# Wabamun Lake

*State of the Watershed 2013*

Aquality Environmental Consulting Ltd.

Wabamun Watershed Management Council

# Wabamun Lake
# State of the Watershed Report

Prepared for the Wabamun Watershed Management Council

Wabamun Watershed Management Council

Box 1005, Wabamun, Alberta, Canada, T0E 2K0

(780) 953-2695
info@wwmc.ca

Prepared by Aquality Environmental Consulting Ltd.

Aquality

Suite 204, 7205 Roper Road NW, Edmonton, Alberta, Canada, T6B 3J4

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# Message from the Wabamun Watershed Management Council

The Wabamun Watershed Management Council (WWMC) represents a cross-section of stakeholders in the watershed who are committed and dedicated to developing and implementing a watershed management plan that sustains the natural viability and health of the Wabamun watershed.

The concept of the organization was originally proposed by Dr. David Schindler in a report titled: Lake Wabamun: A Review of Scientific Studies and Environmental Impacts. The Wabamun Watershed Management Council was formed in the fall of 2006.

**Our Vision**

Is that the Wabamun watershed is a healthy ecosystem with a community that shares its collective responsibility to be the best stewards of that environment.

**Our Mission**

Is to guide the development, management and stewardship of Lake Wabamun through collaborative watershed planning, research, and public education.

**Our Goals**

To maintain and enhance the Wabamun watershed;

To build partnerships, work cooperatively and share information, financial, regulatory and human resources;

To provide a forum for citizens, governments and business to promote and recognize environmental stewardship;

To develop an adaptive, integrated watershed management plan with outcomes, indicators and targets based on science and supported by the community;

To coordinate research and monitoring initiatives to measure long term performance of the integrated watershed management plan and guide responses to new and emerging environmental issues; and

To raise awareness and understanding of local environmental issues.

This State of the Watershed Report is the first step in preparing a watershed management plan that will help us all "Keep Lake Wabamun Clean and Clear" for generations to come. We thank Aquality Environmental Consulting Ltd. and all who contributed to producing this report. It is our sincere hope that in reading it you will be inspired to help us achieve our goal of preserving the watershed. You can do so by becoming a member of WWMC, by making a financial donation, by volunteering your time and expertise, and by helping to keep nutrients and invasive species from reaching the lake. We thank you for your past and ongoing support as we move forward.

Sincerely,

K. Aldridge

Kelly Aldridge, Chair
E-mail: chair@wwmc.ca
Website: www.wwmc.ca

# Executive Summary

Wabamun Lake, one of Alberta's most popular recreational lakes, is located entirely in Parkland County within the North Saskatchewan River basin. Due to its large size and proximity to the city of Edmonton, Wabamun Lake is popular for a wide range of recreational activities, including swimming, fishing and sailing. The lake is one of the most studied in the province, yet many knowledge gaps still exist in determining the overall health of the watershed.

The Wabamun Watershed Management Council (WWMC) was formed in 2006 in response to recommendations made in a report by Dr. David Schindler et al. (2004). This group represents a wide range of stakeholders who are committed to maintaining and improving the overall health of Wabamun Lake and the surrounding watershed. In 2012, the WWMC commissioned Aquality Environmental Consulting Ltd. to write the Wabamun Lake State of the Watershed Report.

The purpose of the Wabamun Lake State of the Watershed Report is to summarize the existing current and historical knowledge of the watershed. This report outlines how natural features, natural processes, land use and water use influences the watershed. The report will also serve as a point of reference for future management and stewardship activities aimed at improving the management of the watershed. The report also indicates areas that need to be addressed and the knowledge gaps that exist.

In order to assess watershed condition, metrics were chosen for several environmental quality indicators. Environmental indicators are measures of environmental quality that are used to assess the status and trends of the physical condition of a watershed. Their purpose is to show how well a system, or watershed, is functioning. If there is concern, low scoring indicators can focus remediation actions or best management practices. The following metrics were used for each of the four major indicators of environmental quality in the Wabamun Lake watershed:

1. Land Use:
    - Urban, Rural and Recreational Developments;
    - Agricultural and Livestock Operations;
    - Oil and Gas Activity;
    - Linear Development;
    - Wetland Loss; and
    - Riparian Health.
2. Water Quality:
    - Nutrients;
    - Bacteria;
    - Parasites;
    - Pesticides; and
    - Metals.
3. Water Quantity:
    - Lake Levels.
4. Biological Community:
    - Land Cover.

The overall condition of the Wabamun Lake watershed was rated as, **"fair"**. Four indicators received a rating of **"good"**, three received a rating of "**fair"**, one received a rating of **"poor"** and five could not be assessed due to a lack of available data. Due to the lack of data for these five indicators, there is some uncertainty in the overall ranking of the watershed. Therefore a more conservative rating of **"fair"** was given to the Wabamun Lake watershed.

Because of its size, proximity to Edmonton and recreational opportunities Wabamun Lake is very popular. Publicized events such as the train derailment and fish kills may have shed some negative light on the lake in the past, but evidence suggested that these events have not had a significant impact on the overall health of the aquatic ecosystem. Efforts need to be made to minimize the overall impacts of industrial, agricultural, rural, urban and recreational developments on the lake through the implementation of best management practices and potentially new environment policy and bylaws. The preservation and conservation of aspects of the Wabamun Lake watershed that are currently in "good" condition is critical for maintaining the long-term health of the lake.

Managing and maintaining the overall health of the Wabamun Lake watershed falls upon a wide range of parties including, federal, provincial and local government, industry, residents, recreational users and stewardship groups. Effort should be made by all groups to work together to achieve the common goal of a healthy watershed for generations now and into the future. However, there are specific roles and responsibilities for each of these groups in watershed management. For example, Parkland County is responsible for developing policy and bylaws that restrict shoreline development, establish riparian areas setback distances, and restrict the use of pesticides, fertilizers and herbicides around waterbodies. The Wabamun Watershed Management Council is responsible for helping to educate the public and driving stewardship efforts within the Wabamun Lake watershed. A more detailed explanation of these roles is presented in Appendix B: Outline of Roles and Responsibilities.

We strongly recommend that the Wabamun Watershed Management Council, Alberta Environment and Sustainable Resource Development, and Parkland County partner immediately to begin the watershed management planning process. Long-term management, planning, and forward thinking is critical to the overall success in achieving goals for the watershed. While the responsibility for enforcement of laws, regulations, and plans generally falls to various levels of government, it is critical that residents and other stakeholders maintain their involvement and ensure that issues within the watershed are not ignored. Continued watershed management planning is necessary to ensure the long-term health and preservation of the Wabamun Lake watershed.

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Aquality Environmental Consulting Ltd.

# Introduction

# 1 Introduction

## 1.1 Purpose of the Report

The purpose of the Wabamun Lake State of the Watershed Report is to summarize the existing current and historical knowledge of the watershed. This includes knowledge in the areas of land use, water quality, water quantity and biological characteristics. Many water quality and other studies exist for Wabamun Lake, as it is a heavily used lake for recreation, has had two major power generation stations on its shores, and was the site of a major oil spill following a CN Rail train derailment in 2005. This report will provide an understanding of how natural features, natural processes, land use and water use influences the watershed. The report will also serve as a point of reference for future management and stewardship activities aimed at improving the Wabamun Lake watershed. This report will also indicate any areas that need to be addressed and the knowledge gaps that are currently present for the Wabamun Lake watershed.

## 1.2 Scope of the Report

The geographic scope of this State of the Watershed report is the Wabamun Lake watershed. The watershed is located approximately 70 km west of Edmonton in Parkland County within the North Saskatchewan River watershed. The size of the watershed reported in most documents is 257 $km^2$, calculated by Mitchell and Prepas in 1990. However, upon examining the most updated GIS watershed boundaries, it was determined that this 257 $km^2$ did not take into account the area of the lake. When determining the total area of a watershed, everything within the boundary is included in the total area. Therefore, based on the most recent GIS information the size of the watershed has been determined to be 351 $km^2$. The north boundary of the watershed extends just over the Trans-Canada Highway (Highway 16) and extends south to Highway 627 (Figure 1). The watershed extends west to Range Road 65 and east to the edge of the Paul First Nations Reserve boundary.

Wabamun Lake is the most studied lake in Alberta, with a seemingly endless amount of information available. As a result, the Wabamun State of the Watershed Report was based on the comprehensive report "Wabamun Lake: A Review of Scientific Studies and Environmental Impacts" by Schindler *et al.* (2004). This report is considered by most to be an authoritative summary of the available knowledge up to 2004 for the Wabamun Lake watershed. For the purpose of this State of the Watershed Report, we focused on information made available since 2004, building on the Schindler et al. report.

This state of the watershed report provides information on lake water quality and quantity, land-use and the potential effects of resource and land-use practices on watershed health. Each section of this report is intended to provide and summarize known social, physical and environmental information for the watershed. The report will identify areas of potential concern within the watershed and identify where information is lacking. The report considers the physical aspects of the entire watershed, first at a broad scale and then on specific land and water resources. The report also identifies the jurisdictions and legislation of the various Federal, Provincial and Municipal regulators to decipher roles and mandates. The report then outlines how state of the watershed reporting fits into the greater context of watershed management planning in Alberta under Alberta Environment's Water Strategy: *Water for Life* and identifies other legislation and policies affecting watershed management in Alberta.

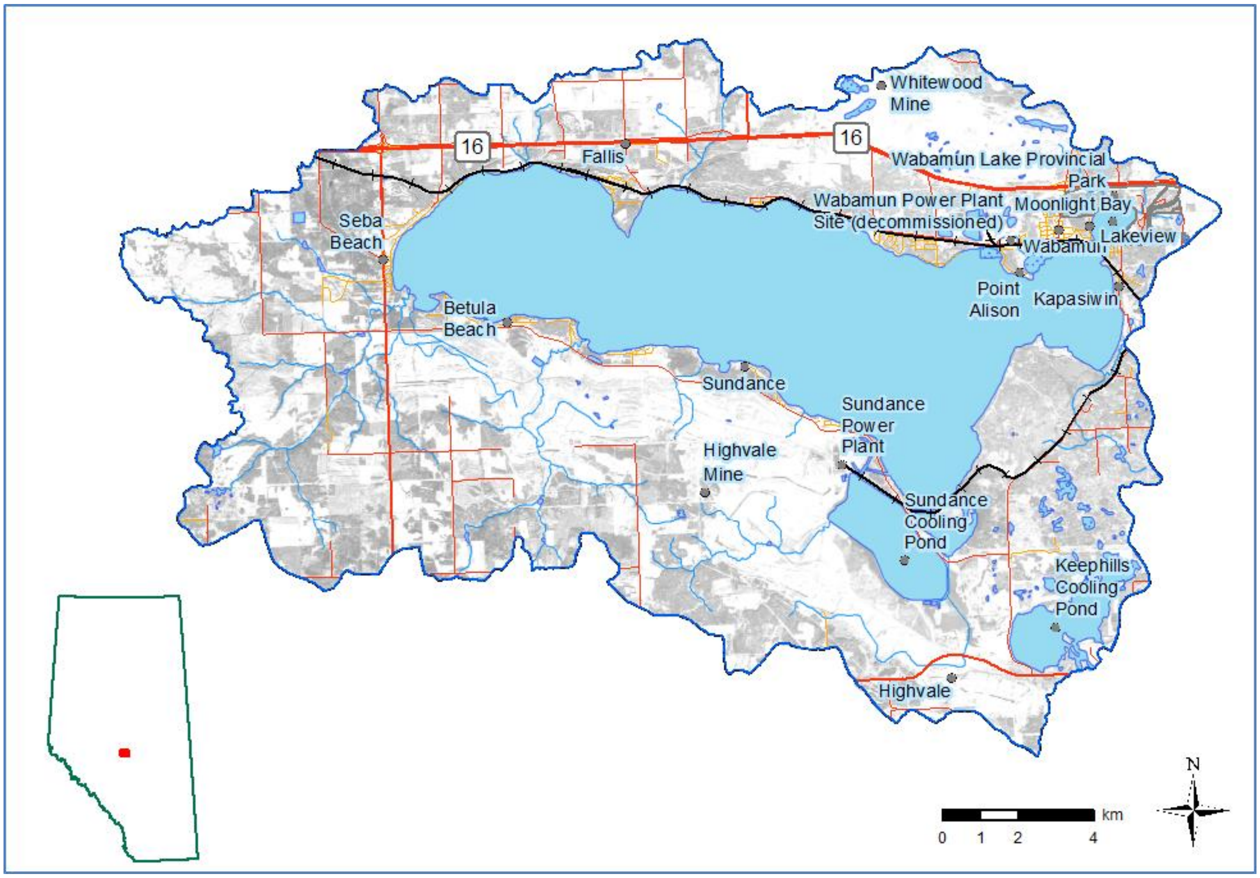


**Figure 1:** Overview of the Wabamun Lake watershed (Natural Resources Canada 2007a,b).

## 1.3 Legislation and Regulation

### 1.3.1 Federal Government

The *Canadian Environmental Protection Act* (CEPA) is the main federal law to protect the environment. With respect to water resources, CEPA empowers the federal government to create and enforce regulations regarding toxic substances, fuels and nutrients in lakes and surface waterbodies. CEPA enables the federal government to undertake environmental research, develop guidelines and codes of practice and conclude agreements with provinces and territories. Environment Canada administers CEPA but assesses and manages the risk of toxic substances jointly with Health Canada.

The *Fisheries Act* is the guiding act that enables Fisheries and Oceans Canada to protect fish and fish habitat. In Alberta, Fisheries and Oceans Canada has jurisdiction over the fish habitat only, and the Province regulates the fish. Fish habitat by definition includes spawning grounds and nurseries, rearing, food supply and migration areas on which fish depend to carry out their life processes. It is the mandate of the Department of Fisheries and Oceans to preserve healthy marine and freshwater aquatic ecosystems in support of scientific, ecological, social and economic interests. The *Fisheries Act* prohibits any activity that results in the serious harm of fish and important fisheries in Canada. Work carried out near a fish-bearing watercourse must have the approval of Fisheries and Oceans Canada. Failure to comply with the Act may result in fines or imprisonment.

The *Canadian Environmental Assessment Act* (CEAA) is a federal statute that requires federal departments, agencies and certain Crown corporations to conduct environmental assessments for proposed projects and activities before providing federal support to a project. Environmental assessment is a planning tool used to identify the potential effects of a proposed project on the environment, which comprises the air, water, land and living organisms, including humans. By eliminating or minimizing potential adverse environmental effects through the implementation of mitigation measures, project proponents can ensure that these effects are addressed, and thereby contribute to the goal of sustainable development. Environmental assessment provides decision-makers with the information required to make project-related decisions that are compatible with a healthy, sustainable environment for both present and future generations. The CEAA is administered by the Canadian Environmental Assessment Agency.

Additional federal acts that are designed to protect water resources and associated habitats and wildlife include the *Navigable Waters Protection Act*, *Canada Water Act*, *Canada Wildlife Act*, *Species at Risk Act* and the *Migratory Bird Convention Act*. Brief descriptions of these acts are provided in Table 1.

### 1.3.2 Provincial Government

The Government of Alberta is committed to sustainable development through an integrated resource management (IRM) approach to protect the environment and manage Alberta's resources. IRM requires a comprehensive, interdisciplinary approach to the management of water, timber, air, public land, fish, wildlife, range, oil, gas and mineral resources. The Alberta Government initiated the development of a province-wide comprehensive strategy called *Water for Life: Alberta's Strategy for Sustainability* in 2003. The purpose of the strategy was to identify short-, medium- and long-term plans to manage effectively the quantity and quality of the province's water systems and supply. The three main goals of the strategy are to ensure that Albertans have a safe and secure drinking water supply, healthy aquatic ecosystems and reliable and high-quality water supplies for a sustainable economy (Alberta Environment, 2003). The provincial government uses both the *Water Act* and the *Environmental Protection and Enhancement Act* (EPEA) to enforce regulations regarding the preservation of Alberta's water supplies.

The *Water Act* supports the conservation and management of water and allows for regional differences in water management to be reflected through the development of water management plans, as outlined in the *Framework for Water Management Planning* released in 2002. The EPEA is intended to support and promote the protection, enhancement and sustainable use of all aspects of the environment, from land to water. It covers conservation, reclamation, pesticide use, waste control and wastewater and storm drainage.

*Public Lands Act* regulates activities that impact on Crown owned Beds and Shores of all permanent and naturally occurring bodies of water. This act is enforced by Alberta Environment and Sustainable Resource Development.

More recently, the Government of Alberta introduced the *Alberta Land Stewardship Act* ("ALSA") on April 27, 2009. ALSA provides the legislative framework to support Alberta's Land-Use Framework ("LUF"), which is a comprehensive strategy to guide the management of public and private lands and natural resources across Alberta.

Other provincial acts that can be utilized to protect Alberta's water resources include the *Agricultural Operations Practices Act*, *Safety Codes Act*, *Regional Health Authorities Act*, *Wildlife Act*, *Public Lands Act*, *Provincial Parks Act*, *Wilderness Areas*, *Ecological Reserve*, *Natural Areas and Heritage Rangelands Act* and policies such as the *Wetlands Policy*. Brief descriptions of these acts are provided in Table 1.

### 1.3.3 Municipal Government

Municipalities have broad powers over water within their lands to ensure the protection of aquatic environments. Subject to any other enactment, a municipality has the direction, control and management of the rivers, streams, watercourses, lakes and other natural bodies of water within the municipality, including the air space above and the ground below.

The *Municipal Government Act* (MGA), Land Use Bylaws, Area Structure Plans and Municipal Development Plans can be used by municipalities to protect and maintain watershed health and integrity. Brief descriptions of these acts are provided in Table 1.

**Table 1: Legislation and policy involving water and watershed management in Alberta.**

| Legislation/Policy | Description |
|---|---|
| Federal *Fisheries Act* – Department of Fisheries and Oceans Canada (DFO) | Regulates and enforces on serious harm, alteration, disruption and destruction of fish habitat. |
| *Canadian Environmental Protection Act* (CEPA) – Environment Canada (EC) | Aimed at pollution prevention and the protection of the environment and human health to contribute to sustainable development. |
| *Canadian Environmental Assessment Act* – Canadian Environmental Assessment Agency | Requirement by federal departments, agencies and certain Crown corporations to conduct environmental assessments for proposed projects and activities before providing federal support to the project. |
| *Canada Water Act* – Environment Canada (EC) | Aimed to ensure that water issues of national significance are conserved, developed and managed. |
| *Canada Wildlife Act* –Environment Canada (EC) | Designed for the creation, management and protection of wildlife areas for wildlife research activities, or for conservation or interpretation of wildlife. |
| *Navigable Waters Protection Act* (NWPA) – Transport Canada (TC) | Aimed to protect the public right of navigation by prohibiting the building or placement of any "work" in, upon, over, under, through, or across a navigable water without the authorization of the Minister of Transport. |
| *Species at Risk Act* – Environment Canada (EC), Parks Canada, Department of Fisheries and Oceans Canada (DFO) | Provides legal protection of wildlife species and the conservation of biological diversity. |
| *Migratory Birds Convention Act* – Canadian Wildlife Service (CWS) | Aimed to protect and conserve migratory birds, both as individuals and populations, as well as their nests. |
| Provincial *Water Act* – Alberta Environment and Sustainable Resource Development (AESRD) | Governs the diversion, allocation and use of water. Regulates and enforces actions that affect water and water use management, the aquatic environment, fish habitat protection practices and in-stream construction practices. |
| Provincial *Environmental Protection and Enhancement Act* (EPEA) – AESRD | Management of storm water, contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement. |
| Provincial *Land Stewardship Act* – Alberta Environment and Sustainable Resource Development (AESRD) | This act supports the Land Use Framework, which is a comprehensive strategy to guide the management of public and private lands and natural resources in Alberta. |
| Provincial *Agricultural Operations* | Regulates and enforces on confined feedlot operation and |

| | |
|---|---|
| *Practices Act* (AOPA) – Natural Resources Conservation Board (NRCB) | environment standards for livestock operations. |
| Provincial *Municipal Government Act* (MGA) – Municipal Affairs | Provides municipalities with authorities to regulate water on municipal lands, management of private land to control non-point sources, and authority to ensure that land use practices are compatible with the protection of aquatic environment. |
| Provincial *Public Lands Act* – Alberta Environment and Sustainable Resource Development (AESRD) | Regulates and enforces on activities that affect Crown-owned beds and shores of waterbodies and some Crown-owned uplands that may affect nearby waterbodies. |
| Provincial *Safety Codes Act* – Municipal Affairs | Regulates and enforces septic system management practices, including installation of septic field and other subsurface disposal systems. |
| *Regional Health Authorities Act* – Alberta Health | RHA have the mandate to promote and protect the health of the population in the region and may respond to concerns that may adversely affect surface and groundwater. |
| *Wildlife Act* – Alberta Environment and Sustainable Resource Development | Regulates and enforces on protection of wetland-dependent and wetland-associated wildlife, and endangered species (including plants). |
| *Provincial Parks Act* & *Wilderness Areas, Ecological Reserve and Natural Areas Act* – AESRD and Community Development | Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas. |
| Provincial Wetlands Policy - AESRD | This policy will be used to protect wetlands and mitigate losses. |
| Land Use Bylaws (Municipal) | The bylaw that divides the municipality into land use districts and establishes procedures for processing and deciding upon development applications. It sets out rules that affect how each parcel of land can be used and developed and includes a zoning map. |
| Area Structure Plans (Municipal) | Adopted by Council as a bylaw pursuant to the *Municipal Government Act* that provides a framework for future subdivisions, development, and other land use practices of an area, usually surrounding a lake. |
| Municipal Development Plans | The plan adopted by Council as a municipal development plan pursuant to the *Municipal Government Act*. |

## 1.4 Existing Plans and Policies

Parkland County has several existing plans and policies that affect the Wabamun Lake watershed. These include the Integrated Community Sustainability Plan, Parkland County Land Use Bylaws, and the Parkland County Municipal Development Plan. These, along with the bylaws implemented by the various summer villages along the lake, help direct land use activities and development within the watershed.

An Integrated Community Sustainability Plan (ICSP) was adopted by Parkland County on August 23, 2011 (Parkland County 2011). This plan aims to increase the County's sustainability performance in four key areas: environment, economy, governance and social/cultural life. One of the goals of this plan is to protect the County's water resources from degradation due to increasing intensive human activity. In order to achieve this goal the County will aim to reduce water consumption and reduce the amount of contaminants in wastewater. Parkland County will also look for ways to minimize the destruction of waterways, wetlands and riparian areas.

Parkland County's Land Use Bylaws for the Lakeshore Residential District allows for the development and redevelopment of smaller pre-existing parcels of land along lakeshores within the County (Parkland County 2009). This bylaw also determines the type of structures that are permitted within the Lakeshore Residential District. Under this bylaw, no re-subdividing of existing small parcels is permitted. In addition, a standard 6.1 m setback from the lakeshore is required for both principal dwelling and accessory buildings.

Under the Environmental Management section of the Municipal Development Plan, Parkland County supports communities that minimize air, water, and soil pollution; reduce resource consumption and waste; and protect natural systems that support life (Parkland County 2007). The environmental management objectives for the Municipal Development Plan include: protecting environmentally significant areas, reducing the impact of development on the natural environment, apply environmental reserves to protect environmentally significant areas, protect water quality through effective subdivision design, developments will require a biophysical assessment, and promote public awareness of development impacts on the environment.

## 1.5 Public Concerns

Below are a list of public concerns and perceptions gathered by the Wabamun Watershed Management Committee and from the Summary of Public Consultation for the Wabamun Lake Citizens' Panel (Alberta Environment 2006).

- Having a lake that provides good fishing, swimming and recreational activities such as sailing
- Having a lake that is healthy for future generations
- Keeping fish populations healthy for sport fishing
- Keeping the lake natural and free from industrial activities
- Having appropriate, natural water levels that allow for recreational activities
- Protection of the Grebe colony and important waterfowl on the lake
- Keeping industrial pollutants out of the lake
- Preventing grey water and sewage related pollution from entering the lake
- Enforcement of government legislation and policy
- Developing of a watershed management plan
- Stricter guidelines for land-use changes, cottage development, waste disposal and use of fertilizer
- Promoting healthy fish habitat for spawning, including discontinuing aquatic vegetation pulling from the lake bed
- Keeping shorelines healthy and promoting shoreline naturalization
- Continuing lake monitoring to ensure a healthy lake
- Community involvement in lake management
- Increasing boat traffic and boat size and the effects of boating on wildlife

# Methods

# 2 Methods

## 2.1 Indicators of Environmental Quality

Environmental Indicators are measures of environmental quality that are used to assess the status and trends of the physical condition of a watershed. Their purpose is to show how well a system, or watershed, is functioning. If there is a concern, an indicator can help determine what direction to take to address the issue. To be effective, an indicator must be:

1. Relevant - able to educate the public about the ecosystem;
2. Straightforward;
3. Easy to Understand;
4. Reliable - the information the indicator provides is trustworthy; and
5. Timely - the information is available while there is still time to act.

A good environmental indicator can simplify large amounts of complex information into a concise, easily understood format. Generally, indicators of environmental quality fall into four major categories: land use, water quality, water quantity and biological community. While assessing the overall condition of the Wabamun Lake watershed is challenging, it is possible to choose indicators of condition, such as nutrient concentrations as measures of water quality. Here, water quality is an indicator of the watershed condition and nutrient concentration is a specific measurement, or “metric”, of the water quality indicator. The following metrics were used for each of the four major indicators of environmental quality in the Wabamun Lake watershed:

5. Land Use:
   - Urban, Rural and Recreational Developments;
   - Agricultural and Livestock Operations;
   - Oil and Gas Activity;
   - Linear Development;
   - Wetland Loss; and
   - Riparian Health.
6. Water Quality:
   - Nutrients;
   - Bacteria;
   - Parasites;
   - Pesticides; and
   - Metals.
7. Water Quantity:
   - Lake Levels.
8. Biological Community:
   - Land Cover.

To assess the condition of the Wabamun Lake watershed, each of these metrics were rated “good”, “fair”, or “poor” relative to data from the scientific literature, environmental guidelines and based on the ranking criteria developed in the Red Deer River State of the Watershed Report (Aquality Environmental Consulting Ltd. 2009). In addition, an overall rating of the watershed is provided in this report. The overall rating takes into consideration not only the ratings of the indicators of environmental quality but also supplementary information, such as point source pollutants, water volume, contributing areas to drainage, surface water and groundwater allocations, groundwater discharge/recharge, wildlife biodiversity, fish populations and species at risk. In addition, the degree to which an individual indicator of environmental quality exceeded guidelines was considered in attaining the overall rating of the Wabamun Lake watershed.

The following section outlines the criteria used to rate each of the indicators of environmental quality:

Urban, rural, agricultural, recreational and industrial developments – Disturbances from urban, rural, agricultural and recreational developments < 50% of the land base were deemed “good”, from 50-89% was deemed “fair” and > 90% was deemed “poor”. Recreational pressure such as boating, which does not rely on extensive areas of infrastructure, is also considered here.

Manure production – Manure production was used as a proxy for agricultural and livestock operations within the watershed. This data are expressed on an area basis as kg/ha. A rating of “poor” was given if manure production exceeded 1,200 kg/ha for livestock operations in the Wabamun Lake watershed. A rating of “fair” was given if manure production ranged from 600-1,200 kg/ha, and a rating of “good” was given if manure production was below 600 kg/ha.

Oil and gas activity – A rating of “poor” was given if the number of total oil/gas wells in the watershed exceeded 1 well/ha. A rating of “fair” was given if the total number of oil/gas wells ranged from 0.5-1 well/ha, and a rating of “good” was given if the total oil/gas wells were below 0.5 well/ha.

Linear developments – Linear development totals < 2% was considered “good”, from 2-3% was deemed “fair” and > 3% was deemed “poor”. These percentages represent proportions of the total area of the Wabamun Lake watershed. Right-of-ways for linear developments followed NSWA (2005) definitions: roads – 16 m width; pipelines – 15 m width; power lines – 30 m width; cut lines/trails – 6 m width; railways (active and inactive) – 15 m width. The width for roads used in this report represents an average of different types of roads (1-lane gravel roads – 8 m; 2-lane gravel roads – 16 m; 2-lane paved undivided highway – 16 m; 4-lane paved undivided highway – 32 m; paved divided highway – 40 m; unimproved road – 8 m).

Wetland loss – The gain, improvement or maintenance of any wetlands was deemed “good”, the maintenance but impairment of existing wetlands was deemed “fair” and any loss of wetlands was deemed “poor”.

Riparian health – Riparian health assessments are performed by various agencies and are generally based on the inventory and assessments protocols of Cows and Fish. The ratings provided for this indicator follow those of the agencies that have performed the riparian assessments, for example, Cows and Fish, ACA, AESRD.

Total phosphorus – Total phosphorus (TP) concentration < 0.05 mg/L was deemed “good”, from 0.05-0.10 mg/L was deemed “fair” and > 0.10 mg/L was deemed “poor”. The cut-off concentration for the “good” rating for TP follows the CCME Protection of Aquatic Life (PAL) guideline of 0.05 mg/L (CCME, 2007).

Total nitrogen – Total nitrogen (TN) concentration < 1.0 mg/L was deemed “good”, from 1.0-1.5 mg/L was deemed “fair” and > 1.5 mg/L was deemed “poor”. The cut-off concentration for the “good” rating for TN follows the CCME Protection of Aquatic Life (PAL) guideline of 1.0 mg/L (CCME 2007).

Total metals – Due to the potentially severe impacts of metals to aquatic organisms, total metal concentrations exceeding CCME Protection of Aquatic Life (2007) guidelines were deemed “poor”.

Bacteria – Fecal coliform counts were deemed “good” if 0-10% of the total number of samples exceeded 200 CFU/100 mL, if 10-50% of the total number of samples exceeded guidelines a rating of “fair” was given and if more than 50% of the total samples exceeded guidelines a rating of “poor” was given. The cut-off concentration of 200 CFU/100 mL follows Health Canada’s Guidelines for Canadian Recreational Water Quality (Health Canada 2012).

Parasites - If any parasite concentrations exceeded Health Canada drinking water guidelines, a rating of “poor” was given.

Pesticides - If any pesticide concentrations exceeded CCME PAL guidelines (CCME 1999), a rating of “poor” was given; otherwise, a rating of “good” was given.

Lake levels - Lake levels will be considered “good” if they are within the normal range of Alberta Environment and Sustainable Resource Development’s normal category of the Historical Lake Level Index Rankings. Lake levels that are much below normal and much above normal will be considered “poor”.

Land cover - Combined land cover values for wetlands, grasslands and all forested areas > 50% was deemed “good”, 25-50% was deemed “fair” and < 25% was deemed “poor”.

## 2.2 Data Collection

Data used in the development of this report come from Alberta Environment and Sustainable Resource Development (AESRD), Alberta Energy Resources Conservation Board, Alberta Biodiversity Monitoring Institute, Natural Resources Canada and Alberta Health Services and may be subject to copyright and/or licensing restrictions. Other sources of data are referred to throughout this report and consist of reports from federal and provincial governments, non-governmental agencies, municipalities, industry and scientific literature. The most recent and publicly available data were used to generate all maps in this report.

**Table 2: Data Sources for maps generated for this report.**

| Map | Data Source |
|---|---|
| Watershed Overview | Natural Resources Canada (2007a,b) |
| Bathymetry | Alberta Geological Survey (2008) |
| Surficial Geology | Alberta Geological Survey (2012) |
| Soil Orders | Canada - Alberta Environmentally Sustainable Agriculture (2001) |
| Oil and Gas Wells | Energy Resources Conservation Board (2013) |
| Linear Features and Human Impact | Alberta Biodiversity Monitoring Institute (2010) |
| Wetland Classes | Alberta Environment and Sustainable Resource Development (2012) |
| Non-Contributing Areas to Drainage | Natural Resources Canada (2007c) |
| Groundwater Quality Risk | Alberta Agriculture and Rural Development (2005) |
| Groundwater Wells | Alberta Environment and Sustainable Resource Development (2013) |
| Land Cover | Alberta Biodiversity Monitoring Institute (2012) |

# Watershed Characteristics

# 3 Watershed Characteristics

## 3.1 Watershed Description

The Wabamun Lake watershed is located 70 km west of the city of Edmonton within Parkland County. The watershed is located within the Modeste sub-basin of the North Saskatchewan River basin (North Saskatchewan Watershed Alliance 2005). When water levels are sufficiently high, the lake's only outlet, Wabamun Creek, flows southwest into the North Saskatchewan River. However, outflows from the lake only occur in very wet years, last occurring in 2008.

The total drainage area of the Wabamun Lake watershed is 351 $km^2$. The area of the watershed is small compared to that of the lake, with an upland area to lake area ratio of 4.4:1. Wabamun Lake itself has a surface area of 79 $km^2$. As a result of the small watershed to lake area ratio, the residence time of the lake is extremely long, estimated to be approximately 100 years (Mitchell and Prepas 1990). This long residence time limits the amount of filling and flushing that occurs within the lake. A recent hydro-acoustic sounding determined that Wabamun Lake has a maximum depth of 10.9 m and a mean depth of 5.1 m (Figure 2, Milne 2007).

Wabamun Lake is considered to be a headwater lake, and only receives a small amount of water from streams that run into it. The majority of these streams only flow during periods of snowmelt in the spring, or in periods with heavy rainstorms. A recent study identified seven natural creeks, or primary streams, that contribute a significant flow to Wabamun Lake (Emmerton 2008). The lake also receives treated North Saskatchewan River water from the Wabamun Lake Water Treatment Plant; this is explained in more detail in section 6.3 Water Allocations and Diversions.

The name Wabamun is derived from the Cree word meaning "mirror". Around the early 1800's the lake was referred to as White Whale Lake, due to the large lake whitefish caught in its waters. Later, around the turn of the century, the lake returned to its original Cree name of Wabamun Lake. By 1876, the Paul First Nations Band had separated from the Stoney Indian Nation, signed Treaty No. 6, and settled on the southeast shores of Wabamun Lake. As such, the watershed is an important traditional hunting and fishing ground for the Cree people (Mitchell and Prepas 1990).

People of European decent began settling around Wabamun Lake in the mid 1910's as part of the Canadian Governments agricultural settlement incentives. The Village of Wabamun itself was originally located on the Northwest corner of Moonlight Bay and with the arrival of the Grand Trunk Pacific Railway the community moved to its present location. The community of Wabamun was officially incorporated into a village in 1912 (Village of Wabamun 2010).

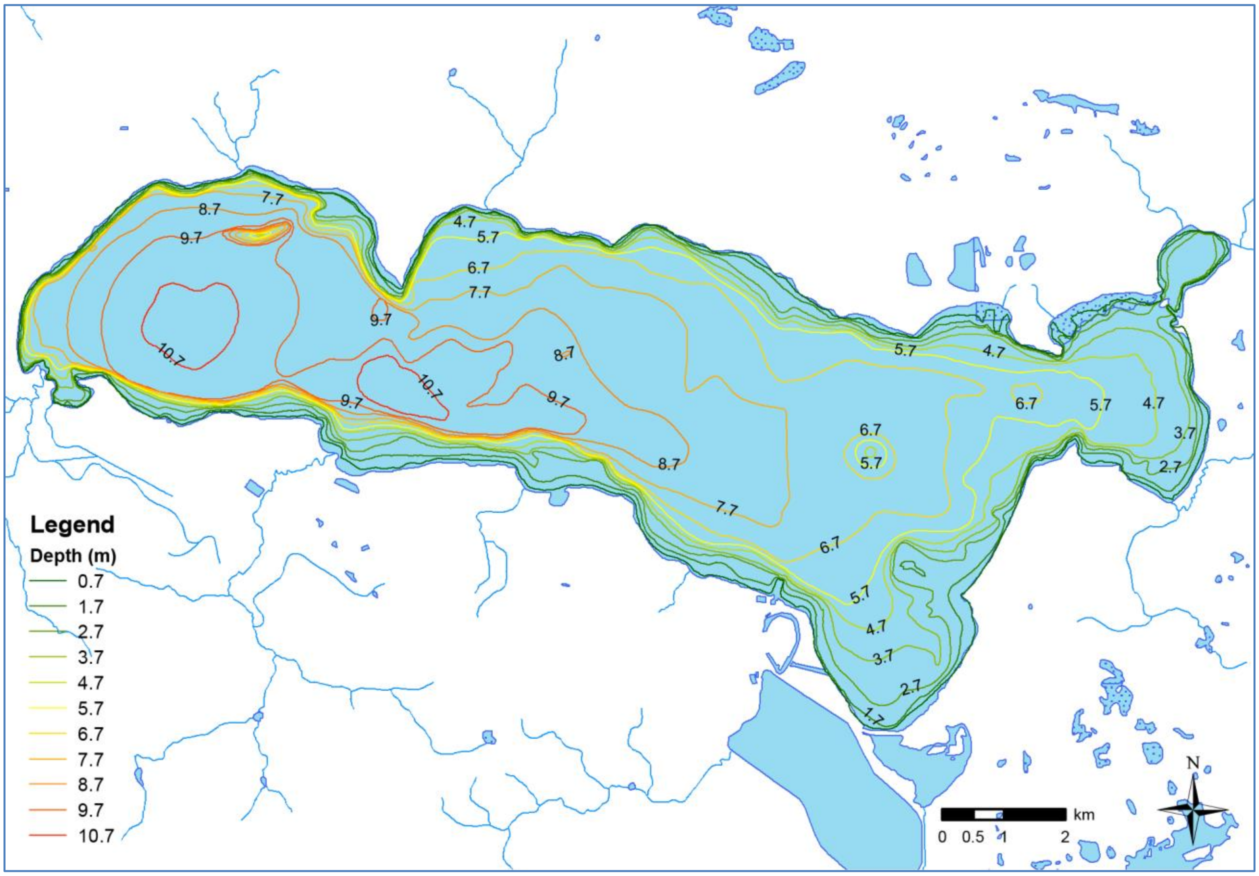


**Figure 2:** Bathymetric map of Wabamun Lake (Alberta Geological Survey 2008).

## 3.2 Natural Regions and Subregions

The Natural Regions classification was adopted by the Government of Alberta to represent ecosystem and biodiversity elements of importance to protected areas. The classification system emphasizes the overall landscape pattern, which mainly reflects climate, but in other cases may predominantly reflect geological and soil factors.  The purpose of the Natural Regions classification is to account for the entire range of natural landscapes and ecosystem diversity and is related primarily to ecosystem and biodiversity conservation.

The Wabamun Lake watershed is located within the both the Dry Mixedwood and Central Mixedwood Subregion of the Boreal Forest Natural Region (Natural Regions Committee 2006). Approximately 79% of the watershed is in the Dry Mixedwood Subregion and 21% is in the Central Mixedwood Region.

### 3.2.1 Boreal Forest Natural Region - Dry Mixedwood Subregion

The Boreal Forest Natural Region is the largest Natural Region in Alberta and the Dry Mixedwood Subregion accounts for 12.9% of the Province. Of the Boreal Forest Subregions, the Dry Mixedwood region has the warmest summers and mildest winters. Elevations range from 200 m along the Peace River up to 1,225 m in the region west of Sundre. The dominant terrain types are level to gently undulating glacial till or lacustrine plains. Orthic Gray and Dark Gray Luvisols are the dominant soils on uplands; with Gleysols and Organic Mesisols dominant in wetlands. Aspen forests are dominant with mixed understories of rose, low-bush cranberry; beaked hazelnut and Canada buffaloberry are typical on uplands. Treed shrubby or sedge-dominated fens are the most common wetland communities and occupy about 15% of the Natural Subregion. Jack pine stands with lichen understories are found on dry, well- to rapidly-drained glaciofluvial and eolian deposits in the Subregion (Natural Regions Committee 2006).

The prevalence of early to mid-seral aspen forests in the Dry Mixedwood Natural Subregion, and the relative scarcity of white spruce compared to the adjacent Central Mixedwood Natural Subregion, might be in part due to a higher incidence of lightning-caused fires in the Dry Mixedwood (Natural Regions Committee 2006).

### 3.2.2 Boreal Forest Natural Region - Central Mixedwood Subregion

In Alberta, the Central Mixedwood Subregion accounts for 25% of the Province and is the largest natural Subregion. This region ranges in elevation from 200 m to 1,050 m and is home to undulating plains and hummocky uplands, which have developed over lacustrine, morainal and fluvial geological parent materials. Dominant soils of the Subregion are Orthic Gray Luvisols and sandy Brunisols in uplands, while wetlands are mainly Organic Mesisols. Grasslands are very rare in the Central Mixedwood Subregion, and are only found in patches of jack pine or black spruce forests on dry, coarse, well drained soils. In upland regions, forest types include aspen, aspen-white spruce, white spruce and jack pine. Of these, the aspen dominant and aspen-white spruce co-dominant are the most common forested communities. In these stands the understory vegetation is typically comprised of the following plants: low bush cranberry, rose, green alder, Canada buffaloberry, hairy wild rye, bunchberry, wild sarsaparilla, and dewberry. Wetlands are very common in the Central Mixedwood Subregion and are often in the form of poorly drained fens and bogs (Natural Regions Committee 2006).

## 3.3 Geology and Soils

The underlying geology of a region is an important player in determining viable land use activities (Figure 3). For example, coal mining in the Wabamun Lake watershed is driven by the presence of coal seams originating from the lowermost Paskapoo formation or the uppermost cretaceous bedrock. The Paskapoo formation is formed from Tertiary Period deposits composed primarily of non-marine sedimentary rocks including primarily calcareous mudstone, siltstone and sandstone, with subordinate beds of limestone, tuff, and coal. In areas around the lake where coal seams reach the surface, black sands can be seen (Mitchell and Prepas 1990).

Surficial deposits to the south and west of the lake are mainly discontinuous glacial till less than two meters thick, or bedrock of the Paleocene age. Surface deposits along the north shore of the lake are mostly sandy lacustrine deposits less than two meters thick. Along the east shore of the lake one can find fine textured glaciolacustrine materials, with few or no stones. The bedrock along the north and west side of the lake is of the Cretaceous age (Andriashek et al. 1979).

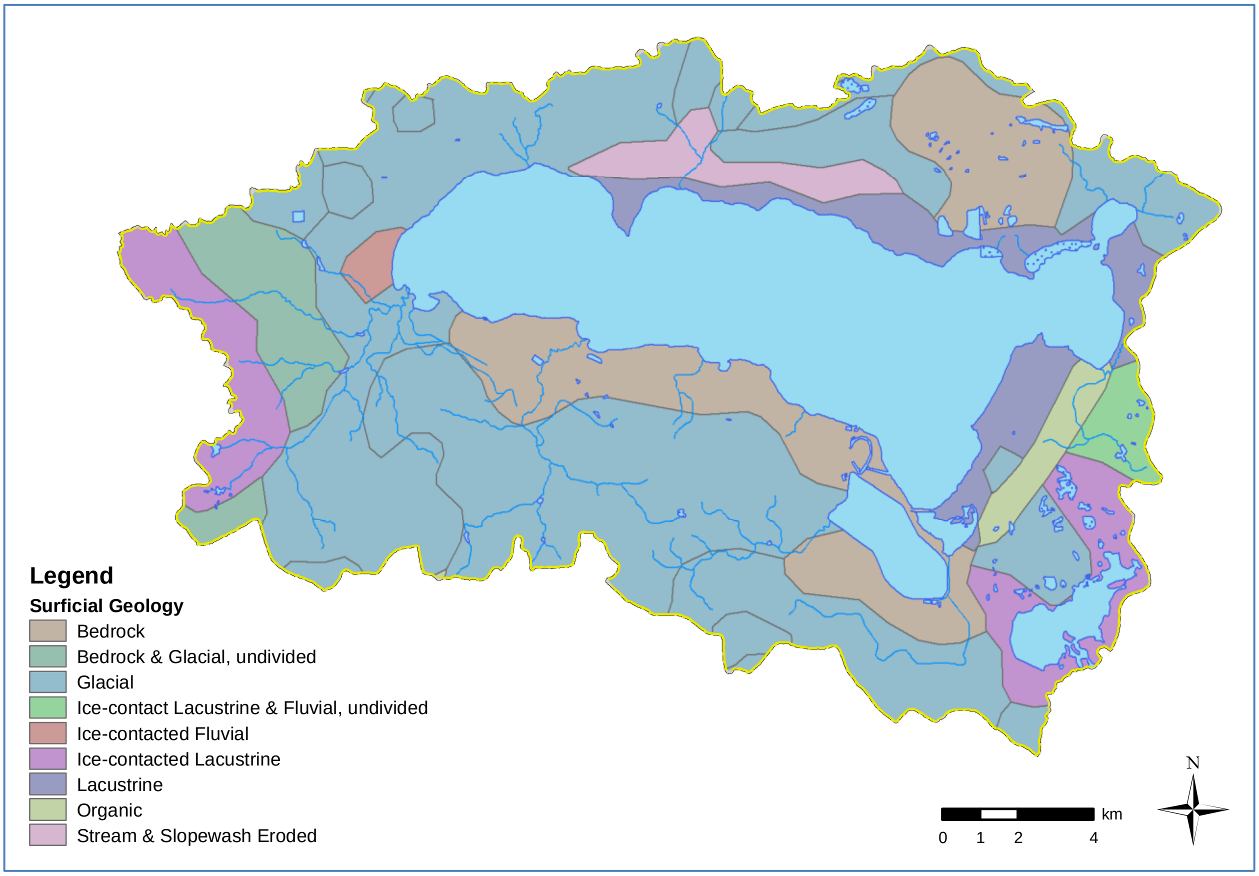


**Figure 3:** Surficial geology of the Wabamun Lake watershed. Data obtained from Alberta Geological Survey (2012a).

The underlying bedrock and surficial deposits directly affect the soils that will develop on a landscape. The characteristics of these soils will in turn drive land use activities. For example, rich chernozemic soils make excellent farmlands; whereas, luvisolic soils have fewer nutrients and better support forests. Soils form over thousands of years and are very difficult to reclaim after activities, such as mining, have taken place.

The soils in the Wabamun watershed are predominantly Grey Luvisols (Figure 4). Luvisols are one of the dominant forest soils across Alberta and are typical of aspen forests. These soils have high base cation contents, resulting in neutral or a slightly alkaline pH (Soil Classification Working Group 1998). The soils represented in Grey in Figure 4 have been disturbed as a result of human activities, predominantly mining.

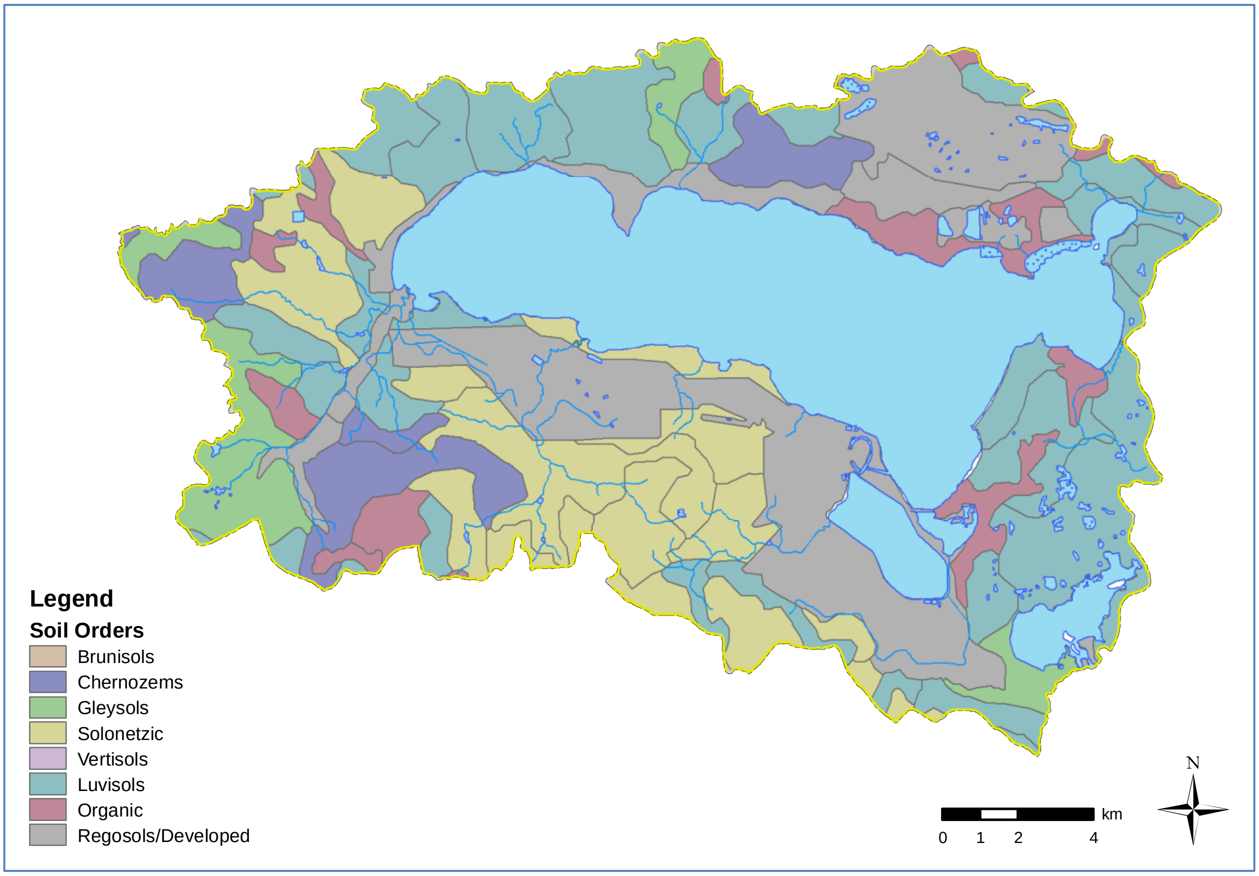


**Figure 4:** Soil Orders of the Wabamun Lake watershed. Data obtained from Canada - Alberta Environmentally Sustainable Agriculture (2001).

## 3.4 Climate

The climate of the Wabamun Lake watershed is continental with short, warm summers and cold winters. There are approximately 1,301 growing degree-days for this region (Natural Regions Committee 2006). The nearest Environment Canada reporting station for which climate normal data is available is the Edmonton Stony Plain station. At this station, the mean annual temperature is 3.4°C with an average growing season (May to September) temperature of 13.6°C. The average amount of precipitation is 536 mm, with July being both the wettest and warmest month. The prevailing winds are mostly from the NW and have an average speed of 10.6 km/hr (Environment Canada 2000).

## 3.5 Air Quality

Air quality is important for all aspects of health in both humans and the environment. Poor air quality is directly linked to respiratory illnesses and reduced quality of life. Air pollution caused by fossil fuel emissions, smoke, and dust all affect the overall air quality. In Alberta, the Air Quality Health Index is a number scale from 1 to 10+, which indicates the level of health risk associated with the air quality. On this scale 1-3 is low risk with no adverse health effects and 10+ being very high risk with warnings to avoid strenuous outdoor activity or remain inside. Provincial guidelines for air pollutants are set based on a one-hour ambient measurement. Guideline levels are based on the evaluation of scientific, social, technical and economic factors (AESRD 2013b).

From 2004 to 2007 Alberta Environment and Sustainable Resource Development monitored the air quality at seven locations surrounding Wabamun Lake (Alberta Environment 2008). During this study, ambient air was monitored for pollutants such as ammonia, carbon monoxide, nitrogen dioxide, ozone, hydrogen sulphide, and sulphur dioxide. None of the monitored concentrations exceeded Alberta's one-hour Ambient Air Quality Objectives and concentrations were similar to those measured in a study from 2000 to 2001. The 2000 to 2001 air quality monitoring showed a high concentration of large particulates in the air, which was thought to be a result of road and windblown dust. In the most recent study large particulates were recorded below the Alberta one-hour Ambient Air Quality Objective, and were not of concern (Alberta Environment 2008).

While air quality monitoring does not show any negative impacts, residents of the south shore of the lake still notice large amounts of dust blowing from the Highvale mine, especially when the wind blows from the southeast (Stan Franklin, WWMC, personal communication). At this time the West Central Airshed Society has one air quality monitoring station, meadows station, located within the boundary of the Wabamun Lake watershed. The meadows station monitors the ambient air for relative humidity, wind speed, wind direction, sulphur dioxide ($SO_2$), nitrogen oxide (NO), and nitrogen dioxide ($NO_2$) (West Central Airshed Society 2013). In the most recent annual report (2011), there were no concerns with levels of $SO_2$, NO, or $NO_2$ detected at the meadows station (WBK & Associates and Stantec Consulting 2012).


# Land Use

# 4 Land Use

Changes in land use patterns reflect major development trends, such as forested lands converted to agriculture. Land use changes and the subsequent changes in management practices impact both the quantity and quality of water within the Wabamun Lake watershed. The following metrics were used to indicate land use and land use practices in the Wabamun Lake watershed:

- Urban, Rural and Recreational Developments;
- Agriculture and Livestock Operations;
- Oil and Gas Activities;
- Linear Developments;
- Wetland Loss; and
- Riparian Health.

## 4.1 Urban and Rural Developments

Urban and rural development is the expansion of urban areas, rural subdivisions and recreational areas into surrounding landscape. This expansion can have many negative effects on the environment, including the loss of wetlands, riparian areas, intermittent streams and wildlife habitat, as well as increased surface runoff into and potential erosion and sedimentation of neighboring creeks, rivers and lakes.

The majority of the lakeside developments on Wabamun Lake reside within the summer villages of Seba Beach (338 private dwellings), Kapasiwin (45 private dwellings), Betula Beach (40 private dwellings), Lakeview (36 private dwellings) and Point Allison (31 private dwellings) (Statistics Canada 2011). Over 200 people list their homes within these summer villages as their primary residence. The village of Wabamun is home to 661 people and the Wabamun Paul First Nations Reserve has 1,086 residents. Other developed areas surrounding the lake, such as Fallis are reported as part of the Parkland County census and as a result exact number cannot be determined. There are approximately 8.0 $km^2$ of urban and rural developments within the Wabamun Lake watershed (Alberta Biodiversity Monitoring Institute 2010).

The Village of Wabamun treats their wastewater through the use of a sanitary sewer system with a water treatment plan and treatment lagoons located 3.2 km north of highway 16. This system can accommodate up to 1,300 residents (Village of Wabamun 2010). Summer villages such as Seba Beach have septic tanks, which are pumped out and sewage is transported to the Entwistle lagoons, which are owned and operated by Parkland County (Sue Evans personal communication).

Careful development of lakeshore property following all regulatory approvals is needed to ensure the watershed and environment remain healthy. Appropriate environmental reserve setbacks need to be established for shoreline developments, as the *Municipal Government Act* only requires a minimum 6.0 meter buffer, which is inadequate to protect waterbodies (Aquality 2007). Recently in 2012, a *Water Act* enforcement order was issued to Samco Developments Ltd. for unauthorized stripping of vegetation from the floodplain from two of its Wabamun Lake shoreline properties. These activities can cause significant potential for erosion of soil and increased sediment deposition into Wabamun Lake. Under this order the developers are required to take appropriate measures to restore the damage they have caused to the floodplain (AESRD 2012b).

## 4.2 Recreation

Wabamun Lake is one of the most highly used lakes for recreation in the province of Alberta. Recreational developments are those developments that do not support permanent residency, but may experience heavy traffic during certain periods of the year for recreational activities such as boating, sailing, fishing, and camping.

Wabamun Lake has one provincial park, located on Moonlight Bay at the northeast end of the lake. This a full service park with 301 campsites, day use area, beach, showers, pier and boat launch. Camping is also available at many locations including, Kokanee Springs R.V. Resort, located across from Seba Beach, which has 170 full service sites. Shadybrook Resort, Pineridge golf course, and Seba Beach, have permanent seasonal R.V. parks. Both Scouts Canada and the YWCA have youth and outdoor education camps on the north side of the lake.

The Village of Wabamun has developed their recreational facilities to include a waterfront park, federal pier, day-use picnic area, spray-park, recreational trails and a boat launch. The Ironhead and Pineridge golf courses are also located within the Wabamun Lake watershed.

Sailing is very popular at Wabamun and the lake is home to one of Alberta's most popular sailing clubs. The Wabamun Lake Sailing Club was founded in 1960 and is located on the north shore of the lake, near the Village of Wabamun. In 2012, the club had 84 active members and it holds sailing events and races almost every weekend throughout the summer (Wabamun Lake Sailing Club 2013). In addition to the Wabamun Lake Sailing Club, there are several other sailing clubs around the lake including, Sinbad School of Sailing, Sunshine Bay Yacht Club, Edmonton Yacht Club, and Alberta Offshore Sailing Association.

## 4.3 Agricultural and Livestock Operations

Areas of high livestock density and manure production within a watershed are expected to have greater impacts on downstream water quality. Streams that drain land with high intensity livestock operations have higher nutrient concentrations, dissolved nutrients, mass loads, fecal bacteria and exports of total dissolved phosphorus than streams with medium or low intensity livestock operations and manure production (Agriculture Canada 1994).

Due to the small size of the Wabamun Lake watershed, precise statistics about agricultural activities are impossible to obtain from the Canadian Census of Agriculture. The Wabamun Lake watershed is grouped together geographically with other sub-watersheds to give one reporting unit. Estimates can be made based on the proportional area of each watershed within the reporting unit. However, this assumes that activities are distributed evenly across the reporting unit, which is rarely the case. Values for various agricultural activities have been estimated for the purpose of this report, but caution should be taken in the accuracy and precision of these results.

A census was conducted in 2011; however, the results from the interpolated agricultural data have not yet been released. Therefore, we have used the results from the 2006 census in this report. In 2006, there was an estimated 63 farms in the watershed, occupying a land base of 14,819 ha (Statistics Canada 2006). Of this agricultural land, 33% was used for cropland, 24% improved pasture, 24% natural pasture, 1% summer fallow and 18% was other uses (Table 3). Alfalfa, hay and cereal grains made up the majority of the cropland area.

**Table 3: Agricultural land use in Wabamun Lake watershed in 2006 (Statistics Canada 2006)**

| Land Use | Area (ha) | Proportion of Agricultural Land |
|---|---|---|
| **Cropland** | 4,905 | 33% |
| **Improved Pasture (Tame/Seeded)** | 3,567 | 24% |
| **Natural Pasture** | 3,506 | 24% |
| **Other** | 2,714 | 18% |
| **Summer Fallow** | 128 | 1% |
| **Total** | 14,820 | 100% |

The Wabamun Lake watershed contains an estimated 5,395 cattle and calves, 2,948 poultry animals, 392 pigs and 174 sheep. Cattle are responsible for the majority of the manure production in the watershed. Total manure production of all livestock was estimated at 62,314 tons annually, or 1,583 kg/ha (Statistics Canada 2006). However, because the Wabamun watershed is grouped together geographically with other sub-watersheds to give one reporting unit, these numbers are likely over estimates.

## 4.4 Oil and Gas Activities

Oil and gas exploration and extraction activities are very common throughout the province of Alberta. With oil and gas development there can be a number of associated impacts, including loss of wetlands, habitat fragmentation, increased water use, and surface water and groundwater contamination (Alberta Centre for Boreal Studies 2001). Within the Wabamun Lake watershed boundary there are five abandoned or suspended non-sour gas wells; 13 sour gas wells, six of which are abandoned; and 69 unknown $H_2S$ or historical wells of which 48 are considered abandoned (Figure 5). Abandoned wells are not usually considered to be a large contributing factor to the overall water quality of a watershed. Alberta's Energy Resources Conservation Board (ERBC) currently regulates the abandonment of oil and gas wells under *Directive 020: Well Abandonment*.

In addition to the wells, there is approximately 1.1 $km^2$ of oil and gas pipelines within the watershed (Alberta Biodiversity Monitoring Institute 2010). This includes a natural gas pipeline operated by TransAlta, which runs under the lake east of the Village of Wabamun to the Sundance Power Plant (ERCB 2012).

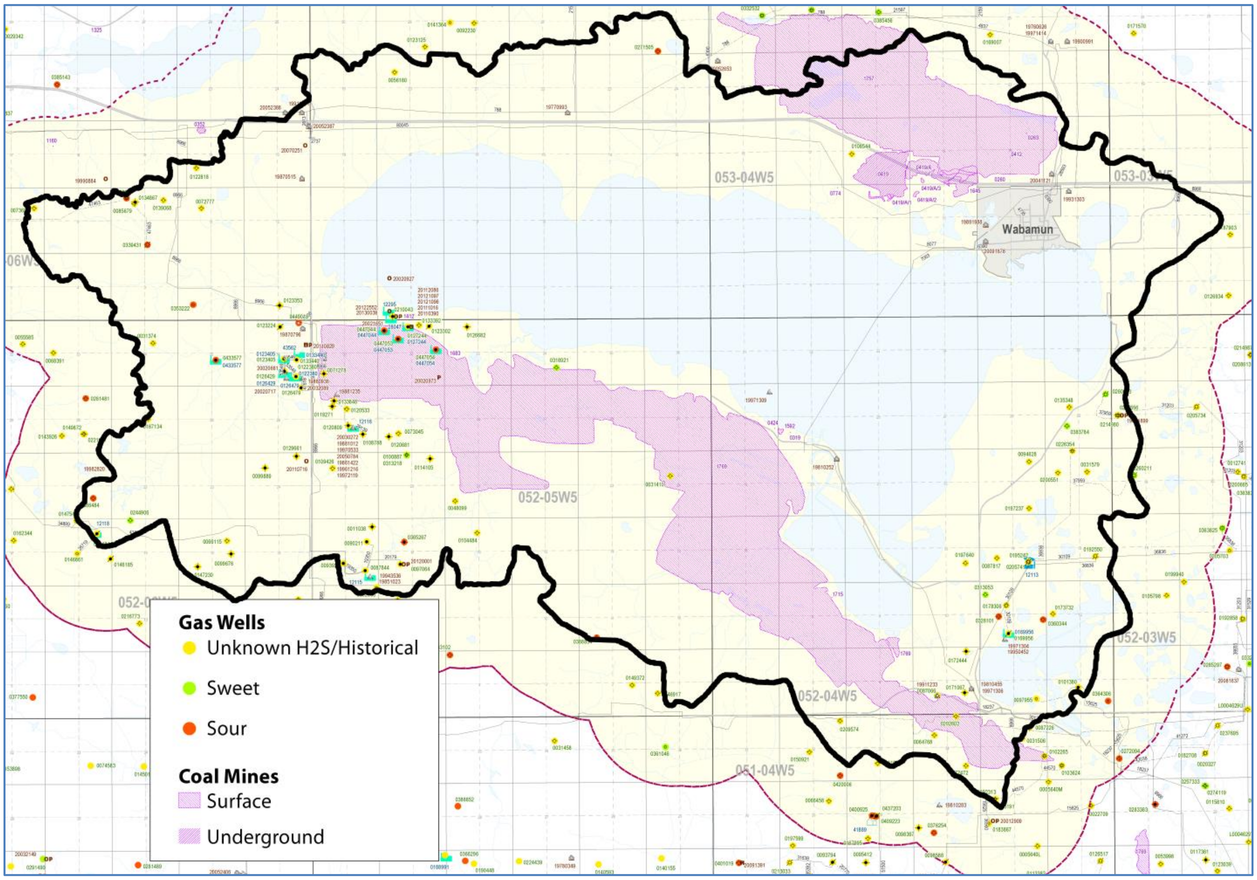


**Figure 5:** Pipeline and well locations for oil and gas activities in the Wabamun Lake watershed. Data provided by Alberta's Energy Resources Conservation Board (2013).

## 4.5 Mining and Industrial Activities

There are many impacts that industrial activities can have on the environment, including air pollution, decreasing water quality and quantity, increased noise, habitat destruction and negative esthetic appearances. Industrial activity within the Wabamun Lake watershed extends back to the early 19$^{th}$ century. Currently, the industrial and mining developments within the watershed occupy an area of 41.2 km$^2$, or 14.9% of the total land area (ERCB 2013). As the number of power plants within the region increased, so did the demand for coal; resulting in the development of the Highvale Mine to the south of the Wabamun Lake and Whitewood Mine to the north. The first coal mines in the area began as underground operations in 1910, and the mines were converted to strip mines in 1948 (Mitchell and Prepas 1990).

In operation since the 1970's, the Highvale Mine is Canada's largest strip coalmine. The mine produces approximately 12 million tons of coal each year, which is delivered to the Sundance and Keephills Power Plants. The mine boundary extends along the entire length of the south shore of Wabamun Lake and beyond the watershed boundary south of the Keephills cooling pond (Figure 6). At this time, there are six actively mined pits, and an application is currently underway for a new pit within the current mine boundary. This proposed pit, pit 09, will be located outside of the Wabamun Lake watershed boundary to the south of the Keephills cooling pond. Currently, reclamation activities have begun at the Highvale Mine, with Pits 03 through 07 scheduled to have their reclamation activities complete between 2016 and 2029 (TransAlta 2012a). Reclamation of these pits will include 224.95 ha of wetlands, 443.3 ha of forest and 179.1 ha of open water in the form of end-pit lakes (Leriger, TransAlta, personal communication).

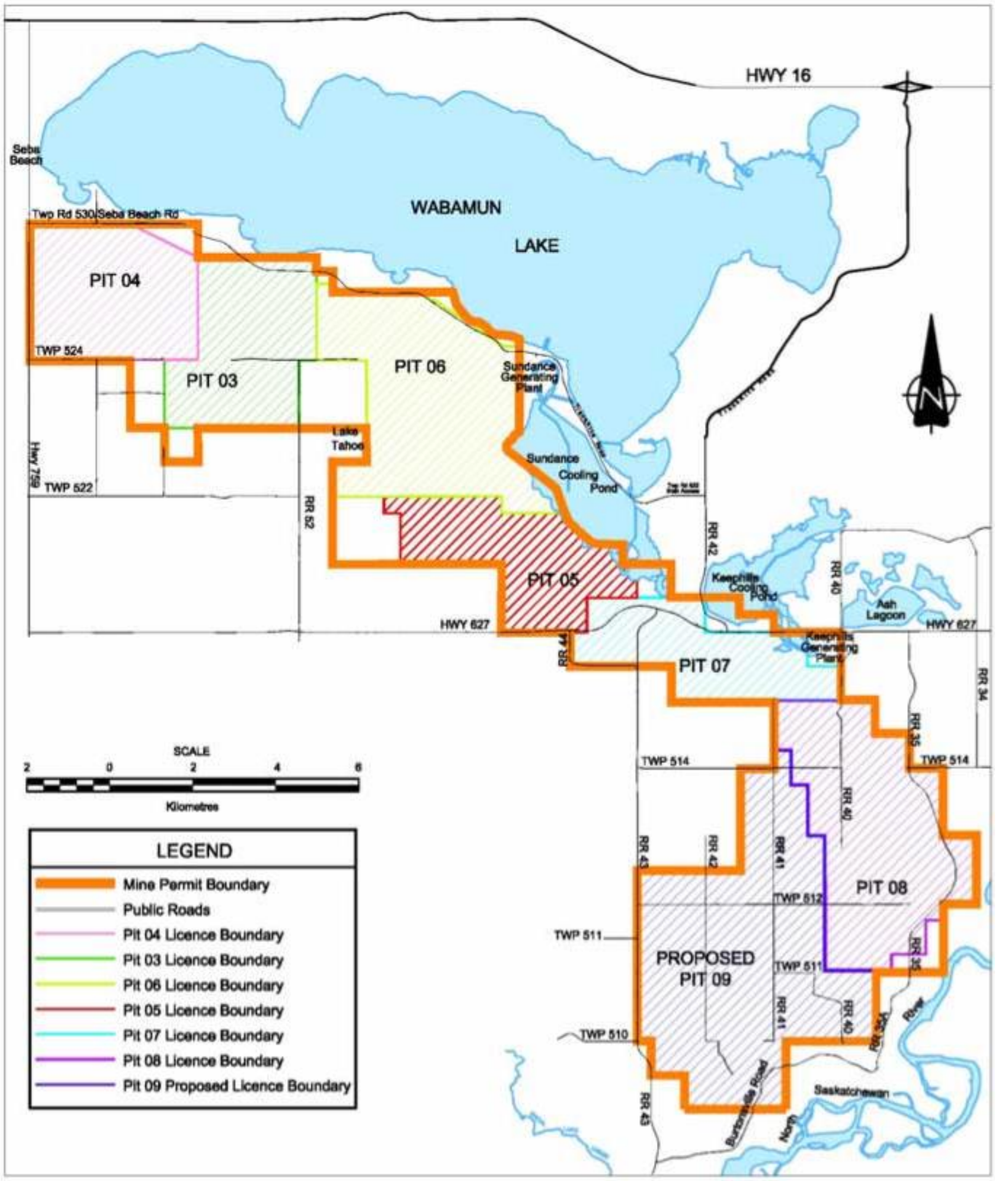


**Figure 6:** Highvale Mine boundary and pit locations (TransAlta 2012a)

The first power plant on the lake, Wabamun Power Plant, was constructed in 1956 along the north shore at the Village of Wabamun and consisted of two gas fired units. These gas-fired units were later converted to coal-fired in 1963 and 1983 and further expansion added two more units (Schindler et al. 2004). The Wabamun Power Plant ceased operations in 2010 and TransAlta pulled down the stacks and imploded the structure of the power plant in August of 2011. When the Wabamun Power Plant fully ceased operations in 2010, Whitewood Mine was also closed. The final reclamation activities at the Whitewood Mine will be completed in 2013 and the restored land will be suitable for a variety of uses. The reclaimed land will include 54.8 ha of wetlands, 194.2 ha of forests and 77.7 ha of end-pit lakes (Leriger, TransAlta, personal communication).

A portion of the shoreline between Point Allison and Rich's Point, previously owned by TransAlta, has been donated to the Alberta Fish and Game Wildlife Trust Fund. This 19 ha parcel of land protects the Western Grebe colony along the shoreline. In addition, TransAlta plans to donate 24 ha of land on the south shore of Wabamun Lake to this organization. This land is located north of the Highvale Mine and shares borders with the Wabamun Lake to the north and Beaver Creek to the west. This area consists of a range of ecological communities including, forests, wetlands and grassland meadows (Leriger, TransAlta, personal communication).

The Sundance Power Plant was constructed in 1970 and is currently the largest coal-fired power plant in western Canada. This power plant is located on the south shore of the lake and has six power generating units with a maximum capacity of 1566 MV. Originally the Sundance power plant used lake water for cooling, but a large cooling pond was constructed in 1975. The cooling pond was created on the southeast corner of the lake by berming a portion Goosequill Bay, a large wetland complex (Schindler et al. 2004).

Although both the Genesee and Keephills Power Plants are located outside of the Wabamun Lake watershed, the lake still receives airborne emissions from these plants. While the Keephills Power Plant footprint does not fall within the Wabamun watershed boundary, its cooling pond does. Both of these power plants obtain water for operations from the North Saskatchewan River (Schindler et al. 2004).

The Wabamum Lake Water Treatment Plant was built in 1997 to mitigate the historic and ongoing changes in lake levels due to the diversions made by TransAlta operations within the watershed. The historic water debt was repaid by the water treatment facility in 2007. As of 2005, no water is taken from Wabmun Lake for any of TransAlta operations or facilities (Leriger, TransAlta, personal communication). Currently, TransAlta diverts water from the North Saskatchewan River into the Sundance cooling pond. From the cooling pond the water is either treated and returned back into Wabamun Lake, or used for the operation of the Sundance Power Plant (TransAlta 2013a). The water in the treatment plant is clarified, filtered, chlorinated and ozonized, then de-chlorinated and cooled to within 3 degrees of the ambient temperature of the lake water before the water is released to Lake Wabamun (Leriger, TransAlta, personal communication). At peak production the water treatment plant can contribute up to 20% of all the water diverted into the lake annually (Seneka 2002).

## 4.6 Linear Development

Linear development within the watershed includes seismic lines, pipelines, roads, railways and utility right of ways. Quantifying linear developments will help us understand potential changes in water quality and fish and wildlife populations. For example, wildlife corridors can be interrupted by roads, and watersheds can have their drainage patterns permanently altered by increases in impervious or compacted surfaces.

Within the Wabamun Lake watershed, there are approximately 17.6 $km^2$ of linear features (Figure 7). This number includes all roads, trails, railways, pipelines, seismic lines, and transmission lines. The largest linear feature is the Yellowhead Highway, which is a four lane divided highway, running along the north side of the watershed. One of the oldest linear features is the CN Rail line, constructed in the 1900's, which runs directly along the north shore of the lake.

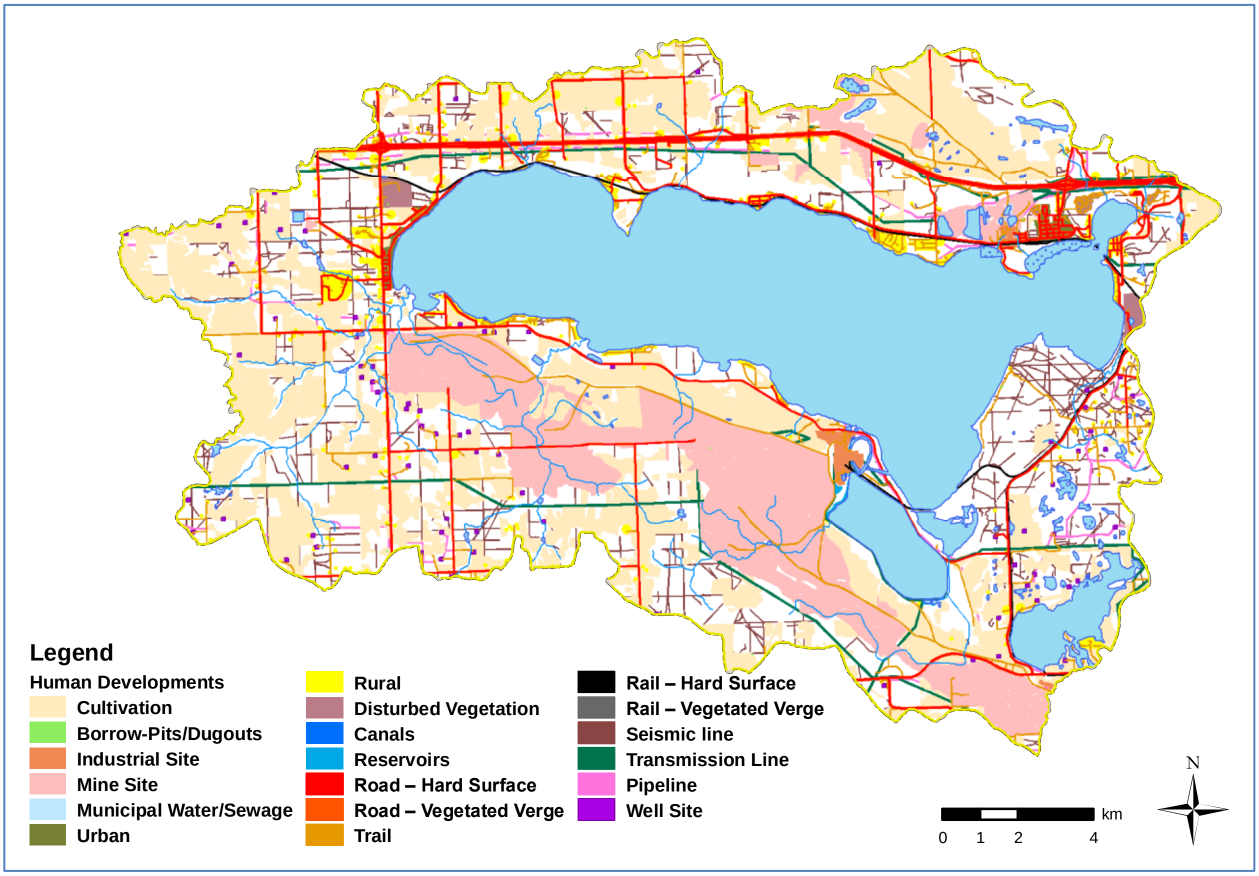


**Figure 7:** Linear features and human developments in the Wabamun Lake watershed. Data obtained from Alberta Biodiversity Monitoring Institute (2010).

## 4.7 Wetland Loss

Wetlands have numerous ecological functions on a landscape including: storing water, trapping and storing sediments, filtering nutrients and contaminants, recharging groundwater and maintaining a high level of biodiversity. Wetlands are often seen as a natural alternative to engineered water treatment options. The loss of wetlands to development and/or agriculture can be detrimental to surface and groundwater quantity and quality.

The Wabamun Lake watershed is located entirely within the White Zone of Alberta. Wetlands have historically been quite common within the White Zone, but significant wetland area has been lost due to drainage for agricultural and other development activities (Strong et al. 1993). Across the entire Dry Mixedwood Natural Subregion, peatlands cover about 9.3% of the area, where tree, shrub and graminoid dominated fens are most common. In addition, bogs, marshes and shallow open water wetlands occur in this Subregion (Vitt et al. 1996). Bogs and fens are very common within the Central Mixedwood Natural Subregion, while marshes and shallow open water are less common (Natural Regions Committee 2006).

Based on the inventory done by Alberta Environment and Sustainable Resource Development, 11% of the Wabamun Lake watershed land base is comprised of wetlands. Marshes covered 30.4 km$^2$, fens 7.5 km$^2$, bogs 1.6 km$^2$ and swamps 0.4 km$^2$ (Figure 8, AESRD 2012b). Loss of wetlands has undoubtedly occurred within the Wabamun Lake watershed due to the high industrial and agricultural activity; however, there is no form of historical data that the current wetland cover can be compared to.

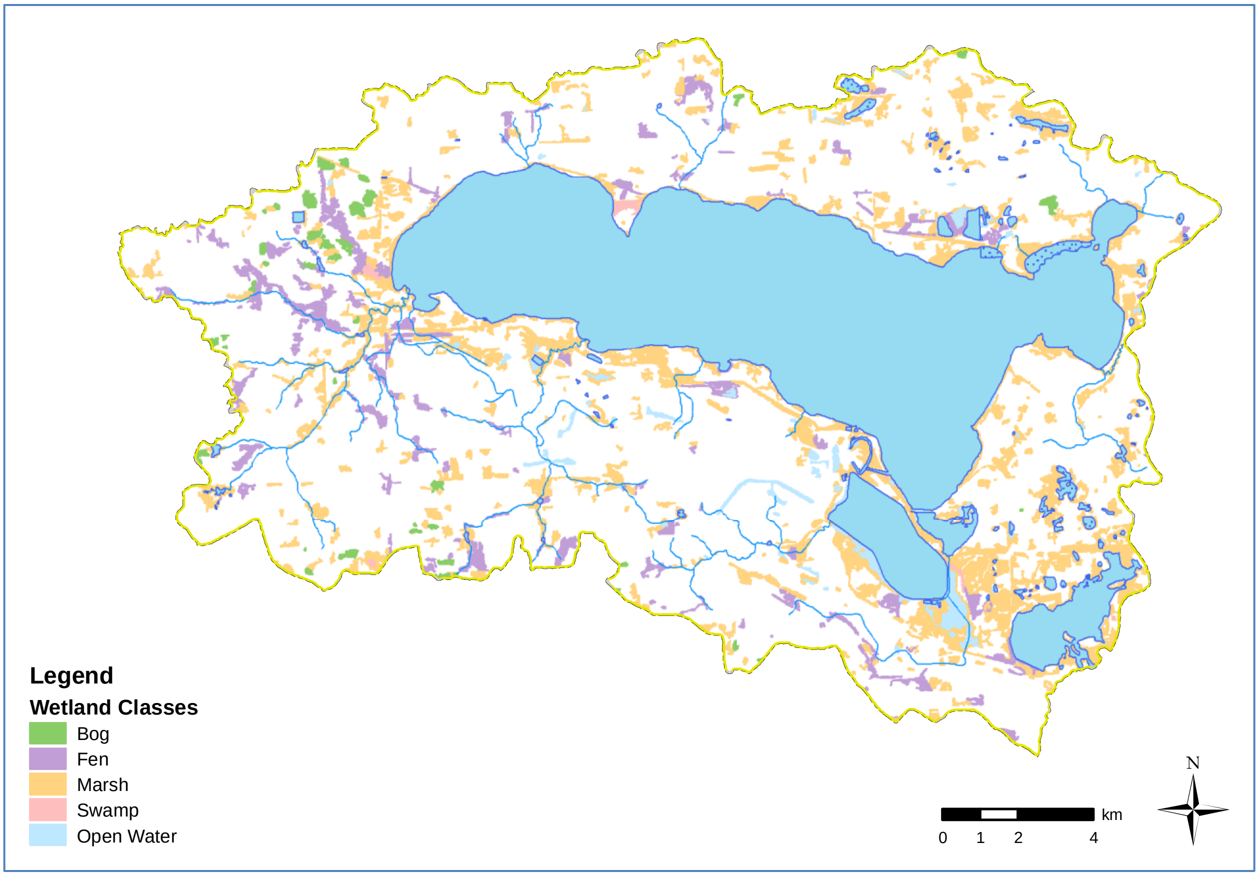


**Figure 8:** Wetlands classes present within the Wabamun Lake watershed. Data collected from Alberta Environment and Sustainable Resource Development (2012b).

## 4.8 Riparian Health

Riparian areas are the transition zones between open water and upland ecosystems. These transition zones are generally characterized by water loving soils, vegetation and physical characteristics that are directly influenced by hydrological processes. Riparian areas have many important ecological functions including buffering and filtering water, trapping and storing sediments, regulating water flow, and stabilizing banks or shorelines. Riparian areas have proven to remove nutrients and other anthropogenic pollutants from water before it flows into larger hydrologic systems.

At this time we could not find any riparian health data for the Wabamun Lake watershed. However, the Wabamun Watershed Management Council (WWMC) has worked with the Alberta Living by Water program to conduct shoreline assessments on properties around the lake (Kelly Aldridge, WWMC, personal communication). During the summer of 2009 and 2010 a shoreline naturalization project was undertaken at one of the WWMC member's property. This project allowed the group to work through and demonstrate the appropriate steps to returning a shoreline to its natural state. This involved removing an existing retaining wall, adjusting the slope of the landscape and planting various native plants along the shoreline. This project provided an excellent learning opportunity for WWMC members and lake residents (WWMC 2010).

# Water Quality

# 5 Water Quality

Changes in water quality indicate either a deterioration or improvement in the condition of the watershed and demonstrate specific areas that require further attention or protection. Changes in water quality result from changes in land use or land management practices, landscape disturbance and natural events. The major anthropogenic impacts on water quality result from natural resource extraction and processing, wetland drainage, dredging, dam construction, agricultural runoff, industrial wastes, municipal wastes, land erosion, road construction and land development. Six metrics were used to indicate water quality in Wabamun Lake:

- Nutrients;
- Bacteria;
- Parasites;
- Pesticides; and
- Metals.

These six water quality indicators reflect socioeconomic growth in a region. Hence, while human activities in a region can have negative impacts on aquatic ecosystems, it is important to strive for a balance between socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

Alberta Environment and Sustainable Resource Development provided data on water quality, with data available (with varying degrees of completeness for various parameters) from 1982-2012 (AESRD 2012). Wabamun Lake is sampled by AESRD as part of the Alberta long-term lakes monitoring network. In addition, data collected on fecal coliforms concentration was provided by Alberta Health Services (Alberta Health Services 2008, 2009, 2011, 2012).

## 5.1 Nutrients and Routine Parameters

### 5.1.1 Nutrients

Nitrogen and phosphorus are essential nutrients for most aquatic plants. As a result, excess nutrients can lead to eutrophication, which causes an excessive amount of aquatic plant and phytoplankton growth. Associated with increased plant and phytoplankton growth, oxygen levels may become significantly reduced in the water column, which may negatively impact aquatic organisms, including fish. In addition, excessive phytoplankton growth, particularly of cyanobacteria, can lead to the release of toxins into the water column, which may be harmful to aquatic organisms, waterfowl, livestock and humans. The input of nutrients into aquatic systems can occur naturally, but large amounts of nutrients typically originate from indirect anthropogenic sources; including, improperly treated wastewater, residential and industrial use of fertilizers, industrial activity and agricultural operations.

Total nitrogen concentrations regularly exceed the Alberta Surface Water Quality (ASWQ) guidelines for the Protection of Freshwater Aquatic Life (FAL) throughout the entire period of record. Concentrations of total nitrogen ranged from 0.394 to 1.385 mg/L, with an overall average of 0.90 mg/L, compared to a guideline value of 1.0 mg/L (Figure 9). This average was derived from composite samples taken over the period of record from 1982-2012.

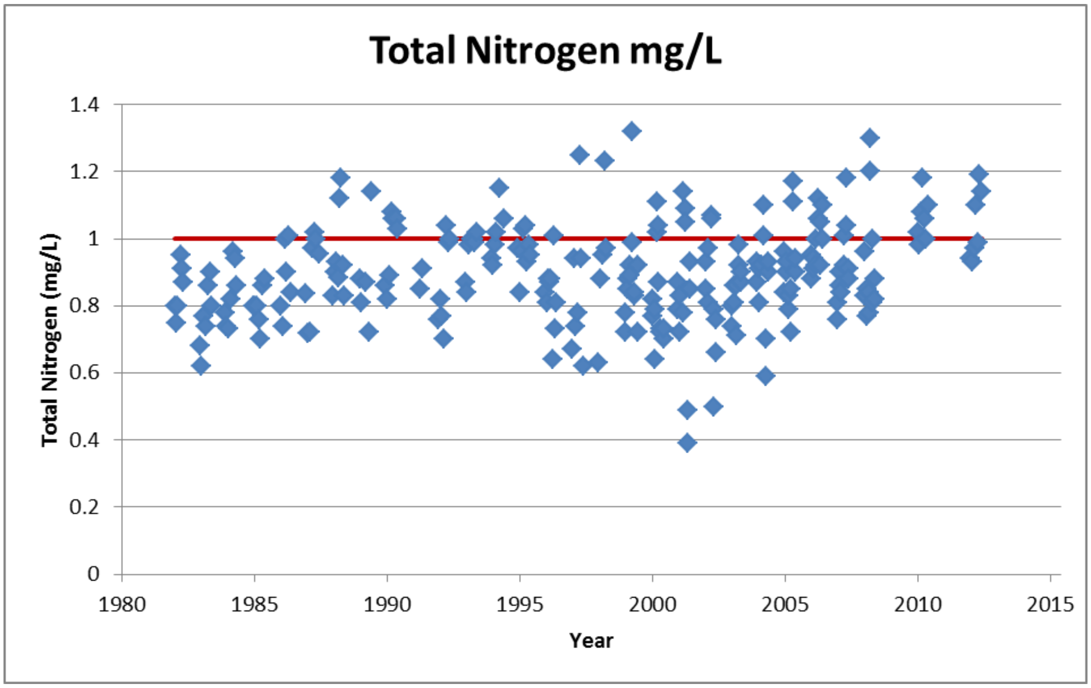


**Figure 9:** Total nitrogen concentrations in Wabamun Lake. Red line is the ASWQ guideline of 1.0 mg/L. Data from Alberta Environment and Sustainable Resource Development (2013a).

Total phosphorus is also measured as part of Alberta Environment and Sustainable Resource Development's water quality monitoring program. Phosphorus can enter a lake from a wide range of sources including: watershed runoff, atmospheric inputs, biological recycling, groundwater seepage, lake sediments and anthropogenic additions such as farms and sewage (Emmerton 2008). Figure 10 shows the concentrations of total phosphorus over the period of record from 1982-2012 for composite samples taken from Wabamun Lake. With the exception of two samples, total phosphorus concentrations remained below the Alberta Surface Water Quality (ASWQ) guidelines for the Protection of Freshwater Aquatic Life (FAL). Total phosphorus concentrations ranged from 0.005 to 0.057 mg/L, with an average concentration of 0.03 mg/L.

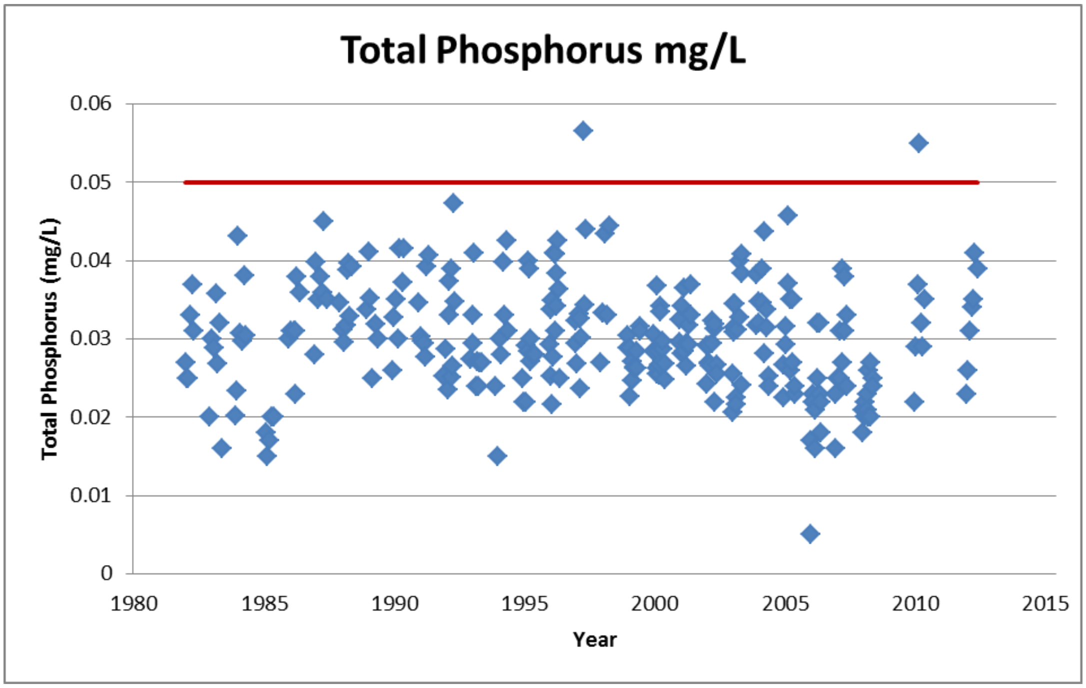


**Figure 10:** Total phosphorus concentrations in Wabamun Lake. Red line is the ASWQ guideline of 0.05 mg/L. Data from Alberta Environment and Sustainable Resource Development (2013a).

Historical sampling from Wabamun Lake has shown an overall decline in total phosphorus concentrations after 1998. This is likely due to the opening of the Wabamun Lake Water Treatment Plant in 1999, which began pumping treated water from the North Saskatchewan River into the lake to offset diversions caused by TransAlta operations within the watershed. The decline in phosphorus is likely facilitated by a co-precipitation of phosphorus and calcium due to high levels of calcium carbonate in the treated water (Casey 2003 and 2011).

A phosphorus budget was produced for the open water season of Wabamun Lake by AESRD in 2008 (Emmerton 2008). This budget measured the amount of total phosphorus from runoff, atmospheric deposition, sediment and lake water. This information, combined with the historical phosphorus budget produced in 1980-1982 can give a representation of the overall phosphorus budget of Wabamun Lake.

The results from the 2008 budget show that 43% of phosphorus originated from the lake sediments and 44% came from atmospheric deposition (Table 4). The remaining phosphorus was from groundwater (5%), diversions (3%), runoff (3%), and domestic sewage (1%). Very little surface runoff was observed in 2008 as it was a very dry year, with little precipitation and low snowpack. The historical phosphorus budget from 1980-1982 was conducted in years that were considered wetter than average. Because of the differences in hydrologic regimes, it is difficult to directly compare these two phosphorus budgets for changes over time. However, in both cases the amount of phosphorus released from the sediments accounts for approximately half of the total phosphorus, regardless of snowpack and precipitation (Emmerton 2008). The amount of phosphorus released from the sediments is very difficult to change without aggressive management techniques. As a result, it is critical to control phosphorus entering the lake through external input, specifically from non-point source surface runoff. In wetter years this will be particularly important as surface can make up a large portion of phosphorus inputs (Emmerton 2008). Emmerton indicated that streams that drain agricultural areas and have high potential for increased phosphorus additions should be selected for future remediation activities. This includes streams in the area of Fallis and Ascot Bay.

**Table 4: Wabamun Lake phosphorus budgets produced in 1980-1982 and 2008 (Emmerton 2008)**

| Year | Runoff (%) | Atmospheric Deposition (%) | Sediments (%) | Domestic Sewage (%) | Diversions (%) | Groundwater (%) |
|---|---|---|---|---|---|---|
| **1980-1982** | 23 | 13 | 55 | 1 | 6 | 2 |
| **2008** | 3 | 44 | 43 | 1 | 3 | 5 |

### 5.1.2 Routine Parameters

Alberta Environment and Sustainable Resource Development also collects a number of routine parameters as part of their lake monitoring program. A long-term trends report is also produced for numerous lakes in the province of Alberta, which includes Wabamun Lake. Wabamun Lake is currently showing an increasing trend in total dissolved solids, and ammonia nitrogen (after 2004/2005) (Casey 2012).

Decreasing trends were seen for total phosphorus, dissolved phosphorus, calcium carbonate, dissolved organic carbon, and silica concentrations. While these trends are likely connected to the treated water entering the lake from the Wabamun Lake Water Treatment Plant, it is difficult to clearly distinguish the cause of these changes (Casey 2012).

Table 5 shows routine parameters that have been analyzed from composite samples collected from Wabamun Lake. With the exception of fluoride concentrations, all of the average concentrations for routine parameters were below guidelines. Fluoride concentrations typically exceeded the ASWQ guidelines with an average concentration of 0.36 mg/L. Fluoride has low solubility in water and naturally occurs in low concentrations in freshwater.

**Table 5: Nutrient and routine water quality parameters for Wabamun Lake. Data from Alberta Environment and Sustainable Resource Development (2013a).**

| Parameter | CCME/ASWQ FAL Guideline | Average | Minimum | Maximum |
|---|---|---|---|---|
| Ammonia mg/L | Varies | 0.025 | 0.001 | 0.25 |
| $NO_3$ & $NO_2$ mg/L | | 0.004 | 0.0005 | 0.039 |
| Total Nitrogen mg/L | 1.0 mg/L | 0.9 | 0.394 | 1.385 |
| Total Phosphorus mg/L | 0.05 mg/L | 0.03 | 0.005 | 0.057 |
| Total Dissolved Phosphorus mg/L | | 0.01 | 0.0035 | 0.027 |
| Chlorophyll-a mg/$m^3$ | | 11.4 | 1.1 | 28.2 |
| Dissolved Organic Carbon mg/L | | 12.0 | 8.6 | 28.2 |
| Secchi Disk Transparency m | | 2.3 | 1.0 | 4.1 |
| pH | 6.5 – 9.0 | 8.5 | 7.46 | 8.9 |
| Specific Conductance (Field) µs/cm | | 488.77 | 382.0 | 616.0 |
| Total Hardness $CaCO_3$ mg/L | | 123.13 | 82.50 | 153.00 |

| | | | | |
|---|---|---|---|---|
| Bicarbonate mg/L | | 232.69 | 142.00 | 264.00 |
| Total Dissolved Solids mg/L | | 266.9 | 217.0 | 365.0 |
| Chloride mg/L | 120 mg/L | 7.62 | 2.00 | 14.10 |
| Fluoride mg/L | 0.12 mg/L | 0.36 | 0.24 | 0.55 |
| Sulphate mg/L | | 46.12 | 20.00 | 93.00 |
| Calcium mg/L | | 23.14 | 8.90 | 30.00 |
| Magnesium mg/L | | 16.00 | 10.00 | 21.00 |
| Potassium mg/L | | 8.92 | 6.60 | 12.30 |
| Sodium mg/L | | 59.4 | 40.00 | 80.40 |

Cyanobacteria, or blue-green algae, are a class of photosynthetic bacteria often found in freshwater bodies. Under certain conditions, cyanobacteria can form nuisance blooms that are hazardous to both humans and the environment. In addition to the issues generally associated with eutrophication as a result of algal growth (decreased light penetration and visibility, anoxic conditions due to decay), cyanobacteria can also produce toxins that can cause illness or even death in humans and animals. These cyanobacterial toxins include the microcystins, which affect the liver and neurological pathways (Zurawell 2011).

In 2012, Health Canada released the Guidelines for Canadian Recreational Water Quality. Under these guidelines total microcystin toxins must not exceed 0.02 mg/L for direct contact recreation, such as swimming and other water related activities. Guidelines for total cyanobacteria are 100,000 cells/mL. If the guidelines for cyanobacteria or microcystin toxins are exceeded, an advisory will be issued warning lake users against drinking lake water or using the lake for recreational purposes. While these advisories are common across Alberta, no algae related advisory has ever been issued for Wabamun Lake.

Alberta Environment and Sustainable Resource Development began sampling Wabamun Lake for microcystins in 2010 (AESRD 2013a). All of the samples collected to date were well below the guidelines set by Health Canada.

### 5.1.3 Trophic Status

Trophic status is a common indicator of overall health and represents the level of productivity in a lake. This is typically based on the algae production of a lake which is measured by the concentration of chlorophyll-a in the water. Lakes are classified as oligotrophic (low productivity), mesotrophic (moderate productivity), eutrophic (high productivity), or hypereutrophic (very high productivity) based on their concentration of chlorophyll-a. In most Alberta lakes, phosphorus is considered to be the main nutrient limiting growth. Therefore, there is a direct link between the concentration of phosphorus in the water and the amount of algae growing in the lake.

Paleoecological records for the past century have indicated that Wabamun Lake is slowly becoming more productive. This is evident from the increasing phosphorus fluxes and the change in diatom species from those who prefer mesotrophic conditions to those who prefer eutrophic conditions (Schindler et al. 2004). This trend is also supported by water quality monitoring conducted by Alberta Environment and Sustainable Resource Development. Currently, Wabamun Lake is classified as a mildly eutrophic, lake having a chlorophyll-a concentration between 8 and 25 μg/L. The average chlorophyll-a concentration for Wabamun Lake is 11.4 μg/L with a minimum concentration of 1.63 μg/L and a maximum of 27.8 μg/L (AESRD 2013a). Appendix A shows the trophic status of numerous lakes in Alberta, including Wabamun Lake and how they compare to each other.

## 5.2 Bacteria

Bacteria can come from a wide variety of sources in the aquatic environment, including natural sources such as soil, decomposing plants, and animal waste, and from anthropogenic sources such as raw sewage, manure runoff, and pet waste. Many types of bacteria found in the aquatic environment are harmless, but some can be pathogenic and cause human health issues.

Bacteriological data is not collected as part of AESRD's water monitoring program. However, Alberta Health Services does collect data on the fecal bacteria concentrations as part of their province-wide beach monitoring program. On Wabamun Lake, Alberta Health Services samples five different popular swimming locations including Ascot Beach, Camp YoWoChAs, Seba Beach, Village of Wabamun, and Wabamun Lake Provincial Park. Guidelines for fecal coliforms include the CCME CEQG Guidelines for Irrigation Water of 100 CFU/100 mL, and the Canadian Recreational Water Quality Guidelines of 200 CFU/100 mL (based on a 5-sample geometric average). If a beach exceeds these guidelines an advisory is announced and users are warned against drinking lake water, swimming and other direct contact recreational activities.

Like many lakes in Alberta, Wabamun Lake has increases in fecal coliform counts after heavy rainfall events or following windy periods that re-suspend lake sediments (Schindler et al. 2004). Beaches on Wabamun Lake that have displayed high fecal coliform counts are thought to be linked to the abundant waterfowl present both in the water and on the shorelines by Alberta Health Services (Schindler et al. 2004). Since the monitoring program commenced in 2004, the Village of Wabamun has showed higher levels of coliforms in comparison to other beaches on the lake (Alberta Health Services 2008). However, overall coliform levels for the lake have shown a decline from 2004 to 2012 at all beaches. Figures 11, 12 and 13 show the three most recent years of beach monitoring data collected by Alberta Health Services.

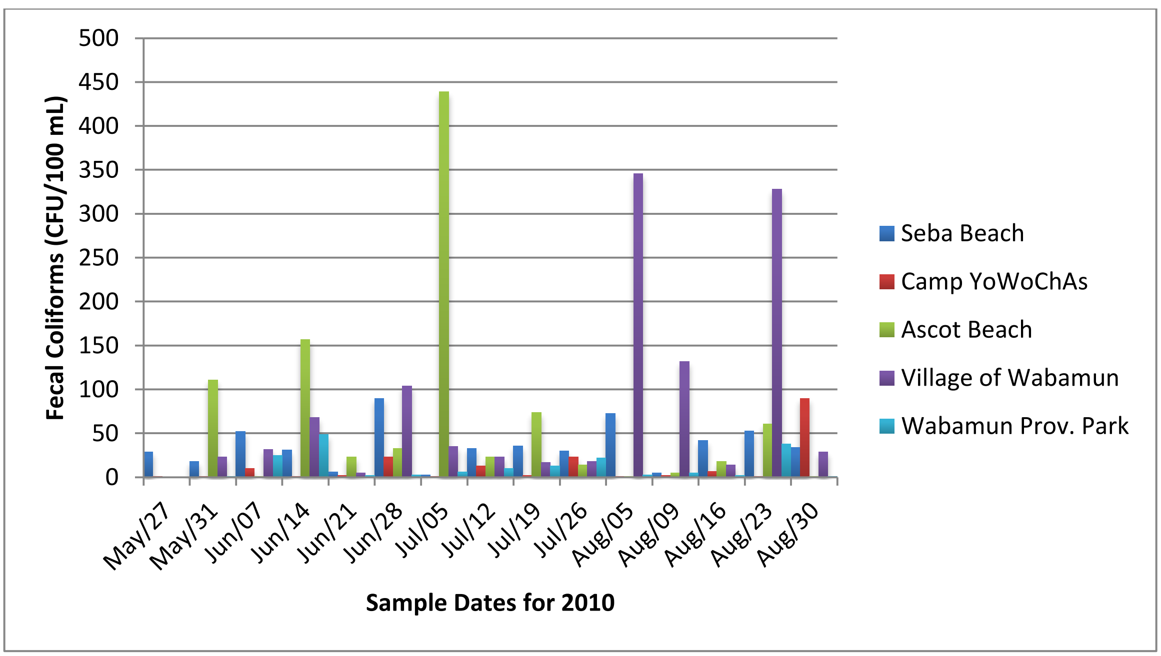


**Figure 11:** 2010 Alberta Health Services Wabamun Lake Beach Monitoring Data (Alberta Health Services 2010)

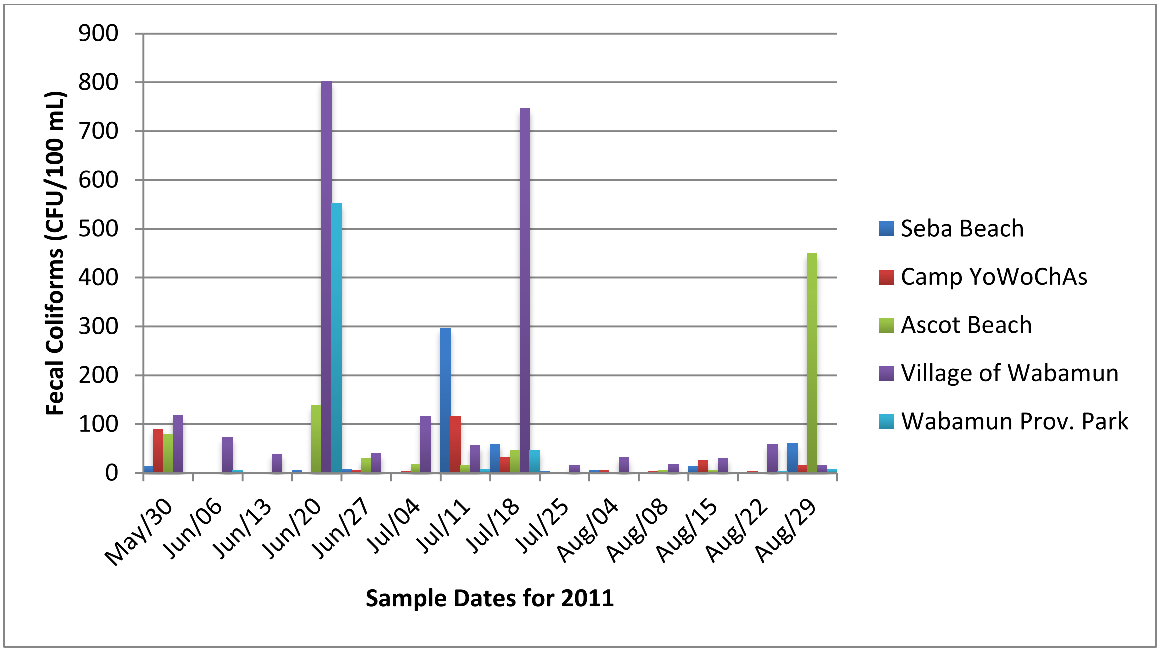


**Figure 12:** 2011 Alberta Health Services Wabamun Lake Beach Monitoring Data (Alberta Heath Services 2011)

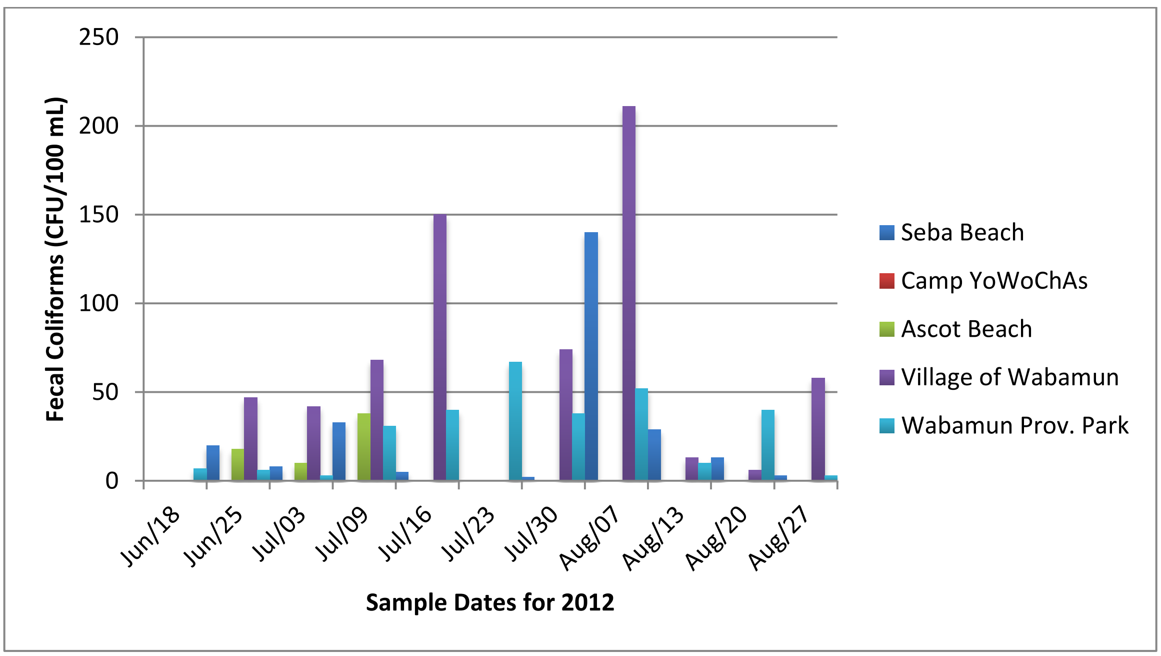


**Figure 13:** 2012 Alberta Health Services Wabamun Lake Beach Monitoring Data. Camp YoWoChAs was not monitored in 2012 (Alberta Health Services 2012).

In addition to the regular sampling program, in 2009 Alberta Health Services conducted extensive one-day bacteriological sampling at Seba Beach (Alberta Health Services 2009). This was conducted in response to public concern of sewage contamination in the lake. These samples were collected to provide baseline data and identify any problem areas along the Seba Beach shoreline. Water samples were collected from 26 locations along the Summer Village of Seba Beach and tested for presence of fecal coliforms and *E. coli.* None of the samples collected from any of these locations exceeded the Guidelines for Canadian Recreational Water Quality, suggesting that no sewage contamination was present during the time of the study.

## 5.3 Pesticides

Pesticides are a group of chemicals, including herbicides, insecticides, rodenticides and fungicides, which are used for many purposes, including pest control, aesthetics in urban areas, golf courses and in forestry and agricultural production. Pesticides are a common contaminant of streams and dugouts in the high intensity agricultural areas of Alberta.

Pesticide data was only available for the east basin of the lake and was collected on one occasion in 1995. At this time 40 different pesticides and herbicides were tested for and only very low concentrations of 2, 4-D and MCPA were detected. 2, 4-D is a common herbicide used to control broadleaf plants and is the active ingredient in over 1,500 different herbicides. MCPA is a herbicide that is used to control broadleaf weeds, most commonly in agricultural crops. MCPA is also called Weed and Feed or Weed be Gone.

## 5.4 Parasites

Parasites generally include microbiological organisms such as *Cryptosporidium*, the micro-organism responsible for the parasitic disease cryptosporidiosis, and *Giardia lamblia,* the micro-organism responsible for the parasitic disease giardiasis, or beaver fever. Data on parasites have not been collected on Wabamun Lake as part of Alberta Environment and Sustainable Resource's ongoing water quality monitoring program or as part of any other sampling program.

## 5.5 Metals

Metals and metalloids include a wide range of parameters in surface waters, ranging from compounds that are required as micronutrients which may or may not be detrimental at high concentrations (e.g. copper, selenium) to those which are not required for aquatic life at any concentration and which may be extremely toxic (e.g. mercury, lead, arsenic). Many metals and metalloids have both naturally occurring and anthropogenic sources.

Several activities on Wabamun Lake are thought to contribute to the presence of metals in the lake water. These activities include coal mining, diversions from the mine and ash lagoons, agriculture, transportation of mined materials, and construction. The levels of metals present in the lake do not appear to have caused any detectable change in the aquatic community and are not cause for concern in terms of recreational use (Schindler et al. 2004).

Alberta Environment and Sustainable Resource Development have analyzed lake water samples for the presence of metals from 1999 to 2012. Table 6 displays the average, maximum and minimum concentrations of metals taken from profile sites from both the East and West basin of the lake. Discrete depth samples were taken, one near the surface of the lake and one near the bottom of the lake for the purpose of metals analysis. None of the metals sampled exceeded their respective guidelines and the average concentrations were well below guidelines (AESRD 2013a).

**Table 6: Average, minimum and maximum metals concentrations for Wabamun Lake profile sites (1999-2012). Data from Alberta Sustainable Resource Development (2013a).**

| Metal | Guideline (µg/L) | Average (µg/L) | Maximum (µg/L) | Minimum (µg/L) |
|---|---|---|---|---|
| Aluminum | 100[1] | 16.95 | 84.70 | 2.9 |
| Antimony | 6[5] | 0.21 | 0.28 | 0.15 |
| Arsenic | 5[1] | 2.98 | 3.89 | 2.08 |
| Barium | 1000[5] | 132.7 | 171.00 | 110 |
| Beryllium | 100[4] | 0.04 | 1.00 | BDL |
| Bismuth | | 0 | 0.03 | BDL |
| Boron | 5000[5] | 945.8 | 1106.0 | 754 |
| Cadmium | 0.047[3] | 0.01 | 0.04 | BDL |
| Chromium | 8.9[1] | 0.36 | 0.55 | 0.134 |
| Cobalt | 50[4] | 0.03 | 0.06 | BDL |
| Copper | 7[2] | 0.88 | 7.0 | BDL |
| Iron | 300[1] | 9.28 | 31.0 | 2.1 |
| Lead | 4[3] | 0.09 | 1.05 | 0 |
| Lithium | 2500[4] | 39.62 | 48.7 | 32 |
| Magnesium | | 23.20 | 23.5 | 22.9 |
| Manganese | 200[4] | 63.78 | 543.0 | 2.44 |
| Mercury | 0.013[2] | 0.00118 | 0.0122 | BDL |
| Molybdenum | 73[1] | 5.5 | 10.2 | 3.91 |
| Nickel | 110[3] | 0.11 | 0.50 | BDL |
| Selenium | 1[1] | 0.22 | 1.0 | BDL |
| Silver | 0.1[1] | 0 | 0.06 | BDL |
| Strontium | | 353.13 | 572.0 | 262 |
| Thallium | 0.08[1] | 0.01 | 0.04 | BDL |
| Tin | | 0.77 | 46.40 | BDL |
| Titanium | | 0.87 | 2.10 | BDL |
| Uranium | 100[2] | 0.54 | 0.75 | 0.376 |
| Vanadium | 100[4] | 1.08 | 1.74 | 0.21 |
| Zinc | 30[1] | 2.36 | 8.89 | BDL |

Below Detection Limit (BDL)
[1] CCME Canadian Water Quality for the Protection of Aquatic Life
[2] Alberta Surface Water Quality Guidelines for Aquatic Life
[3] CCME/ASWQG FAL based on an average hardness of 150
[4] CCME Water Quality Guidelines for Agricultural Uses (Irrigation Water)
[5] Canadian Drinking Water Quality Guidelines

### 5.5.1 Metals in Sediments

Several surveys have been conducted on Wabamun Lake that examine the concentrations and sources of heavy metals present in lake sediment. In 2003, Alberta Environment and Sustainable Resource Development (AESRD) conducted a large-scale sediment survey of Wabamun Lake and eight nearby reference lakes (Pigeon, St. Anne, Isle, Wizard, Gull, Sylvan, Bonnie and Amisk). Wabamun Lake was sampled in a 1 km by 1 km grid pattern and in transects along the shoreline. It was found that Wabamun Lake had higher concentrations of Mercury, Cadmium, Copper, Arsenic, Zinc and Antimony compared to the eight other reference lakes. However, concentrations of Chromium, Lead, Thallium, Strontium and Tin were similar. Sediments samples collected near the TransAlta ash lagoon discharge had concentrations of Chromium, Arsenic and Cadmium that exceeded the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Sediment characteristics were thought to account for the variable concentrations of metals found across the lake. Concentrations were highest in the west basin where the sediment is fine and rich in organic materials (Anderson 2003).

Enrichment of metals such as Arsenic, Selenium, Cadmium, Mercury, Antimony, Thallium, and Tin has been attributed to the burning of coal by many studies (Cheam et al. 2000, Pacyna and Pacyna 2001). However, other studies conducted on Wabamun Lake suggest that coal burning may not be entirely responsible for the metal enrichment. Donahue (2002) conducted a paleolimnological study of sediment cores taken from Wabamun Lake. He found that concentrations of Mercury, Copper, Lead, Selenium, and Zinc had been increasing since the 1950's before the opening of Wabamun Power Plant, suggesting that atmospheric deposition also plays a role in the increasing sediment metal concentrations.

### 5.5.2 Mercury

In North America mercury released as a result of anthropogenic activities has recently become a great concern due to the perceived potential health risks. Mercury is vaporized in the combustion process of coal-fired power plants and release into the atmosphere as a gaseous element that can be carried a considerable distance. Upon entering an aquatic system, mercury can be methylated by sulfate-reducing bacteria to methyl mercury. Methyl mercury is biomagnified (increased in concentration) in the aquatic food chain and can cause health problems for both humans and fish-eating mammals. High mercury concentrations are the listed as the number one reason for fish consumption advisories in the United States, and can also pose a concern in Canada (Schindler et al. 2004). A fish consumption advisory is in place for Wabamun Lake for women and children consuming Northern Pike, due to the levels of mercury present in the fish tissue. Women are to limit consumption to 3 servings per week and children to 1 – 0.5 servings depending on their age (Alberta Government 2012a).

At this time, mercury deposition in pristine areas of North America is about 2-3 times greater than that of the mid-19$^{th}$ century. This is believed to be a result of long-range transport of gaseous mercury released from anthropogenic sources, like coal-fired power plants. Many lakes that have no local source of mercury production are thought to be affected by this globally transported mercury (Schindler et al. 2004). Data collected from a sediment core suggests that mercury levels in Wabamun Lake began to increase at the installation of the first coal burning power plant (Figure 14, Donahue et al. 2006).

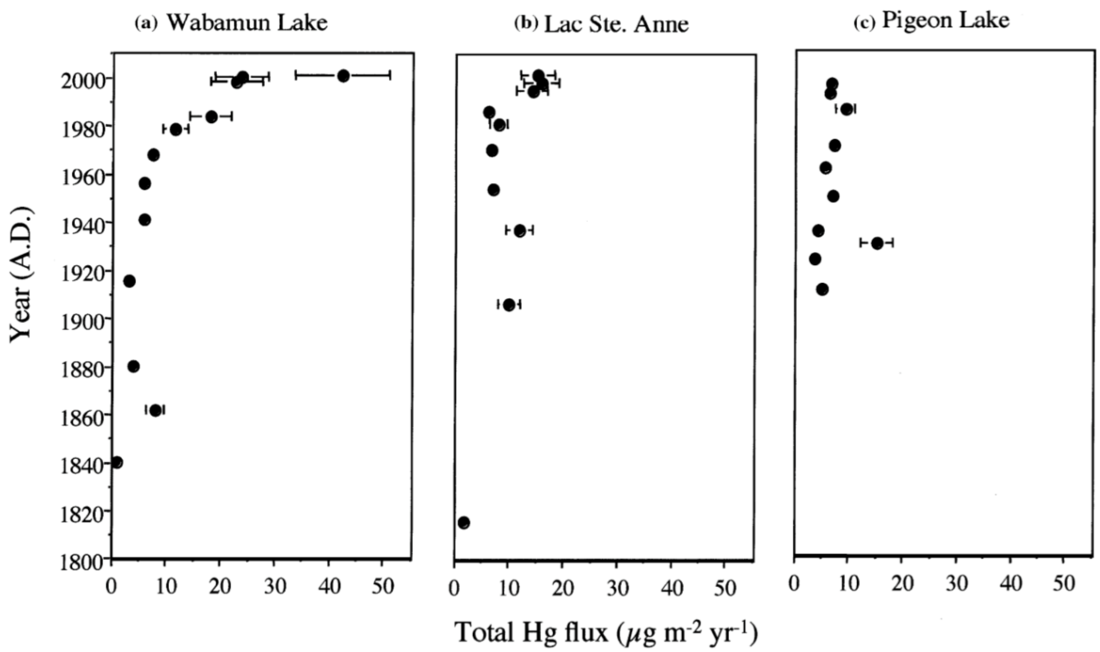


**Figure 14:** Total mercury flux per year from 1800 to 2000 for Wabamun, Lac St. Anne and Pigeon Lake. This figure was taken from Donahue et al. 2006.

Total mercury flux to the sediments in Wabamun Lake has increased six fold since the 1950's. This is compared a 2 fold increase in Pigeon Lake and 1.5 fold increase in Lac St. Anne. The amount of mercury accumulated in the sediments of Wabamun Lake each year is also greater than in Lac St. Anne and Pigeon Lake. The current yearly mercury deposition to Wabamun Lake is 21-32 $\mu g/m^2/yr$, compared to 10-15 $\mu g/m^2/yr$ for Lac St. Anne 20 km to the North. Adapting and developing better pollution abatement technology is the only way to compensate for the increasing power generating capacity from the coal-burning industry in Alberta (Donahue et al. 2006).

TransAlta has installed mercury abatement technology at each of its coal-fired generating units near Lake Wabamun, starting with a pilot project at Sundance Unit 5 in 2006. This technology removes on average up to 75% - 80% per cent of mercury emissions from TransAlta's coal-fired power plants, which exceeds the Alberta government's regulatory requirements of reducing emissions by 70% (Leriger, TransAlta, personal communication).

## 5.6 Organic Contaminants and Pollution

As a result of the industrial activity in the watershed organic contaminants have become a concern for lake residents and lake users. While we can determine the presence and absence of these substances, little is known about the long-term effect on the aquatic ecosystem.

### 5.6.1 Disinfection by-products

Chlorination and ozonation are two treatment processes used in the Wabamun Lake Water Treatment Plant. Both of these processes are known to produce disinfection by-products (DBPs), which include a wide range of chemicals such as chloroform, chlorinated phenols and aldehydes (Alberta Environment 2002). Although disinfection by-products are not a concern to human health, there is little known about the toxicity to aquatic life (Schindler et al. 2004).

Alberta Environment conducted a study from July 2002 to March 2003 in order to determine the disinfection by-products present in the Wabamun Lake Water Treatment Plant and in Wabamun Lake. Concentrations of disinfection by-products were highest in the receiving canal of the treatment plant and lowest in the open water of the lake. Aldehydes were the most commonly found DBP outside of the receiving canal; however, these compounds can also be a result of natural processes, such as forest fires. With the exception of chloroform concentrations, all levels of DBPs were below existing toxicity guidelines. Chloroform concentrations in the receiving canal and two of the lake samples near the receiving canal were close to or greater than the CCME Guidelines for the Protection of Aquatic Life (Casey 2003).

Chloroform is formed as a by-product of the water treatment process through a reaction of chlorine with organic material. This reaction is poorly understood and thought to be influenced by organic precursor concentration, chlorine dose, contact time, water pH, water temperature, and bromide ion concentration. Levels of chloroform are typically higher in chlorinated water originating from surface water compared to groundwater. This is due to higher amounts of organic matter in surface water compared to groundwater (Health Canada 2009).

### 5.6.2 PAHs

Polycyclic aromatic hydrocarbons (PAHs) are atmospheric pollutants that occur in oil, coal, and tar deposits and are a by-product of fuel burning. There are numerous sources for the PAHs in Wabamun Lake including coal mining, coal burning, leaching from coal seams, fuel consumption, and runoff from creosote treated wood from wood structures and railways around the lake (Schindler et al. 2004).

Historical increases in PAHs to remote lakes have been widely attributed to regional and global increases in fossil fuel emissions. PAHs are predominantly emitted from coal burning power plants in the vapor phase and thus are widely dispersed. In a 2006 study, 21 different PAHs were detected in Wabamun Lake, 19 in Lac St. Anne and 10 in Pigeon Lake. Although the compounds detected were similar, the total overall flux into the sediments was much higher in Wabamun Lake. Total fluxes were estimated at 730-1100 $\mu g/m^2/yr$ for Wabamun Lake, 290-420 $\mu g/m^2/yr$ at Lac St. Anne and 140-240 $\mu g/m^2/yr$ at Pigeon Lake (Donahue et al. 2006).

PAHs do not bioaccumulate or biomagnify in food chains like some other contaminants, and the PAHs detected in Wabamun Lake do not pose a threat to human health at this time. There is still little known about the secondary and interactive effects of PAHs on aquatic life and more research needs to be conducted to determine these effects (Schindler et al. 2004).

### 5.6.3 Thermal Pollution

The effects of thermal pollution have been a topic of discussion for Wabamun Lake since the Wabamun Power Plant was first constructed. At that time, water used by the power plant was discharged directly into Wabamun Lake. Without having the time to rest in a cooling pond, the discharge water was much warmer than that of the lake. This resulted in the lake remaining open near the effluent outlet throughout the entire year. With the decommissioning of the Wabamun Power Plant, the lake now completely freezes over during the winter. This may have both positive and negative effects on the aquatic plants and animals of Wabamun Lake.

The complete freezing of the lake will likely have a negative impact on the old growth reed beds that the Wabamun Lake Western Grebe colony depends on. When the ice completely freezes and begins to thaw from the inside out, an ice pan forms, which can move freely at the surface and sever off the reed stems. As a result, new reeds have to grow each year. When the lake remained open, this ice pan effect was absent, resulting in old growth reed beds that provide excellent habitat for the Western Grebe (Hugh Wollis, AESRD, personal communication).

### 5.6.4 Train Derailment

On Wednesday August 3, 2005, 46 Canadian National Railway (CN) cars derailed 7.5 km west of the Village of Wabamun. This resulted in the release of 712,500 L of Bunker 'C' oil and 88,000 L of Pole-Treating Oil. Bunker 'C' oil is the residue remaining from crude oil after the light oils, gasoline, naphtha, fuel oil #l, and fuel oil #2 have been fractioned off. The Bunker 'C' oil that remains after this separation is predominantly comprised of heavy hydrocarbons. Pole-Treating Oil is used in wood treating chemicals. It is estimated that 149,000 L of Bunker 'C' oil and only trace amounts of Pole-Treating Oil entered Wabamun Lake (Golder Associates 2006). The oil spread rapidly over the eastern and southeastern portion of the lake, strong westerly winds later in the week helped push the oil back against the shore (Anderson 2006). Unfortunately, another large storm did push the containment booms with the oil they accumulated back out into the lake, allowing some of the oil to accumulate or sink into the open water (Hugh Wollis, AESRD, personal communication). Various measures were used to remove the oil from the surface of the lake and along the shorelines.

Monitoring of water quality was conducted by Alberta Environment, focusing on the deep-water zone, from the time of the spill and into late September. Overall water and sediments in the open water area of the lake were not contaminated with spilled hydrocarbons. There also was no evidence of post-spill increase in water or sediment metal concentrations (Anderson 2006).

Assessments during the spill found that over 50% of the shoreline around the perimeter of the lake was oiled. Of the total 32,688 m of shoreline, 18,677 m was heavily oiled consisting mostly of bulrush/reed beds. The amount of oil on the reeds depended on the density of the reed beds and the height of the waves when oil was present. A multi-agency team of Environment Canada, Alberta Environment, Alberta Sustainable Resource Development, and the Environmental Section of CN decided on shoreline clean-up methods and priorities. Three main clean up treatment techniques were used, manual removal, vegetation removal and natural recovery. The majority of the reed beds were cut, sediment shorelines were manually cleaned and lightly oiled areas were left to naturally recover (Sergy et al. 2009). Recovery of the oiled bulrush/reed beds was examined in the summers of 2006 and 2007. This study concluded that exposure to oil during the late growing season did not cause large scale damage to the overall health and growth of the reed beds (Wernick et al. 2009).

Golder Associates was hired by CN to design and conduct a monitoring program to assess the environmental effects of the spill. The goals of this program were to assess the potential effects of the spill on aquatic plants, animals and sediments of the lake. To do this, Golder established a weight of evidence framework to determine the long term effects to algae, macrophytes, zooplankton, benthic invertebrates, and fish. For each of these categories the weight of evidence framework considered exposure concentrations, lab effects and field effects (Golder Associates 2006).

The weight of evidence framework for algae considered water chemistry, lab toxicity of similar species and phytoplankton community structure of the lake. Experimental tests revealed that water collected from the spill site caused a decline in algae growth compared to three reference stations. No changes in the phytoplankton community were observed after the spill compared to historic data for Wabamun Lake (Golder Associates 2006).

Water chemistry, toxicity testing with native species and assessment of post spill growth were included in the weight of evidence framework for macrophytes. Experimental studies were conducted on the growth of duckweed (*Lemna minor*) the lab using water collected from the spill location. Experimental results showed that duckweed growth was not significantly reduced, although some reduction in frond production was observed (Golder Associates 2006).

The weight of evidence framework assessment conducted for zooplankton included toxicity of daphnia and ceriodaphina, surface water toxicity and zooplankton species taxonomy before and after the spill. Some of the oil related chemical parameters were detected in the water samples collected; however, all results were below the water quality guidelines. Experimental tests showed that survival of daphnia was 100% in spill water, suggesting that hydrocarbon concentrations were not lethal to zooplankton. Post spill zooplankton data was collected and compared to historical data for Wabamun Lake and showed no changes in community composition (Golder Associates 2006).

For assessment of the benthic community, 19 transects were established at three depths over a wide range of contaminated sites across the lake. The highest concentrations of spill related PAHs were measured at sites immediately adjacent to the spill site. However, examination of these sites after the spill showed no changes in community structure. Lab toxicity experiments showed that at least one or more organisms collected from the spill site were significantly affected by toxicity (Golder Associates 2006).

The fish component of this study was the most in depth and considered contaminant concentrations in the water and those biologically available for accumulation by fish (adults and eggs). It also examined the concentration of contaminants accumulated in fish tissue and fish bile, both in the short and long term. Laboratory tests included fish toxicity tests and *in situ* whitefish egg incubation studies using fish from Wabamun Lake. Concentrations of oil-related PAHs in muscle tissue and PAH metabolites in the fish bile indicated that sampled fish were exposed to oil. When the same test was repeated two months after the spill, there were no traces of PAHs found in the fish tissue or bile. Water collected from the spill site on Wabamun Lake caused a reduction in growth of fathead minnows in laboratory experiments. However, this trend was also observed in water collected from reference sites on the lake, indicating that oil was not the only factor causing this observation (Golder Associates 2006). The in-situ study of Lake Whitefish egg incubation found that some deformities did occur in white fish eggs as a result of oil spill related PAHs at sites that had high levels of contamination (Debruyn et al. 2007). However, there was no indication if this exposure would lead to any long-term effects.

Overall, results of the weight of evidence framework indicate that effects of the oil were negligible in the open-water portion of the lake, including both near shore and offshore areas. Algae and zooplankton showed little exposure and no evidence of negative effects. Fish populations showed initial exposure to PAHs, but two months later no PAHs were detected in fish tissues. There was some indication of contamination to sediments to the near shore areas of the spill (Golder Associates 2006). Overall the initial spill did not appear to significantly impact the aquatic environment of Wabamun Lake, however long term monitoring will indicate if any long-term changes have occurred.

# Water Quantity

# 6 Water Quantity

Water quantity is important for the maintenance of aquatic habitat, it has functions related to water quality and it is essential for the production of drinking water to meet demands. Irrigation, industry and livestock production are highly dependent on a minimum amount of available water. Sufficient water quantity is necessary for many recreational activities, and in recent years many cottagers and recreational lake users across Alberta have voiced concerns about the decreasing volumes of water seen across the province. Four metrics were used as water quantity indicators in the Wabamun Lake watershed:

- Lake Levels;
- Contributing Areas to Drainage;
- Water Allocations; and
- Groundwater.

Water discharge rates, allocations and minimum flow rates to maintain ecological integrity can reflect socioeconomic growth in a region. Human activities in a region frequently reduce available water quantities required to maintain healthy aquatic ecosystems. It is important to balance socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

## 6.1 Lake Levels

Lake levels provide a convenient measure of the amount of water present in a water body at a given time. Lake levels vary both seasonally and annually with shifts in weather patterns and general climatic trends. Water withdrawals for consumptive uses have increased dramatically in recent years across Alberta, and have resulted in some watersheds within the province being closed to new water license applications. Concerns have been expressed about falling levels at a number of lakes across the province; in general, the majority of lakes that are currently being monitored fall within "Normal" water levels within the Province, but a greater number are below normal levels than above (AESRD 2011).

Figure 15 shows the lake levels for Wabamun Lake over the period of record from 1915 to 2013, as measured by Water Survey of Canada. Over this period, the maximum lake level was recorded in 1927 at 725.17 m and a minimum level was recorded in 2003 at 723.72 m. The maximum level of the weir is set at 724.55 m (Water Survey of Canada 2013).

The lake level at Wabamun Lake was reported to be normal for 2011 and 2012 by Alberta Environment and Sustainable Resource Development (AESRD 2013d). However, the report Water Quality Conditions and Long-Term Trends in Alberta Lakes produced by AESRD (Casey 2011) shows a statistically significant declining trend in lake levels at Wabamun Lake.

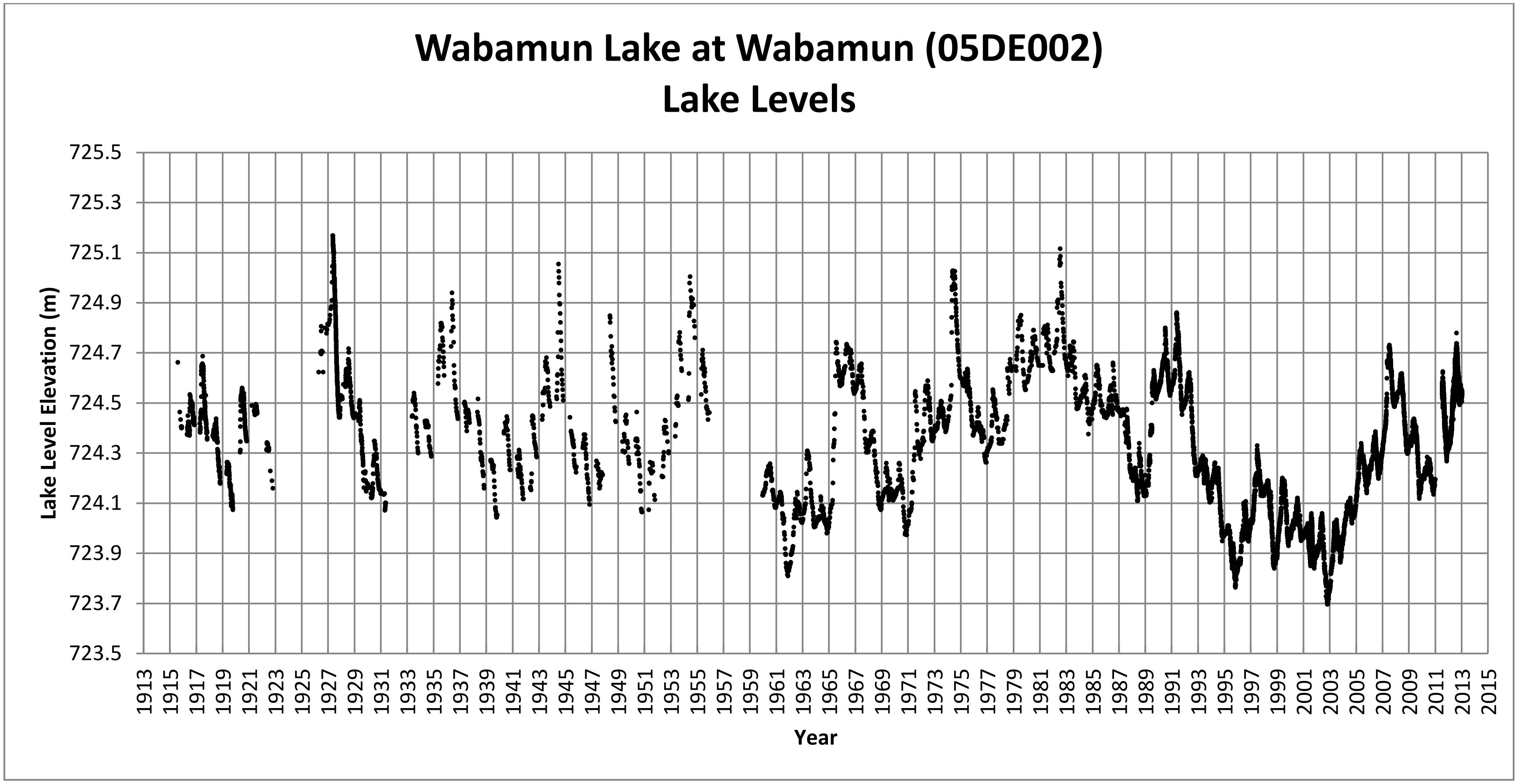


**Figure 15:** Recorded levels of Wabamun Lake from 1915 to 2013. Data from Water Survey of Canada (2013).

### 6.1.1 Weir

The only outflow for Wabamun Lake is controlled by a weir on Wabamun Creek, located at the east end of the lake. Management of the lake level has been an issue of controversy since the early 1900's. There are records of the outlet being altered many times as far back as 1912 to resolve conflicts of various lake interest groups. In 1912, an illegal outlet was dug which by-passed 1.5 km of Wabamun Creek. This activity is believed to be responsible for a large drop in lake level; consequently, in 1927 the illegal outlet was dammed to recover this loss. In 1940, a wooden weir was constructed to control the flow to Wabamun Creek and was replaced by a steel weir in 1960. The weir was vandalized in the early 1980's resulting in a drop in lake level of 0.9 m. In 1988, the outlet was set at a level of 725 m and controlled by a roadbed. In 1997, the level was dropped to 724.55 m and the roadbed was capped with concrete (Schindler et al. 2004 and Glover 1967).

Debate still remains over the natural level of Wabamun Lake. Differences in recording procedures, water withdrawals, and changes to the outlet make the historical level difficult to determine. In 2004, David Schindler and committee observed by helicopter that Wabamun Lake is much lower than it was historically, and it has been for some time.

## 6.2 Contributing Drainage Areas to the Watershed

Contributing drainage areas of the watershed, or effective drainage areas, are those areas, which might be expected to entirely contribute runoff to the mainstream, or lake, and eventually flow out of the watershed. Non-contributing drainage areas are just the opposite, as they do not contribute to the overall drainage of a watershed. These areas are often referred to as a "sink" and include low lying areas such as depressions and wetlands which are not connected by a channel to facilitate drainage. Figure 16 shows the areas that do not contribute to the overall drainage of the Wabamun Lake watershed. These non-contributing areas only make up a small percentage of the total watershed area.

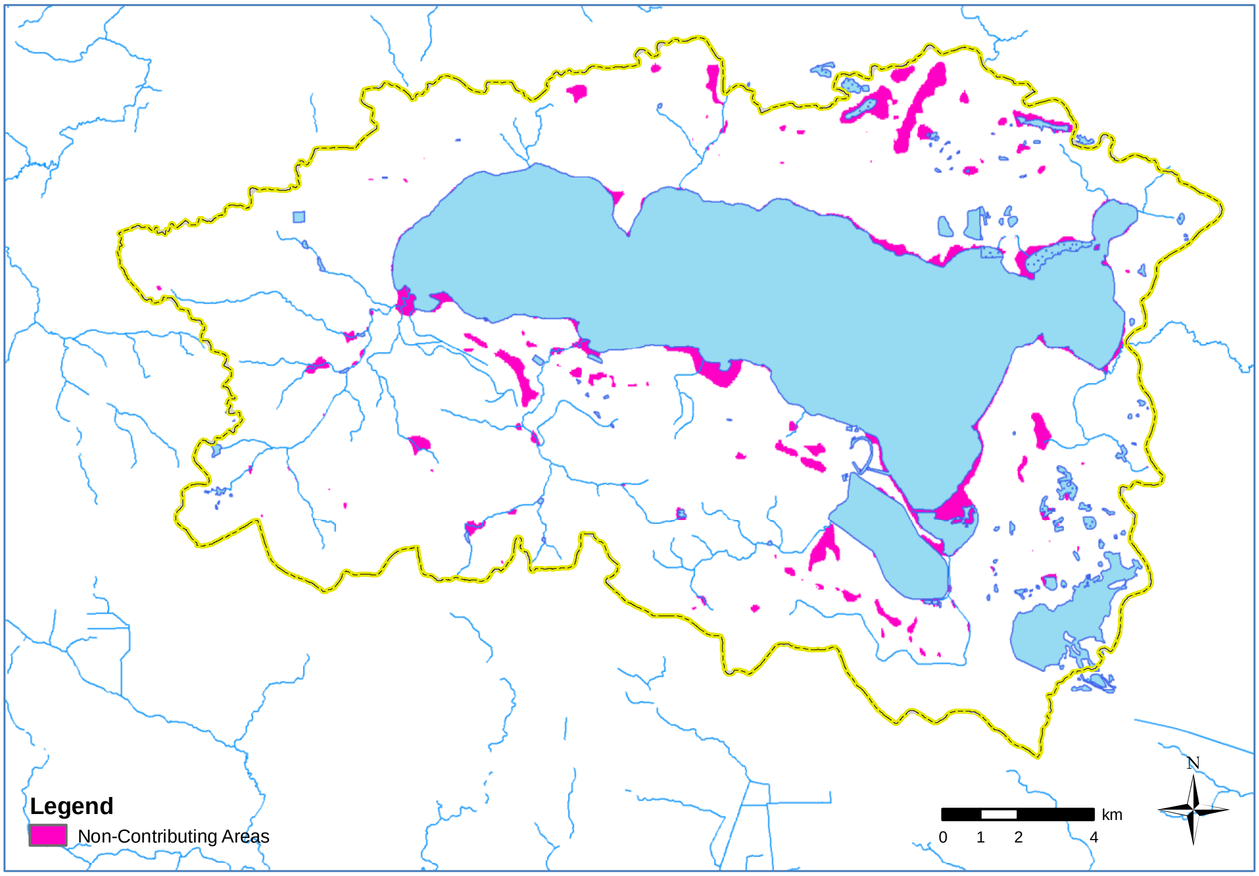


**Figure 16:** Non-contributing areas to drainage for the Wabamun Lake watershed. Data for this map was derived from Natural Resources Canada (2007c).

## 6.3 Water Allocations and Diversions

Water diversions in Alberta are regulated by Alberta Environment and Water under the authority of the *Water Act*. Diversions include both the removal and addition of water from or to a water body, but may also include changes in drainage patters. Under the *Water Act*, traditional agricultural users are not required to have a water license, and can remove up to 6,250 $m^3$ per year from a water body adjoining their property for domestic use and cattle watering. However, from 1999-2002, traditional agricultural users were afforded the opportunity to license these diversions. Without a license, access to these traditional diversions could be lost during droughts, because water supply in based on the principle of "first in time, first in right" for licenses.

### 6.3.1 Surface Water Allocations

Currently, there are a total of 68 surface water licenses within the Wabamun Lake watershed boundary (Figure 17). It is important to note that license locations are recorded at the center of the owner's property, not at the exact location of the diversion. As a result, there may be some licenses that are misleadingly included or excluded from the overall surface water allocations data. The majority of licenses fall under the registry category, which is for licensing traditional agricultural water uses. There are six (6) licenses for flood control, two (2) for industrial cooling purposes, and one (1) for each of stock watering, lake stabilization, and golf course watering. There are also three (3) licenses which fall under the other category, which are used for commercial purposes. At this time these 68 licenses have total maximum annual diversion of 730,587,311 $m^3$. This number represents the maximum amount of water that may be diverted based on the current licenses. However, this may be much different from the total amount of water actually consumed. There are no requirements for licensees to report water consumption, which makes it difficult to determine the actual volume of water used.

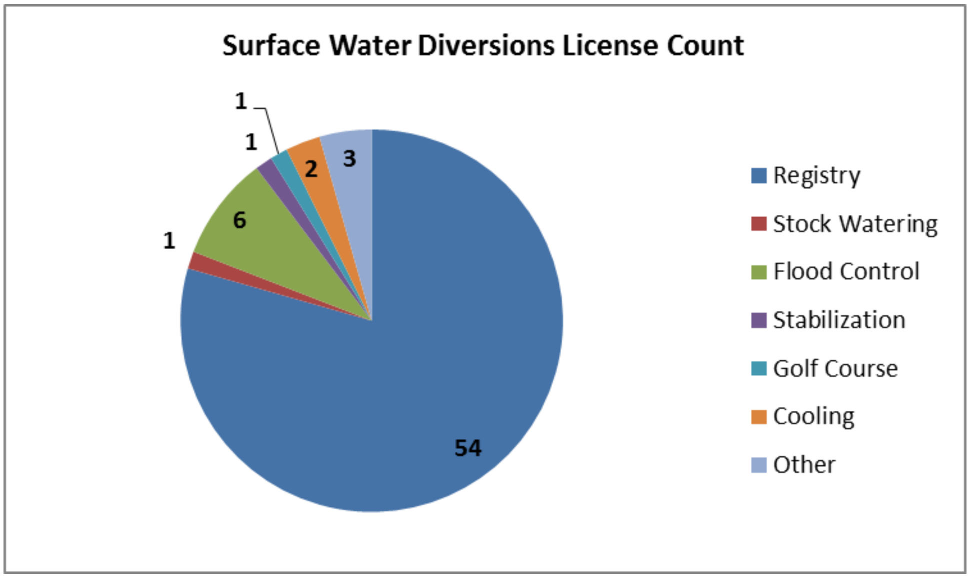


**Figure 17:** Number of surface water licenses in the Wabamun Lake watershed. Data from AESRD (2013c).

Of the maximum diversion volume, 99.7% is allocated to the three cooling licenses held by TransAlta Corporation (Figure 18). These three licenses also require a return flow, meaning that the volume of water diverted must equal the volume of water returned to the system, in this case to Wabamun Lake. All of the other licenses within the watershed boundary do not have return flow requirements, as such; the volume of water consumed is expected to be lost from the system. The maximum consumptive loss that could possibly be incurred with the Wabamun Lake watershed is 2,192,311 $m^3$ (Figure 19).

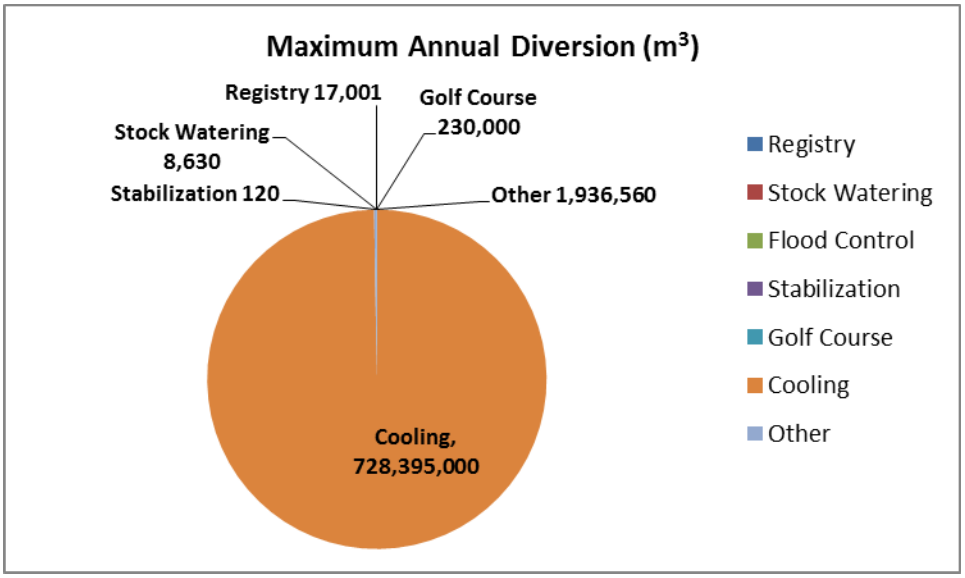


**Figure 18:** Maximum annual surface water diversions by license type in the Wabamun Lake watershed. Data from AESRD (2013c).

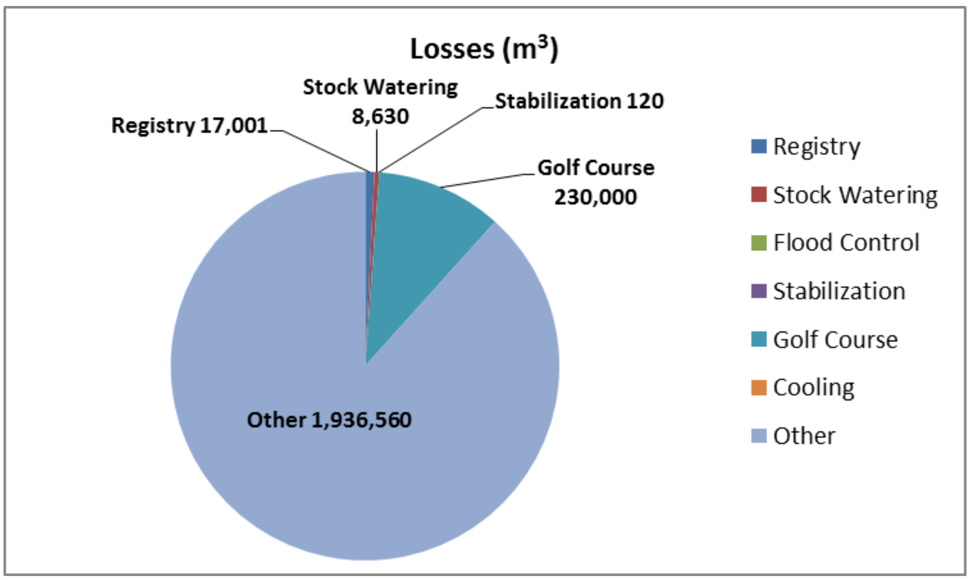


**Figure 19:** Maximum consumptive surfacewater losses in the Wabamun Lake watershed. Data provided by AESRD (2013c).

TransAlta diverts water from the North Saskatchewan River into the Sundance cooling pond, where it is treated and returned back into Wabamun Lake or used in the Sundance power plant (TransAlta 2013a). At peak production, the water treatment plant can contribute up to 20% of all the water diverted into the lake annually (Seneka 2002). Figure 20 shows the volume of water produced by the Wabamun Water Treatment Plant for year from 2002-2011.

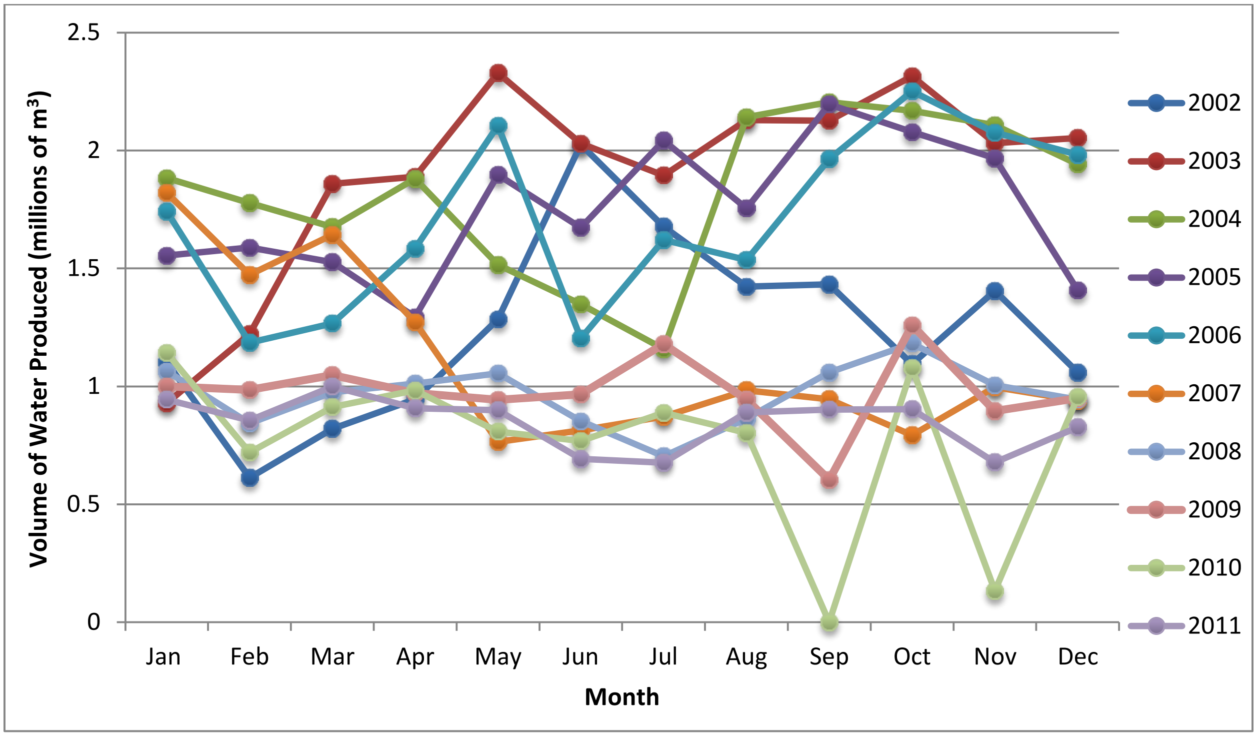


**Figure 20:** Volume of water, in millions of $m^3$, produced by the Wabamun Lake Water Treatment Plant from 2002 to 2011 (Adapted from TransAlta 2013).

### 6.3.2 Groundwater Allocations

Currently, there are a total of 61 groundwater diversion licenses within the Wabamun Lake watershed boundary (Figure 21). Similar to the locations of the surface water diversions, ground water licenses are recorded at the center of the licensee's property rather than the exact well location. As a result, there may be some wells that are misleadingly included or excluded from the overall groundwater allocations data. The total maximum annual diversion from all of these groundwater licenses is 303,876 $m^3$. The majority of licenses fall under the categories of registry (39) and stock watering (12), with the remaining licenses for recreation (4), urban (3), golf course (2) and drainage (1). Maximum diversion volumes are allocated to urban licenses held by the Village of Wabamun, with similar volumes allocated to registry, stock watering and drainage. The maximum volume of groundwater that can possibly be diverted under these licenses is 303, 876 $m^3$ (Figure 22).

All categories, except drainage, have no requirement for return flow; therefore, all diverted water is expected to be lost from the system. However, the licenses in the remaining categories do not necessarily use all of their allocated volume, and no reporting requirements for actual consumed water volumes is required for these particular licenses. Therefore, these numbers likely overestimate the consumption of groundwater in the vicinity of the Wabamun Lake watershed.

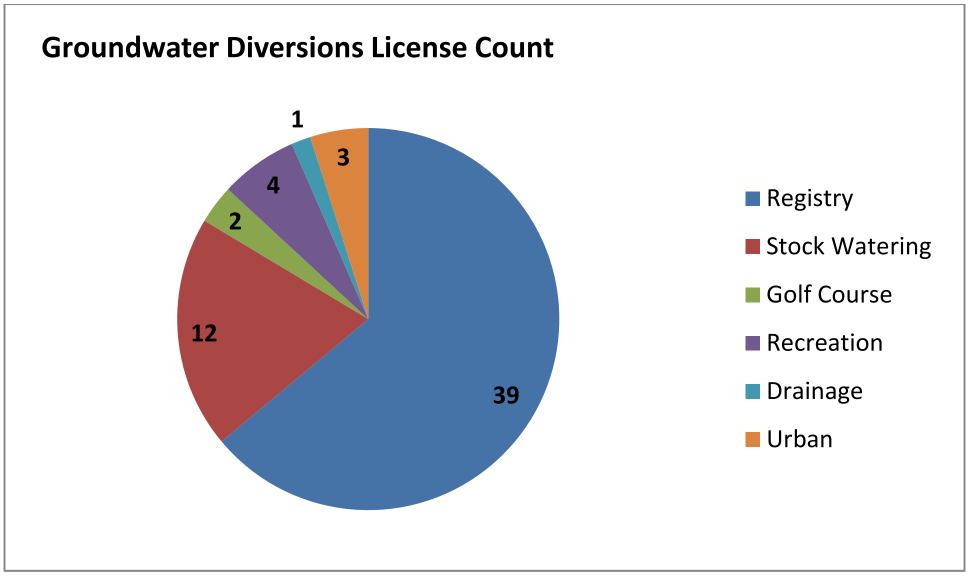


**Figure 21:** Number of current groundwater diversion licenses within the Wabamun Lake watershed. Data provided by AESRD (2013c).

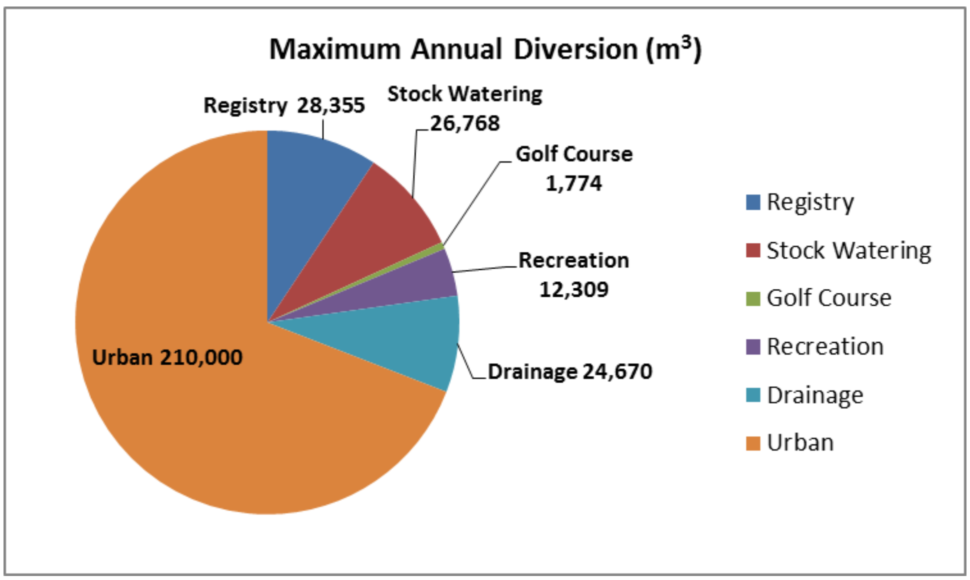


**Figure 22:** Maximum annual groundwater diversions in the Wabamun Lake watershed. Data provided by AESRD (2013c).

## 6.4 Groundwater Risk

Groundwater quality risk has been assessed for the agricultural areas, or white zone, of Alberta. Since the Wabamun Lake is located in the White Zone of Alberta, this data is available for the watershed. The quality of groundwater can be influenced by numerous activities on the landscape including agriculture. Agricultural activities such as livestock production, crop production and agrochemical use can have an impact on the groundwater.

To assess groundwater quality risk, the aquifer vulnerability, aridity and agricultural intensity were specifically considered and then a ranking was established. A ranking of 0 is no risk, whereas, 1 is considered to be a very high risk of groundwater contamination. The Wabamun Lake watershed falls into the low risk end of the spectrum for groundwater risk according to Alberta Agriculture Land resources (Figure 23).

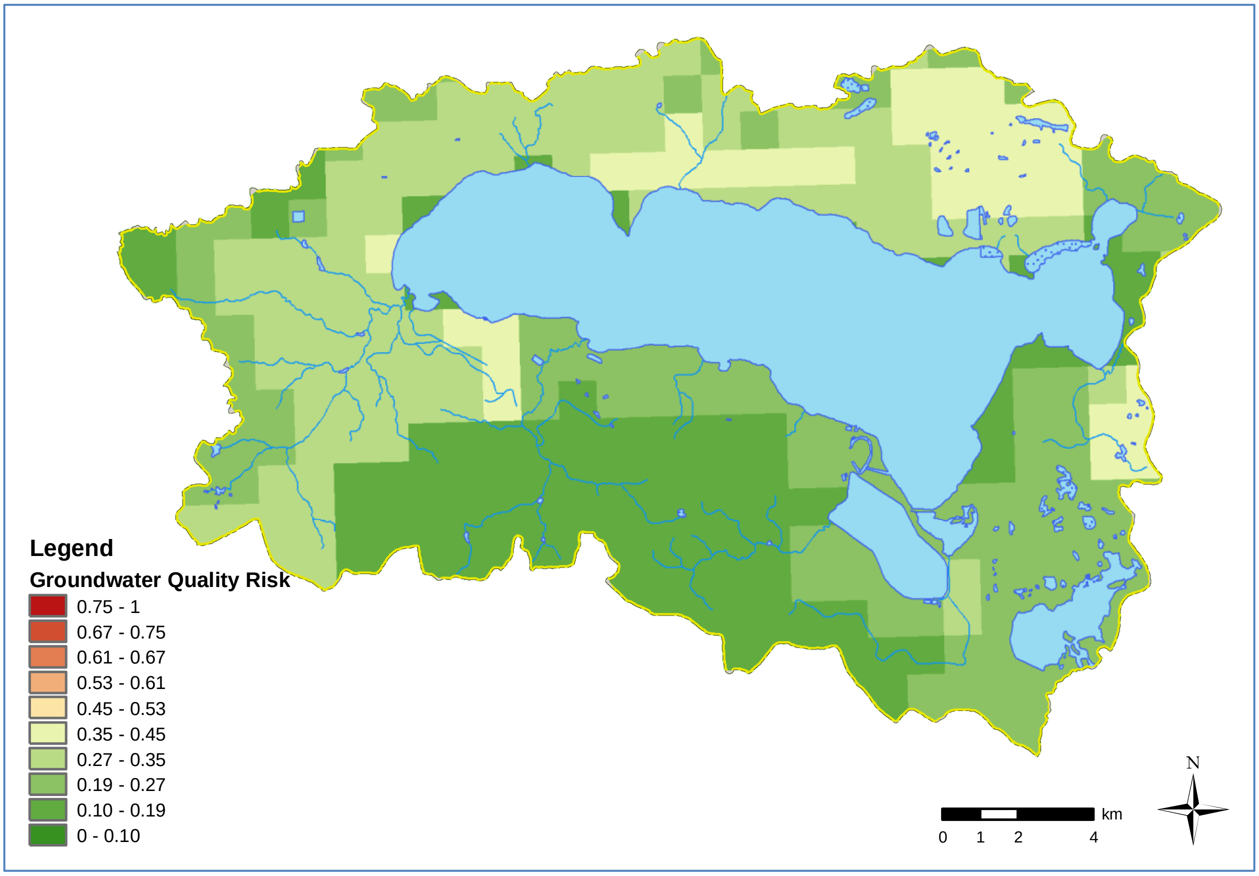


**Figure 23:** Risk to groundwater quality in the Wabamun Lake watershed. Risk is ranked from 0 (no risk) to 1 (high risk) Data from Alberta Agriculture and Rural Development (2005).

Water well density can indicate the total licensed and unlicensed water use, and the potential impacts on the groundwater resource. Areas with high levels of both active and abandoned wells are thought to be at greater risk for groundwater contamination. Approximately 90% of rural Albertans get their water supply from groundwater wells. While there are no requirements for recording individual volume used for these wells, the overall number on the landscape can indicate the overall pressure on the groundwater resource.

There are 3,106 wells located within the Wabamun Lake watershed resulting in a density of 8.0 wells/km$^2$ (Figure 24). Wells are reported from the center of the landowner's property and the locations are often misreported, resulting in well locations mapped within the body of the lake.

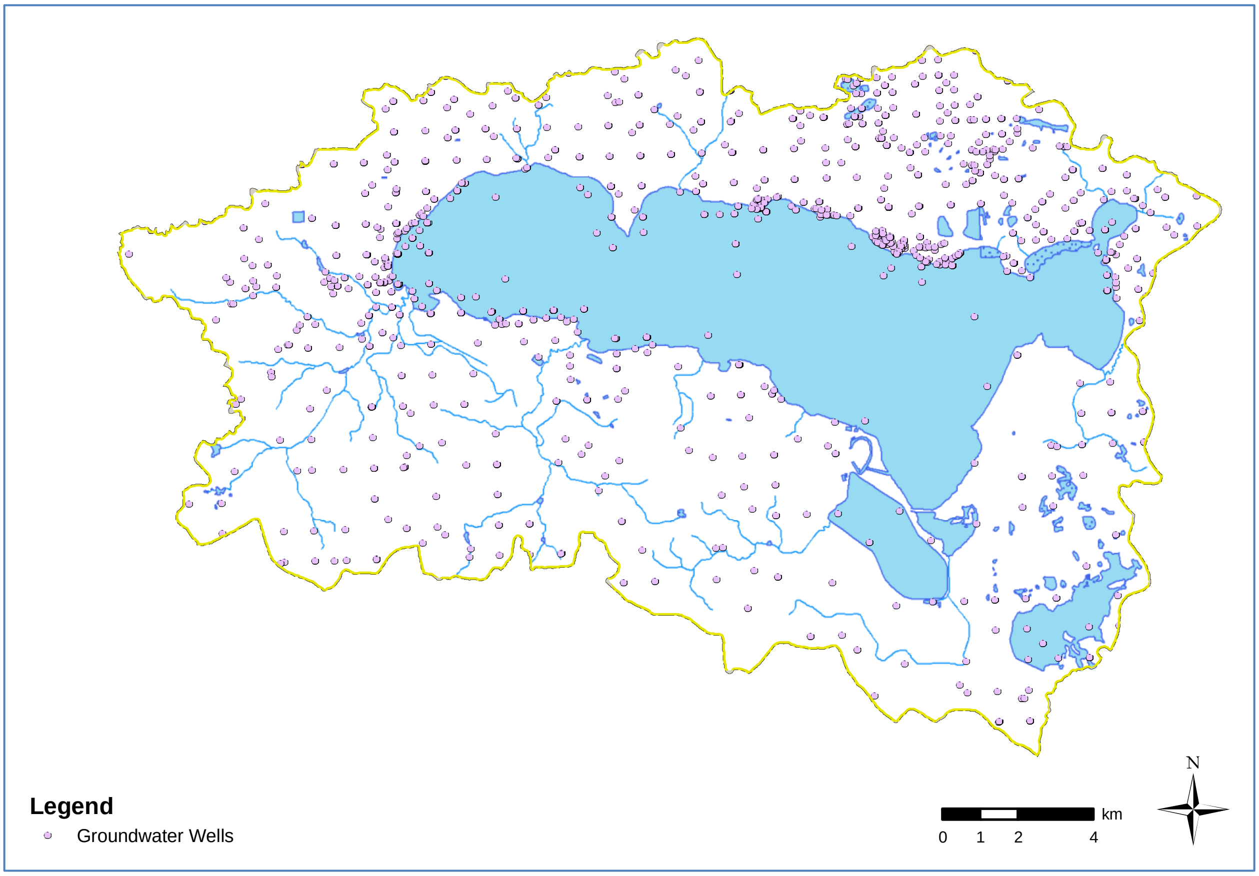


**Figure 24:** Locations of groundwater wells within the Wabamun Lake watershed. Data from Alberta Environment and Sustainable Resource Development (2013d).

# Biological Community

# 7 Biological Community

The biological community has data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of such data can be linked to water quality, quantity and ultimately to overall health of the Wabamun Lake watershed. Six metrics were used as biological indicators in the Wabamun Lake watershed:

- Land Cover;
- Wildlife Biodiversity;
- Fish;
- Species at Risk;
- Invasive Species; and
- Benthic Invertebrates and Zooplankton.

Changes in biological populations often reflect socioeconomic growth in a region. Human settlement and the subsequent exploration and extraction of natural resources alters the landscape and with it the habitat of the indigenous flora and fauna. It is important to balance socioeconomic growth with the preservation of natural habitat integrity to ensure the long-term health of natural biological populations.

## 7.1 Land Cover

Land cover is the type of vegetation, or lack thereof, covering the landscape. Inventory of vegetation populations may show increases or declines through introductions or changes in environmental conditions. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show areas of concern with their presence. Changes in land cover can indicate a change in land use and identify areas that need restoration, are at risk of erosion and/or areas with rare plant species that need protection. Land cover is a separate measurement from land use, even though these two terms are sometimes used interchangeably.

Based on the available land cover data, the Wabamun Lake watershed is covered primarily by agriculture, forest and grasslands (Table 7). It is important to note that a large portion of the grassland cover type on the north shore of the lake is actually the Highvale Mine site and therefore should be considered developed or barren land (Figure 25). Agricultural and forested lands cover 23.3 and 23.2 percent of the watershed respectively. The forested areas are almost entirely broadleaf, which is typical of the Dry Mixedwood Subregion of the Boreal Forest Natural Region of Alberta.

**Table 7: Summary of land cover types in the Wabamun Lake watershed (Alberta Biodiversity Monitoring Institute 2012)**

| Land Cover Type | Area ($km^2$) | % Land Cover |
|---|---|---|
| **Water** | 97.7 | 27.9 |
| **Developed** | 30.8 | 8.8 |
| **Shrubland** | 12.0 | 3.4 |
| **Grassland** | 47.3 | 13.5 |
| **Agriculture** | 81.6 | 23.3 |
| **Forest - Coniferous** | 4.1 | 1.2 |
| **Forest - Broadleaf** | 76.1 | 21.7 |
| **Forest - Mixed** | 1.0 | 0.3 |

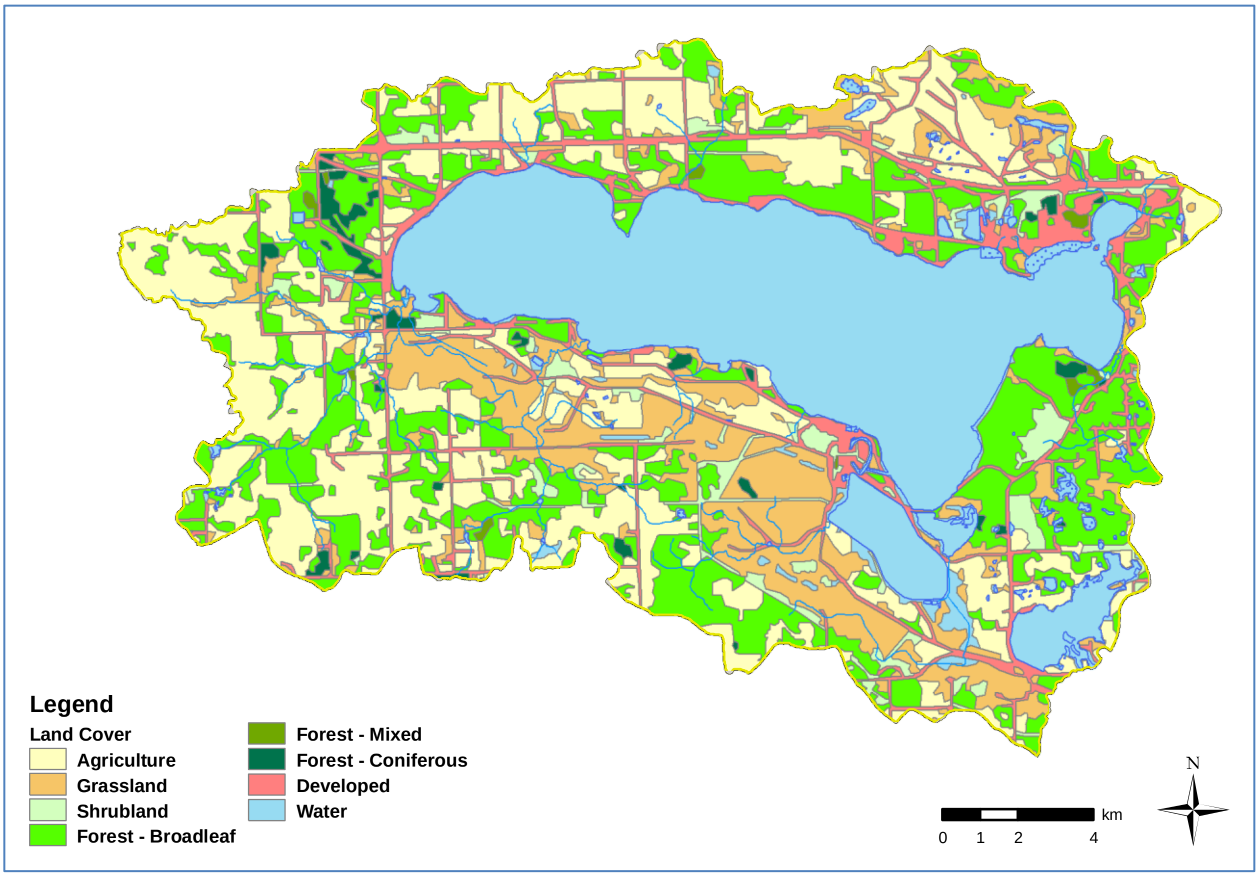


**Figure 25:** Distribution of land cover in the Wabamun Lake watershed (Alberta Biodiversity Monitoring Institute 2012).

## 7.2 Wildlife Biodiversity

Wildlife inventories to determine the biodiversity within the watershed can indicate changes in environmental conditions; such as, habitat fragmentation, loss of nesting and breeding sites, and nutrient enrichment. A loss of biodiversity can cause an ecosystem to become less stable and more vulnerable to environmental change. A change in diversity may also affect nutrient cycling and/or energy flow through the ecosystem.

The Alberta Biodiversity Monitoring Institute (ABMI) maintains a network of monitoring stations across the province to provide information about biodiversity. Unfortunately, none of the current AMBI stations lie within the boundaries of the Wabamun Lake watershed. The closest monitoring locations are to the Southwest of Wabamun Lake, near the town of Drayton Valley.

### 7.2.1 Grebe Colony

The Western Grebe (*Aechmophorus occidentalis*) is North America's largest grebe, nesting in colonies from a few to thousands of individuals. This bird is a migratory species, breeding in central and western North America and overwintering along the Pacific coast from Alaska to New Mexico. Grebes feed almost exclusively on fish, thus selecting only fish bearing lakes for nesting. The Western Grebe can be identified by a long curved neck, contrasting black and white coloring, a long sharp bill and red eyes (Fisher and Acorn 1998).

Alberta's Endangered Species Conservation Committee lists the Western Grebe as a species of special concern for the province. There are three lakes within the Stony Plain region that have Western Grebe colonies, Wabamun Lake, Lac St Anne and Lake Isle (Yanch 2006). Of the three lakes, the colony at Wabamun is the largest and is considered a regionally important population.

Western Grebes have overwintered on Wabamun Lake since the 1960's, coinciding with the construction of the Wabamun power plant, which returned warm effluent to the lake keeping the ice open. Currently, there is one grebe colony on Wabamun Lake, located on the north shore of the lake near the Village of Wabamun. Most recently in 2009, the grebe population on Wabamun Lake was estimated to be 340 adults. The maximum colony size was recorded in 2002 at 1,510 adults. This decline in population size is thought to be due to an increase in lake levels up to 2007, which reduced the density and extent of old growth reed beds, making them less desirable for nesting. In addition, egg predation by crows is thought to be a problem on Wabamun Lake (Wollis and Stratmoen 2010). The oil spill that occurred in 2005 also proved to be problematic for Western Grebes on Wabamun Lake. As a result of the oil spill, 368 birds were killed, which was about 76% of the 2005 colony population. Almost of all the birds that were killed during the spill were adults; surprisingly the population rebounded in the following year to approximately 1,000 individuals (Yanch 2006).

High rates of nest abandonment have been seen at both Wabamun Lake and Lac St Anne, which likely indicates failed nest attempts due to disturbance. This may indicate that these grebe colonies have low reproductive success. As a result, populations would be slow to recover from events such as the 2005 oil spill (Yanch 2006). As described in section 5.6.3 Thermal Pollution, the complete freezing of the lake during the winter could result in changes in the composition of the reed beds that the grebes depend on for nesting. Further monitoring will indicate how these changes will affect the grebe population on Wabamun Lake (Hugh Wollis, AESRD, personal communication).

## 7.3 Fish

Presence or absence of fish, or changes in species abundance, can indicate the overall health of an aquatic environment. Changes in fish populations can be attributed to a species tolerance to particular conditions within a water body. For example, removal of vegetation in a spawning habitat can lead to a decline in fish populations. In this case the fish are intolerant to the condition of the spawning habitat within the lake.

Wabamun Lake has been a popular location for both commercial and sport fishing since the 19$^{th}$

century. Fish species found in the lake include Northern Pike (*Esox Lucius*), Lake Whitefish (*Coregonus clupeaformis*), Walleye (*Sander vitreus*), Yellow Perch (*Perca flavescens*), Burbot (*Lota lota*), Spottial Shiner (*Notropis hudsonius*), Brook Stickleback (*Culaea inconstans*), Iowa Darter (*Etheostoma exile*) and White Sucker (*Catostomus commersonii*) (Mitchell and Prepas 1990). The commercial fishery for Lake Whitefish was historically one of the largest in Alberta based on the numbers of fish caught; however, due to the decline in fish populations, commercial fishing licenses have not been allowed on the lake since 2003 (Schindler et al. 2004). The lake was also a traditional fishing ground for First Nations in the area. Fish caught from fishing expeditions was dried and smoked along the shores of Wabamun Lake.

Periodic fish kills have occurred on Wabamun Lake due to industrial related activities despite TransAlta's best efforts to reduce and eliminate them. Documented industry related mortalities date back to the 1970's, when an unplanned outage at the Sundance Power Plant stopped effluent from entering the lake, causing a fish kill due to cold-shock. An estimated 250 Northern Pike and 250,000 Spottail Shiners were killed. This event resulted in the construction of the Sundance cooling pond and the elimination of effluent water directly entering the lake (Schindler at al. 2004). Fish kills have also occurred due to thermal stress and gas bubble trauma in the Wabamun Power Plant cooling water outlet canal (Golder Associates 1999).

One of the most highly publicized fish kills occurred in 2001-2002, when approximately 3,000 Lake Whitefish, Northern Pike and other species were killed on, or near the inlet screens to the Wabamun Power Plant. An investigative study was conducted by Dr. Gregg Goss from the University of Alberta to determine the cause of these occurrences. It was found that this fish kill was not caused by any levels of heavy metal contamination, but likely a result of environmental and physical habitat conditions. The appearance of Lake Whitefish on the screens coincided with spawning time and a decline in lake water temperature. Whitefish normally spawn in the bays of the Wabamun Lake, however if habitat is not suitable it is natural for fish to begin migrating in search of better habitat. The only outlet from the lake at the time was the inlet canal at the Wabamun Power Plant. It was postulated that the drop in lake temperature also caused a reduction in swimming performance; this combined with the attempted migration, resulted in the fish appearing on the inlet screen exhausted, resulting in a fish kill. Dr. Goss postulated that changes in habitat availability and suitability caused these fish to seek out better habitat for spawning. In addition, a decline in zooplankton abundance was noticed in the lake at this time. A change or reduction in food sources could also have contributed to the decreased swimming performance of fish appearing in the inlet canal (Goss 2002).

Although the current mercury deposition in Wabamun Lake is higher than lakes in the surrounding region, it does not appear to have significantly contaminated the fishery. Golder Associates conducted a study from 1996 to 2001 to examine mercury in fish tissue at Wabamun Lake. Northern Pike were sampled and showed mercury tissue concentrations similar to those of other lakes in the region. The average mercury levels from Wabamun Lake fish were in the middle range for all of Alberta's water bodies. The majority of mercury concentrations in Northern Pike were below the Health Canada Guidelines for occasional consumption. However, some of the sampled Northern Pike did exceed the subsistence guidelines set by Health Canada, which is a concern for people who consume Northern Pike on a regular basis. Lake Whitefish were also sampled as part of this survey and did not exceed any Health Canada Guidelines (Golder Associates 2002).

At this time, a fish consumption advisory is in place for Wabamun Lake for women and children consuming Northern Pike, due to the levels of mercury present in the fish tissue. Women are to limit consumption to 3 servings per week and children to 1 – 0.5 servings depending on their age (Alberta Government 2012a).

Historically Northern Pike populations have shown signs of over exploitation and it has been estimated that 78% of the pike population was harvested yearly. This over harvest has resulted in an unsustainable fishery, where few fish reach reproductive age; which is six years in Northern Pike. Illegal harvest of undersized pike by anglers has also contributed to the declines in population (Schindler et al. 2004). Lake Whitefish have fluctuated between periods of very successful and unsuccessful reproduction. This is thought to be linked to low predation and competition from other fish, resulting in a population which overpopulates and collapses in a series of cycles (Stephen Spencer, AESRD, personal communication).

From December 2004 and March 2005, the Alberta Conservation Association conducted an assessment of the winter sport fishing on Wabamun Lake. During this time an estimated 8,900 anglers visited the lake. Approximately 3,287 Lake Whitefish with a mean weight of 0.94 kg and 3,263 Northern Pike with a mean weight of 2.99 kg were harvested from the lake. It was observed that the majority of anglers targeting pike used two lines, while those targeting whitefish only used one. Results of the study indicated that Northern Pike were in a growth-overfished state and Lake Whitefish were in a recruitment-overfished state. Both of these states do not allow populations to successfully reproduce at a rate that can sustain heavy angling pressures (Park and Patterson 2006).

The sport fishing regulations changed to a year round zero catch limit in 2008, in order to allow fish species to recover to a more appropriate population age structure. As a result of commercial and sport overfishing, and destruction of important habitat, Walleye have become extirpated from the lake and few Northern Pike no longer reach reproductive age. Modifications of the outlet stream, lowering of lake levels, conversion of shorelines to lawns and beaches, removal of reed beds and aquatic vegetation and the berming a portion of Goosequill Bay are all thought to have removed critical fish habitat from the lake basin (Schindler et al. 2004).

Despite restocking efforts in the early 80's, the population of Walleye in Wabamun Lake remains small. Habitat changes and high hooking mortality are thought to have contributed to the decline in Walleye populations (Schindler et al. 2004). With the total closure of the sport fishing in Wabamun Lake, a new Walleye restocking effort has begun by Alberta Environment and Sustainable Resource Development (AESRD). Between 2010 and 2012 AESRD has stocked 6,482,000 Walleye fry, 21,760 Walleye between 6-12cm, and 1,829 Walleye that were over 40 cm in length (AESRD 2011, 2012; Alberta Government 2012b). No reports have yet been released to determine the success of these stocking efforts.

Alberta Sustainable Resource Development conducted a net survey of Wabamun Lake in both 2007 and 2010 (Table 8). The catch per unit effort for Lake Whitefish was 51 CUE/net in 2007 and 19 CUE/net in 2010. This indicates that more fish were caught in 2010 than in 2007 for the same total of fishing time.

**Table 8: Fall Walleye Index Netting surveys conducted by AESRD on Wabamun Lake (AESRD 2007 and 2010a).**

| | Year | Number of Individuals | Maximum Total Length | Average Total Length |
|---|---|---|---|---|
| **Walleye** | 2007 | None | 0 | 0 |
| | 2010 | None | 0 | 0 |
| **Northern Pike** | 2007 | 39 | 888 | 614 |
| | 2010 | 62 | 1026 | 657 |
| **Lake Whitefish** | 2007 | 363 | 520 | 347 |
| | 2010 | 157 | 567 | 342 |
| **Yellow Perch** | 2007 | 83 | 199 | 121 |
| | 2010 | 89 | 233 | 147 |

## 7.4 Species at Risk

Identifying species at risk and their habitat requirements will help to determine sensitive areas and level of habitat protection required. The *Species at Risk Act* (*SARA*) was introduced in June 2003 to provide legal protection of wildlife species, conservation of biological diversity, and protection of critical habitat. The Act aims to prevent Canadian native species, subspecies and distinct populations from becoming extinct or extirpated, to provide for the recovery of endangered or threatened species and encourage the management of other species to prevent them from becoming at risk. In order for a species to qualify for legal protection under *SARA*, it must first be assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). COSEWIC, established in 1977, is an independent body of experts responsible for determining if a species is endangered, threatened, of special concern, extirpated or not at risk. COSEWIC does not just assess wildlife, but vascular plants, insects, mosses and lichens as well. Unfortunately, the process by which a species becomes listed under *SARA* is complicated and time consuming. Therefore, some species have been assessed by COSEWIC but are not yet protected under the laws of *SARA*.

The province of Alberta also has its own methods of protecting species at risk. Under the *Wildlife Act* the Endangered Species Conservation Committee (ESCC) and the Scientific Subcommittee, assess the risk of extinction or extirpation for Alberta species that have been identified as being potentially at risk. The Scientific Subcommittee is responsible for the assessment, while the ESCC makes recommendations for legal designations, management objectives and recovery strategies to the Minister of the Environment. Under the *Wildlife Act,* a species at risk is defined as a species at risk of extinction or extirpation, or a species that needs special management attention to prevent it from becoming at risk. Only species determined to be threatened or endangered are entitled to legal protection under the Alberta *Wildlife Act* (AESRD 2010b).

There are limitations to the level of detail that is provided by the SARA registry, and without ground surveys it is impossible to tell if a particular species is present. However, there are species whose range overlaps with the area of Wabamun Lake. For the species of birds, The Atlas of Breeding Birds in Alberta was also used to determine if a species had been sighted within the watershed. Wabamun Lake watershed is potentially home to several *SARA* listed species; including three threatened species Common Nighthawk (*Chordeiles minor)*, Olive-sided Flycatcher (*Contopus cooperi*), Peregrine Falcon (*Falco peregrinus*); and five species of special concern, Yellow Rail (*Coturnicops noveboracensis*), Rusty Black Bird (*Euphagus carolinus*), Short Eared Owl (*Asio flammeus),* Northern Leopard Frog (*Lithobates pipiens)*, Monarch Butterfly (*Danaus plexippus*).

The Common Nighthawk is considered threatened and occupies a range of habitats across Alberta. This bird prefers open habitats and areas devoid of vegetation including: forest clearings, rocky outcrops, prairies and plains, bogs and gravel rooftops. This bird is insectivorous feeding at dusk and dawn, unlike other species of nightjars; the Common Nighthawk locates its prey with vision rather than echolocation. Breeding bird surveys have shown a decline in relative abundance between 1985 and 2005. Changes in habitat from forest fire suppression, reforestation, intensive agriculture and the replacement of gravel roofs with other materials are thought to be contributing factors in population declines. Population declines may also be linked to declines in insect populations in breeding and wintering grounds. This may be linked to an increase in the use of pesticides since the 1900's. In some areas of North America, high mortality rates are cause by collisions with motor vehicles and aircraft (COSEWIC 2007a). The Common Night Hawk is currently ranked as a sensitive species in Alberta (AESRD 2010b).

Olive-sided Flycatcher's, are aptly named from the olive-like color seen on their backs, sides, and flanks. This bird is considered threatened under *SARA* and is found in the North and Central regions of Alberta

(COSEWIC 2007b). The Olive-sided Flycatcher prefers semi-open coniferous and mixedwood forests that are near water. Large tall trees and snags are important for foraging and singing and nests are found in open-air areas (Federation of Alberta Naturalists 2007). In Canada this species has seen a widespread, constant decline of 29% in the last decade. The reasons for the decline in this species are unclear, but are thought to be linked to habitat loss and alteration. At one time, it was believed that populations would increase with activities such as timber harvesting, but this has not been the case. It is possible that these habitats are not suitable as breeding grounds; but more research is needed to determine if this is the case (COSEWIC 2007b). The Olive-sided Flycatcher has been observed in the Wabamun Lake watershed (Federation of Alberta Naturalists 2007). In the 2010 species at risk assessment for the province of Alberta, it was determined that the Olive-sided Flycatcher may be at risk. This species was considered to be secure in Alberta in both the 2000 and 2005 assessment reports (AESRD 2010b).

Peregrine Falcon is a threatened bird. Falcons are birds of prey that are smaller and more streamlined than hawks. The habitat requirements of the peregrine falcon can be divided into three components: (1) the nest site: nests are usually scrapes made on cliff ledges on steep cliffs, usually near wetlands, including artificial cliffs such as quarries and buildings; (2) the nesting territory: the area defended around the nest prevents other pairs from nesting within 1 km or more, ensuring adequate food for all nesting pairs and their young; the density of nests tends to be related to food availability; (3) the home range: the extended, non-defended area in which the peregrines hunt for additional food and which can extend to 27 km from the nest; peregrines prefer open habitats such as wetlands, tundra, savannah, sea coasts and mountain meadows, but will also hunt over open forest. The major cause of decline of Peregrine Falcon populations was the presence of agricultural pesticides, especially organochlorine compounds, in the environment. These compounds caused egg-shell thinning, egg breakage, reduced hatching success, reduced brood-size and reduced breeding success. Since peregrine falcons are at the top of the food chain, their tissues accumulate a great deal of these substances. Organochlorine contamination is no longer a major limiting factor for peregrines. Current threats include the small population size and the diminishing quality of habitat. Locally, peregrines may be affected by destruction of breeding sites and breeding areas, or by human intrusion near nest sites. A successful captive breeding program was operated between 1972 and 1996, which has contributed to an increase in population numbers (COSEWIC 2007c). This falcon is currently listed as endangered under the *Alberta Wildlife Act* (AESRD 2010b).

The Rusty Blackbird is considered a bird of special concern under *SARA*. This bird breeds in the Boreal Forest, Parkland and Foothills Natural Regions of Alberta. Wet forest habitats including bogs, swamps and along ponds are the preferred habitats of the Rusty Blackbird. The most prominent threat facing this species is the conversion of wintering grounds on the Mississippi valley floodplains to agriculture and urban land use. Destruction of wetland breeding habitats may also be contributing to population declines. The Rusty Blackbird populations have likely been affected by bird control programs aimed at keeping nuisance bird species away from agricultural crops (COSEWIC 2006). This bird has also been observed in the vicinity of Wabamun Lake (John Acorn, University of Alberta, personal communication). The Rusty Black Bird is not currently listed as a species at risk under Alberta legislation.

The Short-eared Owl is named after the tufts of feathers on its head that resemble ears. This is the most widely distributed owl in the world; however, it is currently listed as a species of special concern by *SARA*. The Short-eared Owl is found mostly in the Grassland Natural Region but often is found in the Parkland, Boreal Forest, Foothills, and Rocky Mountain Natural Regions. This owl nests on the ground and likes open areas, hunting both during the day and at night. Suitable breeding, migration and wintering habitat has declined in the 20$^{th}$ century, particularly in coastal marshes and tall grasslands which are preferred nesting habitats. Although elevated levels of pesticides have been detected in the eggs of the Short-eared owl, the effects are not known. A landscape level recovery plan for this species has been implemented by the South Okanagan Similkameen Conservation Program (COSEWIC 2008). According to AESRD the Short-eared owl may be a species at risk in province of Alberta (AESRD 2010b).

The Yellow Rail is a bird of special concern that is typically found in marshes dominated by sedges, grasses and rushes, where there is little or no standing water (generally 0-12 cm water depth), and where the substrate remains saturated throughout the summer. They can be found in damp fields and meadows, on the floodplains of rivers and streams, in the herbaceous vegetation of bogs and at the upper levels (drier margins) of estuarine and salt marshes. Nesting habitats usually have a dry mat of dead vegetation from previous growing seasons. The loss and degradation of wetlands due to agricultural and human development is the greatest threat to this species throughout its breeding range. On the wintering grounds, habitat loss has been so extensive that the wintering range may no longer be contiguous, and the yellow rails are becoming largely restricted to a narrow band of coastline. Coastal marshes are threatened throughout the Gulf States (COSEWIC 2001). The status of the yellow rail has not yet been assessed in Alberta (AESRD 2010b).

The Monarch butterfly has been assessed as an insect of special concern. In Canada, it exists primarily wherever milkweed (Asclepius spp.) and wildflowers (such as goldenrod, asters, and purple loosestrife) exist. This includes abandoned farmland, along roadsides and other open spaces where these plants grow. Environmental conditions and loss of breeding habitat pose threats to all Monarch butterflies. In the Prairie Provinces, habitat disturbances from agricultural practices and residential land conversions reduce suitable habitat for monarch butterflies. In addition, the widespread and increasing use of herbicides poses a significant threat to the caterpillars that require the milkweed and the adults that require nectar-producing wildflowers (COSEWIC 2010). In Alberta, this species is identified as sensitive and there are thought to be very few know occurrences (AESRD 2010b).

The Northern Leopard Frog is a species of special concern and is named after the leopard-like spots that can be seen on its back and sides. Leopard Frogs use several distinct habitat types throughout the year. They overwinter in well oxygenated water bodies that do not freeze to the bottom. Breeding occurs in ponds, pools, marshes and lakes which have the following characteristics: 30 to 40 meters in diameter, 1.5 to 2.0 meters deep, in an open area with abundant vegetation and lack fish. In the summer the frogs use a wide range of habitats including moist upland meadows, ponds, native prairie and riparian areas. Removal of one of these habitats can make the landscape unsuitable for the Northern Leopard Frog. Therefore, population declines are linked with habitat loss, degradation and fragmentation. Introduction of non-native plants and fish, such as common carp, are also a threat to the populations (COSEWIC 2000). The Northern Leopard frog is considered threatened in Alberta under provincial legislation (AESRD 2010b).

There are five species that may occur in the Wabamun Lake watershed that COSEWIC has recommended for listing under *SARA*. These species include one endangered species (Northern Myotis (bat), *Myotis septentrionalis*), two threatened species (Barn Swallow, *Hirundo rustica* and Bobolink, *Dolichonyx oryzivorus*) and two species of special concern (American Badger, *Taxidea taxus taxus* and Horned Grebe, *Podiceps auritus*). Of these SARA candidates, the province of Alberta has already designated statuses for Northern Myotis (bat), may be at risk; Barn Swallow, sensitive; Bobolink, sensitive; American Badger, sensitive; and Horened Grebe, sensitive (AESRD 2010b).

## 7.5 Invasive Species

Invasive species are species that are considered non-native which have been introduced intentionally or unintentionally from other countries and pose a threat to native ecosystems and biodiversity. These species can often reproduce very rapidly as they have no natural predators in their new environment. Because of their highly competitive nature, invasive species can be very difficult to remove once they have become establish in a particular area.

Aquatic invasive species are easily spread unintentionally from water body to water body on boats, boat trailers, fishing equipment and fishing bait. Eurasian Watermilfoil (*Myriophyllum spicatum*), Didymo or Rock Snot Algae (*Didymosphenia geminate*), Zebra Mussels and Quagga Mussels are currently some of the top species of concern for establishment in Alberta's aquatic environments.

Eurasian Watermilfoil, which is a problem in British Columbia, Ontario and Quebec, has been detected and confirmed at four locations in Alberta (Alberta Biodiversity Monitoring Insitute 2011). This species is of particular concern as it can form large mats, blocking out light to native species below and can easily become tangled in boat propellers. Eurasian Watermilfoil is easily transported from lake to lake on boats and boat trailers. To prevent the spread of this invasive species boaters are encouraged to clean their boat and trailer before launching into a new water body. At this time there is no evidence that Eurasian Watermilfoil is present in Wabamun Lake.

Didymo (*Didymosphenia geminate*), or Rock Snot Algae, is a diatom that attaches to the surfaces of rocks, plants and other submerged surfaces in rivers and streams. Didymo can produce rapidly, forming thick mats that reduce the quality of spawning habitat and abundance of food sources for fish. Didymo is native to North America, but historically was not widespread and only found in small amounts. The movement of Didymo to new bodies of water is largely attributed to the felt soled wading boots of commercial and recreational fishermen. There are restrictions for the use of felt soled boots in some regions and some commercial manufacturers are discontinuing the production of these wading boots (Bothwell et al. 2009).

Native to the Black and Caspian Seas, Zebra (*Dreissena polymorpha*) and Quagga (Dreissena rostriformis) mussels came to North America in the ballasts of trade ships. These prolific mussels have no native predators in Canada and are virtually impossible to eradicate once established. Mussels can live up to 30 days without water and each mussel can produce up to 1 million eggs each season. Currently, mussels have been assigned a medium to high risk for introduction and establishment in Alberta (AESRD 2013e).

Mussels have a negative impact on both the environment and the economy. In the United States millions of dollars are spent each year cleaning mussels from irrigation lines, intake pipes, and hydroelectric dam structures. Mussels also accumulate toxins, damage boats, and fill beaches with sharp shells (Kate Wilson, AESRD, personal communication).

Recreational boaters are the highest risk for transporting mussels from lake to lake and even between countries. You can stop the transporting these aquatic hitchhikers by ensuring you clean, drain and dry all boats and equipment prior to launching in a different water body. To date there are no known occurrences of Zebra or Quagga mussels reported in Alberta. However, as of June 2013 several mussel-fouled boats have been found entering Alberta from the United States. Lake, reservoir, and irrigation canal monitoring initiatives have begun this year by Alberta Lake Management Society, Alberta Environment and Sustainable Resources Development and the Irrigation Districts (Kate Wilson, AESRD, personal communication).

Non-aquatic invasive species are also important to the overall health of a watershed. Purple loosestrife (*Lythrum salicarial*) in a prohibited noxious weed listed under the *Alberta Weed Control Act*. This plant is considered highly invasive and occupies semi-aquatic habitats. Purple Loosestrife can outcompete and displace native vegetation growing into a dense monoculture in a short period of time as one plant can produce up to 2.5 million seeds each year. This plant is very difficult to remove and the best method is to pull out the entire plant before it goes to seed, bag it and thoroughly burn it. This often needs to be repeated for several years to entirely remove the plant (Alberta Invasive Plants Council 2012). Purple Loosestrife does occur within the Wabamun Lake watershed. As a result, Parkland County has taken the initiative to control known infestations of this species around Wabamun Lake. Recently in 2012 an effort to control Purple Loosestrife was conducted on Rich's Point by Parkland County and Stony Plain Fish and Game (AARD 2012).

Other invasive species that have been found in the Wabamun Lake watershed include Himalayan Balsam (*Impatiens glandulifera*), Flowering Rush (*Butomus umbellatus*), Common Tansy (*Tanacetum vulgare*), and Scentless Chamomile (*Tripleurospermum perforatum*).

## 7.6 Benthic Invertebrate and Zooplankton Communities

### 7.6.1 Benthic Invertebrates

Benthic invertebrate communities can be used as indicators of aquatic ecosystem health as they are particularly sensitive to changes in their environment. Characteristics such as abundance, richness, diversity and community composition can be monitored to detect changes over time. In lakes, benthic invertebrates are found mainly in shallow waters and decrease in diversity and density as depth increases. Benthic species can indicate the health of a system based on the community composition. As a result, examining the benthic community can give an idea of the health of a particular water body.

The benthic community was first studied in 1979 by Rasmussen and again in 2003 by Stantec Consulting Ltd. The study by Rasmussen was conducted over a period of three years and identified nearly 200 taxa of benthic invertebrates. A similar number of species were found within the vicinity of the thermal effluents and the main body of the lake (Rasmussen 1979). In comparison, the study conducted by Stantec only found 128 species (Stantec 2003). However, these studies cannot be directly compared as only the 1979 surveyed over multiple seasons (Schindler et al. 2004).

In 2002, a study by Stantec aimed to address the effects of the discharge from the ash lagoon on the north shore of the lake and the Wabamun Lake Water Treatment Plant on the south shore. The species found in Wabamun Lake were similar to those of most shallow, productive lakes in Alberta. Chironomidae were the dominant taxa of invertebrates at the ash lagoon, Wabamun Water Treatment Plant and lake reference sites. However, there was a slight difference in the overall species compositions between the ash lagoon and the lake reference site. This is likely a result of a mild enrichment at the ash lagoon rather than any toxic effects from the outfall. There was also a difference in substrate compositions at each site, which could result in the presence of different benthic species (Stantec 2002).

### 7.6.2 Zooplankton

While the zooplankton community in Wabamun Lake is sampled as part of Alberta Environment and Sustainable Resource Development's long-term lakes monitoring program, there are no recent reports or data available. A study conducted in 2002 examined the changes in historical zooplankton populations and found no significant changes in overall species composition (Schindler et al. 2004).

# Data Gaps

# 8 Data Gaps

The assessment of the current condition of a watershed relies on complete information being available for all indicators. However, such data are often collected only periodically and may be restricted only to limited areas. Below, information on the availability of data for each indicator is discussed with reference to how much uncertainty these data gaps may introduce in the assessment of the state of the Wabamun Lake watershed.

## 8.1 Land Use

**Rural and Urban Developments**

Urban and rural developments include all permanent population centers including towns, summer villages and rural subdivisions. Data on these population centers are up-to-date with the current 2011 census. However, some of the developments around the lake, such as Fallis, are reported as part of the Parkland County census. As a result, the true population within the watershed is likely under estimated.

**Recreational Developments**

Recreational development not only takes into account the recreational structures such as parks, campsites and facilities, but the actual recreational activities that take place in these locations. Wabamun Lake is well known for recreational activities such as sailing; however, there is no information on the level of use throughout the year. Boat density, average use per day, and carrying capacity for boats all represent a knowledge gap for the Wabamun Lake watershed.

**Agricultural Development**

Livestock, manure production and agricultural intensity data are based on the 2006 Agriculture Census and data from Agriculture and Agri-Food Canada (2007). These datasets are complete for the Wabamun Lake watershed; however, the reporting unit for the watershed is grouped together with other sub-watersheds, giving uncertainty in the actual numbers for the Wabamun Lake portion of the watershed. More recent data from the 2011 Agriculture Census have not yet been released to the public.

**Oil and Gas Activities**

Data on oil and gas wells and pipelines for the watershed is complete and up-to-date as of February 2012 by the Alberta Energy Resources Conservation Board. As a result, there are no data gaps for oil and gas activities.

**Linear Developments**

Linear development data is complete as of 2010 and includes a fairly high level of detail for the Wabamun Lake watershed. Information is available for various types of linear features including roads, trails, railways, pipelines, seismic lines and transmission lines. The data available allows for an accurate assessment of linear features.

**Wetland Loss**

Wetland inventory for the watershed is complete as of 2012 and has been conducted by Alberta Environment and Sustainable Resource Development. This inventory identifies wetland types based on the Canadian Wetland Classification System including bog, fen, swamp, marsh, and shallow open water wetlands. There is no historical data to compare the current data to determine wetland loss or changes in composition for the watershed. However, the current inventory can be used to ensure no further loss of wetlands occurs within the watershed, as wetlands have a wide range of important ecological functions.

**Riparian Health**

No comprehensive studies of riparian health are available, either within basin as a whole or for the lakeshore. Riparian aerial videography was recorded for Wabamun Lake in 2002; however, this video was never analyzed for riparian health and integrity (George Walker, personal communication). This represents a significant data gap, as the health and integrity of riparian areas strongly influences the health and integrity of the associated aquatic ecosystem. This lack of information may be especially important for Wabamun Lake, as small intermittent streams feed the lake; such watercourses are capable of contributing significant amounts of pollutants relative to the volume of water that they carry. The reed beds along the lakeshore also provide important fish spawning and bird nesting habitats.

## 8.2 Water Quality

**Nutrients and Routine Parameters**

Data on nutrients and routine parameters is available from 1982-2012 and is complete. Wabamun Lake is part of Alberta Environment and Sustainable Resource Development's long-term lakes monitoring network and the report that is produced as part of this program can further supplement the data presented in this report. There are no data gaps for nutrients and routine parameters.

**Metals**

Alberta Environment and Sustainable Resource Development collect metals data as part of their lake monitoring program; however, the period of record for this data only extends back to 1999. Data is also collected on a less regular basis compared to other water quality parameters. In addition to metals in the water column, some studies have been conducted to examine metals in the sediments, mercury flux and PAHs. As a result, there no data gaps for metals in the water column. However, more research needs to be done to determine the long term effects of other metal sources in the lake to determine the long term effects on the aquatic ecosystem.

**Bacteria**

Alberta Health Services collects data on fecal coliforms for Wabamun Lake from five different popular swimming locations for much of the open water season. Data is available from 2004 to present day. This frequency of collection is sufficient for assessing bacterial conditions in the lake, as bacteria do not build up in a water body over time in the same way that compounds such as nutrients or metals may. There are no current data gaps for bacteria, though long- term historical trends cannot be addressed with the available data.

**Parasites**

No data on Cryptosporidium or Giardia are available for the watershed. This represents a significant data gap as parasites can have a significant effect on human health. These parasites are responsible for gastrointestinal conditions known as cryptosporidiosis and giardiasis.

**Pesticides**

Data on pesticides was only collected on one occasion for the east basin of the lake in 1995. This represents a significant data gap, as these compounds are easily transportable from surrounding agricultural and residential lands. Pesticides are relatively frequently found in surface waters of the settled region of the province, though concentrations may vary widely between water bodies and from year to year.

## 8.3 Water Quantity

**Lake Levels and Withdrawals**

Lake level data have been collected since 1915 and are complete; therefore, there are no data gaps. Information on licensed water withdrawals available from the province is complete. However, not all licenses require reporting of withdrawals, consumption, or losses, so actual diversions from ground and licensed diversion volumes may not reflect surface water sources. Moreover, not all withdrawals (limited traditional agricultural uses and household uses) require licenses, so not all withdrawals from the watershed are accounted for.

## 8.4 Biological Community

**Land Cover**

Land cover data is complete for the most recently available coverage (2000), so no significant data gaps exist for this indicator. However, this data represents a large portion of the disturbed mined area as grasslands. By combining the data from the human footprint and land cover sources, a more accurate representation of land cover data can be reported. More recent data would be useful for addressing changes in land cover and use, in particular to show changes due to industrial activities, but such datasets are quite labor intensive to produce, and are completed at long intervals.

Available information on other biological indicators, such as fish and wildlife populations, generally represents a snapshot in time and there is no long-term, or publically available data. While the Alberta Biodiversity Monitoring Institute maintains a network of monitoring stations across Alberta, no stations are located within the vicinity of the Wabamun Lake watershed. Monitoring data for increases, presence or absence of species at risk and invasive species would also be helpful in determining the health of the watershed. This data is not available and represents a data gap for the watershed.

# Discussion, Conclusions and Recommendations

# 9 Discussion

## 9.1 Land Use

**Rural, Urban, Recreational, Agricultural and Industrial Development**

Overall, rural and urban developments within the watershed are lower than many lakes in the region, where development can be seen around the entire perimeter of the lake. This is in part due to the high industrial development directly along the lakeshore, which has limited the growth of summer villages and cottage properties around the lake. Industrial developments such as coalmines and power plants make up a large portion of the developed area within the watershed.

Disturbances from rural, urban, recreational, agricultural and industrial activities cover approximately 50% of the land base of the watershed. There are no data to indicate the recreational pressure on the lake throughout the year in terms of use by boats. However, the lake is known for its local sailing and is easily accessible from Edmonton for recreational opportunities. As a result, this indicator receives a ranking of **"fair"**.

Annual manure production for the watershed is estimated at 1,583 kg/ha, which receives a rating of "poor". However, as discussed previously the numbers for agricultural operations were extracted from a larger reporting unit. Therefore, a considerable amount of uncertainty surrounds this figure; ultimate densities may be much lower. Due to the uncertainty surrounding manure production, the raking for this indicator will not be used in the overall calculation of ranking for the watershed.

**Oil and Gas Activities**

There are a total of 87 oil and gas wells within the Wabamun Lake watershed. This includes abandoned, undetermined and active wells, for a total well density of 0.003 wells/ha of land. As a result a rating of **"good"** is given for this indicator. There are also 1.15 $km^2$ of pipeline within the watershed boundary, which represents 6.5% of the linear features within the watershed.

**Linear Developments**

Within the Wabamun Lake watershed, there are a total of 17.6 $km^2$ of linear features. This represents 4.7% of the total area of the watershed, and results in a rating of **"poor"**. Roads account for the majority of linear features with 11.5 $km^2$ of the total 17.6 $km^2$ of linear features within the watershed.

**Wetland Loss**

Historical inventories of wetland density are not available at the scale of the Wabamun Lake watershed, so no rating can be given for this indicator. There has been clearing of land for agricultural and residential development, suggesting that some loss of wetlands has occurred. Wetlands fill a wide variety of important roles on the landscape, providing stabilization of water levels, recharge groundwater sources, and provide habitat for a wide variety of organisms.

**Riparian Health**

No information on riparian health in the basin is available, so no ranking can be provided for this indicator. Residential development of the lakeshore has occurred in many areas, so direct human impacts in those areas are expected. However, the extent of these and other impediments to riparian health are unknown. Like wetlands, riparian areas are critical features on the landscape in protecting aquatic ecosystems, as they help filter pollutants, store water for longer-term release and thus reduce the risk of both flooding and drought, and are important storehouses for biodiversity.

## 9.2 Water Quality

**Nutrients and Routine Parameters**

Average concentrations of total phosphorus were 0.03 mg/L and concentrations only exceeded the guidelines of 0.05 mg/L on two occasions. As a result a rating of **"good"** is given. Total nitrogen concentrations exceeded guidelines on many occasions over the period of record. The average concentration of total nitrogen was 0.90 mg/L and results in a **"fair"** rating. As phosphorus is the nutrient limiting growth of cyanobacteria (blue-green algae) within the lake, an overall rating of **"good"** will be given for nutrients.

Despite the rankings for nutrients, Wabamun Lake is considered to be a eutrophic lake, or highly productive. This suggests that if levels of nutrients, particularly phosphorus, are not managed the negative effects seen in highly productive lakes may become apparent. This includes reduced water quality, reduced clarity, oxygen depletion and more prolific cyanobacterial blooms.

**Bacteria**

In the most recent three years of sampling, nine of 166 samples exceed the Heath Canada guidelines of 200 colony forming units per 100 mL for direct contact recreation. This results in only 5% of the samples being above guidelines and a rating of **"good"** is given.

**Parasites**

No data on parasites were available for Wabamun Lake; therefore, a rating cannot be given for this indicator. It is important to sample for parasites as the can have a detrimental effect on human health.

**Pesticides**

Data for pesticides was only available for one sampling event in 1995. While the concentrations of pesticides detected were very low, there is not enough data to draw any conclusions on this indicator. Pesticide concentrations in a water body can vary with season, weather conditions and the type of agriculture in the watershed. As a result no score will be provided for this indicator.

**Metals**

None of the metal concentrations collected from the open water samples of Wabamun Lake exceeded their respective guidelines. As a result a rating of **"good"** was given. This does not take into account the information available on mercury deposition or sediment analysis. While these topics may have an effect on the overall health of the lake, there is limited data available on these topics and the overall effects are not widely known. This is an area that could be researched further in the future.

## 9.3 Water Quantity

**Lake Levels**

Lake level has been a topic of constant dispute for the Wabamun Lake watershed, and much uncertainty still remains over the true natural lake level. Alberta Environment and Sustainable Resource Development rank the lake levels as normal for the past two years (AESRD 2013d). However, the long-term lakes report shows a statistically significant overall decline in lake level since 1980 (Casey 2011). Due to the uncertainty surrounding lake levels, a score of **"fair"** for this indicator.

## 9.4 Biological Community

**Land Cover**

Natural land cover represents 37% of the Wabamun Lake watershed land base. The land cover data includes the disturbed mine areas under the category of grasslands, therefore the total mine area was subtracted from grasslands to obtain the total natural land cover for the watershed. As a result, a rating of **"fair"** was given to land cover.

A high percentage of natural cover types can contribute strongly to watershed health, providing wildlife habitat and corridors, protecting the land base from erosion, and acting as a filter in riparian areas and preventing pollutants from entering surface waters. Changes in land cover as a result of human population growth or increased human activities, however, may put the watershed at risk in the future if protections for natural areas are not put into place and enforced.

# 10 Conclusions

The overall condition of the Wabamun Lake watershed was rated as, **"fair"**. There were four indicators that received a rating of **"good"**, three that received a rating of "**fair"**, one that received a rating of **"poor"** and five that could not be assessed due to a lack of available data (Table 9). Due to the lack of data for these five indicators, there is some uncertainty in the overall ranking. Therefore a more conservative rating of **"fair"** was given.

The areas of greatest concern for the Wabamun Lake watershed include linear developments; urban, rural, recreational, agricultural and industrial developments; and land cover.

**Table 9: Overview of Wabamun Lake watershed indicator rankings.**

| Indicator | Rating | Description |
|---|---|---|
| **Land Use** | | |
| Urban, Rural, recreational, agricultural and industrial development | **"Fair"** | Developments cover 50% of the watersheds land base; however, this does not include density and intensity of boat use |
| Manure Density | - | Annual manure production is 1,583 kg/ha; however, this is likely an overestimate due to regional nature of data available. Therefore, the data for this indicator was not used. |
| Oil and Gas Activity | **"Good"** | Oil and gas wells are estimated to be 0.003 wells/ha |
| Linear Developments | **"Poor"** | Linear developments total 17.6 $km^2$ or 4.7% of the total are of the watershed |
| Wetland Loss | - | Insufficient data available for rating |
| Riparian Health | - | Insufficient data available for rating |
| **Water Quality** | | |
| Nutrients and Routine Parameters | **"Good"** | Average total phosphorus concentrations of 0.03 mg/L and total nitrogen concentrations of 0.09 mg/L |
| Bacteria | **"Good"** | Concentrations exceeded guidelines less than 10% of the time |
| Parasites | - | Insufficient data available for rating |
| Pesticides | - | Insufficient data available for rating |
| Metals | **"Good"** | All concentrations of metals collected from the open water were below guidelines |
| **Water Quantity** | | |
| Lake Levels and Withdrawals | **"Fair"** | Normal for the last two years, but with and overall declining trend in lake level |
| **Biological Community** | | |
| Land Cover | **"Fair"** | Between 25% and 50% of the basin under natural land cover types |

The overall water quality in Wabamun Lake is good, with lower levels of total phosphorus inhibiting the growth of problematic algae blooms. Wabamun Lake is currently under high pressure from development, particularly industrial, recreational and agricultural developments. Additional problems may occur with water quality if measures are not taken to ensure nutrients in the lake are not increasing as a result of development activities.

Although bacterial concentrations have been a concern for residents and recreational users of Wabamun Lake, data from the last three years of sampling shows much lower concentrations of fecal coliforms compared to earlier years of sampling. Preservation of riparian and wetland areas surrounding the lake can slow and impede these bacteria from entering the lake.

While data shows that metals detected in the open water column of Wabamun Lake are below guidelines, there is still concern for increasing mercury levels in the lake due to proximity to coal fired power plants. There is currently a fish consumption advisory is in place for Wabamun Lake for women and children consuming Northern Pike, due to the levels of mercury present in the fish tissue. Women are to limit consumption to 3 servings per week and children to 1 – 0.5 servings depending on their age (Alberta Government 2012a).

The lack of information available on pesticides, parasites, riparian health and wetland loss represents a significant knowledge gap within the Wabamun Lake watershed aquatic and terrestrial ecosystems. This lack of data could affect the overall score given for the watershed.

Land cover data indicates that a significant portion of the land base has been removed from natural cover for various land uses, predominantly agriculture and mining activities. Manure density for agricultural operations is high within the watershed. In years where precipitation and runoff are high, streams that drain these areas may convey higher levels of nutrients into Wabamun Lake.

# 11 Recommendations

In the past, recommendations have been made to maintain the health of Wabamun Lake watershed (Schindler et al. 2004). Some of these recommendations have been implemented including, eliminating the commercial fishery, restricting all sport fishing to catch and release and establishing a watershed stewardship committee. Other recommendations from the Schindler et al. report have yet to be addressed such as, closing all angling (including catch and release) in areas of Walleye congregation; monitoring and enforcement for aquatic vegetation pulling; modifying the outlet on Wabamun Creek for fish passage; and implementing more stringent guidelines for fertilizers, cottage development, land-use changes and waste disposal in order to reduce nutrients entering the lake. These recommendations should be considered in addition to those made in this report in the development of a watershed management plan.

Currently there is limited information on several indicators within the Wabamun Lake watershed, including wetland loss, riparian health, parasites and pesticides. If possible, future studies should be conducted to address the lack of information in these categories. These studies are not a requirement of any one group, but could be facilitated through various partnerships. Continuation of current monitoring programs by Alberta Environment and Sustainable Resource Development and Alberta Health Services is highly recommended to monitor for any changes in water quality.

Effort should be made to include pesticides and parasites into a regular sampling routine to ensure the health and safety of residents and recreational users. Since Wabamun Lake drains an area with agricultural activity, it is important to know if any pesticides used are entering the lake. Monitoring for these parameters does not have to be something that is conducted by Alberta Environment and Sustainable Resource Development, but could be periodically carried out by municipalities or even stewardship groups. Implementation of best management practices to manage these parameters should occur, even if the sampling does not. Best management practices include runoff and erosion control from agricultural and industrial settings, modernization and maintenance of septic and sewage management systems, limiting fertilizer and pesticide application around waterbodies, and the protection and restoration of riparian areas. All organizations, industry, governments (local and provincial), residents and stewardship groups can work together to implement these best management practices. However, the responsibility to implement regulations and policy falls on Parkland County. The County has the capacity to restrict development around the lakeshore, establish riparian setback distance policy and implement policy restricting the use of fertilizers, herbicides and pesticides near waterbodies.

Lack of information on the quality of riparian habitats and loss of wetland habitat is an important knowledge gap in determining the condition of the watershed. Both riparian areas and wetlands provide many important ecosystem services to the environment; including, carbon storage, flood control, contaminant filtering, wildlife habitat and many more. Maintaining and protecting these features on the landscape can ultimately lead to a healthier watershed. Promotion of shoreline naturalization and discontinuing aquatic vegetation pulling will not only improve riparian areas, but also help improve important fish and wildlife habitat. Alberta Environment and Sustainable Resource Development has the capacity to protect the bed and shores of waterbodies under the Public Lands Act. In addition, Parkland County can set stricter regulations for the setback of developments from waterbodies, including those on Wabamun Lake. Partnering with organizations such as Living by Water and Cows and Fish can help assess and improve riparian habitats within the watershed. Aerial videographic or aerial photographic assessments can also provide an opportunity for rapid assessment of riparian areas, and indicate areas of concern. The Counties of Lac La Biche and Northern Sunrise have already completed, or are in the process of completing, aerial riparian assessments and developing setback distance policy from the results. Residents with lake front property play an important role in maintaining healthy natural riparian areas. Education and outreach programs should encourage residents to keep their shorelines in a natural state. The Wabamun Watershed Management Council has already taken initiative on these actions.

Both past and present phosphorus budgets conducted for Wabamun Lake indicate that almost half of the phosphorus in the lake is coming from within the lakebed sediments. This source of phosphorus is extremely difficult to manage and as a result, it is extremely important to focus on controlling phosphorus that is entering the lake from external sources. Particular attention should be paid to phosphorus that is entering the lake from non-point source surface runoff in agricultural, rural and residential areas. This may include imposing stricter guidelines, in the form of municipal bylaws or policy, for use of fertilizers within Parkland County, Village of Wabamun and all summer villages around the lake. Public education is also a necessary tool in reducing nutrient loading to the lake.

While concentrations of metals in the lake water remain low, there is still much public concern over the health effects of mercury concentrations, particularly in fish tissue. At this time there is no commercial fishery on the lake and all sport fishing for all species is restricted to a zero catch limit year round. At such a time when the fishing regulations for the lake change, concentrations of mercury in fish tissue should be examined to determine if there are any risks to the public. Closure of all sport fishing on Wabamun Lake has been implemented to allow for fish populations to recover to a more normal age structure. Illegal poaching can still be a problem during catch and release restrictions and any illegal poaching should be reported. The management of the fishing regulations and the fish populations is the responsibility of the Alberta Government.

We recommend continual monitoring of aquatic species to determine changes in populations and community structure as a result in changes in industrial activity in the watershed. As the aquatic environment fully adapts to the lake completely freezing over there may be significant changes. Walleye populations are thought to benefit, as they are highly susceptible to changes in water temperatures. However, the western grebe may be negatively affected due to changes in the reed bed growth from ice-pan action (Hugh Wollis personal communication).

Monitoring for invasive species is important to ensure the health of native terrestrial and aquatic ecosystems in the watershed. Several prohibited noxious weeds, such as Purple Loosestrife and Himalayan Balsam have already been reported in the watershed. Public education is the key in this respect to ensure that no new invasive species are introduced to Wabamun Lake. Stewardship effort such as weed pulling events can be successful in controlling the spread of these weeds, such as purple loosestrife. Know locations of prohibited noxious weeds should be reported to the county, who coordinates noxious weed control efforts. Prior to launching, recreational users should check their boat and boat trailers to ensure no aquatic invasive species such as Zebra and Quagga Mussels or Eurasian milfoil are introduced to the lake. In addition, boaters should follow the clean, drain and dry method to ensure no transport of aquatic hitchhikers.

The Wabamun Lake watershed is currently in “fair” condition. Because of its size, proximity to Edmonton and available recreational opportunities Wabamun Lake is very popular. Publicized events such as the train derailment and fish kills may have shed some negative light on the lake in the past, but evidence suggested that these events have not had a significant impact on the overall health of the aquatic ecosystem. Efforts need to be made to minimize the overall impacts of industrial, agricultural, rural, urban and recreational developments on the lake through the implementation of best management practices and potentially new environment policy and bylaws. The preservation and conservation of aspects of the Wabamun Lake watershed that are currently in “good” condition is critical for maintaining the long-term health of the lake.

Managing and maintaining the overall health of the Wabamun Lake watershed falls upon a wide range of parties including, federal, provincial and local government, industry, residents, recreational users and stewardship groups. Effort should be made by all groups to work together to achieve the common goal of a healthy watershed for generations now and into the future. However, there are specific roles and responsibilities for each of these groups in watershed management. For example, Parkland County is responsible for developing policy and bylaws that restrict shoreline development, establish riparian areas setback distances, and restrict the use of pesticides, fertilizers and herbicides around waterbodies. The Wabamun Watershed Management Council is responsible for helping to educate the public and driving stewardship efforts within the Wabamun Lake watershed. A more detailed explanation of these roles is presented in Appendix B: Outline of Roles and Responsibilities.

We strongly recommend that the Wabamun Watershed Management Council, Alberta Environment and Sustainable Resource Development, and Parkland County partner immediately to begin the watershed management planning process. Long-term management, planning and forward thinking is critical to the overall success in achieving goals for the watershed. While the responsibility for enforcement of laws, regulations, and plans generally falls to various levels of government, it is critical that residents and other stakeholders maintain their involvement and ensure that issues within the watershed are not ignored. Continued watershed management planning is necessary to ensure the long-term health and preservation of the Wabamun Lake watershed.

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# 13 Glossary

**Anoxic:** In freshwater systems, anoxic refers to a lack of dissolved oxygen. Bacterial decomposition of excessive organic matter under winter ice cover frequently causes anoxia.

**Anthropogenic:** Literally, "human origin", such as sewage inputs into a freshwater system.

**Benthic:** Refers to the substrate at the bottom of aquatic habitats (e.g., lakes, oceans and rivers). Also describes the life strategy of organisms living in or on that substrate (e.g., clams and oligochaete worms) (CCME, 1999).

**Chlorophyll *A*:** A plant pigment involved in photosynthesis that can be used to indicate the concentration of algal biomass in water.

**Colony-forming unit (CFU):** A unit of measurement of viable cells, especially for bacteria, based on the principle that each bacterium in a sample is capable of producing a viable colony on a plate of growth medium.

**Conductivity:** A measure of the ability of a material or solution to carry an electric current; in terms of water quality, it provides an indication of the concentration of all ions in a solution.

**Ecological Integrity:** See Environmental Integrity.

**Ecosystem:** An ecological system of an assemblage of plants, animals, bacteria and fungi that are treated together as a functional unit in their natural environment.

**Ecoregion:** A distinct geographic area characterized by a distinctive climate, ecological features, and plant and animal communities.

**Environmental Integrity:** The degree to which all environmental (ecological) components and their interactions are represented and functioning.

**Eutrophic:** Refers to aquatic environments that have abundant nutrients and high productivity. In waterbodies such as lakes, ponds and slow-moving rivers, oxygen levels below the surface layer may be depleted. Opposite of oligotrophic.

**Eutrophication:** The natural and/or anthropogenic processes by which the nutrient content of natural waters is increased, generally resulting in an increase of biotic productivity and biomass.

**Fauna:** Animals of a particular region, considered as a group.

**Fecal Coliform:** Refers to the group of bacteria associated with the feces of warm-blooded animals. They constitute one of three bacteria commonly used to measure possible contamination of water by human or animal wastes. The others are *Escherichia coli* (*E. coli*) and *Enterococcus* spp.

**Fluvial:** Geological landforms or processes associated with streams and rivers.

**Flux:** The movement of particles from one medium or substance to another, for example from the sediment into the water.

**Glaciolacustrine:** Refers to geological processes and landforms associated with glacial lakes

**Green Zone:** The forested zone of Alberta, encompassing the northern part of the province

**Growing Degree Days:** A measure of the available growing season, calculated as the average temperature for each day minus 5 C, summed over the period of interest.

**Guidelines:** Generic numerical concentrations or narrative statements that are recommended as upper limits to protect and maintain the specified uses of air, water, sediment, soil or wildlife. These values are not legally binding.

**Hardness:** The concentration of all metallic cations, except those of the alkali metals, present in water. In general, hardness is a measure of the concentration of calcium and magnesium ions in water and is frequently expressed as mg/L calcium carbonate equivalent.

**Hummocking:** Depressions in soil resulting from large animals walking through soft or moist soil.

**Invasive Plant Species:** Weed species classified as noxious or restricted by a municipality or county with the potential to infest riparian areas.

**Linear Developments:** Human development associated with seismic lines, pipelines, roadways, railways, and utility right-of-ways

**Macrophytes:** Macroscopic (large) aquatic plants, which can be rooted, submersed, emergent or sessile.

**Mass Loads:** The mathematical weight of a pollutant in a waterbody. The load is the calculated product of the concentration of a pollutant in water multiplied by the water volume.

**Mesotrophic:** Refers to aquatic environments with adequate nutrients and sufficient rates of productivity to sustain aquatic life (meso = "middle").

**Moraine:** A landform of unconsolidated soil and rock resulting from the melting of a glacier.

**Natural Region:** A region characterized by common geological, ecological, and climatological factors.

**Nitrogen:** A nutrient necessary for the growth and development of animals and plants. Typically, nitrogen is the limiting nutrient in terrestrial systems.

**Oligotrophic:** Refers to aquatic environments that have scarce nutrients and low productivity. The opposite of eutrophic.

**Pathogen:** An agent that causes disease, especially a living microorganism, such as a bacterium, parasite or fungus.

**Peatland:** Wetlands that accumulate large amounts of organic matter (peat), including bogs and fens.

**pH:** A logarithmic scale used to measure the acidity of water. Values less than 7 (pH of pure water) are acidic, values greater than 7 are basic.

**Phosphorus:** A nutrient necessary for the growth and development of animals and plants, which is typically the limiting nutrient of aquatic systems. It can be measured as several variables: total phosphorus (TP), total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP).

**Phosphorus Budget:** A biogeochemical cycle that accounts for the major sources of phosphorus to a lake (soil erosion, transport by streams, human waste) and from the lake (withdrawals, surface and groundwater outflows).

**Plankton:** Assemblage of small drifting organisms suspended in the water column, including plants/algae (phytoplankton), animals (zooplankton), and bacteria (bacterioplankton).

**Residence Time:** The amount of time it takes for a lake to entirely replace its water supply.

**Riparian:** The transitional zone between upland and aquatic habitat. Riparian areas perform important ecological functions, contain a diverse assemblage of plant and animal species, provide essential habitat for wildlife and are influenced by seasonal water levels.

**Secchi Disk:** An 8-inch (20 cm) disk with two alternating black and white quadrants used to measure water transparency to light penetration. Transparency decreases as color, suspended sediments or algal abundance increases.

**Seismic:** An exploration technique to identify oil and gas deposits by producing sound waves at the surface, recording how the waves are reflected from underlying features and interpreting these reflections to produce a computer model of subsurface geological structures.

**Solids:** Matter suspended or dissolved in water, which may negatively affect water quality in terms of palatability, industrial use and aesthetics.

**Standard:** A legally enforceable numerical limit or narrative statement, such as in regulation, statute, contract or other legally binding document that has been adopted from a criterion or objective.

**Till:** A glacial deposit consisting of unsorted sediment, possibly including clay, silt, sand, gravel, and larger rocks.

**Total Dissolved Phosphorus:** A measure of the phosphorus concentration in a solution, as the sum of soluble reactive phosphorus and organic phosphorus that passes through a 0.45 µm filter.

**Total Dissolved Solids:** A measure of all organic and inorganic substances dissolved within a liquid. These dissolved solids must passes through a 2.0 µm filter.

**Total Coliforms:** A group of closely-related, mostly harmless bacteria that live in soil and water as well as the gut of animals. The extent to which fecal coliforms are present in the source water can indicate the general quality of that water and the likelihood that the water is fecally contaminated. Total coliforms are currently controlled in drinking water regulations, because their presence above the standard indicates problems in treatment or in the distribution system. If total coliforms are found, then the public water system must further analyze that total coliform-positive sample to determine if specific types of coliforms (i.e., fecal coliforms or *E. coli*) are present.

**Total Nitrogen:** A measure of the nitrogen concentration in a solution, as the sum of total Kjeldahl nitrogen and nitrate-nitrite**.**

**Total Phosphorus:** A measure of the phosphorus concentration in a solution, as the sum of soluble reactive phosphorus and organic phosphorus.

**Trophic:** Refers to the nutrient availability and productivity status of a waterbody. See oligotrophic, mesotrophic, and eutrophic.

**Total Suspended Solids:** The portion solids that are retained from liquid passed through a 2.0 µm filter.

**Watershed:** The area of land draining into a stream, lake, wetland or other waterbody.

**Wetland:** A wetland is land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or "peatlands" and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

**White Zone:** Agricultural or settled zone of Alberta.

## Appendix A: Trophic Status of Alberta Lakes

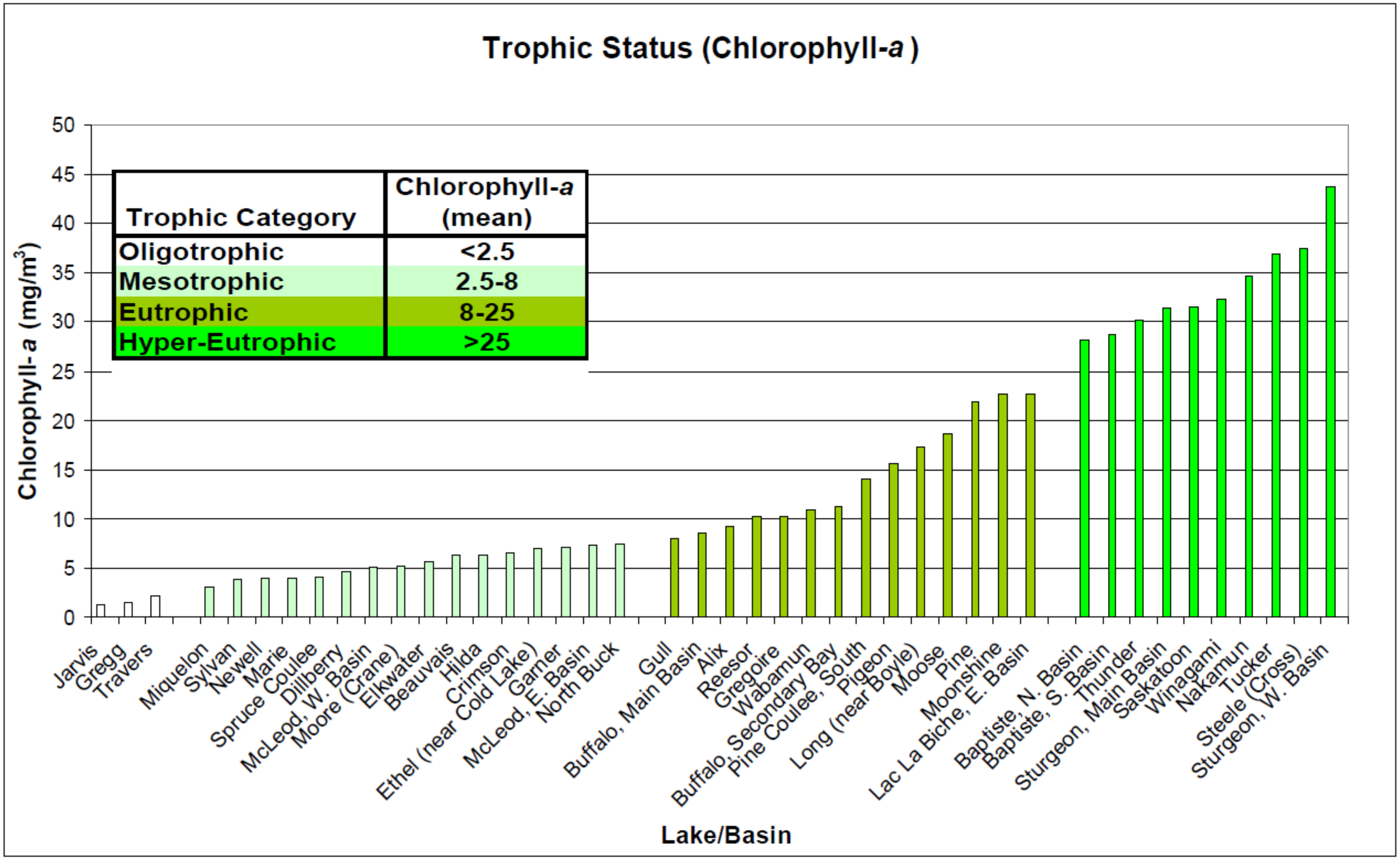


**Figure 26:** Trophic condition of Alberta Lakes with more than 10 years of composite samples. Condition is based on the average annual median chlorophyll-a concentration of the composite samples (Casey 2011).

# Appendix B: Outline of Roles and Responsibilities

**Table 10: Roles and responsibilities of various groups in regards to the management of the Wabamun Lake watershed. This is by no means an exhaustive list, but is meant to highlight some of the key points.**

| Organization | Role and Responsibility |
|---|---|
| **Alberta Government** | Protection of wetlands, shorelines and waterbodies from harmful activities and distruction through the enforcement of the *Water Act*, *Environmental Protection Act*, and *Public Lands Act.* |
| | Managing recreational and commercial fishing regulations. Managing fish populations. |
| | Lead and provide support for watershed management planning. |
| **Parkland County** | Development of municipal policies and by-laws that protect waterbodies including but not limited to: riparian setbacks, tree removal, land development, sewage management, wetland policy objectives and use of fertilizers, pesticides and herbicides. |
| | Enforcement of municipal by-laws and policy. |
| | Lead and encourage partnerships for the purpose of watershed management planning. |
| **Industry** | Follow and beware of all legislative requirements pertaining to their operations. |
| | Be good stewards of the resources and social license. |
| | Participate and support watershed management planning. |
| **Wabamun Watershed Management Council** | Identify goals and priorities for future actions. Following the Water for Life goals and processes. |
| | Work with individual residents and local communities to raise awareness and gather information on water quality, quantity, usage and surface-ground water interactions in their local watershed. |
| | Developing partnerships and providing input for watershed management planning. |

| | |
|---|---|
| **Residents** | Participate in educational, awareness and stewardship activities within the watershed. Practice best management techniques on the landscape. |
| | Become informed in the areas of municipal and government regulations that affect their activities and lifestyle within the watershed. |
| | Provide feedback and local knowledge for the purpose of watershed management planning. |


**Wabamun Watershed Management Council**

*PO Box 1005*
*Wabamun, AB • T0E 2K0*

Phone: 780.953.2695
Email: info@wwwmc.ca
www.wwmc.ca

**Aquality Environmental Consulting Ltd.**

*Suite #204, 7205 Roper Road*
*Edmonton, AB • T6B 3J4*

Phone: 780.757.5530
Fax: 866.654.2826
www.aquality.ca


Aquality
Environmental Consulting Ltd.

Wabamun Watershed
Management Council