



# Hutchinson

Environmental Sciences Ltd.

Lac La Biche Foreshore  
Inventory and Mapping Report

Prepared for: Living Lakes Canada  
Job #: 170009

June 14, 2017

1-5 Chancery Lane, Bracebridge ON P1L 2E3 | 705-645-0021  
202-501 Krug Street, Kitchener ON N2B 1L3 | 519-576-1711  
4482 97 Street NW, Edmonton AB T6E 5R9 | 587-773-4850

## Lac La Biche Foreshore Inventory and Mapping Report

June 14, 2017

HESL Job #: J170009

Ms. Heather Leschied  
Program Director  
Living Lakes Canada

Dear Ms. Leschied:

**Re: Lac La Biche Foreshore Inventory and Mapping Report**

Hutchinson Environmental Sciences Ltd. has completed the first deliverable of the Lac La Biche Sensitive Habitat Inventory Mapping Project, the Lac La Biche Foreshore Inventory and Mapping Report. The report presents and describes information collected through 2016 field investigations and a background review including: land use, shore type, shoreline modifications, riparian vegetation, aquatic vegetation, phytoplankton, fisheries, wetlands, wildlife and birds. We have addressed the comments provided by Living Lakes Canada in this final version of the report.

Lac La Biche is a large, moderately developed lake with numerous modifications associated with development such as docks, retaining walls and boat launches. The lake supports a mixed fishery that is intensively monitored due to recent declines, and is impacted by the annual occurrence of blue-green algae blooms. Lac La Biche is naturally eutrophic and blue-green algal blooms have occurred for several years but cultural eutrophication likely impacts the size and abundance of such blooms.

Wetlands are abundant around the lake, especially within the floodplain of the La Biche River, and aquatic vegetation, especially submerged vegetation, is also common in nearshore areas of the lake, providing habitat and food for a variety of fish and other wildlife. During the breeding season, the lake's islands and marshes support significant concentrations of several colonial waterbird species and the lake also provides habitat for numerous bird species during the non-breeding season, including migrating waterfowl.

The information presented in this report will be used as building-block for future reports to determine an Aquatic Habitat Index, categorize shoreline sensitivities of all shoreline segments and ultimately, develop shoreline management guidelines to help protect sensitive features moving forward.

Sincerely,  
Per. Hutchinson Environmental Sciences Ltd.



Brent Parsons, M.Sc.  
[brent.parsons@environmentalsciences.ca](mailto:brent.parsons@environmentalsciences.ca)



## Signatures

Report Prepared by:



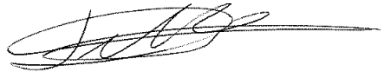
---

Brent Parsons, M.Sc.  
Senior Aquatic Scientist



---

Andrea Smith, Ph.D.  
Senior Scientist



---

Eric Dilligeard, Ph.D.  
Geospatial Analyst

Report Reviewed by:



---

Dörte Köster, Ph.D.  
Senior Aquatic Scientist



## Lac La Biche Foreshore Inventory and Mapping Report

### Acknowledgements

Fieldwork for this assessment was completed by Bruce MacDonald and Heather Leschied, Living Lakes Canada, with additional support from Brayden Torresan and Evan Hendry, Lac La Biche County and Brian Deheer and Jason Ponto, Athabasca Watershed Advisory Council. Bruce MacDonald and Heather Leschied also provided invaluable technical support throughout report production.

Financial and in-kind support for this project was provided by Environment Canada EcoAction, Alberta EcoTrust, Alberta Real Estate Foundation, Land Stewardship Centre, and Lac La Biche County.



## Executive Summary

Lac La Biche is a large lake situated in the Boreal Mixedwood Ecoregion of northeastern Alberta. It has numerous bays and rocky offshore islands, as well as wide areas of shallow littoral habitat characterized by extensive submerged and emergent vegetation. The lake provides important habitat for many fish species, as well as colonial and migratory waterbirds and aquatic mammals. It supports sport and domestic fisheries and is a popular recreational destination for swimming, boating, fishing, hiking and nature appreciation.

In recent years, Lac La Biche has experienced declines in water quality and fish populations, leading to widespread blue-green algal blooms and fishery closures. The Sensitive Habitat Inventory Mapping (SHIM) project for Lac La Biche was initiated in 2016 to respond to community concerns over the health of the lake. This project characterizes the physical and biological features of the lake's foreshore so that sensitive areas can be identified and subsequently protected during shoreline development. While this method has been applied to several lakes in British Columbia, and successfully incorporated into land use planning there, the Lac La Biche SHIM project, once completed, will be the first example of its use elsewhere in Canada.

The SHIM project consists of three main components: (i) Foreshore Inventory and Mapping Report; (ii) Aquatic Habitat Index and Activity Risk Table; and (iii) Shoreline Management Guidelines. Field work was conducted in 2016 to inform these three components, and supplemented with a background review of local, provincial, federal natural heritage information to characterize the Lac La Biche foreshore. The Foreshore Inventory and Mapping Report is the first deliverable of the project, which summarizes the physical and biological features of the lake's shoreline. It will serve as a building block for the development of future reports in the project.

The 167 km length of Lac La Biche shoreline was divided into 60 segments based on shore type, land use and vegetation. Most of the shoreline (85%) was natural, especially around the islands and along the northern side of the lake. The predominant shore type was rocky (65%), followed by wetland (19%) and sand (8%). Rocky shorelines were scattered throughout much of the lake, while wetlands were mainly concentrated along the north shore. The most common land use was natural area (65%).

Although most of the shoreline was characterized by natural habitat, numerous shoreline modifications were also recorded, including 229 docks, 248 boat lifts, 39 private boat launches and 5 retaining walls. Removal of riparian, wetland and submerged vegetation was also a common modification, as well as addition of substrate (such as gravel and sand) for boat launches and beaches.

The riparian zone was primarily characterized by forest (45% of shoreline was comprised of broadleaf forest and 39% of mixed forest). The remaining riparian habitat was made up of wetland (5%), shrubs (5%), landscaped habitat (4%), herbs/grasses (2%) and exposed soil (<1%). Wetland riparian habitat occurred mainly in the southeastern embayment and shrubs dominated areas around High, Black Fox, and Fox Islands. Forested riparian zones occurred throughout the lake's shoreline, while landscaped habitat was associated with developed areas, especially in the eastern basin.



**Lac La Biche Foreshore Inventory and Mapping Report**

The main types of substrate documented in the foreshore were sand (27%), cobble (23%), and gravel (22%). Boulders (17%), organic material (10%), and trace amounts of fine cobble, fine gravel, fines and coarse cobble were also recorded.

Submerged vegetation covered approximately 70% of the littoral zone, and had greatest coverage along the north shore of the western basin, adjacent to the La Biche River floodplain, as well as through most of the eastern basin. Emergent vegetation was less abundant, occupying 18% of the shoreline, typically associated with wetland areas.

Blue-green algal blooms occur annually in Lac La Biche during the summer, although coverage and abundance varies from year to year. The highest concentrations were typically reported in the eastern basin (due to westerly winds). Lac La Biche is naturally eutrophic and thus prone to blooms, although human activity has likely increased eutrophication of the lake over the last 30 to 50 years.

No fish surveys were conducted as part of the SHIM project. Lac La Biche is home to thirteen fish species and supports important sport, and domestic fisheries. A fisheries restoration program was initiated in 2005 in response to declines in fish populations due to overfishing, which includes catch limit reductions, protection of critical fish habitat, and monitoring of the fish community. Resident fish rely on a variety of aquatic habitats for spawning and rearing of young, including rocky substrates, flooded vegetation and the presence of macrophytes and woody debris.

Wildlife surveys were not conducted as part of the 2016 field work, but incidental observations were recorded. Wildlife species seen included beaver, fox and moose. Numerous bird species were also documented during field investigations, including waterfowl (e.g., ducks, geese), waterbirds (e.g., pelicans, herons), raptors (e.g., Bald Eagle) and songbirds (e.g., sparrows, chickadees). Lac La Biche is an important breeding and staging area for a wide variety of bird species. During the breeding season, the lake supports significant concentrations of several colonial waterbird species in offshore islands and marshes, and provides habitat for numerous migrating species during the non-breeding season.



## Table of Contents

Transmittal Letter

Signatures

Acknowledgements

Executive Summary

<b>1.</b>	<b>Introduction</b> .....	<b>1</b>
<b>2.</b>	<b>Lac La Biche</b> .....	<b>1</b>
<b>3.</b>	<b>Methodology</b> .....	<b>4</b>
3.1	Sensitive Habitat Inventory Mapping .....	4
3.2	2016 Field Work .....	4
3.3	Data Collection and Analysis .....	5
<b>4.</b>	<b>Results</b> .....	<b>6</b>
4.1	Physical Features .....	6
4.1.1	<i>Shore Type and Land Use</i> .....	8
4.1.2	<i>Shoreline Modification</i> .....	14
4.2	Biological Features .....	17
4.2.1	<i>Riparian Zone</i> .....	17
4.2.2	<i>Substrates</i> .....	18
4.2.3	<i>Aquatic Vegetation</i> .....	21
4.2.4	<i>Phytoplankton</i> .....	26
4.2.5	<i>Fisheries</i> .....	28
4.2.6	<i>Wetlands</i> .....	29
4.2.7	<i>Wildlife</i> .....	30
4.2.8	<i>Birds</i> .....	31
<b>5.</b>	<b>Conclusions</b> .....	<b>34</b>
<b>6.</b>	<b>References</b> .....	<b>36</b>

## List of Figures

Figure 1.	Lac La Biche study area .....	3
Figure 2.	Physical landmarks and shoreline segments of Lac La Biche. ....	7
Figure 3.	Percent of natural and disturbed shoreline on Lac La Biche. ....	8
Figure 4.	Percent of shoreline occupied by various shore types. ....	8
Figure 5.	Physical features of Lac La Biche – western basin. ....	10
Figure 6.	Physical features of Lac La Biche – eastern basin. ....	11
Figure 7.	Percent of shoreline occupied by various land uses. ....	12
Figure 8.	Types of riparian vegetation observed in the B1 zone. ....	17
Figure 9.	Percent of various substrates in the littoral zone of Lac La Biche. ....	19
Figure 10.	Wetland and vegetation features of Lac La Biche – western basin. ....	24
Figure 11.	Wetland and vegetation features of Lac La Biche – eastern basin. ....	25



## List of Tables

Table 1. Percent coverage of submerged vegetation at all shoreline segments. ....	21
Table 2. Spawning habitat requirements of resident sport fish (Scott and Crossman 1973). ....	29
Table 3. Summary of wildlife observations from 2016 field work. ....	31
Table 4. Summary of bird observations from 2016 field work. ....	33
Table 5. Summary of bird nest observations from 2016 field work. ....	34

## Appendices

Appendix A. Foreshore Inventory and Mapping Field Code Definitions





## Lac La Biche Foreshore Inventory and Mapping Report

# 1. Introduction

Sensitive Habitat Inventory Mapping (SHIM) is a method for characterizing the physical and biological features of a lake's foreshore so that sensitive areas can be identified and protected from shoreline development. The SHIM approach has been used to date in 15 British Columbia lakes (e.g., Monroe Lake, Moyie Lake, Windermere Lake), where results have been successfully incorporated into local and regional land use planning to develop appropriate mitigation measures and minimize impacts to sensitive features. In 2016 Living Lakes Canada and the Stewards of the Lac La Biche Watershed (in partnership with Lac La Biche County) initiated the Lac La Biche SHIM, which, when completed will represent the first application of the method outside of British Columbia.

Lac La Biche has recently experienced declines in water quality and fish populations (e.g., Walleye, *Sander vitreus*) leading to blue-green algal blooms and fishery closures. The Lac La Biche Watershed Management Plan was developed in 2009 to address the impacts of development on the lake's ecology (Aquality 2009). The Plan evaluated the lake's water quality and quantity, and described riparian areas and wetlands, as well as fisheries, waterfowl and other wildlife. The Plan made a number of recommendations, which included mapping a variety of natural heritage features, determining the location and nature of sensitive features, and developing science-based guidance that could be incorporated into planning policy to protect these sensitive resources.

The Lac La Biche SHIM project was launched in response to community concerns over the health of the lake, to act on the recommendations from the 2009 Watershed Management Plan, and to engage area residents in stewardship. Fieldwork was conducted in 2016 for the SHIM project. There are three main components to the project for Lac La Biche: (i) the Foreshore Inventory and Mapping Report; (ii) the Aquatic Habitat Index and Activity Risk Table; and (iii) the Shoreline Management Guidelines. The Foreshore Inventory and Mapping Report is the first deliverable of the study. The scope of work is based on the general approach used to complete other SHIM projects led by Living Lakes Canada in British Columbia, with modifications to address site-specific features and sensitivities particular to Lac La Biche.

# 2. Lac La Biche

Lac La Biche is a large lake (surface area = 234 km<sup>2</sup>; 167 km of shoreline) located approximately 220 km northeast of Edmonton, Alberta, in the Boreal Mixedwood Ecoregion (Figure 1; Mitchell and Prepas 1990). The drainage basin area is 4,040 km<sup>2</sup> and the major inflow is the Owl River, which in turn receives flow from tributaries, such as the Logan, Clyde and Piche Rivers, and Gull Creek. Approximately 50% of the immediate catchment has been cleared for agriculture, primarily to grow hay or provide pasture for cattle. Agriculture makes up less than 5% of the entire watershed, however, which is mainly covered by forest and wetlands, as well as other lakes (Mitchell and Prepas 1990).

The lake consists of two distinct basins and numerous bays and rocky islands. The eastern basin contains most of the lake's islands and has a maximum depth of 12.2 m, while the western basin has a maximum depth of 21.3 m (McGregor 2014). Wide areas of shallow nearshore (also known as the littoral zone) are common throughout the lake, and support extensive patches of submerged and emergent vegetation. These areas provide critical habitat for a wide diversity of wildlife, including fish, waterfowl and aquatic mammals.



## Lac La Biche Foreshore Inventory and Mapping Report

Sir Winston Churchill Provincial Park encompasses the major islands located on the lake: Long Island, Big Island, Current Island, Birch Island, Fox Island, Black Fox Island and High Island. The lake provides an important nesting and staging area for many species of waterfowls and supports a significant recreational fishery.

Habitat surrounding the lake includes coniferous and mixed forest, wetlands (marshes, bogs and fens), rivers, and streams. Approximately two-thirds of the shoreline is privately owned for cottages and permanent residences, with the remainder of the lakeshore comprised of parkland, commercial, agricultural and recreational land uses. The Hamlet of Lac La Biche (population ~2,500) is located adjacent to the southeast part of the lake.



## Lac La Biche Foreshore Inventory and Mapping Report

**Figure 1. Lac La Biche study area.**



## 3. Methodology

### 3.1 Sensitive Habitat Inventory Mapping

Sensitive Habitat Inventory Mapping (SHIM) was designed to identify sensitive foreshore ecosystems and critical habitats with a Geographical Information System (GIS) to provide an overall picture of the health of a lake's shoreline. The protocol has been used to characterize shoreline condition on 15 lakes in British Columbia; this is the first application of the methodology in Alberta. Modules describing tools to inventory, map and compile data for watercourses are provided in Mason and Knight (2001). The protocol has been adapted for different lakes based on site-specific features, including the unique characteristics of the study lake, development pressures and study objectives.

### 3.2 2016 Field Work

Field information was collected by Bruce MacDonald and Heather Leschied in July and September 2016. The July field program was shortened due to logistical issues, and consequently served mainly as reconnaissance for the September field work.

Field data was collected using a Trimble Global Positioning System (GPS) unit with SHIM Lake v. 2.4 software (FIM Data dictionary name), photos and video recording. Field personnel travelled by boat along the shoreline, collecting information from the boat or by land where possible while staying at sufficient water depth to ensure the boat could be operated safely. The study area stretched from approximately 100 m offshore (or approximately 3 m of water depth) to the high-water mark, with features assessed further inland via interpretation of aerial photography. Foreshore inventory details and mapping field code definitions are provided in Appendix A. Information included:

- Lake Reference
  - Lake name, date, time, weather, air temperature and water temperature
- Segment class
  - Shore modification, slope, land use and level of impact
- Shore type
  - Cliff, rocky, gravel, sand, stream mouth and wetlands
- Land use
  - Single family, natural area, park, commercial, agricultural, industrial, institution and recreation
- Substrates
  - Organic, fines, sand, gravel, fine gravel, coarse gravel, cobble, fine cobble, coarse cobble and boulder
- Littoral vegetation
  - Percent coverage of submerged vegetation, percent coverage of emergent vegetation
- Modifications
  - Number of docks, boat launches, retaining walls, marine railways
- Flora and fauna
  - Incidental observations



## Lac La Biche Foreshore Inventory and Mapping Report

Shoreline segments were delineated during field investigations by marking GPS break points. Segments were based on maximizing similarities of shore type, land use and vegetation within a segment, while maintaining a manageable total number of segments. All information was recorded per shoreline segment and data was later interpreted and analyzed according to the same segments. The assessment also included the establishment of 20 sample sites throughout the littoral environment where information on wildlife, shore type and general comments were recorded in more detail. Sample sites were established to confirm observations of shoreline segments and provide another layer of information when characterizing sensitive habitats.

Photographs were taken to depict shoreline conditions. Photograph numbers were sorted per segment number to allow for spatial analysis. Video recorded through aerial reconnaissance on August 26, 2004 was provided by Lac La Biche County and included audio commentary to provide spatial awareness. Review of photographs and video was conducted to clarify substrates, land use, and land cover, and to classify or validate shoreline segments where required.

Alberta Environment and Parks did not issue a fish collection permit because it indicated that ample fisheries information was already available for Lac La Biche. As a result, fish were not collected during field investigations.

### 3.3 Data Collection and Analysis

A background review was completed to summarize all available information on the physical and biological characteristics of the Lac La Biche foreshore. For this study, the foreshore included both the riparian and littoral environments stretching from approximately 30 m inland to 3 m of water depth (in general this depth extended out to approximately 100 m offshore). We reviewed provincial, federal and local wildlife, fish habitat and plant community data. Background review sources included:

- Bird monitoring data available through Ebird Canada, Alberta Bird Records, Canadian Wildlife Service's Marsh Monitoring Program, Alberta Breeding Bird Atlas (2000-2005), Ducks Unlimited, Lac La Biche Birding Society and the Prairie Shorebird Survey;
- Alberta Biodiversity Monitoring Institute (for invertebrates, plants, birds and mammals);
- Alberta Conservation Information Management System (for invertebrates, plants, and ecological communities);
- Fisheries and Wildlife Management Information System (for birds and fish);
- Lac La Biche County (for GIS layers on wetlands, transportation, legal description, cadastre, water features, depth contour line, aerial imagery);
- Cows and Fish Alberta Riparian Habitat Management Society for potential riparian health assessment data; and
- Peer-reviewed literature.

Fisheries information from Alberta Environment and Park's Fisheries and Wildlife Management Information System was reviewed. Although there is substantial information from Lac La Biche, it was not particularly informative for this study. Most fish surveys used gill net catches to inform sport fish management considerations, such as stocking of Walleye, and setting both recreational and commercial catch limits. To determine shoreline sensitivities, fisheries information needs to include habitat descriptions and collection methodologies that typify local populations so that results can be linked to characteristics of the shoreline



## Lac La Biche Foreshore Inventory and Mapping Report

and littoral zone. Gill netting was typically completed in the pelagic zone and results cannot be used to inform microscale/shoreline segment conditions.

Data was collected and reviewed per shoreline segment. Data was interpreted by percent of total shoreline and length of shoreline, assessed spatially through a review of maps, and information was verified through review of photographs and field notes.

## 4. Results

Information from 60 shoreline segments was collected along 167 km of Lac La Biche shoreline (Figure 2). The most pertinent information which will be used during later stages to calculate the Aquatic Habitat Index and the sensitivity of shoreline segments is discussed in the following paragraphs.

### 4.1 Physical Features

The percent of each shoreline segment that was natural and disturbed was estimated along the entire Lac La Biche shoreline. Shoreline segments ranged from 100% natural to 100% disturbed depending on adjacent land use and level of impact. The total length of disturbed shoreline was 24.8 km (14.8%) and the total length of natural shoreline was 141.8 km (85.2%; Figure 3). The islands contained predominantly natural shoreline because much of them are designated as protected area, while other predominantly natural shorelines were prevalent throughout the northern shorelines of the eastern and western basins. Modified shorelines were most abundant along the southern shoreline of the eastern basin near the hamlet of Lac La Biche (e.g., shoreline segments 1, 51) and adjacent to other areas of high density development, such as the Mystic Subdivision (segment 24).



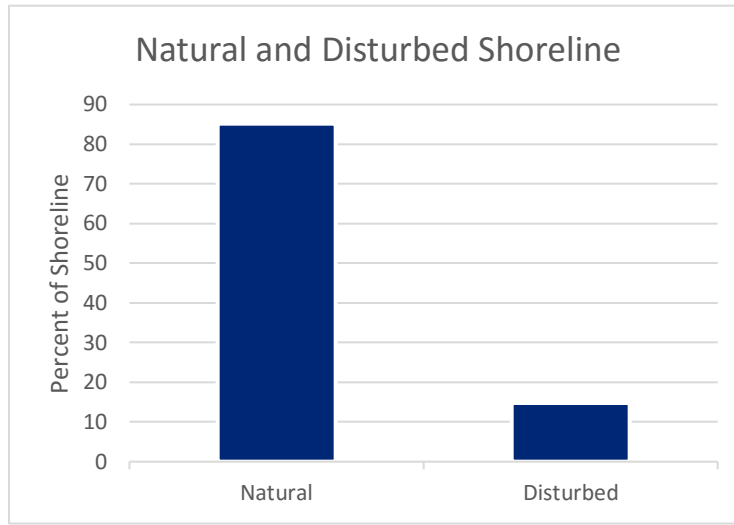
## Lac La Biche Foreshore Inventory and Mapping Report

**Figure 2. Physical landmarks and shoreline segments of Lac La Biche.**



Lac La Biche Foreshore Inventory and Mapping Report

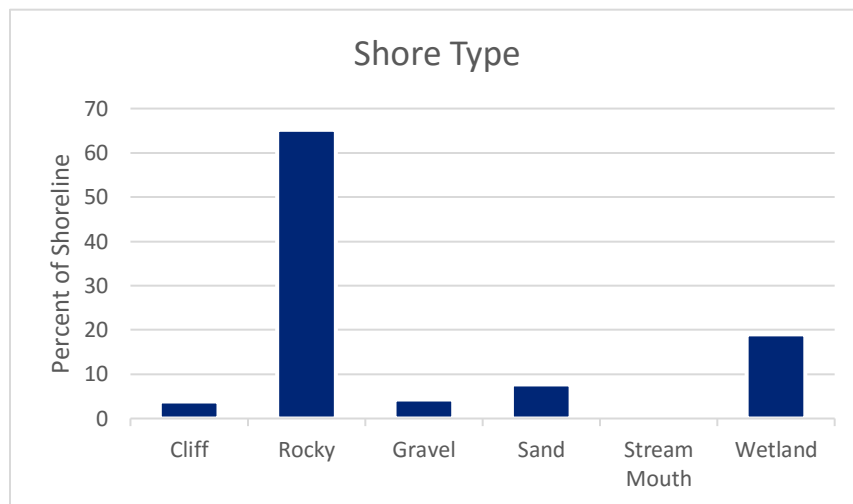
Figure 3. Percent of natural and disturbed shoreline on Lac La Biche.



4.1.1 Shore Type and Land Use

The predominant shore type on Lac La Biche was determined and mapped for each shoreline segment, and the percent cover of each land use for each shoreline segment was estimated. The most abundant shore type was rocky, which occupied 65% of Lac La Biche’s shoreline, followed by wetland (19%), sand (8%), gravel (4%), cliff (4%) and stream mouth (<1%) (Figure 4; Photographs 1-3). Rocky shorelines are scattered throughout much of Lac La Biche, wetlands are concentrated along the north shore of both the western and eastern basins and sand shore types are located adjacent to residential development at shoreline segments 8, 17 and 24 (Figures 5 and 6).

Figure 4. Percent of shoreline occupied by various shore types.





## Lac La Biche Foreshore Inventory and Mapping Report



**Photographs 1 – 3. Prevalent shore types along Lac La Biche were rocky (top left - shoreline segment 39), wetland (top right – shoreline segment 33) and sand (bottom left – shoreline segment 44).**



## Lac La Biche Foreshore Inventory and Mapping Report

**Figure 5. Physical features of Lac La Biche – western basin.**



**Lac La Biche Foreshore Inventory and Mapping Report**

**Figure 6. Physical features of Lac La Biche – eastern basin.**

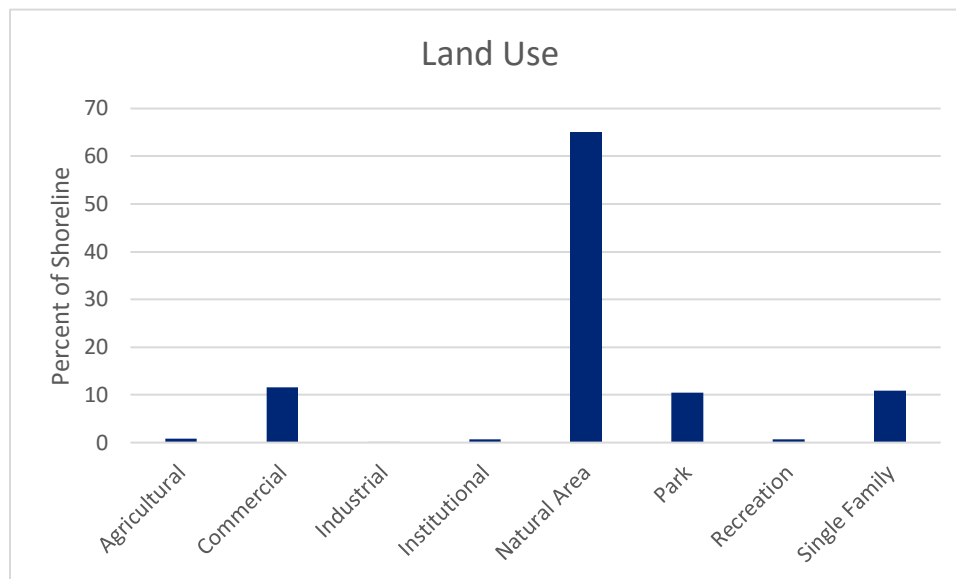


## Lac La Biche Foreshore Inventory and Mapping Report

The predominant land use adjacent to the Lac La Biche shoreline was determined for each shoreline segment and mapped, and the percent cover per land use for each shoreline segment was estimated (Figures 5 and 6). The most abundant land use was natural area, which occupied 65% of Lac La Biche's shoreline, followed by commercial (12%), single family (11%), and natural park (11%; Figure 7; Photographs 4 - 7). Agriculture (<1%), recreation (<1%) and industrial (<1%) land use proportions were minor. Relatively high commercial land use coverage can be attributed to the presence of roads in segments 2, 36, 38, 38, 47, 48, 49 and 53, most of which constitute the causeway to Winston Churchill Provincial Park and were classified as commercial land use according to definitions provided in Appendix A.

Most single-family homes were in segments 4, 7, 10, 13, 14, 16, 24, 27, 28, 29, 30, 35, 50, 51 and 52 associated with the Mystic Subdivision, Mission Subdivision, McGrane Subdivision, Lac La Biche West Subdivision, Golden Sands Subdivision and the hamlet of Lac La Biche (Figure 2).

**Figure 7. Percent of shoreline occupied by various land uses.**





**Photographs 4 – 7. Prevalent land uses along the Lac La Biche shoreline included natural area (top left – shoreline segment 23), commercial (top right – causeway to Big Island, Sir Winston Churchill Provincial Park, shoreline segment 47), natural parkland (bottom right – shoreline segment 46) and single family (bottom left – shoreline segment 51).**



**Lac La Biche Foreshore Inventory and Mapping Report****4.1.2 Shoreline Modification**

Shoreline modifications such as docks and boat houses were counted within each shoreline segment while larger modifications were marked with waypoints (Figures 5 and 6). Larger modifications included eight public boat launches, two ice road accesses, a pump station, a large retaining wall and an area of dredging.

Shoreline modifications observed on the lake were comprised of 229 docks, 248 boat lifts, 39 private boat launches, 50 retaining walls, 10 marine railways, 11 mooring buoys and 1 pump station (Photographs 8 - 10). The retaining walls occupied approximately 1.5 km of shoreline and were made up of a range of materials including wood, stone and concrete. Heavily modified shorelines were observed in segments 24, 30, 51, 7 adjacent to single family residential development.

Other notable modifications to the shoreline were riparian, wetland and submerged vegetation removal, as well as addition of substrate. In-water vegetation removal is often completed to improve conditions for swimming, to provide an appropriate area for establishment of docks or to provide boat access. Many docks on Lac La Biche were located within dense accumulations of aquatic vegetation (Photograph 10). Docks commonly shade out existing aquatic vegetation located beneath the dock and boat use both destroys vegetation communities and stirs up underlying sediment, releasing nutrients and metals in the process. Aquatic vegetation provides important cover habitat for fish and is a vital food source for wildlife and benthic invertebrates. Riparian vegetation is often removed for landscaping purposes and replaced with grass. Native riparian vegetation provides wildlife habitat, stabilizes shorelines, filters stormwater runoff and provides a biological pathway for the uptake of nutrients.

Gravel and sand have also been added to portions of the shoreline to create solid traction for boat launches and beaches for recreation. Introduction of these substrates can cover up existing substrates that might be preferable for fish species or the establishment of aquatic vegetation. It was not possible to quantify vegetation removal or the addition of substrates but these modifications were noted on the lake.



Lac La Biche Foreshore Inventory and Mapping Report



Photograph 8. Ice road access located in shoreline segment 9.



Photograph 9. Retaining wall located near Lac La Biche in shoreline segment 1.





**Photograph 10. Docks located within a nearshore wetland.**





## 4.2 Biological Features

### 4.2.1 Riparian Zone

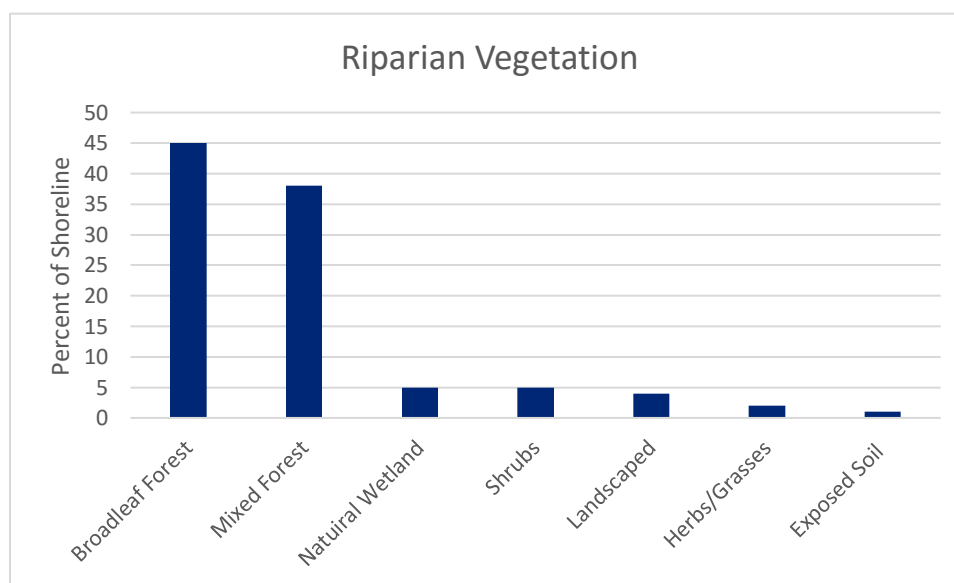
Vegetation within the B1 zone (from the high-water mark inland 30 m) was visually characterized from the lake. Vegetation was classified as Broadleaf Forest (45% of the shoreline), Mixed Forest (39%), Natural Wetland (5%), Shrubs (5%), Landscaped (4%), Herbs/Grasses (2%) or Exposed Soil (<1%; Figure 8; Photograph 11). Landscaped vegetation was located near developed areas (shoreline segments 1, 24, 51 and 53), wetland vegetation was most evident in the southeastern embayment (shoreline segments 28, 33 and 34), and shrubs were most abundant around High Island (shoreline segment 54), Black Fox Island (shoreline segment 55) and Fox Island (shoreline segment 59). Broadleaf and mixed forests were scattered around much of the lake.

Shrub and tree cover was categorized as Abundant (>50%), Moderate (10-50%) or Sparse (<10%; Figure 8). Abundant shrub coverage characterized 70% of the shoreline, followed by Moderate (19%), and Sparse (10%), with only <1% containing no shrubs. Tree coverage was similar: 79% Abundant, 12% Moderate, 7% Sparse and 2% without tree coverage in the riparian environment.

Rocky shorelines generally had shrubs and overhanging vegetation or emergent grasses and herbs beginning at the high-water mark and extending inland 1-3 m. Beyond this, shrubs and larger trees dominated.

Factors contributing to the difference in plant communities could be shoreline ice development and heaving, prevalent wind/wave action, and substrate type as these factors influence colonization and success of vegetation communities through the determination of nutrient availability and physical displacement resulting from erosion.

**Figure 8. Types of riparian vegetation observed in the B1 zone.**





**Photograph 11. Natural and intact herbs/grasses riparian community observed adjacent to the lake.**

#### 4.2.2 Substrates

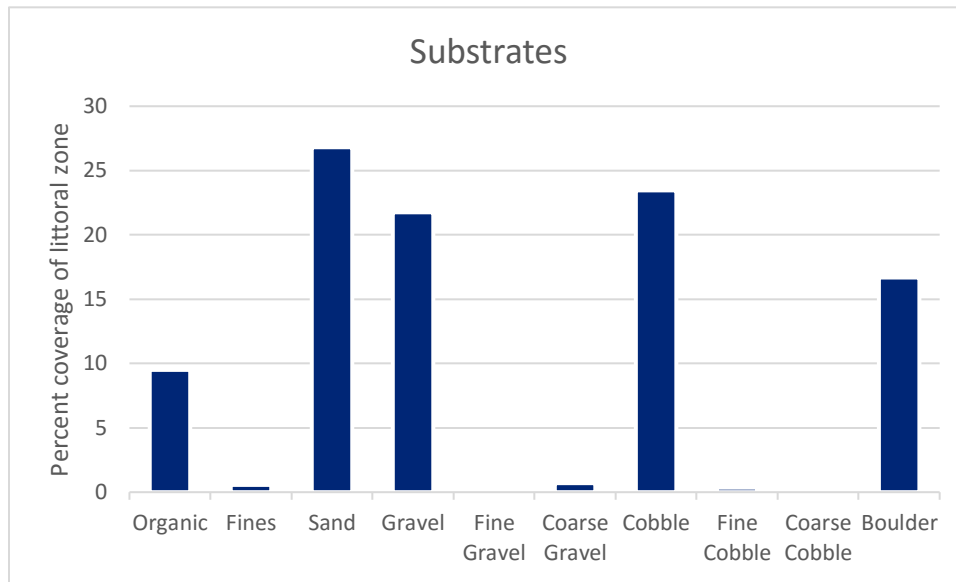
Substrates are important components of aquatic habitat and provide opportunities for fish spawning and egg development, benthic invertebrate colonization, aquatic vegetation and periphytic algae colonization. The Lac La Biche shoreline is composed of glacial till which is often blanketed with glaciolacustrine clays and sands (Mitchell and Prepas 1990). Substrate was estimated as a percent of each shoreline segment based on visual observations. Substrate categories available in the field protocol were organic, fines, sand, gravel, fine gravel, coarse gravel, cobble, fine cobble, coarse cobble and boulder. Gravel and cobble was generally classified as just “gravel” or “cobble” during the 2016 field work at Lac La Biche and not further broken down as “fine” or “coarse”, because visibility was impeded by algal growth, making distinction between the categories challenging.

Sand was the most abundant substrate (27%), followed by cobble (23%), gravel (22%), boulder (17%) and organic (10%), with trace amounts of fine cobble (<1%), fines (<1%), fine gravel (<1%), and coarse cobble (<1%; Figure 9; Photographs 12-14).



### Lac La Biche Foreshore Inventory and Mapping Report

**Figure 9. Percent of various substrates in the littoral zone of Lac La Biche.**





Photographs 12 – 14. Substrates observed in Lac La Biche included cobble (top left), sand (right) and boulders (bottom left).



## Lac La Biche Foreshore Inventory and Mapping Report

## 4.2.3 Aquatic Vegetation

Submerged and emergent vegetation was characterized within the littoral zone in Lac La Biche (Photographs 15-18). Submerged vegetation was abundant, covering approximately 70% of the littoral environment, varying between 0% to 100% coverage per segment (Figures 10 and 11). Coverage was typically highest along the north shore of the western basin adjacent to the floodplain of the La Biche River and throughout the majority of the eastern basin's shoreline. Shoreline segments are sorted according to submerged vegetation coverage in Table 1.

**Table 1. Percent coverage of submerged vegetation at all shoreline segments.**

Percent Coverage	Number of Shoreline Segments	Shoreline Segments	
		East Basin	West Basin
81-100	39	1, 2, 4, 5, 6, 22, 24, 27, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 43, 45, 46, 47, 48, 49, 50, 51, 52, 53, 56, 57, 58, 59	7, 14, 20, 54, 55
61-80	4	26, 34	9, 16
41-60	4	3	8, 12, 13
21-40	0	n/a	n/a
0-20	12	23, 25, 28, 42, 44, 60	10, 11, 17, 18, 19, 21

Most plants were not identified to species, but the presence of Milfoil (*Myriophyllum spp.*), Waterweed (*Elodea spp.*), and Pondweed (*Potamogeton spp.*) was noted. Surveys completed in 1967 included the following species: Canada Waterweed (*Elodea canadensis*), Northern Watermilfoil (*Myriophyllum exalbescens*), Sago Pondweed (*Potamogeton pectinatus*), Small-leaf Pondweed (*Potamogeton pusillus*), Richardson's Pondweed (*Potamogeton richardsonii*), and Flat-Stemmed Pondweed (*Potamogeton zosteriformis*; Pinsent 1967). Pinsent (1967) noted that distribution, species composition and abundance was influenced by substrates, water depth, and wind/wave action.

Emergent vegetation was less abundant than submerged vegetation in 2016, occupying 18% of the shoreline, with coverage ranging from 0% to 100% per segment. Pinsent (1967) noted the presence of Common Great Bulrush (*Scirpus validus*), especially along the north shore and in protected bays, and Common Cattail (*Typha latifolia*). In 2016, abundant coverage (>90%) often occurred adjacent to wetlands and was noted at shoreline segments 5, 8, 12, 15, 17, 19, 22, 25, 28, 33, 34, 42 and 56.



## Lac La Biche Foreshore Inventory and Mapping Report

The littoral zone is wide in portions of the lake, these areas often contained more depository substrates and conditions such as shallow water depths that support the growth of submerged vegetation. Submerged vegetation is a key environmental feature in the lake that provides cover habitat for fish and a food source for a wide variety of wildlife and birds.





**Photographs 15 – 18. Submerged aquatic vegetation was abundant in Lac La Biche (top left, top right and bottom left). An example of intact accumulation of emergent vegetation (bottom right).**



## Lac La Biche Foreshore Inventory and Mapping Report

**Figure 10. Wetland and vegetation features of Lac La Biche – western basin.**





## Lac La Biche Foreshore Inventory and Mapping Report

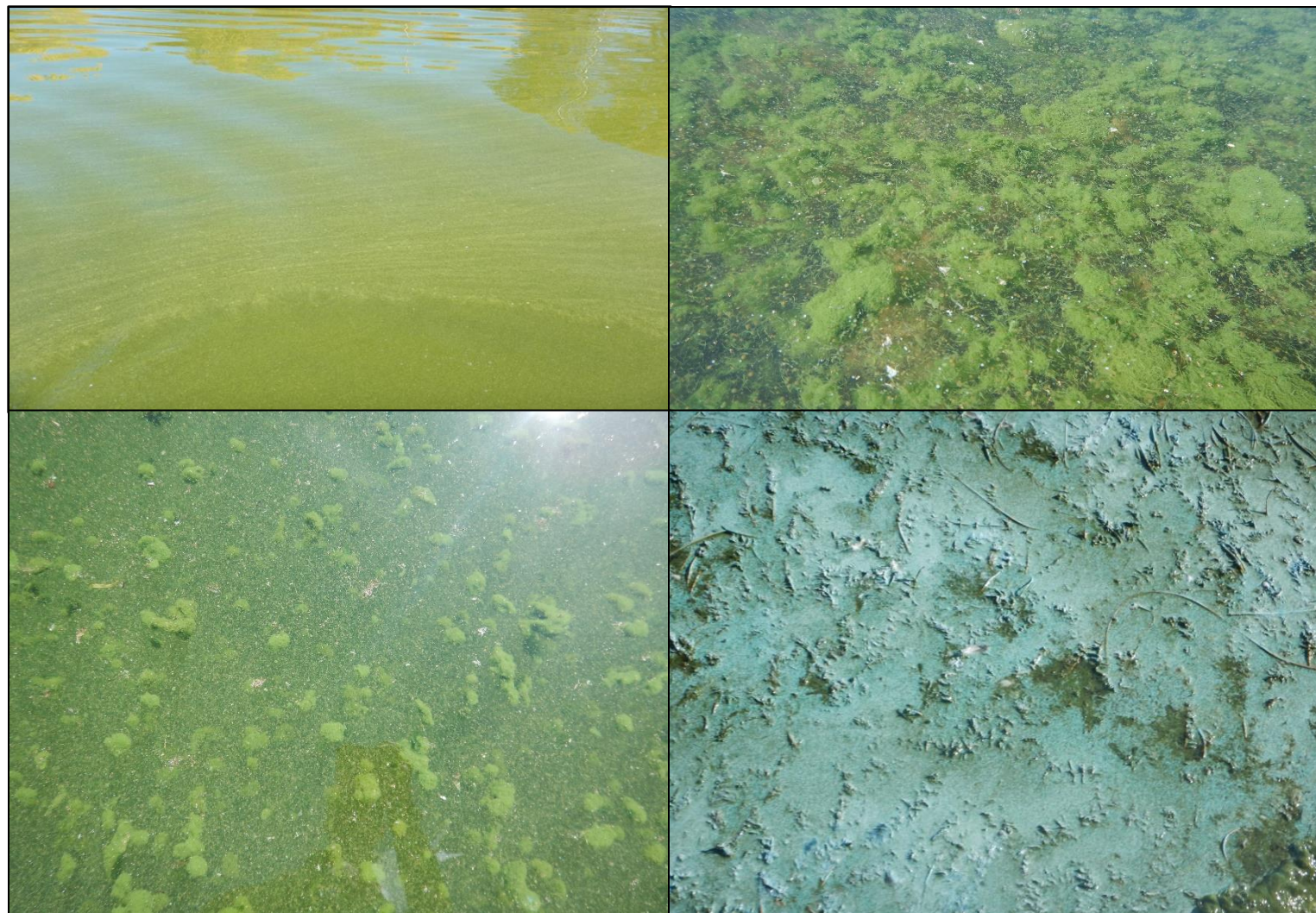
**Figure 11. Wetland and vegetation features of Lac La Biche – eastern basin.**



**Lac La Biche Foreshore Inventory and Mapping Report****4.2.4 Phytoplankton**

Algal blooms are a concern because they limit recreation, produce noxious odours, and, in the case of blue-green species, can release water-borne toxins. Algae were abundant and observed throughout the lake in 2016, with extensive blue-green algal mats noted in the northeastern embayment near the shore and around Red Fox Islands (Photographs 19 – 22). Blue-green algal blooms occur annually in the summer with coverage and abundance varying from year to year. The highest accumulations are typically found in the east basin due to the predominant western winds (Mitchell and Prepas 1990). Blue-green algae dominated the algal communities at two out of three sample sites in 1979 from June through September (Beliveau and Furnell 1980), and blue-green algae, particularly *Anabaena flos-aquae*, accounted for 49% of total biomass on July 4, 1983 (Trimbee and Prepas 1987). Recent cyanobacteria monitoring conducted in shallow waters in front of the hamlet of Lac La Biche resulted in a blue-green algae bloom advisory in 2013, due to cyanobacteria cell counts exceeding 100,000, with *Anabaena flos-aquae* identified as the dominant species as well (Alberta Health 2014). Trimbee and Prepas (1987) noted that blue-green algal abundance in Lac La Biche is related to the high total phosphorus concentrations in the water column and low dissolved oxygen concentrations in the deep water during midsummer, promoting sediment release of phosphorus. Lac La Biche is naturally eutrophic but further cultural eutrophication has occurred during the last 30 to 50 years (Schindler et al. 2008).





Photographs 19 – 22. Phytoplankton blooms were observed in various locations within Lac La Biche in July and September 2016.



**Lac La Biche Foreshore Inventory and Mapping Report****4.2.5 Fisheries**

Lac La Biche supports thirteen fish species: Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), Yellow Perch (*Perca flavescens*), Cisco (*Coregonus artedii*), Lake Whitefish (*Coregonus clupeaformis*), Burbot (*Lota lota*), White Sucker (*Catostomus commersonii*), Longnose Sucker (*Catostomus catostomus*), Ninespine Stickleback (*Pungitius pungitius*), Brook Stickleback (*Culea inconstans*), Spottail Shiner (*Notropis hudsonius*), Trout-Perch (*Percopsis omiscomaycus*), and Iowa Darter (*Etheostoma exile*) (McGregor 2014).

Populations of Walleye, Pike and Whitefish have experienced dramatic declines in Lac La Biche in recent decades due to overfishing (Alberta Environment and Parks 2017a). The lake is managed for sport and domestic fisheries, and, until recently, a commercial fishery as well. The Alberta government closed all commercial fisheries across the province in 2014, however, because they are no longer considered viable and other fisheries required protection (Alberta Environment 2016).

A fisheries restoration program was initiated in Lac La Biche in 2005 to address fish declines. The program included a reduction in catch limits, Walleye stocking (from 2006 to 2011), Double-Crested Cormorant population control (since the species was believed to be hindering Walleye recovery), protection of critical fish habitat and monitoring to improve the Walleye population and improve the overall size and structure of the fish community (McGregor 2014). Fishing was closed in the Owl River, other tributaries and the lake outlet, and net fishing was closed from the Owl River embayment out to Birch and Current Islands to protect critical Walleye spawning habitat. In all other areas, Walleye fishing became catch and release only, while bag limits were set as follows for other species: one Pike, three Whitefish, ten Burbot, and 15 Perch (Alberta Environment and Parks 2017a).

Annual index netting surveys are conducted every fall by the province in Lac La Biche to evaluate the effectiveness of the restoration program. Walleye is the focus of the surveys, but other fish species are recorded as well. The latest data available (from the 2014 survey) indicate that Walleye appear to be recovering in the lake. The catch per unit effort (CPUE) for the species has continually increased since the initiation of stocking in 2006 (Government of Alberta 2015). In 2014 a total of 390 Walleye were caught, translating to a CPUE of 22.8 individuals/100 m<sup>2</sup>/24 hours (95% confidence interval: 19.4-26.3), which is slightly above the provincial mean (18.6 individuals/100 m<sup>2</sup>/24 hours). From this, it is estimated that there are now approximately 250,000 Walleye in the lake, compared to close to zero in 2005. The province currently classifies the population as vulnerable, since it is unclear whether it can now be sustained through natural reproduction (Government of Alberta 2015).

The availability of critical habitat (i.e., spawning and nursery habitat) is crucial for the ongoing recovery of Walleye and other fish species in Lac La Biche. Spawning habitat for sport fish species in Lac La Biche is described in Table 2. High quality nursery habitat for all fish typically includes an abundance of cover such as macrophytes, woody debris and coarse substrates. Walleye, Yellow Perch, Lake Whitefish and Burbot require mineral-based (typically rocky) substrates, while Northern Pike commonly spawn over flooded vegetation. Abundance of submerged and emergent vegetation and the presence of rocky substrates will be utilized to identify sensitive fisheries habitat during the development of the Aquatic Habitat Index and determination of shoreline sensitivities in the Shoreline Management Guidelines Report.



## Lac La Biche Foreshore Inventory and Mapping Report

**Table 2. Spawning habitat requirements of resident sport fish (Scott and Crossman 1973).**

Fish Species	Spawning Habitat
Walleye	Running water (0.3 – 1.2 m/sec.), cobble and gravel reefs
Northern Pike	Heavily vegetated floodplains of rivers and marshes
Yellow Perch	Shallows near vegetation, woody debris over sand or gravel
Cisco	1-3 m water depth over gravel or stony substrate
Lake Whitefish	Rocky substrates, typically in 1-3 m of water
Burbot	Sand, gravel or rocky substrates up to 3 m in water depth

#### 4.2.6 Wetlands

Wetlands were characterized during field surveys as a shore type near the shoreline and as a category of riparian vegetation in the B1 zone from the high-water mark to 30 m inland. In addition, Lac La Biche County provided wetland mapping for the County lands surrounding Lac La Biche to allow for assessment of the B2 zone (30 m to 100 m inland). This layer included the following wetland types: bog, fen-graminoid, fen-shrub, fen-tree, fen-mixed type, marsh and shallow open water (Figures 10 and 11; Photograph 23). Wetlands were not constrained by these study areas and commonly stretched across all three environments.

Wetland was the second most abundant shore type and encompassed 19% of the shoreline, much of which was located along the northern shoreline of Lac La Biche in shoreline segments 16 and 22. Wetlands were noted in many adjacent terrestrial environments, with the largest accumulation of wetlands (predominantly fens), located within the floodplain of the La Biche River along the shoreline of the northwestern basin (Figures 10 and 11).

Three types of wetlands were observed during field investigations:

- Largely intact wetlands with rushes, cattails and shrubs at and above the high-water mark;
- Largely intact wetlands with patches of rushes and shrubs at the high-water mark separated by development or another shore type; and
- Altered wetlands with patches of rushes and/or cattails, manicured sandy substrates at the high-water mark, and gravel or sand substrate added to the foreshore with patchy shrubs or landscaped properties located further upland.

Wetlands provide nutrient attenuation, flood control, wildlife habitat, shoreline stabilization and groundwater recharge. Many wetlands have been altered in Lac La Biche to allow for the development of docks and through landscaping. Construction of shoreline structures, operation of boats and landscaping cause short and long-term impacts on wetlands which reduce the effectiveness of wetland functions listed above.





**Photograph 23. Example of a Lac La Biche wetland which provides habitat for a variety of species in the quiescent backwaters.**

#### 4.2.7 Wildlife

Wildlife inventories were not conducted as part of the 2016 field work, but incidental observations of wildlife and evidence of wildlife presence (e.g., beaver lodge, moose scat) were noted during surveys (Table 3).

Additional wildlife recorded in the Lac La Biche foreshore from previous studies include White-tailed Deer (*Odocoileus virginianus*), Mule Deer (*O. hemionus*), Coyote (*Canis latrans*), Gray Wolf (*Canis lupus*), Black Bear (*Ursus americanus*), Common Muskrat (*Ondatra zibethicus*), American Mink (*Mustela vison*), Least Weasel (*M. nivalis*), Short-tailed Weasel (*M. ermina*), Wood Frog (*Rana sylvatica*), Boreal Chorus Frog (*Pseudacris maculate*), and Canadian Toad (*Bufo hemiophrys*) (Gammon 2001; Alberta Environment and Parks 2017b).



## Lac La Biche Foreshore Inventory and Mapping Report

Table 3. Summary of wildlife observations from 2016 field work.

Wildlife Species	Evidence of Presence
American Beaver ( <i>Castor canadensis</i> )	10 beaver lodges (one each in segments 3, 7, 20, 22, 26, 35, 37, 42, 47, and 49), 1 beaver dam (in segment 6), and beaver activity (in segments 19 and 27)
Red Fox ( <i>Vulpes vulpes</i> )	1 individual (in segment 4)
Moose ( <i>Alces alces</i> )	Moose scat (in segment 50)
Gopher species	Potential gopher burrows (in segment 24)

Wildlife habitat requirements vary by species and life stage but in general the highest quality habitat in Lac La Biche is in natural environments that have not been negatively impacted by development such as wetlands, accumulations of submerged and emergent vegetation, well-vegetated riparian environments and forests. Wildlife corridors which link various wildlife habitats are also important considerations because they provide routes for the movement of various wildlife species through otherwise developed lands.

#### 4.2.8 Birds

Lac La Biche is an important breeding and staging area for a wide variety of bird species. The lake and its islands are designated as a federal Migratory Bird Sanctuary, and recognized as an Important Bird Area internationally for its significance in bird and biodiversity conservation (Gammon 2001; Bird Studies Canada undated).

During the breeding season, the lake's islands and marshes support significant concentrations of several colonial waterbird species. More than 2,000 California Gull (*Larus californicus*) nests have been recorded on the offshore islands, representing approximately 1% of the gull's global population. Western Grebe (*Aechmophorus occidentalis*) also nests in large numbers in emergent marshes, where more than 500 nests (over 1% of the bird's global population) have been found. Double-crested Cormorant is abundant on the lake, with up to 1,500 nests occurring on a single island. Other colonial waterbirds include Herring Gull (*Larus argentatus*), Ring-billed Gull (*L. delawarensis*), Common Tern (*Sterna hirundo*) and Great Blue Heron (*Ardea herodias*). The lake provides habitat for numerous bird species during the non-breeding season as well, including migrating waterfowl, and large numbers of Eared Grebe (*Podiceps nigricollis*) and American White Pelican (*Pelicanus erythrorhynchos*; Bird Studies Canada undated; Photograph 24).



**Lac La Biche Foreshore Inventory and Mapping Report**

**Photograph 24. American White Pelican observed on Lac La Biche.**

Incidental observations of birds and nests were made during 2016 field surveys (Tables 4 and 5). Most observations were made during the September field visit, after the breeding season. The majority of birds recorded were waterbird species, including ducks, geese, gulls, cormorants, pelicans, and loons. Many large congregations of waterfowl were observed on the lake, comprised of single species (e.g., 10-125 individuals of Bufflehead, *Bucephala albeola*; 3-200 individuals of Common Goldeneye, *B. clangula*; 40-100 individuals of Hooded Merganser, *Lophodytes cucullatus*) and mixed flocks (from 20-2000 individuals). Birds were recorded in all segments, except #5, 34, and 59.





## Lac La Biche Foreshore Inventory and Mapping Report

Table 4. Summary of bird observations from 2016 field work.

Bird Species	When Observed	General Habitat
<b>Waterbirds</b>		
Bufflehead	September	Lakes, ponds, rivers
Common Goldeneye	September	Wooded lakes, rivers
Hooded Merganser	September	Wooded lakes, ponds, rivers
Mallard ( <i>Anas platyrhynchos</i> )	September	Marshes, wooded swamps, ponds, rivers, lakes, grain fields
Grebe species	July and September	Lakes and ponds bordered by emergent vegetation, marshes
Merganser species	September	Wooded lakes, ponds, rivers
Scaup species	September	Lakes, rivers, marshes
Teal species	September	Rivers, marshes
Canada Goose ( <i>Branta canadensis</i> )	July and September	Lakes, ponds, marshes, fields
American Coot ( <i>Fulica Americana</i> )	September	Ponds, lakes, marshes
Common Loon ( <i>Gavia immer</i> )	September	Wooded lakes
Double-crested Cormorant	July and September	Islands, lakes, rivers
American White Pelican	July and September	Islands, lakes, rivers, wetlands
Trumpeter Swan ( <i>Cygnus buccinators</i> )	July	Ponds and lakes with abundant aquatic plants, marshes, bogs, rivers,
Ring-billed Gull	July	Lakes, farmland, dumps
Gull species	July and September	Lakes, farmland, dumps
Tern species	July and September	Lakes, beaches, marshes
Great Blue Heron	September	Marshes, swamps, lakeshore
Belted Kingfisher ( <i>Megaceryle alcyon</i> )	September	Streams, rivers, lakes
<b>Raptors</b>		
Bald Eagle ( <i>Haliaeetus leucocephalus</i> )	September	Lakes and rivers
Northern Harrier ( <i>Circus cyaneus</i> )	September	Marshes, fields
<b>Passerines</b>		
American Crow ( <i>Corvus brachyrhynchos</i> )	September	Woodland, farmland, shoreline
Common Raven ( <i>C. corax</i> )	September	Forest, beaches, farmland, islands
Black-billed Magpie ( <i>Pica hudsonia</i> )	September	Meadows, grasslands, farmlands, streams
Bank Swallow	July and September	Fields, marshes, streams, lakes
Dark-eyed Junco ( <i>Junco hyemalis</i> )	September	Coniferous or mixed woods
Red-winged Blackbird ( <i>Agelaius phoeniceus</i> )	July and September	Marshes, swamps, farmland
Song Sparrow ( <i>Melospiza melodia</i> )	July	Thickets, marshes



## Lac La Biche Foreshore Inventory and Mapping Report

Bird Species	When Observed	General Habitat
Swamp Sparrow ( <i>M. georgiana</i> )	July	Marshes and swamps
White-throated Sparrow ( <i>Zonotrichia albicollis</i> )	July	Thickets, woodlands
Chickadee species (Boreal or Black-capped)	July	Coniferous and mixed woods, thickets

Several bird nests were observed during 2016 field surveys, including five Bank Swallow (*Riparia riparia*) nests and an eagle nest (likely belonging to a Bald Eagle; Table 5).

**Table 5. Summary of bird nest observations from 2016 field work.**

Wildlife Species	Evidence of Presence
Bank Swallow	5 nests (in segment 31)
Swallow species	1 nest (in segment 38), potential nests (in segment 58)
Eagle (presumed to be Bald Eagle)	2 nests (in each in segments 50 and 58)
Unidentified bird species	6 nests (in segment 56)
Swallow or kingfisher	Potential nests in bank (in segment 57)

Several of the bird species recorded in the Lac La Biche area are species at risk. Western Grebe is a threatened species in Alberta, and a species of special concern federally. Trumpeter Swan is a species of special concern in Alberta. Bank Swallow is a threatened species federally (Government of Alberta 2014; Government of Canada 2017).

## 5. Conclusions

Lac La Biche is a large, moderately developed lake with a large proportion of natural shoreline, but also with numerous modifications associated with development such as docks, retaining walls and boat launches, as well as removal of riparian, wetland and submerged vegetation. All of these modifications may have negative impacts on sensitive habitats and the species they support.

The lake supports a mixed fishery that is intensively monitored due to recent declines and is impacted by the annual occurrence of blue-green algae blooms. Lac La Biche is naturally eutrophic and blue-green algal blooms have occurred for several years but cultural eutrophication likely impacts the size and abundance of such blooms.



## Lac La Biche Foreshore Inventory and Mapping Report

Wetlands are abundant, especially within the floodplain of the La Biche River and aquatic vegetation is also common within the lake, providing cover habitat for fish and food sources for a variety of aquatic bird species. During the breeding season, the lake's islands and marshes support significant concentrations of several colonial waterbird species and the lake also provides habitat for numerous bird species during the non-breeding season, including migrating waterfowl.

The information presented in this report will be used as a building-block for future reports to determine an Aquatic Habitat Index, categorize shoreline sensitivities of all shoreline segments and ultimately, develop shoreline management guidelines to help protect sensitive features moving forward.



## 6. References

- Alberta Environment. 2016. Commercial Fishing in Alberta. <http://aep.alberta.ca/fish-wildlife/fisheries-management/commercial-fishing-alberta.aspx>. Visited May 19, 2017. Last Updated: March 30, 2016.
- Alberta Environment and Parks. 2017a. Lac La Biche Fishery Restoration. Available online at: <http://aep.alberta.ca/fish-wildlife/fisheries-management/lac-la-biche-fishery-restoration/default.aspx> (accessed May 19, 2017).
- Alberta Environment and Parks. 2017b. Fish and Wildlife Internet Mapping Tool (from Fish and Wildlife Management Information System). Available online at: <http://aep.alberta.ca/fish-wildlife/fwmis/access-fwmis-data.aspx> (accessed March 15, 2017).
- Alberta Health. 2014. Alberta Cyanobacteria Beach Monitoring 2010–2013. Health Protection Branch.
- Aquality Environmental Consulting Ltd. 2009. Lac La Biche Watershed Management Plan.
- Beliveau, D., and A. Furnell. 1980. Phytoplankton Data Summary 1976-1980. Alberta Environment, Pollution Control Division, Water Quality Control Branch. Edmonton
- Bird Studies Canada. undated. Lac La Biche IBA Site Summary. Available online at: <http://www.ibacanada.com/site.jsp?siteID=AB097> (accessed March 15, 2017).
- Ecoscope Environmental Consultants. 2009. Foreshore Inventory and Mapping – East Kootenay Integrated Lake Management Partnership – Moyie Lake. Prepared for East Kootenay Integrated Lake Management Partnership.
- Gammon, J.. 2001. Lac La Biche Important Bird Area Conservation Plan. Canadian Nature Federation, Bird Studies Canada, and Federation of Alberta Naturalists, 26 pp.
- Government of Alberta. 2014. Endangered, Threatened, Special Concern and Data Deficient Species in Alberta. Available online at: <http://aep.alberta.ca/fish-wildlife/species-at-risk/documents/SpeciesAssessedConservation-2014a.pdf> (accessed March 15, 2017).
- Government of Alberta. 2015. Fall Walleye Index Netting at Lac La Biche, Alberta, 2014.
- Government of Canada. 2017. Species at Risk Public Registry. Available online at: [http://www.registrelep-sararegistry.gc.ca/sar/index/default\\_e.cfm](http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm) (accessed March 17, 2017).
- Mason, B., and R. Knight. 2001. Sensitive Habitat Inventory and Mapping. Community Mapping Network, Vancouver, British Columbia. 315 pp + viii. M. Johannes, Editor.
- McGregor, A. 2014. Lac La Biche Fisheries Restoration Program: Fall Walleye Index Netting (FWIN) Results, 2005 to 2013. Alberta Government.



**Lac La Biche Foreshore Inventory and Mapping Report**

- Mitchell, P.A., and E. Prepas. 1990. The Atlas of Alberta Lakes. University of Alberta Press, Edmonton, Alberta, 675 pp.
- Pinsent, M.E. 1967. A Comparative Limnological Study of Lac La Biche and Beaver Lake, Alberta. M.Sc. Thesis. University of Alberta, Edmonton.
- Schindler, D.W., A. P. Wolfe, R. Vinebrooke, A. Crowe, J. M. Blais, B. Mickimmin, R. Freed, and B. Perren. 2008. The Cultural Eutrophication of Lac la Biche, Alberta, Canada: A Paleoecological Study. Canadian Journal of Fisheries and Aquatic Sciences, 65:2211-2223.
- Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Environment Canada, Fisheries Research Board of Canada, Ottawa.
- Trimbee, A.M., and E.E. Prepas. 1987. Evaluation of Total Phosphorus as a Predictor of the Relative Importance of Blue-Green Algae with Emphasis on Alberta Lakes. Canadian Journal of Fisheries and Aquatic Sciences., 44:1337-1342.



## Appendix A. Foreshore Inventory and Mapping Field Code Definitions

Source: Ecoscape Environmental Consultants 2009

