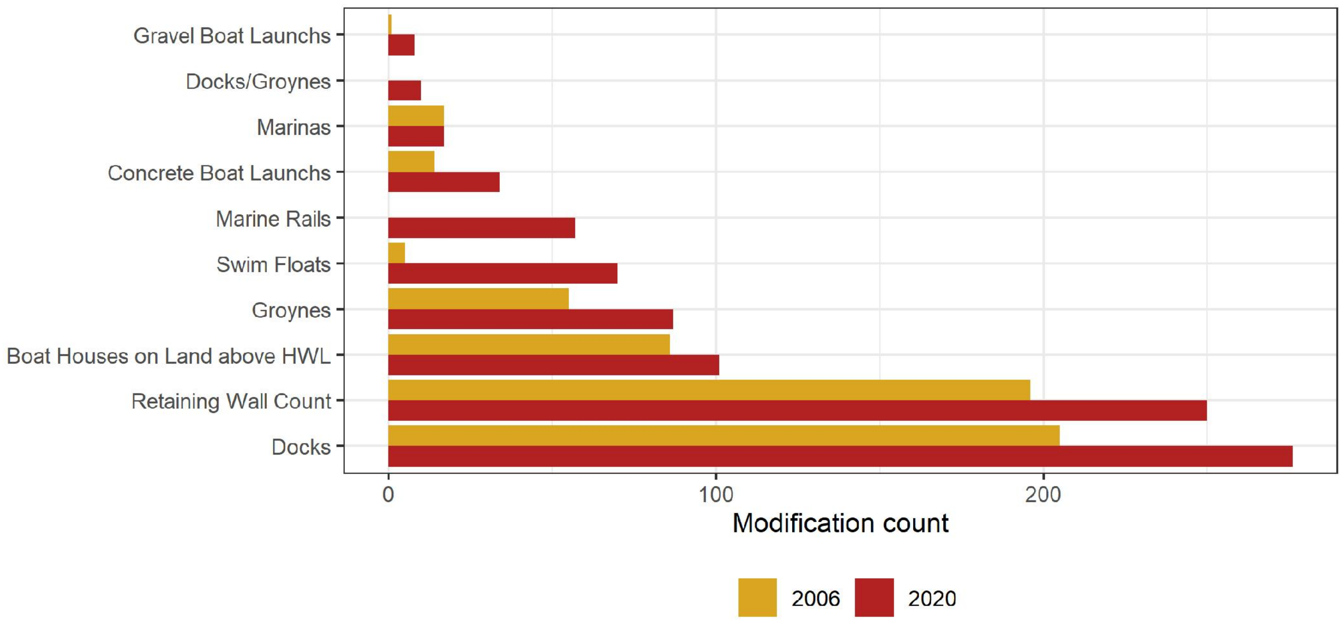

Figure 8. Total number of different shoreline modifications observed.

The extent of shoreline disturbance was reviewed for modifications that were assessed as line features in Figure 9, with the following observations:

- Substrate modification was the most apparent lakebed disturbance and was estimated to occur along 20,905 m or 56% of the shoreline. This modification was not assessed in 2006. Substrate modifications included importation of sand, significant movement of natural substrates or earthworks, and rail ballast deposition used for railroad construction.
- The estimated length of retaining walls more than doubled from 3,504 to 7,215 m (or 9 to 18%) between the study periods. It is suspected that a portion of this difference may be the result of observer biases or inaccuracies with data reconciliation from 2006 to 2020. While estimates may not be precise, the approximate overall length of shoreline covered by retaining walls has increased. This increase seemed commensurate with the apparent level of effort and expenditure by landowners to harden up their shoreline to protect them from erosion (e.g., using rip rap, or vertical structures). Extensive installations appeared to be a standard practice, especially at new builds. Restoration and removal of hard, vertical retaining walls for softer, bioengineered shorelines that allow natural shoreline processes to occur is recommended (see Section 5.0). In 2017, Okanagan Lake experienced significant flooding and during these events it was observed that hardened areas tended to experience more significant impacts than those with natural vegetation cover and a more natural floodplain area (Schleppe, J. personal observation from numerous Okanagan related flood restoration initiatives 2020).

- The railway occurred along 12,156 m or 32% of the shoreline. The railway ran along the near full extent of the west shore of the lake. It was assumed that there were no imminent plans to deactivate the railway, and that it would remain in place in perpetuity. The railway in some respects aided to protect the environment from urbanization. However, the railway did impact the shoreline, particularly stream mouth habitat since all crossings were culverts. The railway also isolated formerly connected backwaters and bay habitats. A detailed assessment of this habitat and identification of improvement opportunities are recommended (see Section 5.0). Opportunities may include replacing the closed bottom culvert crossings with open bottom structures.

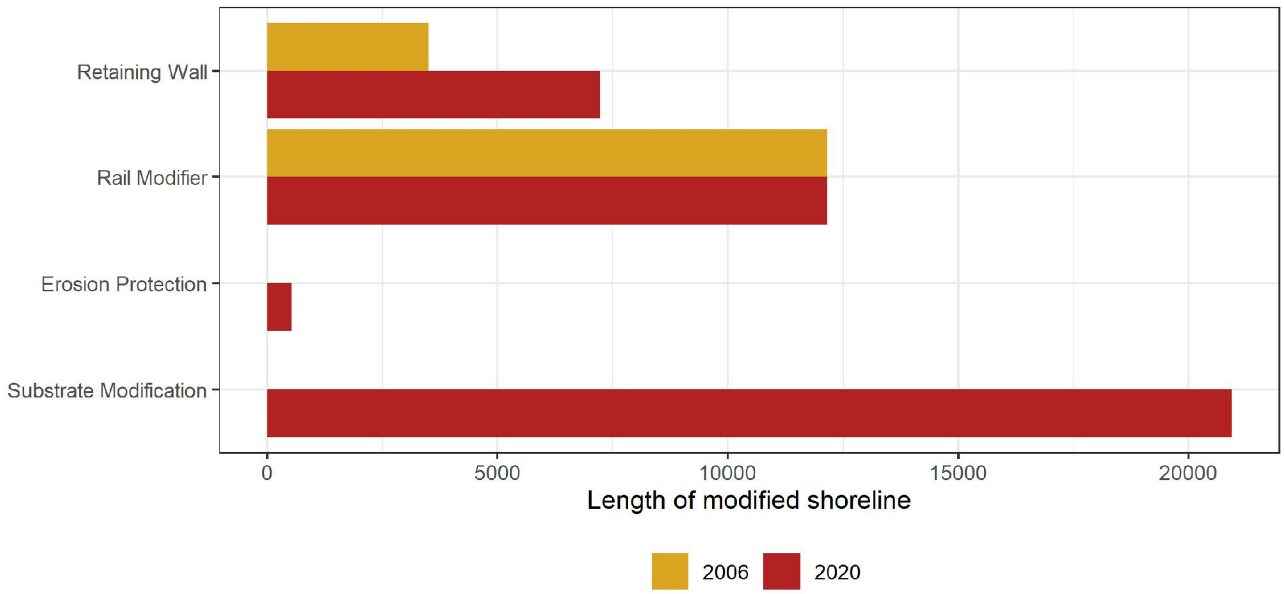

Figure 9. Foreshore length (m) of disturbance.

4.0 FORESHORE HABITAT SUITABILITY INDEX RESULTS

4.1 FHSI Criteria Development

The FHSI analysis considered each habitat category and their criterion weightings, in conjunction with their ecological values they support. These data were supported using the results of a literature review. The literature review identified that Windermere Lake has a variety of important fish, wildlife and ecosystem species and habitat values. A brief overview of these values is provided below, highlighting sensitive species. A detailed summary of species and/or habitat values that were selected as criteria for the FHSI is provided in Table 8.

4.1.1 Fish Overview

The Windermere Lake foreshore fish and wildlife habitat assessment (McPherson and Hlushak 2008) provides an in-depth literature review of fish species present, their life-history, and habitat use in Windermere Lake. The follow-up literature review conducted for this study identified that the bulk of fish and fish habitat assessment work on the lake was conducted prior to 2007, with little in the way of new information since. A summary of key existing information is provided below and relies heavily on the work completed in 2007 by McPherson and Hlushak (2008).

The fish species documented to be present in Windermere Lake include:

Native fish species:

- Bull Trout (*Salvelinus confluentus*),
- Rainbow Trout (*Oncorhynchus mykiss*),
- Mountain Whitefish (Prosopium williamsoni),
- Westslope Cutthroat Trout (*Oncorhyncus clarkii lewisi*),
- Burbot (*Lota lota*),
- Kokanee (*Oncorhyncus nerka*),
- Peamouth Chub (*Mylocheilus caurinus*),
- Torrent Sculpin (*Cottus rhotheus*),
- Largescale Sucker (*Catostomus macrocheilus*),
- Longnose Sucker (*Catostomus catostomus*),
- Longnose Dace (*Rhinichthys cataractae*),
- Redside Shiner (*Richardsonius balteatus*),
- Northern Pikeminnow (*Ptychocheilus oregonensis*).

Non-native species:

- Largemouth Bass (*Micropterus salmoides*)
- Pumpkinseed (*Lepomis gibbosus*).

Four of these species are considered sensitive. Bull Trout (interior lineage) and Westslope Cutthroat Trout are species of Special Concern in BC and under Committee on the Status of Endangered Wildlife in Canada (COSEWIC;Province of BC 2021). Westslope Cutthroat Trout are also a species of Special Concern throughout their range in British Columbia under the federal *Species at Risk Act* (SARA; Province of BC 2021). Burbot and Kokanee are regionally significant (M. Neufeld 2020 pers. comm.), with more specific information provided below.

Shoreline snorkel surveys conducted in the summer and fall of 2007 found Redside Shiners and Largemouth Bass to be most abundant (Table 5; McPherson and Hlushak 2008). Most species were present in low numbers. This was particularly evident for salmonids (or native sport fish), with similar findings in other studies on the lake (Westslope 2001, Urban Systems 2001, Griffith 1994). The limited use by salmonids was attributed to many factors, including: competition and predation by coarse fish species (the other native and non-native species listed above), urbanization and associated loss of habitat, overfishing, warm water temperatures, and sedimentation resulting from activities higher in the watershed (McPherson and Hlushak 2008). Salmonids likely only inhabit the lake for specific periods, such as spawning (in the tributaries), juvenile rearing, overwintering, and when migrating through to access other parts of the Columbia Watershed. The main tributaries to the lake with documented use for spawning are Windermere, Salter, Goldie and Abel creeks (Griffith 1994). Habitat in many of the other tributaries is likely limited by steep gradients (Griffith 1994).

Table 5. Snorkel survey results from 18 sites along the Windermere Lake shoreline in 2007 (McPherson and Hlushak 2008)

Family	Species	Percent of fish community	
		Jul 17-19 (n=2541)	Sept 25-26 (n =1066)
Salmonids	Bull Trout	-	0.2
	Mountain Whitefish	0.9	-
	Kokanee	-	2.0
	Unknown salmonid spp.	<0.1	
Minnows	Redside Shiner	84.1	95.7
	Northern Pikeminnow	-	0.5
	Unknown minnow spp.	5.2	0.3
Sunfish	Pumpkinseed	1.7	-
	Largemouth Bass	7.1	1.0
Sculpins	Sculpin species	0.2	-
Suckers	Largescale Sucker	0.1	0.4
	Unknown sucker spp.	0.2	-

Exotic species are often invasive, strong competitors for habitat and food, eat native fish, may introduce and support disease and parasites, and once introduced are hard to remove from a waterbody. The introduction of Largemouth Bass in particular, has likely been detrimental to the native species in the lake (Westslope 2001, Bissett pers. comm. 2008). Their presence poses a challenge to fisheries managers. On one hand they are suited to thrive in the warm waters[3], soft bottomed habitat, with its abundance of cover (both natural as vegetation, and floating manmade structures such as docks), and are sought by anglers. On the other hand, they pose a threat to the native fish species present on account of their voracious omnivorous appetite, and sheer abundance. In an effort to reduce their numbers, the BC Freshwater Fishing Regulations allow for unlimited harvest of Large Mouth Bass in Windermere Lake (Province of BC 2019), until it proves feasible to eradicate the species from the lake (J. Burrows pers. comm. 2021). Although a native fish species, Northern Pikeminnow is another predatory fish

[3] Water temperatures during the July 2007 snorkel surveys ranged from 19 – 25 °C (McPherson and Hlushak 2008).

species present in the lake, which can influence the success of other species (Taylor 2001, J. Bissett pers comm. 2008). Although this species was not abundant during the 2007 shoreline snorkel surveys, gill net surveys found it to represent 29% of the fish population (Griffith 1994). Like Largemouth Bass, this species is also tolerant of warm temperatures (McPhail 2007). The challenges these fish pose to native salmonids support habitat protection to give salmonids the best opportunity for success.

4.1.2 Wildlife and Ecosystems Overview

The shoreline areas have high wildlife and ecosystem values. The BC Conservation Data Center (BC CDC 2021) identified that there were numerous at risk plant and animal species and communities present at Windermere Lake (Table 6). Further, the detailed literature review identified several other species and habitats of importance. For example, the Bank Swallow (*Riparia riparia*) are a Threatened species under the SARA and data for this species was provided and used. Provincial Vegetation Resource Inventory data was loaded and was also used to help with determination of grasslands and other terrestrial habitats. Terrestrial Ecosystem Mapping data was not found in the review, but may exist. Many of the ecosystem values were carried forward from the previous assessment. More comprehensive details on wildlife and their habitats that were included in the FHSI are detailed in Table 8. As well, additional detail is available in the original study (McPherson and Hlushak 2008 and McPherson and Michel 2007).

Table 6. Species at Risk Occurrences for Windermere Lake (BC CDC 2021).

Species Group	Common Name	Scientific Name	BC Listing	COSEWIC Status	SARA Status (Schedule)
Vascular Plant - aquatic	Stiff-Leaved Pondweed	*Potamogeton strictifolius*	Blue	NA	NA
Vertebrate Animal - aquatic	Bull Trout	*Salvelinus confluentus*	Blue	Special Concern	NA
Vertebrate Animal - aquatic	Painted Turtle - Intermountain - Rocky Mountain Population	*Chrysemys picta pop. 2*	Blue	Special Concern	Special Concern (1)
Vertebrate Animal - terrestrial	American Badger	*Taxidea taxus*	Red	Endangere d	Endangered (1)
Ecological Community - terrestrial	Alkali Saltgrass - Foxtail Barley	*Distichlis spicata - Hordeum jubatum*	Blue	NA	NA
Vascular Plant - terrestrial	Saltwater Cress	*Eutrema salsugineum*	Blue	NA	NA
Vertebrate Animal - terrestrial	Lewis's Woodpecker	*Melanerpes lewis*	Blue	Threatene d	Threatened (1)

These wildlife and ecosystem data are also shown spatially on the maps. The FHSI table describes the mapping sources and intended interpretation and use. For example, specific bank swallow nesting locations were masked on the map deliverables but were used to differentiate general bank nesting habitat and known bank swallow nesting values.

4.1.3 Comparison to the original Zones of Sensitivity

We provide a comparison of the current 2020 and original 2006 ZOS (Table 7). The original FIMP identified several features as ZOS. Although all ZOS were mapped, only select features that were classified as Key Habitat Areas contributed to the segment colour zones in the FDG. Overall, when Key Habitat Areas occurred in segments with very high or high ecological values or when present on their own, the areas were designated as red or orange colour zones, requiring a development permit under the

RDEK OCP. The original Activity Risk Matric (ARM) identified risks for select development activities for each colour zone. In the ARM, if a species at risk was present the risk was elevated depending upon the activity. The current FDG uses a similar process.

The approaches used in 2020 to identify, rationalize, validate and incorporate ZOS into planning were more comprehensive. In 2020 FHSI considered more criteria because the former ZOS were considered and new ZOS data were available. Each of the former ZOS criteria aligned in the revised FDG. In 2020, ZOS were also mapped with improved spatial accuracy. For instance, previously, two important mussel beds were identified. In this study, mussels were documented in many areas.

In 2020, the updated methods were used with ZOS included directly in the FHSI, with each weighted accordingly (as per Schleppe et al. 2020 and as described in the methods section of this document). Each ZOS thus contributed to the overall segment ecological value, which in turn was also used to determine the FHSI Ecological Rank (and subsequent segment colour zone in the FDG). Additionally, in the ARM, the activity's risks were identified for both colour zones and areas where a ZOS was present. This may take some additional consultation to align with the OCP, but there is still a high level of overlap with original mapping and it is expected that adjustments would not be challenging to incorporate.

Table 7. Comparison of Current 2020 and Past 2006 ZOS, and areas that contributed to the FDG.

<table>
<tr><th rowspan="2">Current FIMP
ZOS
(contributed to FDG)</th><th colspan="2">Original FIMP</th></tr>
<tr><th>ZOS
(mapped only)</th><th>Key Habitat Areas
(contributed to FDG)</th></tr>
<tr><td>Backwater/Wetland</td><td rowspan="4">Wetlands</td><td rowspan="4">Natural shoreline (incl. most of SE end of lake, with avian bank nesting and wetlands)</td></tr>
<tr><td>Aquatic vegetation nesting</td></tr>
<tr><td>Waterfowl Migration Corridor</td></tr>
<tr><td>Avian Bank Nesting</td></tr>
<tr><td>Grassland</td><td>-</td><td>Native Grasslands</td></tr>
<tr><td>Burbot spawning or rearing</td><td>Gravel/cobble habitat for Burbot</td><td>-</td></tr>
<tr><td>Stream Confluence High value Kokanee Area</td><td>-</td><td>Creek Mouths</td></tr>
<tr><td>Mussel Presence</td><td>-</td><td>Biologically Productive Areas (2 masked mussel beds)</td></tr>
<tr><td>Connectivity Corridor</td><td>-</td><td>Wildlife Habitat and Corridors (incl riparian, badger linkages and select Elk winter range)</td></tr>
</table>

Table 8. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	ZOS	Rationale
FIM	Shore Type	No	Shore type describes the shoreline morphology and is related to many aspects of fish or wildlife productivity. Shore type values were determined using the initial habitat index that considered fish life stage habitat specificity (Schleppe and Arsenault 2006), and subsequent studies completed in the East Kootenay Region, including Windermere Lake (McPherson and Hlushak 2008). These values further considered the methods review completed on all lakes, where the general ranges in former habitat rankings were summarized for all lakes where an FHSI was completed (Schleppe et al. 2019). Finally, shore type was considered based upon the specific habitats observed around Windermere Lake. Stream mouth habitat was highly valued because it was limited on Windermere Lake and provides important spawning, staging and forage habitat for native fish (e.g., Burbot, Bull Trout and Westslope Cutthroat Trout, and Kokanee). Wetlands were also valued high for their fish rearing and avian values. Gravel and rocky shorelines supported emergent bulrush communities and were often proximal to deep water and coarse substrates. Cliff/bluffs were associated with high value emergent vegetation, as well as high value bird nesting habitat. Sand beach habitat was of the lowest value to fish and wildlife and was typically associated with more intensive recreation.
	Foreshore Substrate	No	Substrates relate directly to aquatic life productivity. Lakebed substrate provides key growth media for periphyton; and supports benthic invertebrate communities, fish foraging areas, shoreline spawning and other key habitat functions. Littoral substrates also support wildlife and avian fauna by providing a growth medium for emergent, submergent and floating aquatic vegetation. Substrates were evaluated considering Okanagan and Shuswap watershed studies (e.g., see summary Schleppe et al. 2019), and subsequent studies in the East Kootenay Region. The Windermere Lake studies were an important consideration (McPherson and Hlushak 2008). Foreshore substrates were assessed in two bands, foreshore and littoral (Schleppe et al. 2020). Overall, littoral substrates were ranked slightly higher than foreshore substrates in the FHSI because they provide the largest "footprint" for aquatic life, meaning they were more significant to lake wide productivity for all species. Spawning substrates (gravel and cobble) were valued highest, followed by foraging substrates (finer substrates). Cobble and gravel substrates were generally limiting, but supported important habitats including Kokanee spawning, Burbot rearing, and invertebrate production. Boulder, organic, mud, marl, and fines all supported aquatic vegetation, which in turn provided important forage and cover areas for fish, avian fauna and wildlife. On Windermere Lake, bedrock was not commonly observed, and provided less overall value than other lakes where it may be associated with spawning or deep refuge habitat. Sand had a lower biodiversity potential and was mostly associated with more intensive recreation areas and were ranked lowest (with there being the potential for imported material to be present).
	Littoral Substrate	No	
	Percentage Natural	No	The length of shoreline in a natural condition was determined for an approximate depth upland of 50 m, and this was used to determine the % natural for the segment. As the percentage of lake wide natural shoreline decreases, the inherent value of any remaining natural areas will increase. The % natural criteria has generally been lowered over time in FHSI because even disturbed habitat has value depending upon the level of urbanization present (Schleppe et al. 2019). It is noted that this criterion considers all categories of FIM data, and has some inherent overlap with other FIM criteria.
	Aquatic Vegetation	No	Native aquatic vegetation provides important habitats for fish and wildlife, including nesting, forage, biomass production, and cover. The % aquatic vegetation for each segment was determined using the cover of one or all aquatic vegetation types (submerged, floating and/or emergent). Overall, this criterion was weighted relatively low in the FHSI because of overlap with other criteria such as wetland shore types. This criterion specifically was not used in the original Windermere FIM (McPherson and Hlushak 2008), but was used in subsequent studies in the East Kootenay Region.
	Overhanging Vegetation	No	Overhanging vegetation provides important habitat function, such as cover, nutrient additions and forage opportunities. The weight assigned to this criterion in the FHSI was similar to past studies in the East Kootenay Region. This criterion was not included in the original Windermere Lake study.
	Large Woody Debris	No	Large woody debris (LWD) provides important cover for fish and also provides a variety of wildlife functions. The low weight assigned to this criterion reflects the small ecological contribution and presence of LWD in this large lake. Large woody debris was not included in the past study at Windermere Lake, or in other East Kootenay Lakes.
	Vegetation Band 1	No	Riparian vegetation provides important ecological values for both aquatic and terrestrial species. These values include food, cover, nesting areas, erosion protection etc. The original Windermere study only considered one Vegetation Band 1 width. This study considered both vegetation bandwidth and an estimate of vegetative quality values for the riparian Bands 1 and 2 that were included in the FIM dataset. Band 1 was the first distinct vegetation zone along the shore, while band 2 occurred immediately upslope of it. The two bands together represented a maximum 50 m width along the segment. Vegetation Band 1 was assigned a higher weight than Vegetation Band 2 because it contributed to shoreline fish and wildlife habitat to a greater extent.
	Vegetation Band 2	No	

Table 8. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	ZOS	Rationale
Fish	High Value Kokanee Area	Yes	The Province has identified Kokanee spawning habitat as high conservation value areas in the Rocky Mountain and Kootenay Lake Forest District (Neufeld pers. comm. 2021, Chirico 2005). The most recent Kokanee spawner counts upstream and downstream of the Athalmer Bridge were 2,500 in 2009 and 2,000 in 2008 (K. Bray pers. comm. 2021). Numbers have decreased with time in this area, with 15,000 spawners reported in 1995 in gravel outcrops at the lake outlet 50 m upstream and 200 m downstream of the Athalmer Bridge (Oliver 1995). ., Oliver (1995) also reported 1,500 Kokanee spawners in the lower 500 m of Windermere Creek and 50 fish in the lower 50 m of Goldie Creek. Kokanee may also utilize other shoreline areas for spawning. During the original Windermere Lake FIMP for example, 30 spawning Kokanee were evident 200 m upstream of the lake outlet along the cobble shoreline (McPherson and Hlushak 2008). The lake outlet was also formally classified as an important archaeological area (referenced as Salmon beds Archaeological Site EdQa 121), given its use as a campsite and food processing area for First Nations for over the last 1000 years (Royal BC Museum 1999).
	Mussel Presence	Yes	Native mussels are considered a fish under the Federal *Fisheries Act*, they hold First Nations traditional ecological value, and many populations are declining. Declines are largely the result of habitat loss or degradation. Most mussel species have a complex life cycle involving a fish host, free living form, and the more commonly observed mussel. Previous sampling on Windermere Lake has found *Anodonta californiensis/nuttalliana* clade (California/Winged Floater) mussels to be present (Moore and Machial 2007, McPherson 2020a and 2020b). The Anodonta species are evidenced by their singular "finger-like" papillae. Mussel presence in the original FIMP was noted in only a few sites (segments 11 and 16), and these sites were masked as Biologically Productive Areas and included in the FDG. This FIMP identified that mussels were present to a much greater extent around the lake. Marked points were compiled into polygons where mussel presence was expected. Only presence was used because mussel densities were not mapped.
	Burbot Spawning or Rearing	Yes	Burbot are considered a species of regional concern in the Columbia River system due to marked declines in their numbers (McPhail 2007). A conservation strategy for the upper Columbia River Burbot population (Golden to Columbia Lake) is anticipated to be developed, once the outcomes of the Upper Kootenay River Burbot Conservation Strategy are realized (East Kootenay Burbot Scientific Working Group [EKBSWG] 2019). In lakes and rivers, Burbot generally spawn in shallow depths (0 to 10 m) over a variety of substrates from silt and sand to coarse gravel and cobble (McPhail and Paragamian 2000). At Winderemere Lake, Burbot historically spawned by the hundreds in weed beds at the Windermere and Goldie creek mouths and other areas of the lake with macrophytes (Westlope 2001). At Windermere Lake and other lakes in the East Kootenays, peak spawning occurs in the middle of February (Arndt 2001, EKBSWG 2019). Studies in Columbia and Windermere lake found juvenile Burbot to be strongly associated with interstitial spaces in the substrate. Shoreline with gravel and cobble substrates were the preferred habitat for age 0 burbot, while older juveniles were associated with larger substrates of cobble and boulders (Taylor 2001 and 2002). Where aquatic vegetation was utilized, extensively branching species such as bushy pondweed (*Najas flexis*) was preferred (Taylor 2001). The western shoreline of Windermere Lake has been found to provide juvenile burbot habitat (mean density was 4.5 age 0 burbot/100 m, and 0.6 age-1 burbot/100 m; Taylor 2002). For this reason, the outlets of Windermere Creek and Goldie Creek, and shoreline with gravel/cobble habitat and low %fines (<10%) were mapped and reported as being high value in the original Windermere FIMP and were included in this dataset. In addition, areas with proximal deep-water habitat that also had similar substrates to the western shore were considered possibly important to Burbot and were included.
Wildlife	Den / Burrow / Wildlife Tree Observation	No	Observations of wildlife trees, dens, or possible burrows were included in the FHSI. While not all possible trees, dens, or burrows were identified or verified, these observations are considered relevant and contributing to lake wide wildlife productivity. The American Badger is a sensitive species, known to inhabit the Windermere Lake area, and may have prepared some of the dens identified. The American Badger is classified as Endangered federally (Schedule 1 SARA 2018) and provincially (Province of BC 2021b). Windermere Lake lies in a large corridor of known habitat, which extends throughout the Rocky Mountain Trench from the US border near Newgate through to Spillimacheen (Province of BC 2021b). Badgers have been mapped Some relevant habitat details are as follows (BC Water Land and Air Protection [BC WLAP] 2002): "*Females raise their young in dens from late winter through spring. A maternal den is evidenced by a large mound of soil at the entrance, with droppings and shed hair. From late June to August, juvenile Badgers begin to disperse in search of suitable home ranges of their own, which may take them up to 100 km from their birth area and involve crossing rivers, highways and farmland. This is the period of highest mortality for Badgers. In BC, their main prey is Columbia Ground Squirrels, but they are opportunistic and eat a variety of other small animals (rodents and reptiles)*".
	Avian Bank Nesting Locations	Yes	The Bank Swallow (*Riparia riparia*) is a Threatened species under the SARA, that has documented nesting sites along the shoreline of Windermere Lake (Darvill 2021). Bank Swallows generally arrive at their breeding grounds in North America during early spring and depart late summer to midfall. Bank Swallows have high site fidelity if nests were successful the previous year (BC CDC 2021, Darvill pers. comm.). At Windermere Lake, nests were present in steep sand/gravel banks, near the top of the bank, along the edge of the water. Due to their sensitivity, known Bank Swallow nesting locations were masked. Known Bank Swallow nests were valued higher than other general bank nesting locations, which either had past nesting evidence or potential for nests for Bank Swallows or other species. If a project is planned in an area marked as having avian bank nesting, the QEP is to refer to the GIS database to confirm if Bank Swallow nesting habitat is present, as this is where the masked data resides for this sensitive species.

Table 8. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	ZOS	Rationale
Waterfowl	Aquatic Vegetation Nesting	Yes	Surveys in the Columbia Wetlands have documented Lake Windermere as important bird habitat when compared to the rest of the Columbia Wetlands ecosystem (Darvill 2019). Darvill (2019) summarized the significance of Lake Windermere to birds, as follows "Bird data retrieved from an online database indicates that 165 bird species have been detected at Lake Windermere, with 17 of these species considered to be at-risk." The south end of the lake lies within the Columbia Wetlands Wildlife Management Area (the WMA). As outlined by the Province of BC (2021c), "The WMA was established for the conservation and management of fish and wildlife habitats and landscape connectivity so that the Columbia River Wetlands continues to function as a natural floodplain ecosystem. Several species of birds that make floating nests were observed, including several grebes (e.g., Western Grebe (*Aechmophorus occidentalis*) listed as Special Concern by COSEWIC). Large wind and wave events or waves generated from boats can cause nests to become submerged. For this reason, areas of possible nesting were identified using the floating and emergent data sets, looking for areas with large coverage such as the south end of the lake, where nesting and foraging opportunities were most probable. All these areas were digitized from the large expanses of floating and emergent vegetation data collected in this study to inform areas most likely important to waterfowl that nest using floating platforms. These data can be spatially updated as more specific nesting survey data becomes available, and these areas are only considered possible nesting locations. Actual nesting may vary from data presented.
	Migration Corridor	Yes	As outlined by the Province of BC (2021) "*The WMA is an important component of the Pacific Flyway, a waterfowl migration route stretching from nesting areas on the Arctic Ocean to wintering grounds in South America. The WMA is adjacent to the Columbia River, extending 180 km from Canal Flats to the head of the Mica Reservoir, north of Donald*". Darvill (2019) further described that "*The south end of the lake has consistently had large concentrations of staging waterfowl during migration and had the highest single day bird counts resulting from a regional coordinated bird count (i.e. Columbia Wetlands Waterbird Survey). When compared across 105 survey stations in the Columbia Wetlands, the south end of Windermere Lake appears to contain the most important staging area within the continuous wetlands ecosystem for at-risk grebe species, as well as for other bird species such as American Coot. Creek mouths at Windermere Lake are also important habitat for birds, especially for migrating shorebirds.*" The south end of the lake and the Windermere Creek mouth (due to it being the largest tributary) were digitized to inform areas most likely important to migrating waterfowl. These data can be spatially updated as more specific waterfowl staging density data becomes available. These areas are only considered possible locations based upon data available using airphoto interpretation and associated aquatic vegetation data collected in this study.
Ecosystem	Grassland Ecosystem	Yes	The following summarizes some of the unique and sensitive values grassland ecosystems (Grassland Conservation Council of BC [GCCBC] 2018): "*Grasslands cover less than one percent of the province. Their rarity is largely due to loss or fragmentation of habitat. Where they remain, grasslands are frequently impacted by other causes including: invasive species, ranching/hay fields, industrial development grazing, recreation, forest encroachment, and fire suppression. Many animals use grasslands for at least parts of their life cycle, and most of BC's species at risk are found in the grasslands. In the Kootenay Region, grasslands provide high-quality wildlife habitat, and in many areas provide critical ungulate winter range. Much of the grassland area in the Rocky Mountain Trench is on private land and is considered to be a rare or at-risk ecosystem.*" Examples of mapped sensitive species that are associated with grasslands along the shoreline of Windermere Lake are the American Badger (see Wildlife dens/burrows/trees above) and Lewis's Woodpecker. Lewis's Woodpecker is listed as Threatened federally (SARA Schedule 1, 2012), and Special Concern provincially (blue listed), and has been documented utilizing grassland habitat south of Goldie Creek (Province of BC 2021b). These high value habitats were mapped using the RDEK Official Community Plan areas, BC Provincial Grasslands layers, and Vegetation Resource Inventory data. A composite layer was created using all data layers.
	Wildlife Connectivity Corridors	Yes	Connectivity to habitat is important for wildlife immigration and emigration. Connectivity and any specific habitat requirements to facilitate this process varies by species. As outlined in the original FIMP (McPherson and Hlushak 2008): "*Foreshore areas are highly productive and diverse, providing important foraging and refuge habitat for wildlife. They also provide a critical link between aquatic and terrestrial ecosystems. Maintaining the habitat and unrestricted access to upslope habitats is thus important*." In accordance with the original FIMP and the RDEK OCP, this ZOS includes connectivity corridors for wildlife in general, riparian habitat of creeks, linkages for Badger movement and important high value ungulate winter range (RDEK 2019 and McPherson and Hlushak 2008). The badger linkage is provided by the BC Hydro right-of-way, Copper Point Golf Course and Holland Creek drainage. The ungulate winter range of note is located along the southwest facing slopes and includes riparian and shoreline areas. These original FIMP and OCP should be referenced for further specifics by area. These high value habitats were mapped using the RDEK Official Community Plan areas. Additional areas included the mapped occurrence of Painted Turtle in Dorothy Lake in Kinsmen Park. The Painted Turtle - Intermountain - Rocky Mountain Population is listed as a species of Special Concern both federally (SARA Schedule 1, 2007), and provincially (blue listed) (Province of BC 2021b).

Table 8. Summary of FIM, ZOS and modification criteria and rationale for inclusion in the FHSI.

Category	Criteria	ZOS	Rationale
	Wetlands	Yes	Emergent shore wetlands were present in many areas of Windermere Lake. These areas ranged from simple emergent bulrush areas to very complex habitats with submergent, floating and emergent vegetation at the south end of the lake identified in the WMA. There were also several backwater wetlands identified, located behind rail fill that were likely historically connected to the lake. Wetlands provide valuable fish and wildlife habitats. For example, sampling during the original FIMP found Mountain Whitefish fry in the vegetated/wetland habitat in Segment 25 (Cemetery/Hidden Bay shoreline area), and juveniles and subadults in the wetlands at the south end of the lake (McPherson and Hlushak 2008). Wetland areas were identified as all areas that were either mapped as emergent or floating vegetation, and those that were in backwater wetlands.
Rare Occurrences	Red or Blue Listed Community	No	Red listed refers to any species or ecosystem that is at risk of being lost (extirpated, endangered or threatened). Blue listed refers to any species or ecosystem that is of special concern. The following Red or Blue Listed species were considered: Alkali Saltgrass - Foxtail Barley (B), Lewis's Woodpecker (B), Painted Turtle - Intermountain - Rocky Mountain Population (B), Stiff-leaved Pondweed (B). American Badger (R) was also identified but was not included in the numerical weighting because its habitat areas covered the entire lake shoreline. All these data layers were obtained from the BC Datawarehouse. Sensitive species present and rankings are updated and change with time. During a proposed review, the qualified environmental professional (QEP) will need to look up the species accounts for further details using the BC Species and Ecosystems Explorer (Province of BC 2021b). Sensitive species can change with time as more information becomes available. We noted that some species that were ranked as sensitive in the original FIMP were no longer listed (i.e., Scarlett Globe Mallow and Hookers Townsendia) (Province of BC 2021b).
Modifications	Retaining Wall	No	Retaining walls influence fish in a variety of ways and are indicative of further shoreline urbanization (see methods for rationale).
	Docks	No	Dock influence fish in a variety of ways and are indicative of further shoreline urbanization (see methods for rationale).
	Groynes	No	Groynes influence fish in a variety of ways and are indicative of further shoreline urbanization (see methods for rationale).
	Boat Launch	No	Boat launches influence fish in a variety of ways and are indicative of further shoreline urbanization (see methods for rationale).
	Marina	No	Marinas influence fish in a variety of ways and are indicative of further shoreline urbanization (see methods for rationale).
	Substrate	No	Substrate modification or foreshore or littoral lakebed substrates can impact fisheries and wildlife productivity in numerous ways. Highly urbanized shoreline areas typical experience the most substrate disturbance, which can often dislodge emergent or riparian vegetation. This was also included to reflect the observed impacts from rail ballast along the western shoreline.

4.2 Summary of FHSI Calibration

Several iterations (i.e., > 25) of the FHSI analysis were run, each with the weightings adjusted for each criterion to assess the resulting FHSI Ecological Ranks. The results from each iteration outcome and the results of each output were kept in a log for reference. For each iteration, the following items were considered to aid in determination of the final weighting for a criterion:

1. The Ecological Ranks assigned to each habitat segment (and how well they mirrored the professional opinions of the project team).
2. The appropriateness and defensibility of the associated weightings (by category and criterion).
3. The range of the resulting final FHSI scores and how individual criterion or habitat categories could affect the FHSI and act to differentiate habitat values along the shoreline.
4. The identified FHSI score for each segment were categorized between Very High, High, Moderate, Low and Very Low by identifying the largest gap in a histogram of FHSI scores to identify the FHSI Ecological Ranks.
5. Total percentage of shoreline for each FHSI Ecological Rank for each land use type, to understand the influence of FIM attributes and influence of modifications in the FHSI Ecological Ranks.
6. Total percentage of shoreline for each FHSI Ecological Rank for each shore type to understand the influence of shore type using multiple different lines of evidence from habitat categories. For instance, Waterfowl criteria tended to trend with a high level of aquatic vegetation cover in conjunction with wetland or stream mouth shore types.

In running these different iterations, the following broad trends were observed:

1. There was a high degree of spatial overlap between ZOS used to weight some of the FHSI Categories (e.g., Ecosystem, Wildlife, and Waterfowl) and FIM attributes such as shore type and substrate. Since ZOS were treated as binary variables (e.g., present or absent from a habitat segment), weighted similarly across Categories, and overlapped extensively, it was apparent that "duplication" in values may be occurring. These criteria were considered both individually, and as a group in review. The final weightings given to ZOS attributes were reduced to account for duplication but were kept to document known presence of high value habitat areas.
2. The values of FIM attributes, such as shore type and substrate were increased because they provided simple physical descriptions of a broad range of habitat values observed that were apparent in many of the ZOS. There were many different criteria and data available for Windermere Lake. With so many habitat categories present, it was apparent that the FIM dataset needed to have a reasonable influence (meaning a high proportion of the weighting) to better reduce overlapping values to reduce "duplication" in criteria while still considering important ZOS.

3. Important fisheries areas tended to occur in smaller, isolated areas. Some of these areas also overlapped with a greater level of urbanization. As a result, the Fish ZOS Category was generally weighted higher than the Ecosystem, Wildlife, and Waterfowl Categories. It was suspected these small areas were more of a habitat limiting factor than those for other habitat categories.

Table 9 presents all the FHSI criteria considered, and the associated methods used to include them in the FHSI. Mapping provided in Appendix B shows base data that were considered.

Table 9. Summary of criterion and method of incorporation into the FHSI.

Category	Criteria	Percent Within Group	Logic	Uses Weighted FIM Data	Value Categories	Percentage of FHSI
FIM	Shore Type	41.3%	% of Segment * Percentage of FHSI	Yes	Stream Mouth = Wetland (1) > Gravel Beach = Rocky Shore = Cliff /Bluff (0.8), > Sand Beach (0.5), > Other (0.3)	26
	Foreshore Substrate	12.7%	% Substrate * Percentage of FHSI	Yes	Cobble = Gravel (1) > Boulder = Organic = Mud = Marl = Fines = (0.8), > Bedrock (0.5), > Sands (0.3) >	8
	Littoral Substrate	15.9%	% Substrate * Percentage of FHSI	Yes	Cobble = Gravel (1) > Boulder = Organic = Mud = Marl = Fines = (0.8), > Bedrock (0.5), > Sands (0.3) >	10
	Percentage Natural	7.9%	% Natural * Percentage of the FHSI	No	N/A	5
	Aquatic Vegetation	7.9%	% Submergent * (0.5 *Percentage of the FHSI) + % Emergent * (0.5*Percentage of FHSI)	No	N/A	5
	Overhanging Vegetation	1.6%	% Overhanging Vegetation * Percentage of the FHSI	No	N/A	1
	Large Woody Debris	1.6%	# of Large Woody Debris/km * Relative Value * Percentage of the FHSI	No	15 LWD (1) > 10 to 15 LWD (0.8) > 5 - 10 LWD (0.6) > 0 - 5 LWD (0.4) > 0	1
	Vegetation Band 1	7.9%	Vegetation Bandwidth Category * Vegetation Quality * Percentage of the FHSI	Yes	Vegetation Bandwidth Category 20 m (1) > 15 to 20 m (0.8) > 10 to 15 m (0.6) > 5 to 10 m (0.4) > 0 to 5 m (0.2)	5
	Vegetation Band 2	3.2%	Vegetation Bandwidth Category * Vegetation Quality * Percentage of the FHSI	Yes	Vegetation Quality Category Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (1) > Coniferous Forest = Mixed Forest (0.8) > Herbs/Grasses = Unvegetated (0.6) > Lawn = Landscaped = Row Crops (0.3) > Exposed Soil (0.05)	2
Fish	High Value Kokanee Area	45.5%	Present (1), Absent (0)	No	Present (1), Absent (0)	5
	Mussel Presence	27.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	3
	Burbot Spawning or Rearing	27.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	3
Wildlife	Den / Burrow / Wildlife Tree Observation	33.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	1
	Avian Bank Nesting Locations	66.7%	Confirmed Bank Swallow (1), General Bank Nesting (0.5), Absent (0)	No	Present (1), Absent (0)	2
Waterfowl	Aquatic Vegetation Nesting	57.1%	Present (1), Absent (0)	No	Present (1), Absent (0)	4
	Migration Corridor	42.9%	Present (1), Absent (0)	No	Present (1), Absent (0.5)	3

Table 9. Summary of criterion and method of incorporation into the FHSI.

Category	Criteria	Percent Within Group	Logic	Uses Weighted FIM Data	Value Categories	Percentage of FHSI
Ecosystem	Grassland Ecosystem	33.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	2
	Connectivity Corridors	33.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	2
	Wetlands	33.3%	Present (1), Absent (0)	No	Present (1), Absent (0)	2
Rare Occurrences	Red or Blue Listed Community	100.0%	Present (1), Absent (0)	No	Present (8), Absent (0)	3
Modifications	Retaining Wall	14.3%	% Retaining Wall * (Percentage of the FHSI)	No	N/A	1
	Docks	7.1%	High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI)	No	A histogram of Dock Density per km using segment data was used to categorize density as High, Moderate, and Low.	0.5
	Groynes	7.1%	High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI)	No	A histogram of Groyne Density per km using segment data was used to categorize density as High, Moderate, and Low.	0.5
	Boat Launch	28.6%	High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI)	No	A histogram of Boat Launch Density per km using lake segment data was used to categorize density as High, Moderate, and Low.	2
	Marina	28.6%	High = Percentage of the FHSI, Moderate (0.75*Percentage of the FHSI), Low (0.5*Percentage of the FHSI)	No	A histogram of marina total from segment data was used to categorize density as High, Moderate, and Low.	2
	Substrate	14.3%	% Substrate Disturbance * % FHSI	No	N/A	1

4.3 Summary of FHSI Shoreline Rankings

The output of the FHSI was a relative Ecological Rank assigned to the entire lake foreshore for each FIM habitat segment. This result is best viewed on a map (see Appendix B and Figure 11). Figure 10 summarizes the FHSI data, showing the range of scores and values where habitat rankings between each FHSI Rank were split. A summary of the percentage of shoreline for each FHSI rank and for each shore type broad land use category is also presented. Figure 11 presents a summary of the FHSI results in map format at a large scale to portray ecological ranks for the entire shoreline.

The FHSI ultimately identified numerous important and high value areas around Windermere Lake. Spatial patterns in areas of higher value emerged with the iterative results during calibration. With each iteration of the index, it was possible to visually assess the patterns in the FHSI rankings that resulted from the different criteria, their presence, and their weightings. This process also helped identify criteria that trended together from duplication, such as wetland shore types and waterfowl criteria.

The FHSI identified that 30% of shoreline had a Very High Ecological Rank, and 23% of the shoreline had a High rank, which translates to approximately 11,270 m and 8,751m of shoreline respectively. The location of the break between High and Very High was challenging to determine because of longer shoreline segments in more natural areas. In the top part of the Figure 10, the length of the line indicates the relative shoreline length. Many of the segments in the Very High category were longer in nature, which tended to skew the relative distributions of shoreline lengths.

The areas of Moderate ranked shoreline accounted for 30% of the shoreline or 11,261 m. These areas occurred in locations that had fewer overlapping ZOS's or were areas with important ZOSs that were impacted by development. These areas were represented by all shore types, but were more prevalent in areas of multi family, single family, or urban parkland developments.

Areas of Low and Very Low Ecological Rank occurred along 17% or along 6,118 m of shoreline. These areas occurred predominantly in areas of increased development intensity, such as multi family areas. This was expected, as areas with more intense development often lose many of the habitat values that were originally present, highlighting the importance of protection of natural areas in any development process.

The FHSI criteria used in the index, regardless of iteration, identified the following larger scale patterns, which are considered important ecological results:

1. The south end of Windermere Lake was important for aquatic and terrestrial species. The criteria considered in the FIM attributes and in Ecosystems, Waterfowl, and Wildlife Categories all identified this region as important. During iterations, these segments were always ranked Very High or High range depending upon how criterion were valued.
2. Kokanee spawning areas were limited, and often overlapped with areas of increased urbanization, particularly at the lake outlet. Nonetheless, habitats

with these Kokanee spawning areas were generally ranked in the High or Very High range, depending on the index weighting for the iteration. Appropriately weighting the Kokanee ZOS was very important, since these habitats were often urbanized, and urbanized areas generally had lower overall FHSI values. This was accomplished, at least in part, by weighting the Fish ZOS higher than those for Ecosystem, Wildlife, and Waterfowl Categories (see Section 4.1).

3. The west side of the lake had many important habitats. This was because these segments had many of the different ZOS present, and the shoreline type was gravel beach, which had higher fish habitat value.
4. Urban areas with sand or gravel beach habitat were generally ranked lower by the FHSI due to the level of disturbance. This result was evident despite the inherent positive value of gravel for fish for spawning or foraging, for example (i.e., FIM Shore type Gravel Beach had a high influence in the FHSI).
5. The highly urbanized parklands in Kinsmen Beach were an identified migration corridor for the Western Painted Turtle. However, this site was not identified as a very high value segment overall. This was because there were no other habitat factors such as Bank Nests, or Waterfowl Nesting or Migration features present in either the neighboring urbanized area or within the large public beach. The lower FHSI value does not infer no value or that habitat should not be considered. Rather, the lower FHSI ranking infers that this area had lower value when comparted to other areas of the lake. Interestingly, adjacent single-family areas tended to have lower overall values than the beach, due to a greater level of disturbance and smaller overall riparian bands, etc. This distinction between the FHSI value ranking is important to consider, and more so, on lower valued segments that may still have residual and important habitats still present.

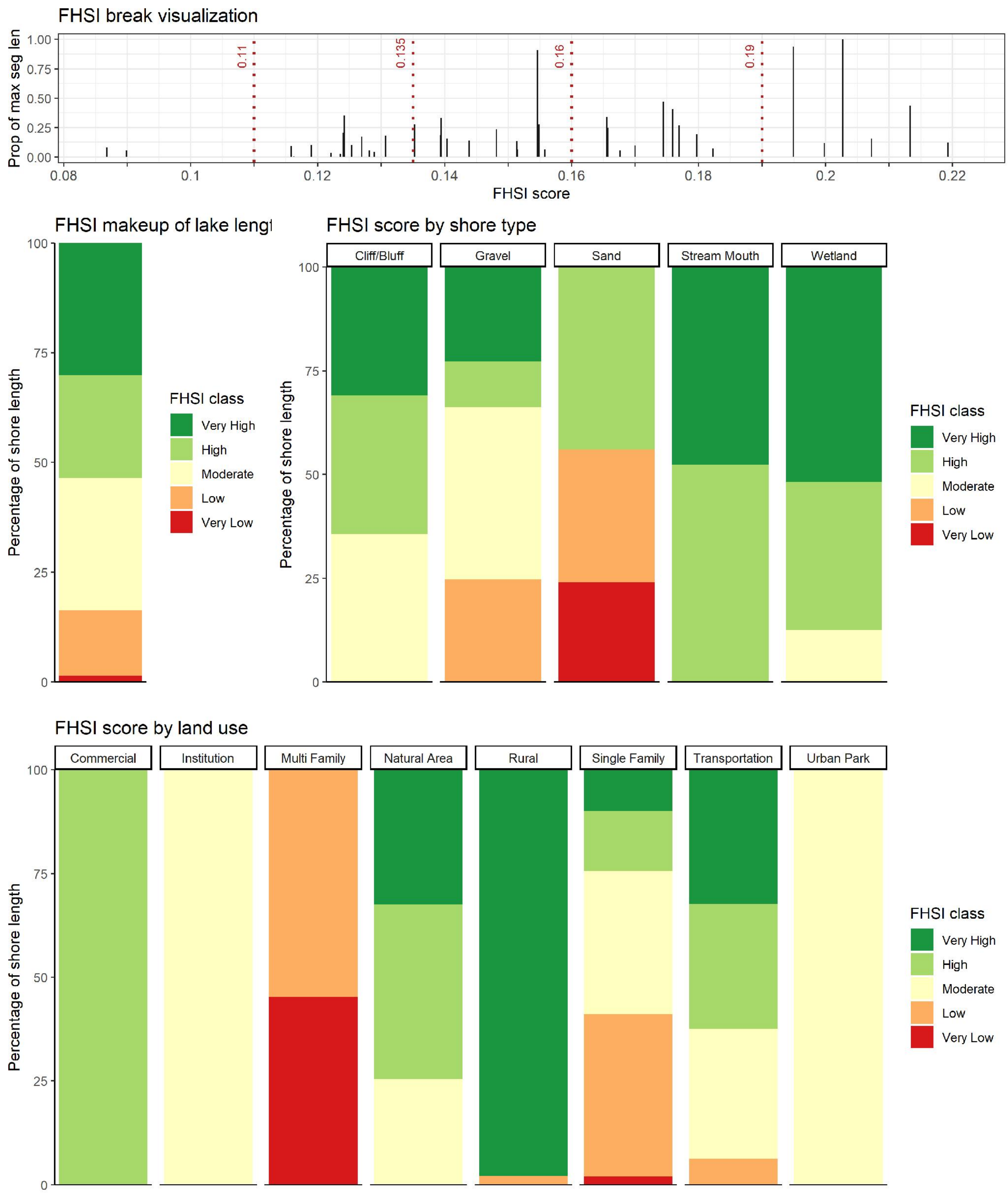

Figure 10. Overview of FHSI Habitat Rankings summarized as Percent of the Shore Length.

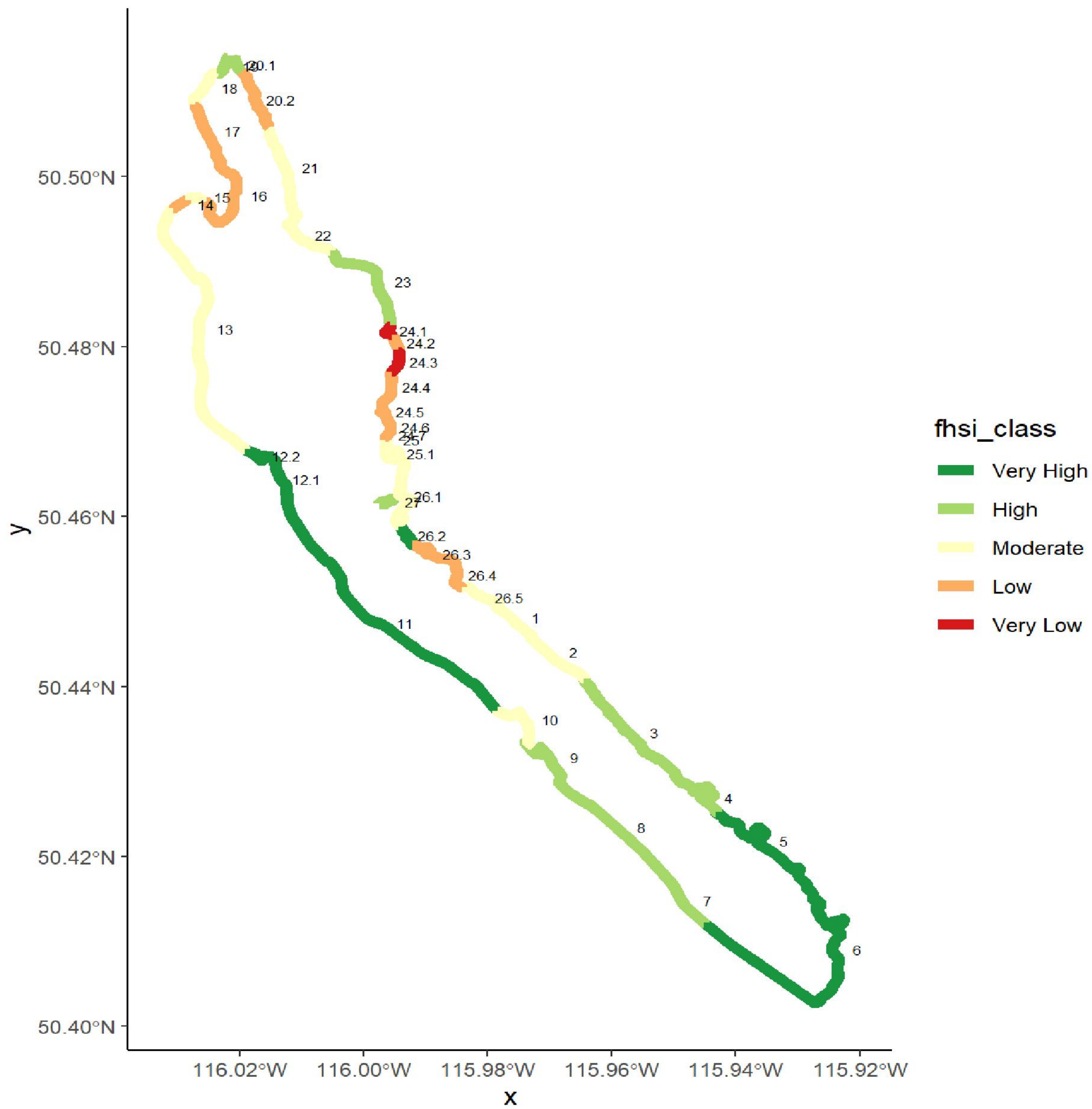

Figure 11. Overview of FHSI Habitat Rankings for Windermere Lake

5.0 CONCLUSIONS AND RECOMMENDATIONS

The FIM showed that the rate of change of loss of natural shoreline was approximately 0.18% per year, consistent with a shoreline that has not experienced significant new development of rural or natural areas. In areas of re-development, restoration was not commonly observed. The data suggest that there were still several, high value areas remaining, and protection of these resources is important. This assessment can act to help document ongoing, long term changes surrounding the lake to help aid in long range land use planning at the local, Provincial and Federal levels of government. An integrated response to lakeshore and ultimately watershed management planning is imperative if these areas are to function ecologically and provide fish and wildlife habitat .

General recommendations to help protect, conserve, and better manage urban impacts on the foreshore of Windermere Lake are provided below. These recommendations highlight that efforts should focus on finding ways to integrate lakeshore planning across and between all levels of government and First Nations. Also, restoration should be highly promoted. The best habitat improvements include re-naturalizing or softening the shoreline on a lot-by-lot basis using riparian restoration, floodplain restoration at important stream confluence and wetlands, and bioengineering. Recommendations are categorized and are generally directed to different levels of government.

5.1 Land Use Policy and Lakeshore Planning

5.1.1 All Levels of Government

1. All agencies need to work in collaboration. Federal and provincial agencies are to work with local government and First Nations to help implement important tools available within existing legislation, such as the *Water Sustainability Act*, *Land Act*, *Fisheries Act,* or an OCP. These pieces of legislation can act together as part of a larger, more regional approach to watershed planning that considers the tools and legislation each agency has available. It is important to link these planning documents with other tools in an integrated management plan because no one level of government has all the tools necessary to appropriately plan and manage lake shoreline areas.
2. Incorporate all ZOS into revised planning documents such as OCPs, bylaws, or other policy documents as appropriate. Many of the original ZOS were updated with more spatial accuracy. Others were added based upon new data and GIS work associated with this project. These ZOSs are intended to identify areas of conservation priority, and are, at minimum, to act as preverbal flags so that government can understand quickly where important habitats may exist. For instance, the *Federal Fisheries Act* protects all fish, and mussels are included as fish in this definition (see Section 2 of Federal Fisheries Act for definition of a fish, which includes all shellfish). Thus, it is important for all agencies to

understand where this habitat is. This recommendation pertains to local, Provincial and Federal governments.

3. There appears to be very little government effort/funding that goes into enforcement and compliance, including of Crown land encroachments, mooring buoys and adherence to navigational standards, best management practices, OCP adherence in DPAs, or the *Water Sustainability Act* in the region. Increased effort and funding should go towards this, similarly to what is being done in the Okanagan, Shuswap, and coastal regions.

5.1.2 Local Government

4. Use the environmental information to update the Official Community Plans, and associated Development Permit Area designations for Windermere Lake to help identify, plan, and design around these important biological features. ZOSs should be identified as areas for conservation. lso, consider this information for Regional Growth strategies, and other planning and policy tools. Where possible, link these planning documents with other regulatory tools (see recommendation 1).

5. Carefully consider any permit applications that will densify the shoreline or further urbanize it. Many remaining rural areas were deemed of Very High or High value and were typically overlain with ZOS. Regardless of protection measures, it has been observed that slow, incremental losses will inevitably continue to occur when a shoreline urbanizes. This means that once a new project is approved and constructed, over time the simple increased intensity of use will result in increased disturbances along the shoreline area. It is the mechanism of shoreline densification and urbanization that is likely the single most important factor affecting shoreline change. The biggest risks typically occur when rural is re-zoned to a denser land use such as single family, multi family, industrial, or commercial. Despite the best measures, urbanization will inevitably result in impact over times, as documented by the slow incremental loss and change identified in this study.

6. Riparian setbacks are an important consideration. Appropriate setbacks for development should be determined using the top of bank and/or using a stream boundary definition that includes consideration of the biological floodplain processes. In some cases, the benchmark used for HWM may vary from a surveyed Present Natural Boundary or property line, depending on vegetative cover, floodplains and their processes. Setbacks should generally occur from the edge of these floodplain areas to ensure adequate riparian protection buffers and these should be surveyed and field reviewed by a qualified professional with suitable experience.

5.1.3 Provincial Government

7. Unpermitted Crown Land encroachments were likely in many locations, from either retaining walls, boat houses, or other types of overwater/near water infrastructure. An inventory of encroachments, and development of a plan to determine the next appropriate steps should occur to bring structures into compliance. Ultimately, a process to begin the removal of illegally constructed structures, as is commonly occurring in the Okanagan and Shuswap regions, is warranted. Public consultation would be useful to begin to educate owners about Crown Lands and their legal requirements to place structures at or below the HWM on Crown Land. Many encroachments appeared to be recently renovated or constructed, noting that at these times are the best opportunities to bring structures into compliance because permits are required, facilitating review of the structures and their locations.
8.
9. Retaining wall structures were typically vertical in nature. An inventory and determination of what is needed to help facilitate removal and transition of these walls to bioengineered erosion control structures under the *Water Sustainability Act* is important. A specific toolkit that addresses permitting and submission requirements would be useful, and could likely be developed in conjunction with other Provincial regions. For instance, for some locations it may be nearly impossible to remove some vertical walls due to other legally approved infrastructure. Whereas, in others it may be easily feasible. It is important for the Province to identify policies to help proponents determine submission requirements and design guidelines for erosion control structures. (i.e., including what is most appropriate and where). This will aid in application submissions and facilitate removal of these structures. This recommendation would also be applicable to local government.
10. Ensure that all permitting and associated data collected by Provincial Agencies is accessible. This could be achieved using a model similar to the *Fisheries Act*

Registry[4] Continue to document habitat related improvements made. These can then be included in FIM inventories as an example, because the locations of works are being tracked. Data storage and retrieval is important to aid agency staff in understanding what works have been done, where, and what values may be present that are not documented in these works.

5.1.4 Federal Government

11. Ensure that all permitting and associated data collected by Federal Agencies is accessible (as outlined above for the Provincial government).

12. There appears to be very little government effort/funding that goes into enforcement and compliance of the Federal Fisheries Act. While no significant active concerns were identified, the lake is very active and numerous values are present that may require consideration, such as the presence of freshwater mussels.

5.2 Addressing Cumulative Impacts

5.2.1 All potential levels of Government

13. Motorized access area restrictions are currently in place for the WMA to minimize environmental impacts to wetland and upland habitats. The current legal restrictions make the area off-limits to motorized watercraft. The restriction reflects that motorized access may cause: abandonment of nests, harassment of wildlife, increased predation, flooding of nests from boat wakes, destruction of emergent vegetation, bank erosion and siltation, and increased invasive plant abundance and spread (Province of BC 2021). Darvill 2019 specifically recommended marking the WMA with educational buoys alerting all recreational users of this boundary. There may be additional areas with similar values that could be identified using educational marker buoys.

14. Buoys marking boundaries of Crown Land tenures or unauthorized structures, such as swimming areas and parks, or moorage, have impacted emergent vegetation in some areas. A review of all mooring buoys and boundaries should be undertaken, with efforts made to remove buoys in ZOS. This would benefit these habitats over the long term. While navigation and buoys are managed by the Federal Government, local government can develop bylaws to manage shore zone areas and help aid in placement. Further, the Province could include requirements for *WSA* applications for mooring buoys to ensure appropriate Habitat Officer Terms and Conditions are implemented. The example photo

[4] Fisheries Act Registry. Available: https://open.canada.ca/data/en/dataset/2c09d2fd-9a8e-4d8c-b5af-95747e36eaac

below shows a boat within approximate swing distance of emergent aquatic vegetation. Other boats were evident right in the vegetation (with a high quality photo unfortunately unavailable).

15. Work with local, Provincial and Federal agencies and First Nations on a recreational usage carrying capacity study that addresses both safety of people and protection of important habitats. During peak periods (e.g., when the FIM was conducted), Windermere Lake was noted to have a high density of motorized boat traffic. Carrying capacity is the concept of identifying a peak or total amount of an activity that can occur before a tipping point is reached. On lakes, there are two important carrying capacities to consider:

    a. First - a recreational carrying capacity or total number of vessels that can use the lake safely.

    b. Second, there is an environmental carrying capacity, which varies by habitats present along the lake (e.g., wake overtopping nests, pollution, noise, physical harms—prop scaring or prop wash, beaching boats, etc.).

    The carrying capacity of Windermere Lake should be determined considering these two elements. The results will identify the most appropriate areas for recreation to occur and the quantity or density of vessels that a particular space can safely support without harm to either people or the habitats the lake can support.

    There are many examples of biological data from this assessment that can be considered and incorporated to help identify areas where boating recreation will have the lowest impact. For example, areas of emergent vegetation important to nesting birds that can be impacted from boat wakes can be identified (and avoided). As can appropriate travel corridors to maintain shallow, littoral areas (to protect mussels, spawning fish etc.). The lake is very shallow in many areas, and during peak usage periods, turbidity from prop wash was apparent in shallow areas experiencing high usage. This result is not unexpected, given the size, density, and shallow nature of the soft lakebed sediments that are prone to disturbance. By identifying appropriate nearshore travel corridors, this would reduce turbidity and subsequent risks to drinking water quality and to fish and their habitats. The recommendations of the Lake Windermere Management Plan should also be reviewed and considered, which outlines slow no wake zones and no boating zones (Catherine Berris and Assoc 2011), which could be considered in conjunction with data from this report to confirm areas appropriate for different recreational types and densities.

A carrying capacity study was conducted on Kalamalka and Wood Lake in the Okanagan. Water quality, boat recreation and use, and habitat values were combined to help aid local government identify and map areas where recreation was preferred (Schleppe et al. 2016). These data have also been useful to help all levels of government engage with different agencies to better manage lakes using available regulatory processes. An example is Transport Canada who can help identify and regulate appropriate travel corridors on navigable waterways.

16. Prepare a greenspace legacy plan that designates a total quantity of greenspace that is desired to be maintained into the future to support a healthy and vibrant shoreline. The goal would be to sustain both residents and tourism, as well as habitats and species that rely upon the lake. This plan should also include maintenance of appropriate connectivity to upland ecosystems and wildlife habitats over the long term.

    The plan should involve public consultation. This will allow residents to be informed about what change may occur, so they will understand how they can contribute to protection of the shoreline. By bringing stakeholders together, and committing to a greenspace legacy, there will be a reduction in the potential for ongoing and incremental losses that are impacting the shoreline habitats remaining.

    This planning exercise should identify, map, and ensure planning and policy are consistent between all agencies and stakeholders to maintain important habitats along the shoreline of Windermere Lake. Lands would then be protected in local, Provincial, or Federal policy aimed at prohibiting densification of areas intended to remain as greenspace. For instance, Local Government (regional or municipal) could incorporate this information into both Regional Growth Strategies, Bylaws, and Official Community Plans. Provincial government could help facilitate use of tools within the *Water Sustainability Act* (e.g., Water Sustainability Plans can link land and water decision policy in a long-term watershed or ecosystem-based framework, see Curran & Brandes 2019). This type of planning is critical because most current policy focusses on addressing site specific impacts, which has helped ensure a low rate of change around Windermere Lake, but may not provide adequate long-term protection for shoreline areas.

17. It is highly suspected that the ongoing, intensive recreational use and moorage along the shoreline will continue to impact important emergent vegetation areas, through slow and incremental losses. Education, and compliance and enforcement, are required to reduce the potential for ongoing impacts. The Lake Windermere Ambassadors may be a good conduit for education, while periodic Conservation Officer presence could help with compliance and enforcement. It is recommended that signage, educational programs, and other forms of communication with lakeside residents and tourists alike are used to help avoid the small, incremental impacts to these important areas.
18. Invasive aquatic species such as Eurasian Watermilfoil (*Myriophyllum spicatum*), Zebra Mussel (*Dreissena polymorph*) and Quagga Mussel (*Dreissena bugensis*) when present, result in severe impacts to the economy and environment (Darvill 2017). There should be continued recognition and financial support to the Lake Windermere Ambassadors, for their efforts to monitor for invasive aquatic plant and mussel species. It is important to detect invasive species early so that a rapid management response can be implemented (Darvill 2017). Since the inception of the Inventory Project in 2009 through to 2020, no aquatic invasive plant or mussel species have been detected (Darvill Pers. comm. 2021).

5.2.2 Provincial Government

19. A reconciliation of FIM data collected with existing Crown Land licenses or tenures was not undertaken in this assessment. Many of the structures on Crown Land are a significant component of the cumulative impacts observed. Simple removal of concrete boat launches that do not have appropriate licenses of tenures in place would easily restore lakebed disturbance in many areas. For instance, if 15 launches were removed, and each was 2 m wide and 3 m long, a total of 90 m^2 of lakebed habitat would be restored. The removal of illegally constructed structures on Crown Land would likely be a significant consideration to help reducing cumulative impacts observed.
20. The railway in some respects aided to protect the environment from urbanization. However, the railway did impact the shoreline, particularly stream mouth habitat since all crossings were culverts. The railway also isolated formerly connected backwaters and bay habitats. A detailed assessment of this habitat and identification of improvement opportunities are recommended to determine if there is the potential for fish passage and ecological improvement. Opportunities may include replacing the closed bottom culvert crossings with open bottom structures.
21. The habitat in the Kokanee spawning locations is vulnerable to physical alteration from boat and recreational use in spawning season, and habitat has shown signs of degradation. The lake's main public boat launch is present at the lake outlet, where the most important staging and spawning habitat on the lake occurs. Further exacerbating the issue, are the shallow depths, with boat scour

evident in the gravels. Ultimately, to address this issue the boat launch would be closed from September 1 through to June 1, or a second public launch would be installed in a better location to avoid potential harm to fish, or their eggs. Further, the banks could benefit from revegetation.

22. Windermere Creek has seen numerous sedimentation events in recent years. Spring flooding in 2011, 2012 and 2020 resulted in significant sedimentation in the lower reaches of Windermere Creek. This resulted in the development of a shallow delta at its mouth, and extensive dredging efforts of its lower reach in 2011 and 2020. Efforts to address the issue at its source or to catch the debris higher in the system (above the highway) have been considered by the RDEK but are subject to funding. To date, there has only been emergency flood response funding available, which has only facilitated the dredge at the mouth. The habitat in this once productive tributary has been highly compromised. Once the issue is addressed, restoration efforts to improve the habitat at the mouth should be sought (revegetation, installation of cover elements etc.).
23. Darvill 2019 provided the following suggestions to help to ensure that Windermere Lake continues to provide important habitat to birds:
    a. *Conduct additional fall bird surveys on the lake.*
    b. *Complete spring breeding bird surveys to assess the utilization of the lake area during a critical life history stage and to identify and conserve key breeding sites.*
    c. *Minimize boat traffic in and near nesting, staging, feeding areas during specific times of year.*
    d. *Public education regarding the importance of Lake Windermere to birds including at-risk species*. This would include identification of areas that should be off limits to recreational power boating.

5.2.3 Federal Government

24. Work with municipal and Provincial agencies and First Nations on the recommendations outlined above (see Section 5.2.1).

5.3 Restoration

5.3.1 All levels of government

25. Shoreline planning should include riparian restoration in all new or redevelopment scenarios. The incremental, slow losses of riparian habitat can only be balanced with appropriate commitment to incremental shoreline restoration. Otherwise, ongoing losses will occur and only a few remnant patches will remain over time.The outcome of shoreline restoration planning will also be slow and incremental because it would usually occur with each home rebuild. It is recommended that a minimum requirement of 25% of the riparian areas be restored with each development proposal. While more

restoration is encouraged, committing to a minimum such as this will help slow and possibly stop the slow rates of loss observed, or even possibly reverse them.

A specific analysis could be completed using data within this assessment, such as rate of loss, total length of urban development shoreline, and rate of application for new or redevelopment to determine a percentage, with appropriate contingencies, that would be needed to reverse the observed rates of loss (or at least try and set them to zero). If undertaken, analyses such as these are imperative to incorporate into policies such as Regional Growth Strategies, where appropriate benchmarks can be set, and monitored over time to determine their effectiveness. Feedback loops such as this help aid policy and help adaptively manage shoreline related risks over time; a necessity given that change is currently occurring in a slow, incremental fashion. Short term policy measures, without appropriate adaptive management may end up failing to achieve their intended results.

5.3.2 Local Government

26. Landscaping plans should be considered for all lakefront developments and it is important that they are endorsed by a suitably qualified professional. Professional endorsements of the plans ensure that restoration planning is incorporated in some manner. Clear guidelines regarding what is and what is not appropriate are important to aid proponents in planning. In particular, large patios, outdoor living spaces, lakeside cabins or cabanas, are all considered structures that should occur outside of riparian areas.

5.3.3 Provincial

27. Wherever possible, Provincial authorities should consider a bioengineered solution for erosion control. The BC *Water Sustainability Act* requires a professional engineer to endorse all shoreline erosion control applications. However, the most appropriate design guideline is not clear. For instance, if a 1:200 year design guideline is required, many shorelines areas transition from gravel beaches to armoured rip rap. While this solution is more robust from an engineering perspective, it can still impact shoreline areas by reducing the ability for natural vegetation to establish. In many cases, the best option is to focus on grading shorelines to stable angles, and possibly allowing some importation of appropriate material to maintain shoreline grades to aid in appropriate vegetation establishment. Obviously, every scenario is different, and feasibility, constructability, existing and legally constructed infrastructure, and associated risks must all be considered. The focus of this recommendation is to try and facilitate a broader consideration of design guidelines that also incorporates consideration of natural shoreline processes. At a minimum, guidelines should ensure that vertical and hard structures are only permitted in cases where no other viable option is possible, and even in these cases, a minimum grade of 2:1 with planting benches with appropriate elevations should be incorporated.

5.4 Education

All agencies need to participate in education. Education can take many forms and is often supported by data collection. Foreshore Inventory and Mapping, FHSI, and ZOS can all be used in educational materials. The idea is to promote awareness and voluntary compliance with policies and regulation, but also to advise owner of necessary and legal permitting requirements such as Development Permits, *Fisheries Act* Authorizations (or advice), and Provincial *Water Sustainability Act* applications as an example.

28. The data in this report should be used in educational outreach to shoreline residents. For example, the Okanagan Collaborative Conservation Program used data from FIM mapping of Okanagan Lake to generate outreach public materials (see: http://lakeshore-living.okcp.ca/).

6.0 REFERENCES

Artech Consulting Ltd. 2002. Reconnaissance (1:20,000 Fish and Fish Habitat Inventory of the Stoddart Creek, Shuswap Creek, Bornais Creek and Windermere Creek Watersheds. Consultant Report prepared for Slocan Forest Products, Radium Division.

BC Conservation Data Center BC CDC). 2021. Online iMap platform. Available: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer.

B.C. Conservation Data Centre. 2009. Species Summary: *Riparia riparia*. B.C. Ministy of Environment. Available: https://a100.gov.bc.ca/pub/eswp/ (accessed Feb 18, 2021).

BC Parks 2020. Windermere Lake Provincial Park information website. Available: https://bcparks.ca/explore/parkpgs/windermere_lake/

BC Water Land and Air Protection (BC WLAP). 2002. Badgers - Wildlife in BC at Risk Summary document. Available: http://www.env.gov.bc.ca/wld/documents/badger.pdf .

Department of Fisheries and Oceans (DFO). 1992. Land Development Guidelines for the Protection of Aquatic Habitat. Available: http://www.sxd.sala.ubc.ca/9_resources/fed_%20files/fed%20land%20development%20guidelines.pdf

Catherine Berris & Associates Ltd. 2011. Lake Windermere Management Plan. Prepared for the Regional District of East Kootenay and District of Invermere.

Chirico A. 2005. High Conservation Value (HCV) Fisheries Watersheds in the Rocky Mountain and Kootenay Lake Forest District. Ministry of Sustainable Resource Management, Fisheries Information Specialist, Nelson BC.

Curran, D., & Brandes, O.M. (2019, October). Water Sustainability Plans: Potential, Options, and Essential Content. Victoria, Canada: POLIS Project on Ecological Governance & Environmental Law Centre, University of Victoria.

Darvill, R. 2021. Columbia Valley Swallow Project - 2020. Consultant report prepared by Goldeneye Ecological Services, for Wildsight Golden.

Darvill, R. 2019. Insight into the Waterbirds of Lake Windermere. Consultant report prepared by Goldeneye Ecological Services, for Lake Windermere Ambassadors.

Darvill 2017. Lake Windermere Aquatic Invasive Species Inventory. Prepared by Goldeneye Ecological Services for the Lake Windermere Ambassadors December.

District of Invermere. 2002. Official Community Plan – Consolidated Zoning Bylaw No. 1145. Available: https://invermere.civicweb.net/filepro/documents/111

East Kootenay Burbot Scientific Working Group (EKBSWG). 2019. Upper Kootenay River Burbot Conservation Strategy. Prepared by Westslope Fisheries Ltd., Cranbrook, B.C. 61 pp. Prepared for Fish and Wildlife Compensation Program (Project Number: UKE-F19-F-2734), the Ministry of Forests, Lands, Natural Resource Operations and Rural Development, and the Ktunaxa Nation Council.

East Kootenay Integrated Lake Management Partnership (EKILMP), McPherson S. Hlushak D, and J. Bisset. 2009. Windermere Lake Shoreline Management Guidelines for Fish and Wildlife Habitats. Combined agency and consultant (Interior Reforestation Co. Ltd) report.

Golder Associates Ltd., Poisson Consulting Ltd., and Okanagan Nation Alliance. 2017. CLBMON-16 Middle Columbia River Fish Population Indexing Survey 2016 Report. Report prepared for BC Hydro Generation, Water License Requirements, Revelstoke, BC. 65 pages + 9 app.

Grassland Conservation Council of BC (GCCBC). 2018. Website. Available: bcgrasslands.org.

Griffith R.P. 1994. A Reconnaissance Survey of Windermere Lake. Consultant report completed for Mica Fisheries Compensation Program, B.C. Hydro /B.C. Environment, Nelson BC.

McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. Published by the University of Alberta Press, Edmonton, Alberta.

McPhail J.D. and V.L. Paragamian. 2000. Burbot Biology and Life History. Pages 11-24. An offprint prepared for Burbot: Biology, Ecology and Management edited by Vaughn L. Paragamian and Dave W Willis. Publication Number 1: Fisheries Management Section of the American Fisheries Society.

McPherson, S. 2020a. Timber Ridge Marina Dredge – Environmental Assessment & Environmental Management Plan (Version 4). Prepared by Lotic Environmental Ltd. for the Timber Ridge Property Owners Association and Terridian Utilities.

McPherson, S. 2020b. Indian Beach Estates Marina Dredge – Environmental Assessment & Environmental Management Plan. Prepared by Lotic Environmental Ltd. for the Indian Beach Estates Management Corporation (IBEMC).

McPherson, S.[1] and J. Schleppe[2]. 2020. Foreshore Development Guide – Template Report. Prepared for Living Lakes Canada. Prepared by: Lotic Environmental Ltd.[1,] and Ecoscape Environmental Consultants Ltd.[2]

McPherson S.M., D.G. Paton and M.D. Robinson. 2012. Tie Lake Shoreline Management Guidelines of Fish and Wildlife Habitats. Consultant report prepared for Ministry of Forests Lands and Natural Resource Operations, Nelson BC. Prepared by Lotic Environmental Ltd, Anatum Ecological Consulting Ltd.

McPherson, S.M. and D. Hlushak. 2008. Windermere Lake Fisheries and Wildlife Habitat Assessment. Consultant report prepared for the East Kootenay Integrated Lake

Management Partnership. Prepared by Interior Reforestation Co. Ltd., Cranbrook, BC.

McPherson, S. and D. Michel. 2007. Windermere Lake Foreshore Inventory and Mapping. Consultant report prepared for the East Kootenay Integrated Lake Management Partnership. Prepared by Interior Reforestation Co. Ltd., Cranbrook, BC.

Moore A., and L. Machial. 2007. BC Conservation Corps Invertebrates at Risk Crew Freshwater mussel surveys (target species Gonidea angulata) in the Okanagan and Kootenay regions, summer 2007.

Oliver G.G. 1995. Kokanee Spawner Distribution Survey and Stock-Monitoring Plan for the Upper Columbia Basin. Prepared for the Columbia Basin Fish and Wildlife Compensation Program, Nelson BC, Canada. 62 pp + 2 App.

Province of BC. 2021a. Foreshore and Aquatic Crown Land Ownership in British Columbia, general information. Available: https://www2.gov.bc.ca/gov/content/industry/crown-land-water/crown-land/crown-land-uses/residential-uses/private-moorage

Province of BC. 2021b. BC Species and Ecosystems Explorer. B.C. Available: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre.

Province of BC. 2021c. Columbia Wetlands Wildlife Management Area. Available: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-habitats/conservation-lands/wma/wmas-list/columbia-wetlands-visitor-use

Province of BC. 2019. 2019 to 2021 Freshwater Fishing Regulations Synopsis. Available: https://www2.gov.bc.ca/gov/content/sports-culture/recreation/fishing-hunting/fishing/fishing-regulations

Regional District of East Kootenay. Regional District of East Kootenay – Lake Windermere Official Community Plan Bylaw No. 2929, 2019. Available: https://engage.rdek.bc.ca/lake-windermere-ocp

Royal BC Museum. 1999. Archaeological investigations at the salmon beds. Living Landscapes Program. Cited in McPherson and Hlushak 2008.

Schleppe, J.[1], S. McPherson[2], L. Porto[3], and B. Mason[4]. 2020. Foreshore Integrated Management Plan Methods. Prepared for Living Lakes Canada. Prepared by: Ecoscape Environmental Consultants Ltd.[1], Lotic Environmental Ltd.[2], Wood Environment and Infrastructure Solutions[3], and BC Community Mapping Network[4].

Schleppe, J., L. Crevier, and R. Plewes. 2019. Foreshore Inventory and Mapping for Species at Risk. Prepared for Living Lakes Canada. Prepared by Ecoscape Environmental Consultants.

Schleppe, J., H. Larratt and R. Plewes 2016. Kalamalka and Wood Lake Boat Capacity Study on Water Sources. Ecoscape Environmental Consultants Ltd. Project File: 16-1796.

Schleppe, J. and B. Mason. 2009. Standard Methods for Completion of Foreshore Inventory and Mapping Projects. Prepared by: Ecoscape Environmental Consultants Ltd. and The Community Mapping Network.

Schleppe, J. 2009. Moyie Lake Foreshore Inventory and Mapping. Ecoscape Environmental Consultants Ltd. Prepared for: East Kootenay Integrated Lake Management Partnership.

Schleppe, J. and R. Plewes. 2017. Okanagan Lake Foreshore Inventory and Mapping Update 2016. Ecoscape Environmental Consultants Ltd.

Schleppe, J. and D. Arsenault. 2006. The Kelowna Shore Zone Fisheries and Wildlife Habitat Assessment. EBA Consulting Engineers and Scientists. Project File: 0808-8840209. March 2006. Prepared for the City of Kelowna.

Taylor, J.L. 2002. Juvenile Burbot Sampling in Columbia and Windermere Lakes, Summer 2002. Columbia Basin Fish and Wildlife Compensation Program Report.

Taylor, J.L. 2001. The Early Life History and Ecology of Columbia Lake Burbot. Thesis for the Degree of Master of Science. University of British Columbia.

Urban Systems. 2001. Lake Windermere Management Strategy. Prepared for the District of Invermere. 87 pp.

Westslope Fisheries Ltd. 2001. A Natural History of Columbia River Fisheries in British Columbia, Canada. Consultant report prepared for Columbia-Kootenay Fisheries Renewal Partnership. 50 pp + app.

Personal Communications or Observations

Bisset, J. 2008. Senior Aquatics Biologist, Interior Reforestation Co. Ltd. Cranbrook British Columbia. Cited in McPherson and Hlushak 2008.

Bray, K. Fish Biologist, BC Hydro. Email Communication February 24, 2021.

Burrows, J. Senior Fish Biologist. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Kootenay-Boundary Region. Nelson, BC. Email communication February 23, 2021.

Darvill, R. Goldeneye Ecological Services, Golden BC. Phone and email communications in January/February 2021.

Neufeld, M. Section Head, Fish and Aquatic Habitat. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Kootenay-Boundary Region. Nelson, BC. Email communication February 22, 2021.

Schleppe, J. 2020. Broad description of flood related impacts on shorelines of Okanagan lake, post 2017 flood.

Appendix A. Foreshore Inventory and Mapping GIS Map

Appendix B. FHSI and ZOS Maps