1.0 INTRODUCTION

The desire to live and recreate in the Okanagan watershed has resulted in a dramatic increase in development pressure on the system. The Okanagan Collaborative Conservation Program and project partners have undertaken a number of planning initiatives to facilitate better information sharing and develop land use policies along Okanagan Lake. Through these planning processes and initiatives, it can be concluded that past development along Okanagan Lake has impacted fish, wildlife, rare plants and terrestrial communities, and/or water quality. As a result of these impacts, project partners are working cooperatively to prevent future impacts to the lake and foreshore.

A complex relationship exists between development pressure, the natural environment, and social, economic and cultural values. In an effort to balance these various community values, a solid understanding of aquatic and riparian resource values, land use interests, and community concerns is needed to formulate long-term planning and policy objectives. Development of long term planning objectives at the local, provincial and federal agencies is also required so that our aquatic resources are effectively managed in a collaborative framework. Detailed shoreline inventories increases the knowledge base of the environmental resources present, allowing all stakeholders to understand how development may affect these habitat features. With this information, better informed land use planning decisions can be achieved resulting in superior natural resource protection.

Of particular importance and the focus of this report, is the link between the aquatic and terrestrial environments along Okanagan Lake. The foreshore – that part of the shore between the high and low water marks – has significant biological, ecological and social significance to residents in the Okanagan Basin and is extremely sensitive to disturbance. (RDCO, 2005). In this report, foreshore and shoreline are used somewhat synonymously. The shoreline, or the area that occurs in proximity to the lake (e.g., within 50 m) through the foreshore to the end of the littoral zone (area of greatest biological productivity), is also extremely important.

Regulators at all levels of government are becoming increasingly aware of the importance of managing our watersheds in a sustainable manner. Land owners and the general public are often concerned about their watersheds and may not understand how they are being managed. Current management practices being implemented in the Shuswap and Kootenay regions are utilizing a three step process. The goals of this process is to help integrate available environmental data (both quantitative and qualitative) with land use planning information to facilitate review and decision making processes at all levels of government. The specifics for implementation vary by region, but generally utilize this process. This study has resulted in two of three steps having been completed with the third and final step outstanding at this time. The three steps include:

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

2. Aquatic Habitat Index or Ecological Sensitivity Index (AHI) – The AHI utilizes data collected during the FIM, additional field reviews, and other data sources (e.g., Land and Data Warehouse, previously published works, etc.) to develop and rank the sensitivity of the shoreline using an index. An index is defined as a numerical or categorical scale used to compare variables with one another or with some reference point. In this case, the index is used to compare the sensitivity of the different shoreline areas around the lake to other shoreline areas within the lake (i.e., the index compares the ecological or aquatic sensitivity of different shoreline areas within the lake system to each other rather than to other lake shorelines). While the index does provide an indication of the relative value of one shoreline area to another, it does not compare these shorelines with shorelines on other lake systems and is not directly transferable.

3. Development of Shoreline Management Guidance Documents - Guidance documents are the final step in the process. Guidance documents are intended to help land managers at all levels of government quickly assess development applications. It is intended to be the first step for review, planning, and prescribing shoreline alterations (i.e., land development) by applicants and review agencies. At this time, the Okanagan Region Large Lakes Foreshore Protocol (OLLP) is the guidance document for Okanagan Lake at the provincial level. This document identifies known kokanee spawning areas, known western ridge mussel locations, and stream deltas as sensitive features. This policy document is only applicable to works occurring below the high water level. Local governments also have a variety of different policy documents that govern land uses above the high water level, including Official Community Plans and Bylaws. At this time, there is not a common understanding of lakeshore sensitivity, which makes integrated governmental policy difficult. The works contained within this assessment provide a framework for an integrated shoreline policy document. The outcomes of this assessment should be integrated into the Okanagan Region Large Lakes Foreshore Protocol (OLLP) and local government policies when time and budgeting permits in a formal guidance document. It is expected that implementing this work into a new guidance document will facilitate better decision making across all levels of government because not the OLLP is not current in use by local government policies because it pertains largely to

structure below the HWL. Another benefit is that this study considers numerous other biological criteria (e.g., wetlands and shore marshes, Western Grebe nesting areas, aquatic vegetation, adjacency to sensitive terrestrial features as identified by the Sensitive Ecosystem Inventory (SEI), migration and staging areas, etc.) that are not currently being considered in the OLLP or within a regional approach to shoreline management. Thus, incorporation of this assessment will be more inclusive of sensitive shoreline areas if it can be integrated into the existing OLLP in some fashion.

This report presents Step 1 and Step 2 for Okanagan Lake. Ongoing efforts in the development of the Shuswap Lake Shoreline Guidance document will help facilitate integration of this work with the OLLP for Okanagan Lake in a Step 3 Guidance Document. In the absence of a formal shoreline guidance document, the OLLP is considered the guiding policy document for features below the high water level (instream).

2.0 PROJECT OVERVIEW

Okanagan Lake supports many non-anadromous (non-sea run or resident) fish stocks, which significantly contribute to First Nations' and sport fisheries. These fish stocks also contribute significant cultural value to local eco tourism opportunities, such as kokanee spawning observations in Mission or Deep (Peachland) Creeks. The lake also provides critical habitats for numerous fish and wildlife species. Finally, the lake is a source of drinking water for a substantial proportion of Okanagan residents. For these reasons, protection of the various environmental values is extremely important and is integral to a functional lake and watershed.

Okanagan Lake is arguably the most important natural resource in the Okanagan for ecological, social and economic, and cultural reasons. The Okanagan has experienced unprecedented development pressure in recent years and development activities are affecting the natural resource values. Responsible and appropriate management of these resources is increasingly recognized by local, provincial, and federal governments, First Nations and the general populace as vital to the future of this region. Community members have raised a number of concerns with regard to the impacts adjoining land uses and recreational uses are having on the lake. This work provides an opportunity for project partners to support an initiative that will inform future policy development and allow for improved management of these resources. The information generated from this project and future steps, including the development of an integrated shoreline management guideline, will help develop policy and promote management that is more comprehensive than the current OLLP. From a local government perspective the project will provide a valuable resource when reviewing land use applications in the area by flagging areas of concern. This work can also be used in the development of Official Community Plan and Local Area Plan policies.

While local residents have expressed a strong desire to preserve and protect Okanagan Lake, baseline data to support these goals for the lake *as a whole* has been not readily available until now. The previous foreshore inventory works on Okanagan Lake, with the first FIM in 2004, have generally only considered specific shoreline areas within smaller local government jurisdictions (e.g., City of Kelowna, Regional District Central Okanagan, etc.). The intent of this project is to provide a baseline overview of the shoreline condition of Okanagan Lake in its entirety.

The methodology employed for this assessment is discussed in detail below and is a consistent with provincial standards being used to map shorelines around the province. The mapping protocol will allow stakeholders to understand current shoreline conditions, set objectives for better shore management, and measure and monitor changes in the shoreline overtime.

This project is a two part process:

- Compile existing FIM data completed from initial works in 2004 with more recent works in the north, south, and central regions in 2009 and 2010. This involved development of one data base for the entire Okanagan Lake to the most recent version of the Foreshore Inventory and Mapping methodology and provide an overview of shoreline condition for the lake as a whole; and
- Develop an Aquatic Habitat Index and rank the sensitivity of the shoreline of Okanagan Lake.

2.1 Project Partners

Numerous different parties have contributed to the success of this project. Foreshore Inventory and Mapping (FIM) protocols have been developed over the last 7 years and have become a standardized approach to shoreline inventory. Numerous different local governments, non-profit organizations, biological professionals, and provincial and federal agencies have contributed to the development of the FIM protocol and Appendix A (Detailed methods) provides a more accurate list of contributing parties.

The following previous FIM reports were used in this assessment:

1. Central Okanagan Foreshore Inventory and Mapping (2004)
2. Foreshore Inventory and Mapping: Okanagan Lake North (2010)
3. Foreshore Inventory and Mapping: Okanagan Lake South (2010)

This project was funded by the following agencies and organizations:

1. Regional District Central Okanagan
2. City of Kelowna
3. Regional District Okanagan Similkameen
4. Okanagan Collaborative Conservation Program
5. District of West Kelowna
6. District of Lake Country
7. City of Vernon
8. The District of Peachland
9. Okanagan Basin Water Board
10. Fisheries and Oceans Canada
11. Community Mapping Network
12. Ministry of Environment

2.2 Objectives

The following are the objectives of this project:

1. Compile existing resource information for Okanagan Lake;
2. Foster collaboration among the local governments (RDCO, RDOS, Kelowna, Peachland, West Kelowna, Lake Country, Vernon), DFO local staff, Ministry of Environment, First Nations bands, and the local communities;
3. Provide an overview of foreshore habitat condition on the lake;
4. Inventory foreshore, land use, riparian condition and anthropogenic alterations and illustrate foreshore morphology;
5. Obtain spatially accurate digital video of the shoreline of the lake;
6. Prepare the video and GIS geo-database for loading onto the Community Mapping Network at www.cmnbc.ca. and Okanagan Habitat Atlas.

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

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

9. Develop an Aquatic Habitat Index that ranks the sensitivity of shoreline areas relative to each other;

10. Act as a "flagging tool" based upon information currently available;

11. Provide a framework and common understanding of sensitive areas of Okanagan Lake as a whole to facilitate improved resource management;

12. Provide a baseline data set for Okanagan Lake as a whole that can be utilized to develop long term objectives, conservation and protection areas, and allow for monitoring of any objectives prepared;

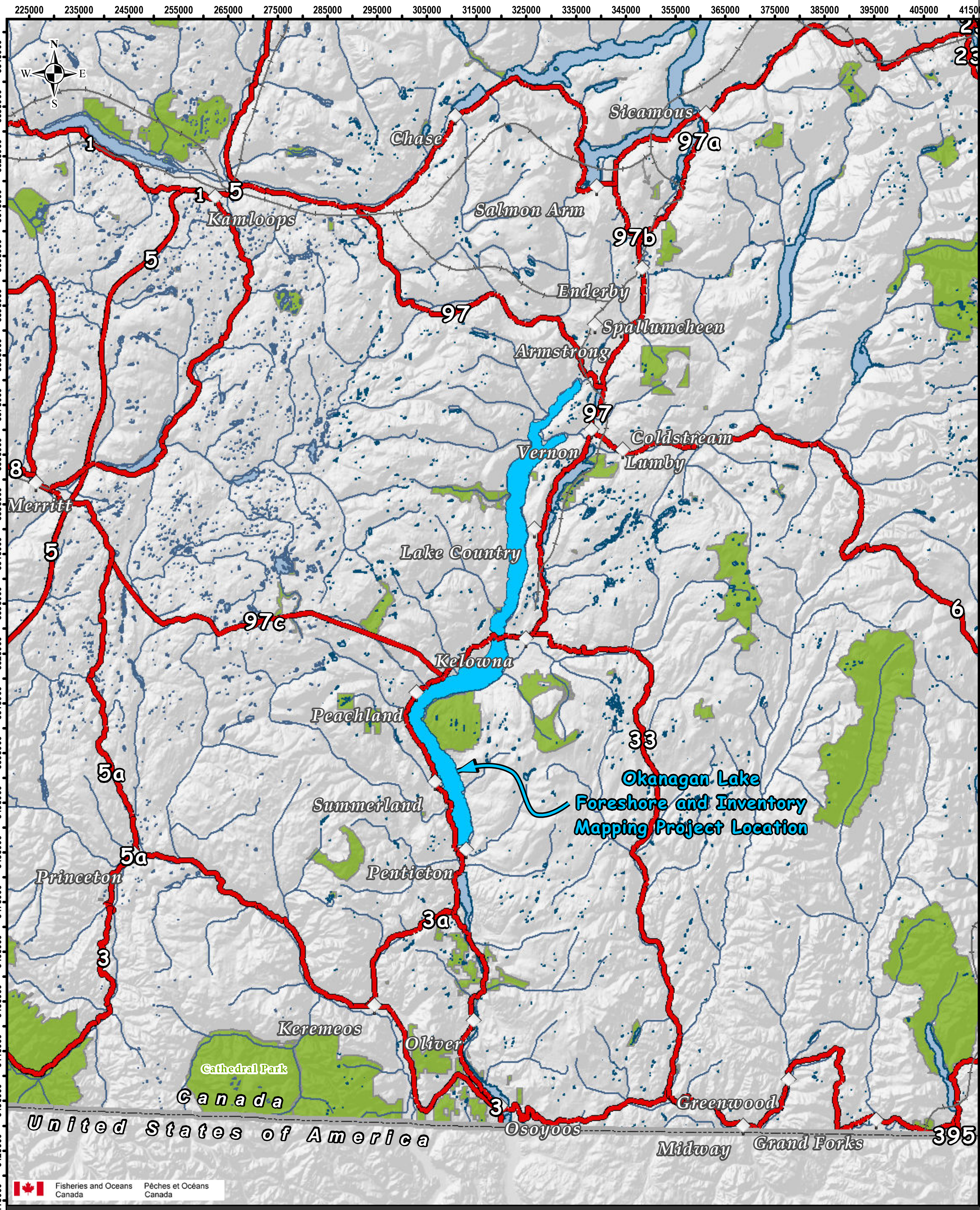
13. Provide a summary of potential locations where habitat improvements are possible along the shoreline based on habitat potential; and,

14. Provide a framework for integration of information with upland development planning in an effort to protect sensitive foreshore areas.

The FIM and AHI completed as part of this assessment will begin to address many of these objectives. Completion of Step 3, Shoreline Management Guidelines, that integrate the OLLP and this data will provide more detailed and comprehensive guidelines to meet long term objectives for lake protection.

2.3 Study Location

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



Okanagan Lake

Foreshore Inventory and Mapping

Figure 1 - Project Location

2.4 Important Fisheries and Wildlife Resource Information

Okanagan Lake contains numerous fish stocks that are important public resources. The most important fish stock is kokanee, a land locked sockeye salmon. This fish is considered a keystone species because of its many interactions with other species. Kokanee are a critical fall food source for bears, eagles, Osprey, and other species and the spawned out carcasses of the adults provide fertilizer for terrestrial and aquatic ecosystems. Salmon are also an indicator species for the overall health of the ecosystem because they are highly sensitive to changes in their habitat (e.g., reductions in water quality). Other important fish stocks include rainbow trout, whitefish (both mountain and lake), and burbot (fresh water cod).

The focus of fisheries management is to further recover stocks of kokanee, which are increasing from historical lows several years ago. The Okanagan Region Large Lakes Fisheries Operational Management Plan 2007-2011 (Redfish, 2007) provides an excellent summary of important fisheries management objectives and concerns. Coupled with this work, the Okanagan Lake Action Plan has provided invaluable information to help understand important trophic interactions in the system (see http://www.env.gov.bc.ca/okanagan/esd/olap.html). Some of the key fisheries issues identified in the management plan were: 1) addressing foreshore development, 2) impacts to lakeside riparian habitats, and 3) addressing losses of kokanee shore and stream spawning habitats (Redfish, 2007).

The fish stocks are also very important to First Nations' culture. The stocks have significant cultural value and within the Okanagan watershed, attempts are being made to increase the stock to a point where harvest may again be possible. Kokanee also contribute to local eco-tourism opportunities (e.g. spawning viewing in the Peachland (Deep) Creek or Mission Creek).

Okanagan Lake also has important habitats for wildlife species (e.g., see the numerous SEI inventories, Conservation Data Centre information, etc.). Numerous waterfowl and predatory birds rely upon the lake. For example, the Western Grebe has known breeding grounds in the north arm (Burger, 1997). This breeding ground is one of only three in the southern interior, which elevates the importance of protecting this habitat. These birds nest on floating bulrush mats and are very sensitive to impact from recreational boating activities, which may overturn nests. Along Okanagan Lake, recreational boating and foreshore development were identified as the two greatest threats to the breeding colony (Burger, 1997). This waterfowl species is one of many which use habitat around the lake. There are numerous other wildlife species, such as the reptile group (e.g., Western Rattlesnake), that rely upon the foreshore areas of Okanagan Lake.

This brief overview highlights the importance of fisheries and wildlife resources along Okanagan Lake and provides clear rational for completion of this shore line inventory project. The concerns discussed above but a few of the many that have been, or will continue to be identified in the coming years along the lake.

3.0 FORESHORE INVENTORY & MAPPING METHODOLOGY

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

3.1 Field Surveys

Field surveys for this project have been carried out over the last 3 years and have integrated through this project. The original FIM conducted for the Central Okanagan in 2004 was updated in order to ensure a consistent database to enable an overall analysis of Okanagan Lake as a whole. The South Okanagan Lake assessment was completed between June 22 through June 26, 2009. Field surveys for the North Okanagan Lake were conducted on August 13 and 14, 2009. Field surveys within the Central Okanagan were conducted on September 15 through 18, and October 13, 2009.

Field surveyors were each assigned data to collect during the surveys. Field assessors used 11X17 inch (Tabloid), scaled colour air photos with cadastre and topographic information to assist with field data collection. Two TRIMBLE GPS units with SHIM Lake v. 2.6 (FIM Data dictionary name) were carried and a hurricane antennae was also used. Finally, digital photographs, with a GPS stamp, were collected.

Other field surveys conducted included the GPS digital video, completed by Fisheries and Oceans Canada staff. The specifics of the GPS digital video are discussed in the FIM methodology.

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

- Photo documentation of the shoreline for the main areas of development;
- Record data relating to the presence or absence of development such as retaining walls and boat launches.

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

3.2 Methodology

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

The following additional information was collected during field surveys:

1. The spatial extent of emergent grasses on flood benches, and areas of submergent and floating vegetation were mapped and photographed, to determine the approximate area where aquatic vegetation occurs. Aquatic vegetation includes any plants growing below the high water level of the lake. These areas are important fish habitat. Also, areas of extensive overhanging vegetation (from the high water level) were also mapped. Not all aquatic vegetation areas could be mapped due to the late timing of surveys and significant size of the foreshore in many areas. For these reasons, additional areas of vegetation may also occur that have not been identified within this assessment. Finally, high resolution air photos were only available for a portions of the shoreline; therefore, air photo interpretation accuracy is not as good within lower resolution air photo areas and information has been prepared as accurately as possible with data available. It should be noted that on larger littoral areas, vegetation mapping may not have captured all occurrences.

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

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

3.2.1 Aquatic Vegetation Mapping and Classification

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

Marsh (Wm)

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

Low Bench Flood Ecosystems (Fl)

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

Mid Bench Flood Ecosystems (Fm)

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

Swamp

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

Aquatic Vegetation

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

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

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

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

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

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

3.2.2 GIS and FIM Database Management

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

- Data and photos were backed up to a computer/laptop on a daily basis.
- A GPS camera that stamps photos and creates GIS shapefiles, and GPS video were used to facilitate data review and interpretation.
- Air photo interpretation was completed using high resolution air photos that were acquired during various flights by numerous agencies. All mapping was completed on the most recent and highest quality we could obtain.
- During data analysis, numerous checks were completed to ensure that all data was analyzed and accounted for.
- A spatial elevation model was run using GIS software, in combination with air photo interpretation and TRIM shoreline files to accurately determine the high water level of the lake. It is believed that for the length of the shoreline, the high water level used is within 5 m of the mean annual high water level for at least 50% of the lake. The HWL assessment for Okanagan Lake could be improved with higher resolution air photos when they become available and better digital elevation modeling. A site specific survey must be conducted to accurately determine the high water level for any site specific considerations and the line presented in this assessment should not be considered a surveyed HWL. For this assessment, the 343 contour elevation was considered the HWL. It is acknowledged that the mean annual high water level of the lake is approximately 342.6 m above sea level.

The following data fields were added to the FIM data dictionary

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

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

3. Several fisheries fields were added. These fisheries fields are similar to the Zones of Sensitivity that were developed for the City of Kelowna Shorezone assessment (Schleppe and Arsenault, 2006). The following describes fisheries fields added and the original data source for the fields:

    a. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was prepared by Ecoscape for this project. Since shoreline utilization data is unavailable, juvenile rearing was based upon known rearing habitat requirements (e.g., proximity to spawning streams, littoral area, field observations, etc.). Please refer to the methodology section for the Aquatic Habitat Index to learn how juvenile rearing categories were developed for this project.

    b. Migration – Probable juvenile and adult fish migration routes (Yes or No) are important migration corridors used by resident fish at some point in their life cycle. These routes were prepared for this project and are based upon areas where fish will concentrate during significant spawning or out migrations from streams. Ecoscape prepared spatial files identifying areas of key migration and these areas were reviewed by Ministry of Environment biologists for confirmation. To develop these migrations areas, key habitat characteristics were used and included adjacency to spawning rivers, outmigration considerations, and review of fish life history characteristics. The limited data available for migration corridors on this lake has resulted in some assumptions. Further research is recommended to better understand the spatial extents of key migration corridors.

    c. Salmon Spawning Stream - A Yes / No flag for this field was added. This field was added for the Juvenile Rearing Habitat value assessment and describes the shoreline segments where known salmon spawning streams occur. The spatial extent of this criterion is very similar to the “Staging” field.

    d. Staging – A Yes / No field to describe salmon staging areas was added. Staging areas occur where fish will concentrate or congregate prior to migrations. Staging areas were created based upon liaison with Ministry of Environment and DFO staff through the course of field work on this assessment and based upon professional opinion of the author. Areas where fish were known to stage or hold prior to migrations and shore areas where migrations are likely present were identified (Yes or No). In general, these areas are loosely defined and vary over space and time. The information presented is limited to the confluences of known salmon spawning streams, where fish are known to congregate before migrations. Information is limited and it may not entirely reflect all locations or spatial extents of staging areas. Further, this field has generally not considered shore spawning kokanee migration areas. Future surveys should be used to better understand where mature adults hold during migrations.

e. Mussels - The Western Ridged Mussel is the most important mussel species in the lake. There is limited survey work for this species to identify key habitat areas for all life stages. Further, some of the host species are still unknown. For these reasons, Ecoscape used cautionary principles to apply this feature to the FIM dataset. The Red and Yellow Zones prepared by the Ministry of Environment identify known locations or highly suitable locations for adult stages. These tended to occur in a clustered fashion, primarily in the south with a few in the Vernon arm. Shoreline segments that were in proximity to clusters, were considered to be suitable adult mussel habitat for the index. These areas may not identify all key habitat areas for all stages of the mussel. More detailed surveys should be completed and further work on understanding the life history should be undertaken to confirm and better identify the spatial extent of key habitat areas for all life stages of this species.

f. Kokanee Shore Spawning Zones - The database contains a summary of the percentage and total shore length for the Black (Per_Black, Bl_Shore_Length), Red (Per_Red, Re_Shore_Length), Yellow (Per_Yel, Yel_Shore_Length) and No Colour Zones (Per_Nop_Colour, No_Colour_Shore_Length) identified within the Okanagan Large Lakes Protocol. These areas have been identified as the key habitat areas for spawning adults.

4. Western Grebe suitable nesting areas in the North Arm were identified. Suitable areas were based upon a significant presence of emergent bulrush vegetation. Suitability rather than known nesting locations were used due to the limited breeding area available or provided to us. Given that breeding grounds are limited, all suitable areas should be considered important.

5. A rare plant species layer was added, using data from the OLLP. Only a few sites had rare plants identified, and a Yes / No flag was added to the database indicating the presence of rare plant species. Due to the limited survey information, this database field is not considered inclusive of all occurrences and others may exist.

6. Sensitive Ecosystem Inventory is available for most of the shoreline of Okanagan Lake. To include this sensitive terrestrial information within the AHI, the intersects between Wildlife Corridors, Core Conservation Areas, Other Areas of Importance, and Not Applicable Areas polygons and shoreline segments was completed. For each segment, the total length of these different categories was used. For areas where SEI has not yet been completed, or areas where only Terrestrial Ecosystem Mapping was available, segments were manually classified by Ecoscape using similar criteria to the SEI. The following descriptions, taken directly from the Core

Conservation Analysis and Updated Ecosystem Mapping for Central Okanagan Valley (Haney and Iverson, 2009) have been included for reference[1]:

a. ***Core Conservation Areas -*** *Areas with a large concentration of high and some moderate conservation values were identified as core conservation areas. These would be the areas of highest priority for conservation. Ideally, activities would be primarily directed towards maintaining ecological and wildlife habitat values in these areas. There may be small areas within the core areas that could be accessed and developed without compromising core values (e.g., by fragmentation); further larger scale mapping and wildlife inventory would be needed to identify these areas. Core areas are high priorities for acquisition by land trusts, conservation organizations, for Regional Parks, and should be zoned for environmental purposes.*

b. ***Buffers -*** *Areas with a large concentration of high and some moderate conservation values were identified as core conservation areas. These would be the areas of highest priority for conservation. Ideally, activities would be primarily directed towards maintaining ecological and wildlife habitat values in these areas. There may be small areas within the core areas that could be accessed and developed without compromising core values (e.g., by fragmentation); further larger scale mapping and wildlife inventory would be needed to identify these areas. Core areas are high priorities for acquisition by land trusts, conservation organizations, for Regional Parks, and should be zoned for environmental purposes.*

c. ***Wildlife Corridors -*** *Wildlife corridors provide animals with an opportunity to move freely between two or more habitat patches or habitat types in an otherwise fragmented landscape. This movement is essential to provide genetic links between populations and prevent inbreeding, and to compensate for temporary population declines in one of the habitat patches. The habitat needs of all priority species should be incorporated into the design of the corridor. Corridors must be suitably wide, with appropriate habitat features to provide security cover during movement. Corridors usually consist of linear habitats such as gully or streamside riparian areas; they are often composed of two or more ecosystem types to provide complexity to the corridor. Development and roads should avoid these zones, and mitigation will be required where roads and other developments transect the corridor. Wildlife corridors were identified to connect core areas to each other and to outside the study area.*
In some cases, important corridors have already been fragmented by roads or other disturbances, and connections need to be restored. Although

[1] Additional SEI references are included in the references section of this document. Readers should refer to the full suite of SEI data collected for further information on these various terrestrial projects throughout the Okanagan.

challenging, it is imperative to restore connections through Ellison and the western portion of West Kelowna in particular.
Larger scale mapping and additional wildlife inventory might identify some small areas that could be developed without compromising connectivity and other corridor values. This would depend upon the type and configuration of development, and site-specific issues.

d. ***Other Important Conservation Areas -*** *Areas with a concentration of moderate conservation values, or small and isolated areas of high values, were identified as other important conservation areas. Activities would be directed towards maintaining ecological and wildlife habitat values. There would be areas within that could be accessed and developed without compromising some ecological values; further larger scale mapping and wildlife inventory would be needed to identify these areas.*

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

8. An Aquatic Restoration potential analysis (AHI_POT) which was completed by removing instream features from the AHI results was also incorporated into the database. This analysis provides a summary of potential locations where habitat improvements are possible along the shoreline. This analysis *does not consider improvements to riparian vegetation*. A more detailed analysis of habitat restoration opportunities, including riparian restoration is advised in the future.

3.2.3 2004 Foreshore Inventory and Mapping Comparison

In 2004, the original FIM mapping was compiled for Okanagan Lake. The premise of this initial work was to inventory the shoreline of the lake and provide a basis to measure change along the shoreline. In 2010, the shoreline of Okanagan Lake was inventoried again using the same methodology. It has been approximately 6 years since the lake was last surveyed and an analysis of change has been complete for all jurisdictions that fall within the original 2004 survey area. These areas include the Regional District Central Okanagan (Areas East and West), City of Kelowna, District of West Kelowna, District of Lake Country, and Westbank First Nations.

The databases between 2004 and 2010 are slightly different. The FIM database version used in 2010 is the most commonly used version in use at this time. Primary differences between the two include differences in Land Use Categories and Shore Types. For these reasons, the analysis focused on the comparing the following factors:

1. Percentage of Natural and Disturbed Shoreline;
2. The percentage of natural shoreline along different slope categories (e.g., Bench, Low (<10%), etc.
3. The density of shoreline modifications (e.g., docks, groynes, retaining walls, etc.).

4. The percentage of shoreline classified as having a High, Moderate, or Low level of Impact;
5. The percentage of natural shoreline found within areas classified as being High, Moderate, or Low Juvenile Rearing Value.
6. The percentage of natural shoreline within areas classified as a Black, Red, Yellow, or No Color Kokanee shore spawning area.
7. The percentage of natural shoreline in areas classified as being Very High, High, Moderate, Low, or Very Low by the Aquatic Habitat Index.

To complete the above analysis, the segment numbers in the databases were rectified with each other between 2004 and 2010. The databases needed to be rectified because some segments were split out in 2010 due to changes in shore type and due to recent developments. A qualifier is contained in the database to identify how the segments were split. Some small changes were made to the 2004 database to reflect the changes in the 2010 database. These changes were minor and ensured consistency between the databases. For example, in 2004, some shorelines classified as a High Level of Impact were 40% natural and some were classified as Moderate if they had 40%. This example was only apparent in a few circumstances. Other examples of changes made include assuming that for split segments, the disturbance levels of each resultant segment split was the same. However, in one or two cases, this assumption skewed results which became apparent in the jurisdictional analysis. In all cases where data were skewed due sampling changes such as this, adjustments were made using air photo interpretation, appropriate assumptions, or other logic to correct for the changes. Best attempts were made to rectify the two databases to ensure a consistent level of comparison between years.

The analysis of data for the two databases focused on the rate of change. By looking at the percent of natural shoreline in 2004 and in 2010, it allowed tracking of the change in shoreline condition from a natural state to a disturbed state. In looking at the data in this fashion, it is possible to understand both the rate of change and the direction (i.e., is the shoreline becoming more natural or more distured). A simple best of fit line (using Excel) was used to determine this. The equations for the best of fit lines can be found on the figures.

4.0 AQUATIC HABITAT INDEX METHODOLOGY

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

The AHI utilizes a number of parameters collected during the FIM. The index uses a points based mathematical index to assign the relative habitat value to each different parameter. Thus, features with higher estimated significance are assigned higher relative values by increasing the weight applied to them within the index. Features impairing the habitat value (e.g., groynes) are assigned negative scores to better reflect the current condition of the shoreline.

Subsequent analysis assessed the habitat potential of a segment. This analysis involved removing ALL negative habitat parameters to determine if shoreline restoration could achieve a measurable benefit. The Habitat Potential index can be used to help assess where instream restorative efforts are best directed. The habitat potential analysis did *not include effects of riparian restoration* due to the extent of database and predictive mapping that would be required to facilitate such an analysis. More detailed habitat restoration analyses are required.

The index generated has only utilized information that is currently available or that can be safely inferred from previous works. In many instances, data gaps have been identified and assumptions have been made. As more information is collected regarding shoreline areas of Okanagan Lake, the Aquatic Habitat Index may need to be updated.

4.1 Parameters

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

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

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

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

Category	Criteria	Maximum Point	Percent of the Category[1]	Percent of the Total[1]	Logic	Uses Weighted FIM Data	Value Categories
Biophysical	Shore Type	15	31.3	8.8	% of Segment * Maximum Point	Yes	Stream Mouth = Wetland (15) > Gravel Beach = Rocky Shore (12) > Sand Beach (8) = Cliff /Bluff (8), Other (5)
	Substrate	12	25.0	7.0	% Substrate * Maximum Point	Yes	Cobble (12) > Gravel (10) > Boulder = Organic = Mud = Marl = Fines (8), Sands (4) > Bedrock (2)
	Percentage Natural	5	10.4	2.9	% Natural * Maximum Point	Yes	
	Aquatic Vegetation	8	16.7	4.7	% Aquatic Vegetation * Maximum Point	Yes	
	Overhanging Vegetation	4	8.3	2.3	% Overhanging Vegetation * Maximum Point	Yes	
	Large Woody Debris	4	8.3	2.3	# of Large Woody Debris/km * Relative Value * Maximum Point	Yes	**Relative Value** >15 LWD/km (1) > 10 to 15 LWD/km (0.8) > 5 - 10 LWD/km (0.6) > 0 - 5 LWD/km (0.4) > 0 LWD/km (0)
Fisheries	Kokanee Spawning	20	29.4	11.7	% Shore Length of Colour Zone * Score	Yes	Black Zone = 20, Red Zone = 10, Yellow Zone 5, No Colour Zone = 0
	Juvenile Rearing	10	20.8	5.8	High (12), Moderate (6), Low (3)	No	High (12), Moderate (6), Low (2)
	Migration Corridor	8	21.1	4.7	Present (8), Absent (0)	No	Present (5), Absent (0)
	Staging Area	8	26.7	4.7	Present (8), Absent (0)	No	Present (5), Absent (0)
	Mussel	12	54.5	7.0	Present (12), Absent (0)	No	Present (12), Absent (0)
	Grebe	10	14.7	5.8	Present (10), Absent (0)	No	Present (10), Absent (0)
Shoreline Vegetation[2]	Band 1	8	66.7	4.7	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	Yes	**Vegetation Bandwidth Category** 0 to 5 m (0.2) < 5 to 10 m (0.4) < 10 to 15 m (0.6) < 15 to 20 m (0.8) < 20 m (1)
	Band 2	4	33.3	2.3	Vegetation Bandwidth Category * Vegetation Quality * Maximum Point	Yes	**Vegetation Quality Category** Natural Wetland = Disturbed Wetland = Broadleaf = Shrubs (1) > Coniferous Forest = Mixed Forest (0.8) > Herbs/Grasses = Unvegetated (0.6) > Lawn = Landscaped = Row Crops (0.3) > Exposed Soil (0.05)
Terrestrial	Conservation Core Areas	10	28.6	5.8	% Shore Length of Colour Zone * Score	Yes	% Length of Conservation Area * Value
	Conservation Buffer Areas	3	8.6	1.8	High (12), Moderate (6), Low (3)	Yes	% Length of Buffer Area * Value
	Wildlife Corridor	8	22.9	4.7	Present (8), Absent (0)	Yes	% Length of Wildlife Corridor * Value
	Other	8	22.9	4.7	Present (8), Absent (0)	Yes	% Length of Other Area * Value
	N/A	1	2.9	0.6	Present (8), Absent (0)	Yes	% Length of N/A Area * Value
	Rare Plants	5	14.3	2.9	Present (8), Absent (0)	Yes	% Length of N/A Area * Value
Modifications	Retaining Wall	-2.00	25.1	-1.2	% Retaining Wall * (-2)	Yes	% Retaining Wall * (-2)
	Docks	-1.76	22.0	-1.0	# Docks/km * (-0.05)	Yes	# Docks per Kilometer * (-0.05)
	Groynes	-1.71	21.4	-1.0	# Groynes/km * (-0.1)	Yes	# Groynes per Kilometer * (-0.1)
	Boat Launch	-0.50	6.3	-0.3	# Launches * (-0.25)	No	# Launches * (-0.25)
	Marina	-2.00	25.1	-1.2	# Marina * (-1)	No	# Marina * (-1)

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

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

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

4.1.1 Biophysical Parameters

The following summarizes the biophysical parameters of the index:

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

2. Substrate – Substrates also relate directly to productivity. In general, there are two types of productive substrate, those utilized for spawning and those that produce more biomass. The substrate values and parameters used for Okanagan Lake are similar to Shuswap and Mabel and are originally based upon species habitat matrices developed for Okanagan Lake in the Kelowna Shorezone Assessment (Schleppe and Arsenault, 2006). Substrates utilized for spawning were given higher weighting than those for foraging. Areas of bedrock were considered the least valuable because they are not utilized for spawning and do not provide good foraging areas for fish.

3. Percent Natural –Areas of natural shoreline have a relative habitat value that is greater than disturbed shoreline areas because the condition of the habitat is better. The value of this parameter in the index is the same as Shuswap and Mabel but is still less than the original AHI for central regions of Okanagan and Windermere Lakes. This value was given less weighting from the original AHI within the City of Kelowna limits on Okanagan Lake (Schleppe and Arsenault, 2006) Lake because the devaluing effects of disturbance are believed to be less than original inferred in the AHI for the City of Kelowna areas.

4. Aquatic Vegetation – In more recent versions of the FIM database, more detailed information regarding aquatic vegetation was collected. On Okanagan Lake, all vegetation below the HWL is considered productive. Since the FIM now allows analysis of this parameter, it was added to the index following the same methods as Shuswap Lake. The benefits of aquatic vegetation are many and include forage, biomass production, cover, etc. For Okanagan Lake, the relative value of aquatic vegetation was increased slightly from Mabel and Shuswap because impacts to historical vegetation areas is considered to be greater. The remaining vegetation areas have a slightly higher relative value because of the historical impacts (e.g., most shoreline areas within the City of Kelowna have had almost all large woody debris and emergent floodplain areas affected reducing the cover of aquatic vegetation).

5. Overhanging Vegetation – In the more recent FIM database versions, more detailed information regarding overhanging vegetation was collected. Along Okanagan Lake, overhanging vegetation was documented infrequently, likely due to the dry arid climate, steep shorelines in many areas, and past historical development along floodplain areas within Kelowna. Since it provides nutrients and opportunities to forage, it was added to the index.

6. Large Woody Debris – The detailed large woody debris information collected was used in the index because it has importance for salmonid and other species. Large Woody Debris was not present in many areas. Woody debris was absent for several reasons, including proximity and quantity associated with sources such as large rivers, and removal from "beach grooming" activities by residents in areas where shore drop would typically occur. Since large woody debris provides nutrients, cover, and opportunities to forage, it was added to the index. Numerous studies have identified the importance of large woody debris to salmonids in lake and stream systems.

4.1.2 Fisheries Parameters

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

1. Juvenile Rearing shoreline habitat value (High, Moderate, and Low) was prepared for this assessment. Juvenile rearing values were prepared using an index similar to the AHI. The index was based upon original surveys of Shuswap Lake by Graham and Russell (1979) and Russell *et al* (1981) who documented juvenile utilization along the shoreline. In these assessments, habitat criteria similar to those collected in the FIM were utilized to assess areas as High, Moderate, or Low Juvenile Rearing Value. Similar to Russell's approach, a Juvenile Habitat Suitability Index was developed for Okanagan Lake (without a field sampling confirmation component). The values of Sand shore types and sand substrates was increased in the Okanagan Lake index (when compared to Mabel) to account for the increased substrate modification and impacts to historical floodplain shores that would have been classified as wetlands. The following criteria were used in the Juvenile Rearing Habitat Suitability Index for Okanagan Lake.

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

Category	Criteria	Maximum Point	Percent of the Category[1]	Logic	Uses Weighted FIM Data	Value Categories
Criteria	Shore Type	12	22.6	% of Segment * Maximum Point	Yes	Stream Mouth (12) > Wetland (8) = Sand Beach (8)> Gravel Beach = Rocky Shore (6) = Cliff /Bluff (4), Other (1)
	Substrate	9	17.0	% Substrate * Maximum Point	Yes	Organic(9) = Mud (9) = Marl (9) = Fines (9) > Boulder (8) > Cobble (7) > Gravel (7) > Sands (6) > Bedrock (4)
	Aquatic Vegetation	5	9.4	Aquatic Vegetation Category Score	No	**Aquatic Vegetation Category Score** Aq. Veg > 80% = 5, Aq. Veg 50% to 80% = 3. Aq. Veg < 50% = 1
	Littoral Width	12	22.6	Littoral Width Category Score	No	**Littoral Width Category** Wide (>50m) = 12, Moderate (10 to 50 m) = 8, Narrow (<10m) = 3
	Overhanging Vegetation	1	1.9	% Overhanging Vegetation * Maximum Point	No	
	Large Woody Debris	4	7.5	Large Woody Debris Category Score * Maximum Point	No	**Large Woody Debris Category Score** >15 LWD/km (1) > 10 to 15 LWD/km (0.8) > 5 - 10 LWD/km (0.6) > 0 - 5 LWD/km (0.4) > 0
	Migration Corridor	5	9.4	Present / Absent	No	Present (5), Minor (0)
	Salmonid Spawning Stream Present	5	9.4	Present / Absent	No	Present (5), Minor (0)

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

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