WABAMUN LAKE

DRAFT Watershed Management Plan

Prepared by:
Wabamun Lake Watershed Management Plan
Steering Committee

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Wabamun Lake Watershed Management Plan Steering Committee

The *Wabamun Lake Watershed Management Plan* was prepared by the Wabamun Lake Watershed Management Plan Steering Committee, a multi-stakeholder collaboration of Provincial Government, local municipalities, industry, stewardship groups and individuals with an interest in the Wabamun Lake watershed. For a list of Steering Committee members, see Appendix 1.

For updates about the *Wabamun Lake Watershed Management Plan's* development and implementation, please see the Wabamun Watershed Management Council's webpage at https://www.wwmc.ca/watershed-management-plan.

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Acknowledgements

On behalf of the Wabamun Lake Watershed Management Plan Steering Committee (SC), we thank the Wabamun Watershed Management Council (WWMC) for initiating the watershed management planning process. We also acknowledge our respective organizations for their in-kind support (e.g., staff time and meeting spaces). This includes those municipalities (staff and councils) surrounding Wabamun Lake, as well as TransAlta. We are also grateful for the financial, logistical and technical support of Alberta Environment and the North Saskatchewan Watershed Alliance (NSWA). Finally, we thank the many reviewers, technical experts, and members of the public who provided reference materials, reviewed earlier versions, or provided comments on the plan.

Endorsements

The following organizations accept the *Wabamun Lake Watershed Management Plan (2020)* as information and resolve to:

> *1. work collaboratively through the Wabamun Watershed Management Plan Steering Committee to implement the plan as time and resources allow; and*
>
> *2. consider the plan in their own programs and activities, including the development of new or updated statutory and other governing documents.*

Organization	Signature, Position	Date

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Executive Summary

Wabamun Lake is a relatively large lake located in central Alberta, about an hour's drive west of Edmonton. Highly valued for recreational boating, fishing and other activities, the lake also supports several long-established communities along its shorelines, with a mix of both permanent and seasonal residents. Wabamun Lake watershed lies within Treaty 6 Territory and is included in Region 4 of the Métis Nation of Alberta: Paul First Nation occupies a portion of the east shore. Over the past several decades, Wabamun Lake has been the subject of a large number of studies, often undertaken in reaction to an activity occurring on or near the lake (e.g., coal mining, a train derailment and fishery declines). Several of these studies have recommended that a Wabamun Lake Watershed Management Plan be developed in order to guide work to ensure the lake remains healthy.

The responsibility for Wabamun Lake health is shared among a number of different jurisdictions, each accountable for different activities. Hence, to coordinate responsibilities, a collaborative approach to lake management is required. The Wabamun Lake Watershed Management Plan Steering Committee, with provincial, municipal and local representation and input, was formed to develop and implement a watershed management plan. The intent of this plan is to ensure that the things we value about the lake (e.g., good water quality for swimming, adequate lake level for boating, good fishing, etc.) are maintained. Additionally, the plan ensures that issues are identified and prioritized; actions are undertaken to address issues; and all together, a comprehensive system of management is put in place such that the Wabamun Lake watershed remains healthy, today and in the future.

The Wabamun Lake Watershed Management Plan (WMP)is guided by a vision:

> *The Wabamun Lake watershed is a healthy ecosystem with a robust economy and a thriving community that actively demonstrates its collective responsibility to steward the lake environment, for current and future generations.*

While lake management is complex and can be looked at through a number of different lenses, this plan focusses on four overarching goals, broken down further into nine objectives, as follows:

1. Good Water Quality
    - *Objective: Surface water quality is maintained or improved throughout the watershed*.
    - *Objective: Lake users are knowledgeable about and able to adapt to lake levels, which fluctuate with natural variability, thereby contributing to lake health.*
    - *Objective: Groundwater quantity and quality is maintained and protected for human consumption and recognized as a component of surface water quantity and quality.*
2. Healthy Aquatic Ecosystems and Biodiversity
    - *Objective: Aquatic ecosystem health is maintained or improved.*

- *Objective: Biodiversity is maintained or improved and the occurrence and spread of invasive species in the watershed is prevented or mitigated.*

3. Wise Land Use
    - *Objective: To the extent possible, natural land cover is retained and land use does not impair lake or watershed health.*
    - *Objective: Policies and plans are aligned between authorities and regulatory bodies such that development does not impair lake watershed health.*
    - *Objective: Knowledge needed to manage the Wabamun Lake watershed is gathered and made available to decision-makers.*
4. Engaged Stewardship
    - *Objective: Residents and visitors are knowledgable about how they can lessen their impact on and contribute to lake health.*
    - *Objective: The community shares its collective responsibility to be the best stewards of the Wabamun Lake watershed and stewardship programs inspire individual and collective action.*

In turn, each objective has a number of strategies and actions that support its achievement. Note however that watershed management plans are advisory only, and actions will only be implemented as time and resources allow. Hence it is important that the plan identifies priorities for implementation as well as key leads responsible for carrying out different tasks, as is done in the Ten Year Workplan included in Appendix 3. Taking a risk-based approach, the Steering Committee agreed that priority areas to focus on in the near future include the following:

Highest Risks:	**Priority WMP Focus Areas:**

• Invasive species
• Blue green algae blooms
• Nutrient overload from:
  ○ residential development
  ○ loss of riparian filter function
  ○ agricultural intensification
• Cumulative effects of development and climate change
	• Maintaining a collaborative WMP implementation governance structure via a representative Steering Committee;
	• Continuing to build on educational activities with an initial focus on invasive species, riparian health and agricultural beneficial practices;
	• Restoring shoreline riparian function;
	• Setting up a robust water quality monitoring program that discerns trends and informs decision-makers;
	• Continuing to align municipal policies, plans and processes (e.g., fertilizer and pesticide bylaws, septic bylaws, building and development requirements) that promote watershed health.

Finally, the plan lists a number of performance measures to be reported on regularly, to ensure the plan is effective. The plan should also be revisited in ten years to ensure it is still relevant, or sooner, if conditions warrant. Although lake management is a long term commitment, it is hoped that the content of this plan will contribute to a healthy Wabamun Lake watershed, for current and future generations to enjoy.

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Acronyms and Abbreviations

ABMI	Alberta Biodiversty Monitoring Institute
AEP	Alberta Environment and Parks
ACA	Alberta Conservation Association
AH	Alberta Health
ALUS	Alternative Land Use Services
EMRB	Edmonton Metropolitan Regional Board
ESA	Environmentally Significant Area
GOA	Government of Alberta
ha	hectare
IDP	Inter-municipal Development Plan
km or km^2	Kilometres or square kilometres
LUB	Land Use Bylaw
m or m^3	metres or cubic metres
mm	millimetres
MDP	Municipal development plan
NSWA	North Saskatchewan Watershed Alliance
RV	Recreational Vehicle
SC	Wabamun Lake Watershed Management Plan Steering Committee
TA	TransAlta
WLSLUP	Wabamun Lake Sub-watershed Land Use Plan (Parkland County)
WMP	watershed management plan
WWMC	Wabamun Watershed Management Council

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Introduction

The Lake

Wabamun Lake is a popular recreational lake in Parkland County, central Alberta, about 60 kilometres (km) west of Edmonton. The lake is good-sized, at about 19 km long and 6.5 km at its widest point, with a surface area of about 82 km^2, making it Alberta's 16th largest lake. Like many central Alberta lakes, Wabamun is shallow, with a maximum depth of about 11 metres (m) and an average depth of 6 m.[1]

Group of swimmers on a pier at Wabamun Lake. ca 1914. By Nelson Nix. Provincial Archives of Alberta.

As a favorite location for boating, fishing and other recreational pursuits, Wabamun Lake hosts a number of day-use visitors from nearby Edmonton and area, in both summer and winter.[2] The lake's 57.3 km of shoreline also provides space for a number of settlements (with both seasonal and permanent residents) including the Village of Wabamun, five summer villages, the Hamlet of Fallis, about 25 unincorporated sub-divisions (under the jurisdiction of Parkland County) and several camping facilities. Wabamun Provincial Park and the Paul First Nation occupy much of the east end of the lake.

The Watershed

In addition to recreation, Wabamun Lake is also important for the economic activities that occur around it. This includes coal mining, power generation, agriculture and a number of commercial enterprises (e.g., golf courses, RV parks, etc.). As the health of Wabamun Lake can be affected by these activities, a watershed approach that integrates water and land use management is required.

Although surrounded by a mix of private and public lands, Wabamun Lake does not have a large area draining into it. That is, its watershed is relatively small – about 259 km^2 – or roughly three times the area of the lake. Most of the uplands are to the west and south of the lake (Figure 1). Elevation drops off slightly from west (846 m above sea level) to east (718 m). Waters draining into Wabamun Lake eventually drain to the North Saskatchewan River (via Wabamun Creek). The lake and creek are in turn a

[1] For a detailed write up about the lake, see the Atlas of Alberta Lakes (Mitchell and Prepas 1990).

[2] Although its numbers are outdated, the Alberta Water Resource Division conducted The W*abamun Lake Study* in 1970, which looked at recreation area, recreation water use and recreation revenue. More recently, Alberta Culture and Tourism's 2017 Albertan Recreation Survey and the Outdoor Council of Canada's The Economic Impact of Non-Motorized Recreation in Alberta (2018) provide some interesting statistics on swimming, fishing and boating in the province.

part of the Modeste sub-watershed, which in turn is a part of the larger North Saskatchewan River watershed.

Agriculture (crop and livestock) and coal mining activities (which will, for the most part, be returned to agriculture in the future) occur in about half of the watershed. Despite this large footprint, a fair amount of native forest, shrublands and smaller waterbodies remain, with only a small area of urban (mostly concentrated around the lakeshore) and other linear development (such as Highway 16, the CN Rail mainline, Trans Mountain pipeline and power transmission lines).

For a detailed description of both Wabamun Lake and its watershed, see the Atlas of Alberta Lakes (Mitchell and Prepas, 1990). For more information about the Modeste sub-watershed and the North Saskatchewan River, see the North Saskatchewan Watershed Alliance's 2005 The State of the North Saskatchewan River Watershed Report. Additionally, there are a large number of comprehensive reports that provide more descriptive material about different aspects of Wabamun Lake. A number of these can be found on the Wabamun Watershed Management Council's Studies and Reports webpage or by searching the Government of Alberta's open portal publications database. Finally, see Appendix 2 (Resources) for a list of links (and their full URL) for any references provided in this document.

Lake Wabamun, ca. 1913. [na-4723-60] by Byron-May Co. Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

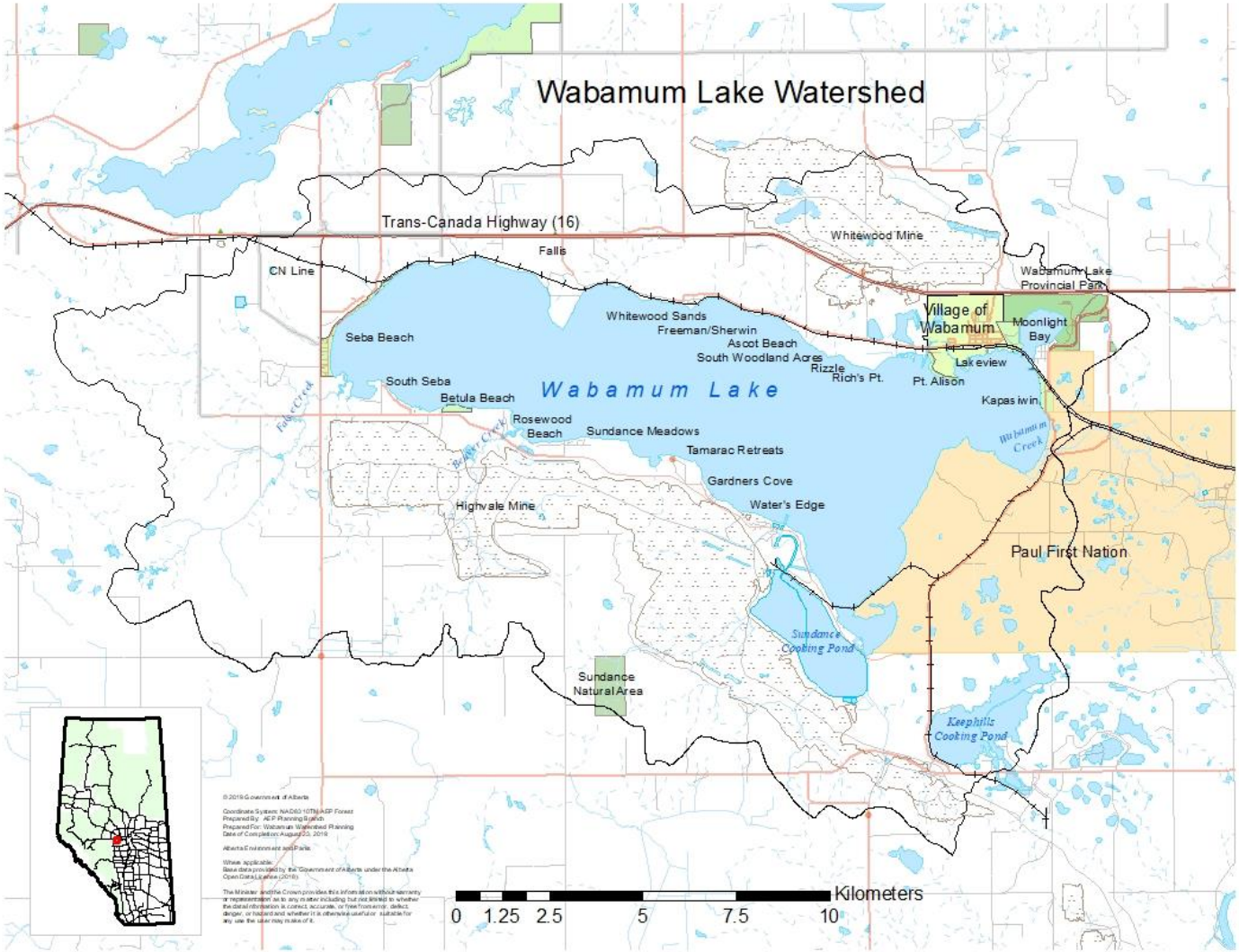

Figure 1. Wabamun Lake and the area of land (watershed) that drains into it (Produced by the Government of Alberta, 2019).

Brief Summary of Early History and Settlement

Like many central Alberta waterbodies, Wabamun Lake was formed as the eastern continental Laurentide and western Cordilleran ice sheets receded from the area to form an 'ice-free corridor' approximately 16,000 years ago. Today, the lake lies within the Wabamun Meltwater Channel[3], cut by waters flowing from the melting glaciers that once covered the land.

What's in a Name?

Over time, Wabamun Lake, or Lake Wabamun as some call it, has enjoyed a number of different names, depending on the people who frequented it. Palliser's party called it 'White Lake' as they passed through the area in 1860, supposedly because it was so clear and blue. At one time, the lake was called 'White Whale Lake' for the large whitefish caught there. The current name, Wabamun, is believe to be derived from the Cree word 'Wapamoun' for 'mirror' or 'looking glass', a reference to the lake's clarity.

As the ice receded, the land around the lake was slowly revegetated, then re-populated by a variety of animals and eventually, humans. Pollen samples (see Holloway et al. 1981) indicate the area was tundra-like up until 11,750 years ago, when birch and alder, followed by conifer forest colonized the area. About 2,000 years ago, the poplar forests of today's Parkland became more common.

Archaeological work, carried out in the Wabamun area since the mid-1970s (see Wright in Hillerud 1979) and still today, suggests that a variety of indigenous people have utilized Wabamun Lake for at least the last 9,000 years. The Ahai Mneh archaeological dig site, just south of the lake, provides a picture of a seasonal camp where tool making occurred from early Clovis period, right up to the Late Precontact and Historic Periods (Hallson 2017).

By the time the fur-trade arrived, the area was well utilized. In 1799, both the northwest Company (White Mud House) and the Hudson's Bay Company (Terre Blanche Fort) built competing forts on the North Saskatchewan River just downstream of Wabamun Creek. However, both were abandoned by 1801. James Bird Jr. of the HBC built a post on the North Saskatchewan River near Wabamun Creek, then known as White Mud River in 1820. It was also short lived, being abandoned in 1821.[4]

After signing Treaty 6, the Paul First Nation (named after Chief Paul) of Stoney (Assiniboine) origin, broke off from the Alexis band and settled on the southeast shore of what was then called White Whale Lake in 1880. The Government of Canada set aside land in 1892 for what became the Paul Band on the Wabamun Indian Reserve.[5] Today, the Wabamun Lake watershed lies within Treaty 6 Territory and is included in Region 4 of the Métis Nation of Alberta. The shores of Wabamun Lake are also home to the Village of Wabamun and five Summer Villages. The community of Wabamun was officially incorporated as a Village in 1912. As described on the Village's website:

[3] For more about meltwater channels, see page 20 of Parkland County's Environmental Conservation Master Plan.
[4] See Historic Sites of Alberta (1953) by Hugh Dempsey.
[5] For a brief history of the Paul Band, see *Schooling in Paul Band, 1893-1923* by Ruby Bird (1998).

Originally, it was situated on the northwest corner of Moonlight Bay. With the arrival of the Grand Trunk Pacific Railway, the community was moved across the ice in the winter of 1911-12 to its present location. The railway company promoted Wabamun as a summer resort to encourage tourists from Edmonton. The rail line also allowed for the development of a commercial fishing industry with fish shipped by boxcar, at first to Edmonton, but later as far away as New York. In winter, ice was cut from the lake to supply railway refrigeration cars. Additionally, the rail line allowed development of the nearby coal resources. Initially, coal was used locally for domestic heating purposes. Later it was also shipped by rail to a power generating station in Edmonton.

Following a similar timeline, Lakeview, once a part of the Village of Wabamun, became its own entity in October 1913. This was done to better serve its seasonal cottage population as compared to the more permanent residents of Wabamun village.

The first cabin at Kapasiwin, ca. 1910. [na-5164-1]
Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

The first cabin built at Kapasiwin was in 1910 but it was first incorporated as the Village of Wabamun Beach in 1913. It was renamed as the Village Municipality of Kapasiwin on August 20, 1918 and officially incorporated as the Summer Village of Kapasiwin on September 1, 1993.[6]

Seba Beach, located on the western end of Lake Wabamun, was incorporated in 1920. The name Seba, a biblical reference, was chosen by the postal authorities when the post office was opened there in 1915. A motor launch, the Lady Belle, used to ferry cottagers from the train station at Fallis to their homes at Seba Beach. At one time, this settlement supported a whitefish cannery. Although cottage development continued to occur around the lake after 1920, no additional communities were formalized for several decades until Point Alison was designated a summer village in 1950 followed by Betula Beach in 1960.

Finally, the remainder of the Wabamun watershed, including the Hamlet of Fallis and 27 subdivisions around the lake, came to be administered by Parkland County. As per the County's history webpage, in the beginning, Parkland County was four townships, known as the Small Improvement Districts. In 1913, the Local Improvement Districts (LID) replaced the Small Improvement Districts, and the eastern portion of what is now Parkland County became LID Number 519. The western portion became the Municipal District of Tomahawk Number 521, and between the two was LID Number 521. The three municipalities amalgamated in 1942 and, together, they formed the Municipal District of Stony Plain No. 520. In July 1968, a public hearing discussed the possibility of combining the MD of Stony Plain and the Stony Plain School Division. In January 1969, the two groups united and were incorporated as the County of Parkland No. 31.

[6] For a look at several interesting historical documents, see the Summer Village of Kapasiwin history webpage.

Previous Lake Studies and Management Initiatives

Wabamun Lake has long been a subject of interest and is likely one of the most studied lakes in Alberta. It also has a lengthy history of being affected by human activities, with the establishment of coal mining activity in the area about 1910 and construction of the weir on the only lake outlet, Wabamun Creek, about 1912.

Wabamun Lake was also important for much of the past century for the subsistence, commercial and recreational fisheries it supported. This resource attracted the attention of early fisheries biologists throughout the 1950s and 1960s. In the 1970s, researchers turned their focus to water quality and the impacts of coal mining and power generation on the lake. By this time, both the Whitewood (est. 1962) and Highvale (est. 1970) coal mines were in operation, eventually supplying the Wabamun (est. 1956), Sundance (est. 1970) and Keephills (est. 1983) power generating plants.

Commercial fishing on Wabamun Lake. [NA-4723-44] Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

In 1980, the Minister of Environment struck the *Lake Wabamun Watershed Advisory Committee* to examine a number of issues raised by users including weed growth, water quality, lake level and land use around the lake. In their *Lake Wabamun Final Report* (1983), the Committee called for a lake management plan to be prepared. The *Lake Wabamun Management Plan*, prepared by Marshall Macklin Monaghan Western Limited for the Yellowhead Regional Planning Commission in 1985, looked at both surface water and land use. Also in 1985, the *Lake Wabamun Eutrophication Study* (Mitchell 1985) was released in an effort to address public concerns that water quality in this important recreational lake was deteriorating.

Drier than usual conditions in the late 1980s and early 1990s resulted in a gradual decline in lake water level. Industrial activities in the watershed also contributed to this decline via the loss of surface run-off that would have occurred naturally but that was now diverted from the lake by coal mining activities. To rectify this situation, TransAlta built the Wabamun Lake Water Treatment Facility in 1997. The facility treats water from the Sundance cooling pond, producing treated water that is put back into Wabamun Lake to make up for the lack of natural run-off from lands being mined. Water from the cooling pond is replaced by water withdrawn from the North Saskatchewan River (as well as wastewater from the Sundance Power Plant, local plant site runoff and runoff and wastewater from Highvale Mine).

After receiving a number of complaints about murky water near the Wabamun Power Plant ash lagoon discharge, Alberta Environment undertook sediment sampling in 2002, finding elevated concentrations of some trace metals near the area.[7] In response, TransAlta commissioned a risk assessment of the site.[8] They also found trace metals in lake sediments but below levels affecting human health, wildlife or fish populations. Their report indicated that the sources of metals in sediments included local emissions, regional geology and global emissions; residential, industrial and agricultural activities; and natural physical and geochemical processes within the lake. *(Note: The Wabamun Power Plant was decommissioned in 2010, at which time the Whitewood coal mine ceased coal processing. Today, the mine site of 1900 hectares has been completely reclaimed, largely to agriculture with some wetland and forested areas. Parkland County approved a 'conceptual plan' for the Whitewood area in March 2018.)*

In December of 2002, then Minister of Alberta Environment Lorne Taylor asked Dr. David Schindler to chair a committee of eight experts to review the scientific studies of Wabamun Lake, write a review of the lake's current state, and make recommendations to guide future management. In November 2004, Schindler released *Lake Wabamun: A Review of Scientific Studies and Environmental Impacts*. This report found that, in general, the lake was in relatively good condition. However, several key issues were identified including poor fishing as a result of overharvest and habitat loss; increasing lake salinity likely due to a combination of industrial and climatic conditions; historical increases in nutrients and algal abundance (although levels were stable at the time); and an increase in mercury deposition to the lake's sediments several-fold over background. (This was believed to be the result of regional emissions, in addition to long-range transport of industrial emissions from other areas. However, the report also noted that mercury had not methylated and hence was not dangerous to aquatic life with concentrations in fish within consumption guidelines. In 2010, TransAlta decommissioned the Wabamun Power Plant and implemented mercury capture technology at their remaining power plants. These changes have reduced mercury emissions by an average of 80% per year. The recent initiative to transition from coal fuel to natural gas is also resulting in further reductions of mercury emissions.)

Schindler's report contained several recommendations to improve the health of the lake. One of the recommendations was: "*that a permanent citizen panel, whose objective it is to protect the health of Wabamun Lake….be established and maintained. This panel must have members who are selected by, and representative of, the community of Wabamun Lake users.*" In response to Dr. Schindler's recommendation, the Wabamun Watershed Management Council (WWMC) was formed.

On August 3, 2005, a CN train taking heavy oil from Edmonton to the West Coast derailed after hitting a faulty section of track on the north shore of Wabamun Lake, with 43 cars leaving the track. About 800,000 litres of heavy bunker and pole treating oils were spilled into the lake. Lake users were warned to stay off the lake and avoid using water for drinking or watering gardens for the remainder of the year.

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[7] See An overview of recent studies on Wabamun Lake (Alberta Environment 2002) and Toxicity Assessment of Wabamun Lake Sediments (HydroQual 2003). Note that Alberta Environment also compiled a 20-year history of water quality studies on Wabamun Lake: see Wabamun Lake Water Quality: 1982 – 2001 (Casey 2003).

[8] The TransAlta risk assessment was carried out by Golder Associates. See a brief summary in Kilowatt Connections, April 2005.

The lake re-opened the following summer but health warnings about tar balls and oil sheen were made into 2007 and cleanup continued for several years after the initial spill.[9]

After getting established in 2006, the WWMC undertook several education and stewardship activities including a shoreline naturalization project in 2009-10. In 2013, they looked at the health of the watershed as per the *Wabamun Lake State of the Watershed Report* (Aquality 2013). This report summarized existing and historical knowledge of Wabamun Lake, identified and assessed the state of several criteria and made several recommendations including that: "*the Wabamun Watershed Management Council, Alberta Environment and Sustainable Resource Development, and Parkland County partner immediately to begin the watershed planning process.*"

Much of the Wabamun Lake watershed lies within the boundaries of Parkland County, hence, this municipality has a large role in its management. Between 2014 - 2016, the county, in collaboration with the WWMC and other stakeholders, commissioned the *Wabamun Lake Sub-Watershed Land Use Plan* (WLSLUP*)*. The Plan, which was accepted as information by Parkland County Council in November 2016, aims to develop and implement responsible land-use practices to assist in maintaining or improving the health of the watershed.

While the County's plan addresses land use in the Wabamun watershed under County jurisdiction, it doesn't address all land and water issues affecting the lake. Nor does it engage other jurisdictions or interest groups in the area in lake management. Therefore, the WWMC approached the North Saskatchewan Watershed Alliance (NSWA) in 2016 to assist with the development of a Wabamun Lake watershed management plan (WMP) in order to address these gaps. Project terms of reference were drafted in February 2017 and the multi-stakeholder Wabamun Lake Watershed Management Plan Steering Committee started meeting in the fall of 2017.

Today, the Wabamun Lake watershed continues to be a busy place. Funded by the provincial government, the Alberta Lake Management Society continues to collect water quality and other information about the lake. Parkland County and other municipalities continue to commit to a watershed approach through their policies, plans and programs. The Wabamun Watershed Management Council continues to build awareness about lake issues and what lake users can do to lessen their impact. Building on this strong history of collaborative lake stewardship, the Wabamun Watershed Management Plan Steering Committee has developed this watershed management plan as a roadmap for the next 25 years of working for the health of the Wabamun Lake watershed.

[9] For more information on the Wabamun rail spill, see the Transportation Safety Board report. Note there are also several reports on the impacts of the CN Rail oil spill on the GOA open portal such as Wabamun Lake oil spill August 2005: data report for water and sediment quality in the pelagic area of the lake (August 4-5 to September 15, 2005).

Plan Purpose and Goals

According to those that live, work or recreate at Wabamun Lake, this waterbody and its surrounding watershed is highly valued by many and for many different reasons. Although a current economic valuation has not been compiled for this area, a look at the industry and commercial ventures around the lake, local real estate values, as well as the many goods and services required by lake users (e.g., builders, renovators, real estate agents, hardware stores, boat and other recreational sales), makes it easy to imagine the significant contribution that this recreational gem makes to the local economy.

As well as economic value, Wabamun Lake also provides a number of social and environmental goods and services that are hard to put a dollar figure on. From a societal perspective, the lake and surrounding area is culturally significant and aesthetically important to those that reside and recreate there. It is also ecologically important for the biodiversity inhabiting this area, particularly fish and waterfowl. Additionally, these values will continue to appreciate over time as population increases in the Greater Edmonton area continues to put pressure on nearby recreational opportunities, and as climate change affects the quality of smaller and shallower lakes in the region.

In order to protect these cultural, social, economic and environmental values, Wabamun Lake requires active management where the precautionary principle is applied and where managers are proactive in providing long-term direction to maintain the quality of the lake and its watershed. The Wabamun Lake WMP is intended to provide this direction. Additionally, the plan will:

- Provide a watershed approach to lake management in order to safeguard lake health, community benefit and economic value;
- Put into play an iterative and adaptive management process (see Figure 2) for watershed management with clear goals and performance measures;
- Support the alignment of Indigenous, municipal, regional and provincial policies and planning initiatives such that, when taken together, such policies and plans support lake and watershed health;
- Coordinate intermunicipal collaboration and stakeholder involvement to ensure successful implementation of strategies and actions;
- Promote stewardship projects to be carried out alongside implementation of the plan; and
- Continue to identify and address knowledge gaps as they become known.

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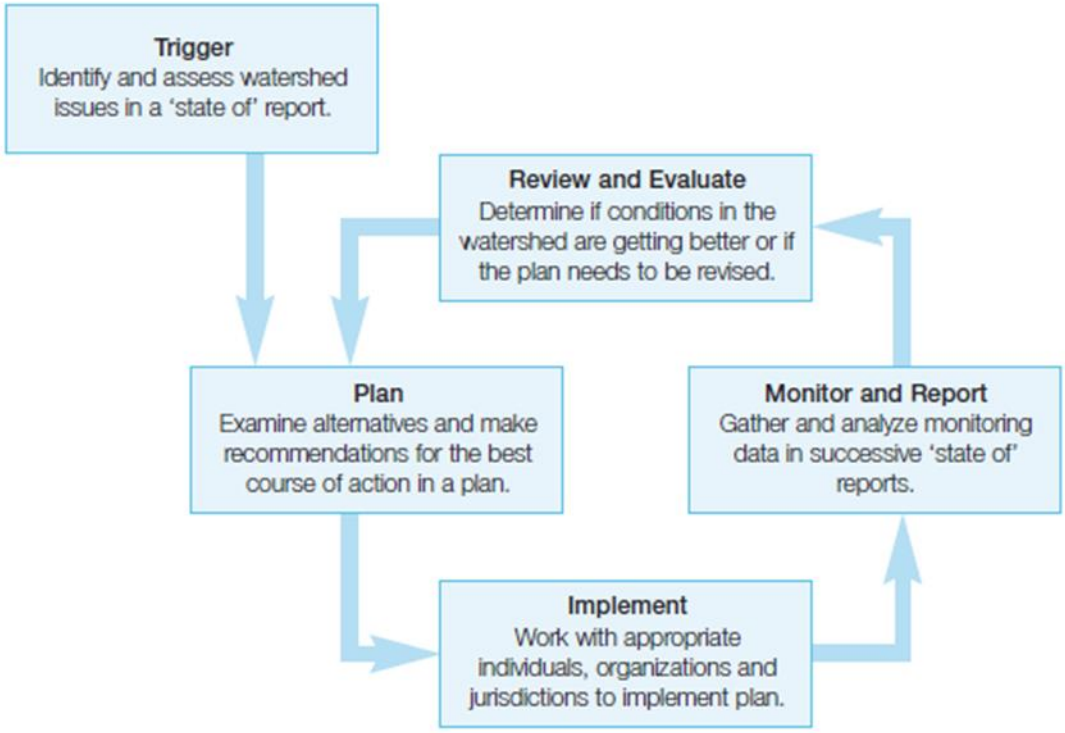

Figure 2. An iterative and adaptive approach to watershed management as outlined in [Enabling Partnerships: A framework in support of the Water for Life strategy].

Skating party on Wabamun Lake. [NA-4723-37] Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

Every day, provincial, municipal and Indigenous governments, industry, private landowners, and others in the Wabamun Lake watershed make land use and other decisions that can affect lake health: in many ways, the lake is an indicator of the activities going on around it. While many of these decisions are well intentioned, it is difficult to see the 'big picture' and if individual actions by different jurisdictions are complementary to lake and watershed well-being. A watershed management plan is meant to provide this landscape level view. A plan is also a tool to coordinate who is doing what, in order to ensure activities are integrated and that they lead to a collective shared goal or outcome. In the Wabamun watershed, stakeholders are guided by the following shared vision:

> Vision: *"The Wabamun watershed is a healthy ecosystem with a robust economy and a thriving community that demonstrates its collective responsibility to be the best stewards of the lake environment, for current and future generations."*

Throughout its review of previous studies, plans and other documents, and in discussion with stakeholders, the Steering Committee identified a number of areas of concern that affect the achievement of this shared vision, and that a Wabamun Watershed Management Plan should address. These concerns were grouped under the following four goals for the Wabamun Lake watershed:

1. Good Water Quality
2. Healthy Aquatic Ecosystems and Biodiversity
3. Wise Land Use
4. Engaged Stewards

These goals are discussed in more detail in the following sections. For each, we look at what is the issue, what is known about it, what can be done about it, and who needs to be involved to be successful.

Seba Beach ca. 1900. [NA-4723-54] Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

Goal: Good Water Quality

Water quality is paramount for aquatic ecosystem health. It is also important to recreational users for many different activities. While studies in the past have focused on water quality in the lake, the contribution of tributary flows and interactions with groundwater are also important areas to examine. Water quality is also tied to water quantity (i.e., lake level as well as incoming and outgoing flows), another area that requires investigation.

Lake and Tributary Water Quality

What is the issue?

Lake users want lake water to continue to be aesthetically pleasing (good clarity), as well as of sufficient quality to maintain water-related activities like swimming, fishing, and boating, without endangering human or animal health. (Note that while most lake property owners get their treated drinking water from other sources, some may also draw raw lake water for other domestic uses. Such users should be aware that untreated water from lakes, streams and rivers can be a source of harmful microbes such as *E. coli* or parasites such as Cryptosporidium and Giardia. Untreated water should not be used for drinking water, preparing food, washing dishes or brushing your teeth. Water from a lake experiencing a blue-green algae outbreak should also not be used for these activities, or for watering a garden, or any other activity that could potentially bring toxins in contact with humans, pets or livestock.[10])

For the most part, Wabamun Lake water quality is regularly sampled and the issues affecting lake water quality have been identified in previous reports and studies. Less is known about the water quality of tributary streams and local groundwater. Upcoming issues, like increasing recreational and residential development, agricultural intensification and climate change, may also affect water quality in the near future.

What do we know about it?

Wabamun Lake has been monitored regularly since 1982. This includes monthly sampling for water quality (including water chemistry, nutrients, algae/chlorophyll-*a*, metals and pesticides) and plankton during open water (May through October), as well as once during winter (February).

Wabamun is naturally nutrient rich and productive (mesotrophic to eutrophic) and thus can become 'weedy' (with native aquatic plant species) over the summer months. According to a paleolimnological study (Hutchinson Environmental 2016), Wabamun Lake has been nutrient rich for at least the past 200 years. While the conversion of natural areas to agricultural lands and the growth of lakeside communities in the 20th century probably added to this richness, nutrient levels have actually been declining in more recent years (Associated Environmental 2018). Despite this, the lake, naturally prone to algal growth, had its first report of a blue-green algae bloom in the summer of 2019.

[10] For more information, see Alberta Health's Blue-Green Algae and Drinking Water in the Backcountry webpages.

From *Wabamun Lake State of Report* (Aquality 2013) Indicator Assessment – Water Quality		
Indicator	**Rating**	**Description**
Nutrients and routine parameters	Good	Average total phosphorus concentrations of 0.03 mg/L and total nitrogen concentrations of 0.09 mg/L. (Note that this rating was based on the Surface Water Quality Index which has since been removed. It was arbitrarily set at .05 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 were below guidelines.

To improve our understanding of where nutrients are coming from, Tuininga et al., building on earlier work, developed a BATHTUB eutrophication model for Wabamun Lake in 2015. This model showed a large portion of the lake's phosphorus budget coming from internal sediment loading (37%) and precipitation (15%), with the remainder from sub-watershed streams and surface run-off (48%) and the Water Treatment Plant (1%). Generally, those areas with more urban and agricultural development contribute more Phosphorus loading potential. This is also shown by a Phosphorus loading model produced by the Alberta Biodiversity Monitoring Institute (ABMI) shown in Figure 3.

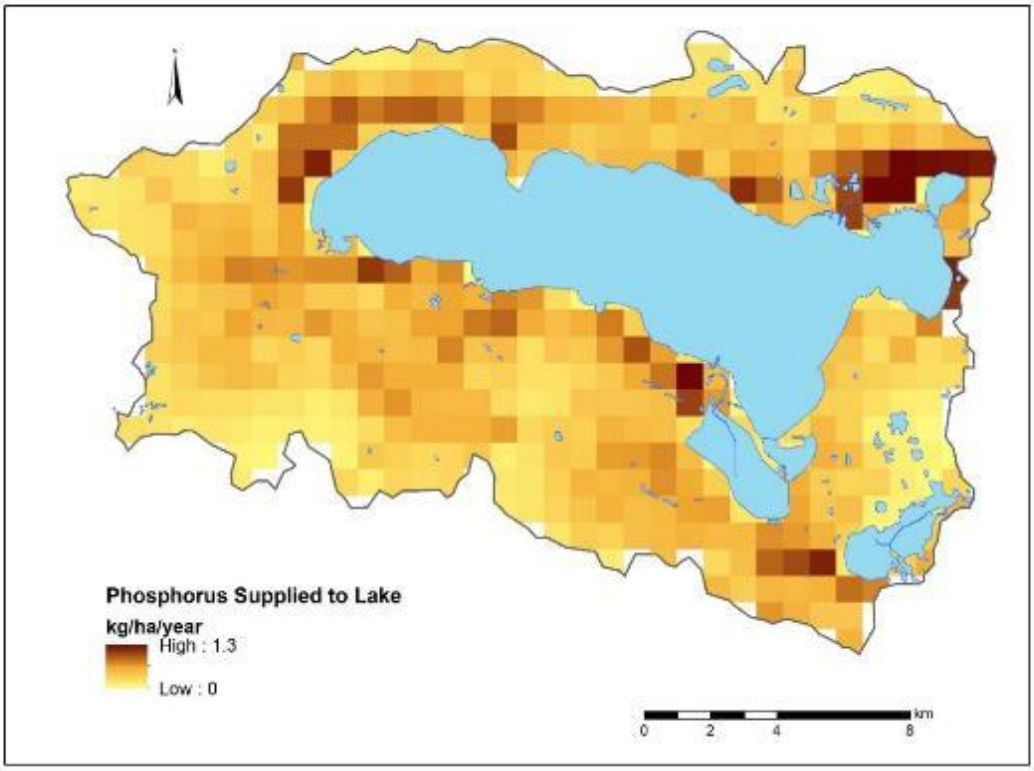

Figure 3. Phosphorus loading at Wabamun Lake as modeled by ABMI using their ecosystem services model.

These findings were similar to work commissioned by Alberta Environment in 2008 to undertake a nutrient balance study of Wabamun Lake (Emmerton 2011). Although dated, this study determined that 44% of phosphorus affecting the lake came from lake sediment. This high internal load of nutrients is released under certain conditions, adding nutrients to lake waters and contributing to plant and algal growth. Other sources of nutrients included precipitation (44%), groundwater (5%), surface run-off (3%), industry-related activities (e.g., the ash settling lagoon and water treatment plant) (3%) and domestic sewage (1%). The decade prior to this study was very dry with little contributions from surface run-off, which may have influenced study percentages. Researchers compared this to a similar study done in the 1980s (Mitchell 1985), when conditions were very wet, with more run-off bringing a greater contribution of nutrients to the lake.

In addition to being nutrient rich, Wabamun Lake may also be getting 'saltier' over time, similar to other waterbodies in Alberta.[11] A 20-year history of water quality by Alberta Environment (Casey 2003) showed that ion concentrations (i.e. salinity) in the lake had increased over this time period. This was believed to be due in part to road run-off, as well as inputs from the Wabamun Lake Water Treatment Plant. (While a variety of disinfection by-products, discharged by the plant at the time, were found throughout the lake, concentrations were low, diluted by lake volume, below thresholds affecting human or animal health, and thus not of major concern). An upward trend in ionic strength was also reconfirmed by Casey (2011) and shown in the 2018 Alberta Environment and Parks (AEP) water quality report (Associated Environmental 2018), which added climatic drivers leading to evaporative enrichment as another reason why this change in lake chemistry may be occurring.

To understand long-term trends in water quality better, a number of studies of lake sediments have been done on Wabamun Lake. These studies have shown increased trace metal concentrations. In particular, arsenic, cadmium, chromium, copper and zinc sometimes exceed sediment guidelines. Additionally, mercury is high, relative to other Alberta lakes, but below guidelines. Wabamun Lake sediments also show increased polycyclic aromatic hydrocarbons (PAH) deposition relative to other lakes in the region, due in part to the power plants on the lake.

In some areas, Alberta lakes can also be affected by air-borne pollutants. An air quality monitoring study was carried out at Wabamun from 2004 to 2007. Additionally, TransAlta does biophysical monitoring on the impacts of its airborne pollutants on Wabamun and a couple of other lakes in the area. To date, no samples reported air quality objectives being exceeded. In the near future, the conversion of seven coal-fired generating units to natural gas at the Keephills and Sundance power plants should further reduce any potential air quality issues in the Wabamun area.[12]

As a natural environment, Wabamun Lake can be home to a number of pathogens, like Giardia and Cryptosporidium. Swimmer's itch, caused by a naturally-occurring parasite, can also occur. As well, beaches can be sites of increased fecal coliforms associated with humans or other warm-blooded

[11] For example, see this study of salinization in the South Saskatchewan River Basin (Kerr 2017).

[12] For more on this conversion, see the TransAlta webpage at https://www.transalta.com/about-us/coal-to-gas/.

animals. Wabamun is also monitored for cells and toxins of cyanobacteria (blue-green algae) due to their human health risks. Beaches are monitored by Alberta Health throughout the summer and can be closed if a health issue arises.

To compound issues with nutrients, salts and other contaminants, Wabamun Lake is almost like a closed basin. That is, it has a small drainage area, relative to lake size, with only a few small, mostly intermittent streams providing inflows. Additionally, the weir on the lake's only outflow, Wabamun Creek, limits the ability of the lake to maximize flushing flow, with very little outflow (only in very wet years) to the North Saskatchewan River.[13] Hence, what goes in the lake stays there for a long time, sometimes decades, and is concentrated as the lake level decreases in late summer due to evapotranspiration. With high lake levels in more recent years, this aspect of the lake has garnered some attention and should be studied more in order to determine the impact of inflows and outflows on water quality.

The weir also impacts downstream flows and and the quality of downstream fish habitat. Note that as the upstream waterbody, Wabamun Lake users also bear some responsibility for the water quality of Wabamun Creek. Recently, EPCOR and several partners undertook enhanced sampling of several tributaries to the North Saskatchewan and produced the report *"Relationship between Beef Production and Waterborne Parasites (Cryptosporidium spp. and Giardia spp.) in the NSR basin, Alberta, Canada"*. This and the City of Edmonton's Source Water Protection Plan show that the water quality in Wabamun Creek is affected by upstream agricultural run-off and municipal wastewater management.

Surface run-off also brings water directly to the lake. Compounding the water quality issue, where cottage development and redevelopment around the lake has resulted in the degradation of riparian areas, run-off waters are no longer filtered before entering the lake, and hence may contain sediment from erosion, cosmetic fertilizers and pesticides, pet waste, etc. Run-off from surrounding land uses also introduces contaminants (sediment, fertilizers, pesticides, livestock manure, etc.) to the lake via tributary streams and run-off. The role of inflowing streams and run-off in the Wabamun watershed, and the source of contaminants they may carry, are not well understood. [14] However, the cumulative effect of land use activities and climate change are likely to continue to affect water chemistry and potentially, water quality of Wabamun Lake, now and in the future.

What can we do about it?

The *Wabamun Lake Subwatershed Land Use Plan,* commissioned by Parkland County in 2015, identified the need to develop and implement a *surface water quality management strategy* for Wabamun Lake. AEP commissioned a report (Associated Environmental 2018) that defines the current and historical

[13] Annual average discharge at the Wabamun outlet is 0.199 m^3/s or approximately 6 million m^3/year; 1.17% of total lake volume of 513 million m^3. This requires 85 years on average for lake waters to completely turn-over.

[14] The NSWA summarized stream nutrient monitoring data for several Alberta lakes, noting that 14 Wabamun lake streams were sampled in 1980-81 (Mitchell 1985) and seven streams were sampled in 2008 (Emmerton 2008). While data varied a great deal, in general, streams flowing through predominately agricultural lands had higher nutrient concentrations than those flowing through forested lands.

condition of surface water quality in Wabamun Lake, as well as identifying trends, potential stressors, and possible chemical indicators to inform the development of a management strategy that would include setting and monitoring site-specific water quality goals. An initial list of potential water quality parameters is provided in Table 1. Note however this list is only a starting point for discussion and can be investigated further and refined over time. It might also be broadened to a larger suite of watershed goals (e.g., lake level, stream flow, riparian health), with water quality parameters only a subset of performance measures to guide adaptive management in the future.

Once set, water quality goals can be achieved by preventing point and non-point source pollution from entering the lake in the first place. This can be achieved by using a variety of both statutory (e.g. bylaws, development regulations) and non-statutory (e.g. education, stewardship) tools to manage, and hopefully, reduce nutrient loading. For example, Schindler (2004) recommended preventing further external loading by enforcing more stringent guidelines for land-use changes, cottage development, waste disposal and fertilizer use. He also advocated for more public education.

As a first step to achieve a goal of 'good water quality', we can start with an objective that current surface water quality is maintained or improved for the lake, as well as for the tributaries and other sources that contribute to it. We then need to develop and implement strategies that will let us understand what current conditions are, and what factors are contributing to this condition, before we can implement more specific management actions, as detailed in Appendix 3 (Ten Year Workplan).

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WABAMUN LAKE WMP GOAL: GOOD WATER QUALITY

Objective: Current surface water quality is maintained or improved throughout the watershed.

Strategy: Undertake adaptive management by developing, monitoring and reporting on surface water quality and other goals that inform management actions.

Strategy: Improve our understanding of current and future sources of nutrient and contaminant loading through targeted research and modeling.

Table 1. Examples of Potential Parameters that could be used in a Watershed Health monitoring program.				
Value or Issue being monitored	**Potential Variable of Concern**	**Historical and Current Status/ Trend**	**Relationship to Guideline**	**Management, Triggers, Limits**
Climate Change	Alkalinity (mean CaCO3 mg/L)	213/Increasing	Below guideline but increasing	
	Chloride (mean dissolved mg/L)	12 / Increasing	Well below guideline of 120 mg/L but incr.	
Fisheries	Barium and manganese	higher in northern pike relative to whitefish		Currently all recreational fisheries catch and release only. Consumption advisory on N. Pike > 7 lbs.
	Mercury (fish tissue)	higher in northern pike relative to whitefish; weakly correlated (p=0.002) with age; Occasional exceedance of mercury for human consumption in some northern pike		
Human Health	Arsenic (sediment) µg/g	concentrations > 5.9	exceeded guideline in 2/3 samples	Monitored via AB Health drinking water well testing program
Water Quantity	Lake Level			Gauge at Wabamun Village
	Stream Flow			Gauge on Wabamun Creek
	Total Phosphorus (mean total mg/L)	0.029 / Decreasing	No guideline	No increase in TP over existing conditions
	Total Kjeldahl Nitrogen mean mg/L	0.94 / increasing		No increase in TN over existing;
	Chlorophyll-a (mg/m3) (eutrophication)	10.68 / seasonal increase but decreasing overall	No guideline	Monitored by ALMS
	Secchi depth mean m	2.4 /seasonal decline but stable overall	Declines over summer but stable	
Recreation	Beach safety	fecal coliforms, parasites, blue green algae blooms		Monitored by beach operators/ AH
Riparian Health	intactness	Declining		Assessed by NSWA.
Water Quality for Aquatic Life	field and lab pH	higher than recommended limit for protection of aquatic life		ALMS
	fluoride	exceeds chronic guideline for protection of aquatic life		
Water Quality for Agriculture	Sodium Absorption Ratio	14.8 / High	Exceeds levels for irrigation	Parkland promotes BMPs via ALUS, Green Acreages programs
Other potential parameters:	Benthic invertebrates, dissolved oxygen, fertilizers, invasive species, other trace metals, PAHs, pesticides, plankton, precipitation, water temperature, etc.			

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Lake Level

What is the issue?

Lake level has been a topic of discussion at Wabamun Lake for decades. Like all Alberta waterbodies, lake level fluctuates between the seasons and from year to year. As mentioned previously, flows into and out of the lake can affect water quality. Additionally, high water levels can erode shorelines and significantly damage infrastructure (e.g., boat lifts, docks[15] and buildings). Low lake levels can affect aesthetics and recreational enjoyment. Wabamun Lake saw a significant decline in lake level in the drier 1980s and early 1990s. More recently, wetter conditions have led to higher lake levels.

What do we know about it?

Wabamun Lake level, measured over the past century, had an average elevation of 724.33 m above sea level. The maximum lake level recorded was in 1927 at an elevation of 725.17 m. The minimum lake level recorded was in 2002 at elevation 723.69 m. Hence, lake level in the past has varied by about a 1.5 m difference between highs and lows.[16]

In the Wabamun Lake state of the watershed report (Aquality 2013), water quantity was assessed by looking at lake level and water withdrawals, with a rating of 'fair' to reflect a trend towards a declining lake level. However, lake levels have risen in more recent years. To understand this variation, we need to understand the natural lake balance, as well as how inflows, the weir, withdrawals, and other human activities affect this balance. Additionally, future climate change may also affect lake level. These components are examined in more detail below.

From Wabamun Lake State of Report (Aquality 2013) Indicator Assessment – Water Quantity		
Indicator	**Rating**	**Description**
Lake levels and withdrawals	Fair	Normal for the last two years, but with an overall declining trend in lake level.

Lake Water Balance

A lake water balance includes the volume of water in the lake up to the outlet elevation, as well as all of the inputs (i.e. inlet streams, run-off, precipitation) and all of the outputs (i.e. lake evaporation, outlet streams, weir height) affecting this volume.

Precipitation, as both snowfall and rain, raises lake level in wet seasons and wet years. Precipitation as rain generally peaks in July. Snowfall peaks in December-January. However, Wabamun Lake annually loses more water to lake evaporation (670 millimetres [mm]) than it gains from direct lake surface precipitation (541.6 mm).[17] Figure 4 shows the lake level measure at Wabamun Lake station 05DE002 as

[15] Note that Alberta has new docks and moorings regulations. For more information, see this link https://www.alberta.ca/lakeshores.aspx.

[16] Personal communication Yaw Okyere, AEP. For a good overview of Wabamun lake level, see this WWMC website article.

[17] For information on lake evaporation rates in central Alberta, see Evaporatin and Evapotranspiration in Alberta, ESRD, 2013.

per Real-Time Hydrometric Data for Wabamun Lake. See also Alberta Environment and Parks' Alberta Rivers page.

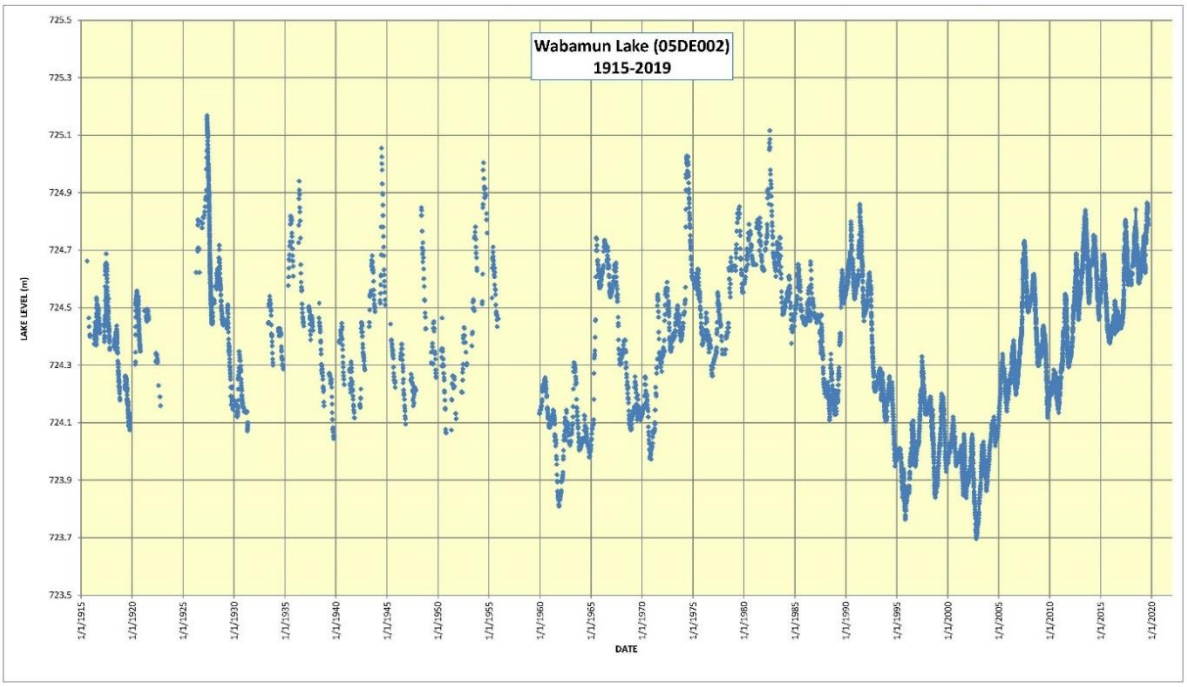

Figure 4. Lake level measure at Wabamun Lake station 05DE002.

Lake water level is influenced by direct precipitation as well as by annual run-off that drains the uplands, bringing water to the lake via streams and direct drainage areas. Wabamun Lake receives water from seven major tributaries or sub-watersheds (Ascot, Coal, Fallis, Freeman, Rosewood, Seba and Seba South creeks). This run-off contributes an annual average of 17.44 mm to the lake. The area drained by these streams' accounts for about 46% (124.8 km^2) of the watershed. Numerous secondary streams make-up another 9% (25 km^2) of the watershed; diffuse run-off accounts for 14% (39.5 km^2). Mine-affected and industrial areas (where run-off is held back) make up a third of the watershed (31% or 83.8 km^2).

Outflow Weir

The only outflow of Wabamun Lake is Wabamun Creek which, in wetter years, carries lake waters to the North Saskatchewan River. However, a weir was built at the mouth of the creek in 1912 and both the weir and creek have been modified several times since.[18] In 1990, the top of the current weir was set at its present elevation of 724.55 m above sea level (slightly above the annual lake level average of 724.25 m). Hence, only when the lake level is higher than this elevation (in an above-average year), do waters flow over the weir. Beaver activity below the weir is also a source of ongoing debate and adhoc

[18] For a good history of the weir and creek outlets, see Alberta Environment's 1987 Wabamun Lake Information Report.

management action. Because they provide many ecological benefits, it is important to maintain some beaver activitiy in the watershed. In the future, beaver management options such as "pond levelers", a technique for lowering water level behind beaver dams, might be worth investigating.[19]

The 1983 Advisory Committee's report identifed issues with beaver dams and the management of the outlet control structure and channel, with committee members calling for Alberta Environment to improve, repair and or replace the weir structure to stabilize the water level of the lake. Schindler (2004) also identifed the weir as an issue for both downstream fisheries habitat (with 1.5 km fish habitat affected) and lake fish spawning and nursery habitats. He recommended that the outlet be modifed to act as a fish passage to allow the upper section of Wabamun Creek to be utilized and to restore the original outlet stream. Today, debate about the weir continues and warrants further investigation.

Water Withdrawals

In years when the lake level is high, water withdrawals are probably not an issue for Wabamun Lake. However, in drier years, water withdrawals may compound issues associated with low water levels. Water withdrawals, other than for domestic household use, are licenced by the Government of Alberta.

The oldest licence issued in the watershed was held by the Village of Wabamun, obtained Feb. 8, 1927, for 120 m^3/year for 'lake level stabilization'. Transalta Corporation has held some of the largest licences for water withdrawals from the lake (May 26, 1967, for 1,850,220 m^3/yr). In the past, these waters were largely used for cooling, before cooling ponds were utilized. (No water has been taken from the lake for cooling since early 2016. No future diversion for this acitivty is anticipated by TransAlta.) The Paul Band First Nation holds the next largest licence at 230,000 m^3/yr for irrigating its golf courses. There are also a number of licences in the upper part of the watershed, largely for stock watering. Note that amounts licenced do not equate to amounts withdrawn or consumed.

Licences	Surface Water (m^3)
Agriculture (stockwatering, irrigation)	15
Commericial (golf courses, aggregate washing)	301,000
Municipal (campgrounds, parks, urban, condo/subdivision developments)	
Other (lake stabilization, flood control, gravel pit/mine drainage)	1,937,180
Total	2,238,195*
* 0.43% of Total Lake Volume 513,000,000 m^3	

TransAlta Mine Reclamation Water Supplement

As coal is extracted from lands around the lake, operators must de-water the mining area and hold back additional surface run-off. To make up for this loss of waters that would have under normal circumstances drained to the lake, TransAlta built the Wabamun Lake Water Treatment Facility in 1997.

[19] For more information about their value and management, see *Beaver: Our Watershed Partner*.

The facility treats water from the Sundance cooling pond, producing treated water that is put back into Wabamun Lake to make up for the lack of natural run-off. Water from the cooling pond is replaced by water withdrawn from the North Saskatchewan River (as well as wastewater from the Sundance Power Plant, local plant site runoff, and runoff and wastewater from Highvale Mine).

The two-plant water treatment facility can pump up to 20 million cubic metres (m^3) of water to the lake each year. This enabled TransAlta to make up its historic water debt to the lake by 2007; since then water has been replaced at a rate that mimics run-off volumes that would have drained to the lake in the previous year of operations. Lake level is not considered in this calculation.

The impact of this water supplement is about 7.2 million m^3 annually[20]; about 1.4% of total average annual lake volume (513 million m^3). This supplement will come to an end as the mines are closed and reclaimed and natural run-off again drains over the landscape to the lake. However, note that mine lands will be reclaimed to a working landscape, with a large agricultural component. Hence run-off chemistry across these lands will not be the same as the treated supplement which in the past has contributed to an increasing trend in sulphates in the lake (Associated Environmental 2018). (The presence of sulphates in the treated water supply has been declining since 2010 due to changes in the treatment process at the Wabamun Lake Water Treatment Plant.) It is currently unknown how these changes will affect water quality but it obviously warrants consideration, particularly around future water quality monitoring requirements.

Climate Trends and Lake Levels

As discussed, water quantity in Wabamun Lake is currently influenced by a number of inputs and outputs. It is currently unknown what the net effect of climate change on this balance will be. Potentially, warmer temperatures could see an increase in lake water temperatures and a corresponding increase in lake evaporation. This loss might be made up by larger late summer rain events.[21] While the overall effect may balance out, it may prove challenging for municipalities and residents to deal with this variability.

What can we do about it?

Fluctuating lake levels are natural and important for maintaining lake health. However, if they fluctuate too far, lake levels can damage property or impair use. Hence, the dilemma is how to live with fluctuating lake levels? Currently the difference between historical lake highs and lows is about 1.5 m (without the weir) or 0.6 m if the weir is maintained at 724.55 m. Note, however, under climate change, the historical maximum and minimums could be exceeded. To reduce risk and uncertainty, some users would like to see the lake artificially managed via alteration of the weir. However, this can be complex, costly and can lead to unintended consequences for other aspects of the lake, like fisheries and aquatic ecosystem health.

[20] See TransAlta water production table at https://www.transalta.com/communities/canada/lake-wabamun/water-production-table/

[21] See the Climate Atlas of Canada for modelled projections for temperature, precipitation, etc.

Another approach is to ensure lake users and surrounding municipalities are prepared and able to adapt to fluctuating lake levels in both flood and drought years. Flood zone mapping or giving property owners a tool to calculate where high and low water is on their property is beneficial. The Wabamun Lake floodplain was delineated by Parkland County in 2015 based on a 1:100 year provincial floodplain map from 1980 that used an elevation of 725.592 m above sea level. The Wabamun Lake floodplain overlay is included in Parkland County's Land Use Bylaw which notes that new structures in the floodplain must be built one metre above the 1:100 year floodplain level. As well, developers may have to take mitigating measures to the satisfaction of the Development Authority to avoid potential flooding.

Finally, we can also look beyond the lake to the rest of the watershed to examine how uplands are storing and slowing the release of waters that ultimately reach the lake. A 'spongy' watershed has adequate wetlands and riparian areas to store and slowly release excess waters to streams and lakes, as opposed to 'flashy' systems that must deal with quick floods and/or drought situations. See more about wetland and riparian area assessments in the healthy aquatic ecosystem section.

As a second step in achieving a goal of 'good water quality', we can recognize the connection between surface water quantity and quality and set an objective that lake users are knowledgeable about and able to adapt to lake levels which fluctuate within a range of seasonal and annual variability. We then need to develop and implement strategies that lead to well-educated lake users and good understanding of future lake level variability, before we can implement more specific management actions as detailed in the Ten Year Workplan (Appendix 3).

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Wabamun Lake WMP Goal: Good Water Quality

Objective: Lake users are knowledgeable about and able to adapt to lake levels, which fluctuate with natural variability, thereby contributing to lake health.

Strategy: Educate lake users about lake level variability and the potential for flood and drought.

Strategy: Improve understanding of current and future lake level variability to inform lake users and managers.

Groundwater Management

What is the issue?

Groundwater was not included in the 2013 Wabamun Lake State of the Watershed report. While there have been some studies since, there are still a lot of unknowns about groundwater in the Wabamun area. However, groundwater is an important source of water for lakeshore and rural residents (acreages and farms). It may also be important to lake water quality and quantity. Hence, it's management is an important consideration in watershed and land use planning processes.

What do we know about it?

Groundwater Contribution to Wabamun Lake Volume

In general, groundwater flows throughout the Wabamun watershed and shallow groundwater does contribute to lake volume. However, lake waters are also lost to groundwater aquifers. Dr. Duane Froese and Katherine Snihur undertook a study to better understand this relationship. This work, undertaken over two years, looked at surface and well water samples provided by volunteers from a number of lakes in Parkland County. Processing involved the study of oxygen and hydrogen isotopes in the water samples. This led to the conclusion that ground water contributes about 4% to Wabamun Lake volumes but also drains about 10% out of the lake to local aquifers. However, other factors, like the timing of this contribution, and its affect on water chemistry, may play a role in overall lake health. (Note that deep aquifers supplying drinking water in the area do not seem to be the groundwater source for the lake.)

Groundwater Use in the Watershed

Many residents throughout the watershed rely on both shallow and deeper groundwater wells for their drinking and domestic water supplies.[22] Most well owners are aware of the need to test their drinking water quality and maintain their wells. Additional information can be provided to well owners via the Government of Alberta (GOA) Working Well program. For the most part, groundwater volumes meet demand. However, in dry years, aquifers may be drawn down faster than they can be recharged.

In its Regional Groundwater Assessment report, Parkland County has produced a 'risk of groundwater contamination' map, that shows areas to the east and south of the lake at moderate risk. Abandoned or improperly managed wells can provide a pathway for aquifer contamination, which in time, could also affect lakes and surface water bodies. Hence, there is a need to build awareness of the importance of groundwater well management and for landowners to properly decommission wells that are no longer in use. For information on decommissioning a well, see the Environmental Farm Plan program webpage.

Additionally, land use activities, like urban development and mining, can influence ground and surface water interactions, particularly where such activities affect key groundwater recharge and discharge areas. While the reclamation of the Highvale mine will see the restoration of surface water run off to the

[22] To view registered wells in the Wabamun area, see the Alberta Water wells website.

lake, it is uncertain how reclamation will affect shallow groundwater flows, and how this in turn will affect lake water quality and quantity.

What can we do about it?

While groundwater does not currently appear to be a major issue for lake health, it is important to those residents who rely on it as a source of domestic and/or drinking water.[23] Hence to achieve the objective that *Groundwater quantity and quality is maintained and protected for human consumption and lake health*, a number of strategies have been developed with corresponding actions detailed in the Ten Year Workplan (Appendix 3).

WABAMUN LAKE WMP GOAL: GOOD WATER QUALITY

Objective: Groundwater quantity and quality is maintained and protected for human consumption and recognized as a component of surface water quantity and quality.

Strategy: Educate groundwater users about well maintenance and how to reduce the risk of well contamination.

Strategy: Improve understanding of groundwater in the Wabamun Lake watershed.

Strategy: Manage development in a manner that minimizes groundwater impacts.

Strategy: Understand the impact of the Highvale mine reclamation on local groundwater flows.

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[23] Note that the proportion of residents reliant on groundwater is likely changing as the EPCOR water line reaches further west.

Goal: Healthy Aquatic Ecosystems and Biodiversity

While recreation is an important value associated with Wabamun Lake, the lake is also highly valued on its own as an important aquatic ecosystem that supports a rich biodiversity and provides other ecological goods and services. More and more, lake managers are also recognizing the importance of aquatic ecosystem health in acheiving lake water quality and quantity objectives.

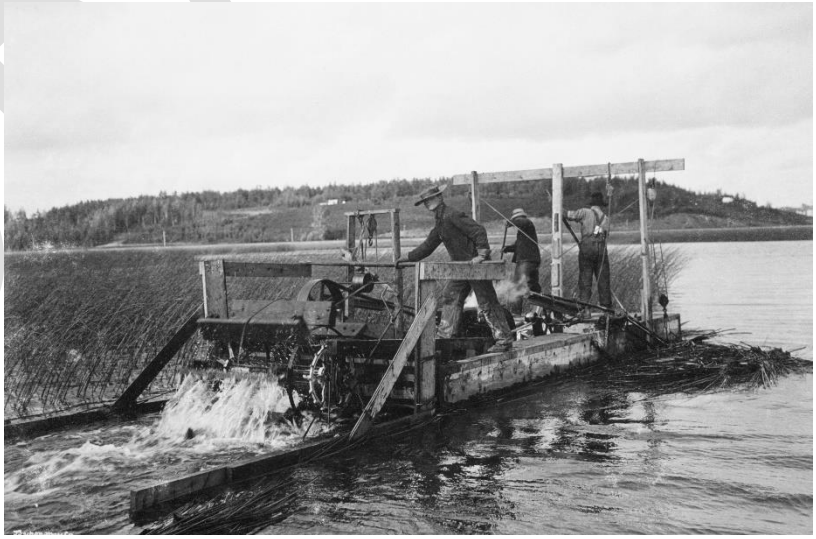
Healthy Aquatic Ecosystems

What is the issue?

An aquatic ecosystem is a body of water in which living and non-living elements interact. This includes the physical, chemical, and biological processes and characteristics of rivers, lakes, riparian areas, wetlands and the plants and animals associated with them. A 'healthy' aquatic ecosystem, as defined by the Alberta Water Council, is "*one that sustains its ecological structure, processes, functions and resiliency within its range of natural variability*".[24] Unfortunately, aquatic ecosystems can be negatively affected by the recreational and land use activities occurring on or around them.

What do we know about it?

Measuring the health of aquatic ecosystems is complex and can involve looking at several components including water quality (discussed previously), littoral zone health, riparian and wetland health, biodiversity and species at risk, and the presence or absence of invasive species. While the focus of this plan is on Wabamun Lake, it is important to note that there are several other aquatic ecosystems in this watershed. This includes a number of small lakes in the headwaters in the southwest, as well as the larger Sundance and Keephills cooling ponds in the southeast. There are also a fair number of small waterbodies in the Paul First Nation reserve. These smaller waterbodies may be important for providing a number of ecological goods and services within the larger watershed, such as providing wildlife habitat as well as storing and slowly releasing water over time. Unfortunately, not much is known about the health of these smaller aquatic ecosystems.



Early efforts at vegetation removal on Wabamun Lake. [na-1328-64786] Used with permission courtesy of Glenbow Archives and Special Collections, University of Calgary.

[24] For more information about this definition, see the Alberta Water Council's Aquatic Ecosystem Health report.

Littoral Zone

Lakes are not uniform and can be divided into different zones, depending on depth, light, productivity, etc. In particular, the littoral zone, or near shore area, is important for a number of reasons. This zone is where sunlight penetrates all the way to the sediment, allowing aquatic plants (macrophytes like bulrushes and cattails) to grow. In turn, these plants provide habitat for fish and other biodiversity such as herons and minnows. The littoral zone can also play a role in managing water quality and reducing shoreline erosion. Unfortunately, activities like weed removal, sand dumping, high speed boating or all-terrain vehicle use, can impair this sensitive area, in turn affecting aquatic ecosystem health.

Riparian Lands

Riparian lands, those areas that are a transition between waterbodies and their surrounding uplands, provide a number of benefits including filtering run-off, stopping erosion, providing habitat, etc. The 2013 Wabamun State of the Watershed Report identified riparian health as a potential indicator; however, insufficient data was available at the time. Hence, the report recommended that a riparian health assessment be conducted. This was done for riparian lands surrounding Wabamun Lake in 2014 (Figure 5). This assessment found 43% of the riparian area surrounding the lake was moderately to highly impaired (partly or fully unable to perform its ecological functions).

This and other survey work[25,26] found that many shoreline properties have removed native riparian vegetation and introduced lawn and other non-native species, sand or hard infrastructure to the shoreline. Where they exist between property owners and the water, many properties are encroaching on environmental reserves and Crown land (bed and shore). To combat this loss, a number of riparian restoration projects have been undertaken at Wabamun Lake. In particular, in 2015, Nature Alberta and the WWMC brought the *Love your Lake* program to the area, initially surveying shorelines before working with homeowners to undertake plantings at 35 properties around the lake. Riparian plantings were highlighted again after the 2018 winter ice heaves, and Parkland County continues to encourage shoreline restoration through its Green Acreages program.

Wetlands

Wetlands play an important but often overlooked role in the watershed of filtering, storing and slowing the release of waters over time. Unfortunately, land conversion to agriculture, mining and urban development has led to significant wetland loss in the Wabamun watershed. In general, the region has seen about a 56% reduction in wetland area compared to pre-settlement.[27] Fortunately, there is an opportunity to restore a number of wetlands with the reclamation of the Whitewood and Highvale

[25] See the Nature Alberta Living by Water program boat assessment of shoreline properties.

[26] In 2018, the NSWA did additional riparian work, assessing the riparian shoreline of an inflowing tributary creek (Creek #7, False Creek?), as well as Wabamun Creek and its tributary, Mink Creek. In general, these riparian areas were largely intact (87%), with only a few areas of poor intactness. Areas that rated poor were largely associated with Mink Creek.

[27] See Parkland County's Environmental Conservation Master Plan, Wetland Inventory and Historical Loss Assessment, and Shoreline Assessment.

mines (e.g. see the Beaver Creek Conservation Area). Alberta's new Wetland Policy and associated tools guide future wetland management in this area.[28]

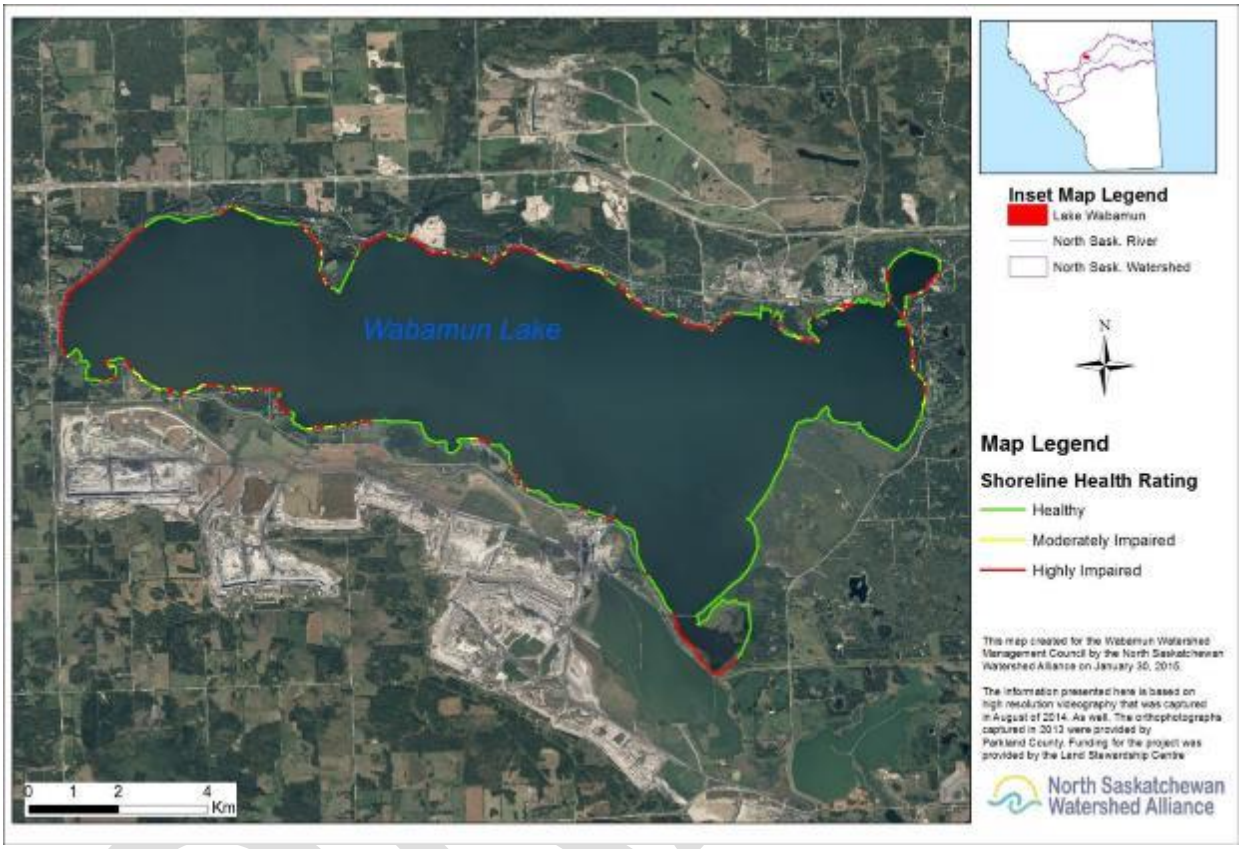


Figure 5. Wabamun Lake Shoreline Health Assessment

What can we do about it?

In order to achieve the objective of maintaining or improving aquatic ecosystem health, a number of strategies and actions are identified in the table and detailed in the Ten Year Workplan (Appendix 3).

[28] Note that the Regional Advisory Council advice to the GOA's North Saskatchewan Regional Planning process also provides direction on wetland management in the North Saskatchewan watershed.

Biodiversity

What is the issue?

Wabamun Lake is home to a broad diversity of plants and animals. However, some species like Common Loon or Western Grebe, are sensitive to disturbance. Some species appear to have declined in recent years. Native wildlife could also be negatively affected by invasive species.

What do we know about it?

Fisheries

In the past, Wabamun Lake supported a mix of cool water fish species including lake whitefish, northern pike, yellow perch, white suckers, burbot and several minnow species. This fishery once provided a number of economic benefits to local communities via a commercial fishery as well as a recreational fishery, along with its associated tourism. The lake also continues to support an Indigenous subsistence fishery.

While fishing was generally good in the 1960s, 70s, and 80s, commercial fishing, sport fishing and the loss of fish habitat has led to population declines, particularly of the larger sport fish. There are a number of reasons for this decline including mortality from hooking/handling; mortality from industry, boating; and loss of fish habitat by weed pulling and shoreline modification. Wabamun also has a large urban population in close proximity. In the 1980's there were years when approximately 80,000 fishers visited Wabamun Lake. Given this harvest pressure, it was recognized that the fishery was not sustainable. Over time, walleye have disappeared from the lake due to over fishing. Commercial fishing was closed at Wabamun in 2003.

According to the Fish and Wildlife Internet Mapping Tool, the following species have been recorded in Wabamun Lake:

- Brook Stickleback
- Burbot
- Emerald Shiner
- Fathead Minnow
- Iowa Darter
- Lake Whitefish
- Northern Pike
- Spottail Shiner
- Walleye
- White Sucker
- Yellow Perch

A walleye restoration program began in the 1980's but only gained traction in the early 2000's when walleye and walleye fry from Lac Ste. Anne were introduced into the lake. Walleye are now observed to be spawning in the lake and further population monitoring will take place in 2020 to determine if the population is sustainable.[29] In the meantime "catch and release" of all species will continue. AEP Fisheries staff are of the view that over time central Alberta lakes will "rebalance" themselves naturally.

AEP currently has several fisheries management objectives for Wabamun Lake including the following:

- Indigenous Management Objective – Honour subsistence, heritage and ceremonial fishery uses through responsible management of fish populations.

[29] For a good overview of fisheries status, see Wabamun Lake Fisheries Management Update.

- Recreational Management Objective – Restoration of the walleye population, old growth or trophy northern pike fishery, and recovery of the lake whitefish population.
- Habitat Management Objective – Decrease phosphorus inputs from fertilizers, minimize erosion of shorelines and maintain natural shorelines.

Other Biodiversity

Although a lot of focus goes to the local sport fishery, Wabamun Lake is also home to many other plant and animal species. Inventories of Wabamun Lake in the 1980s identified aquatic macrophytes throughout the photic (shallow) zone of the lake. The main species of emergent vegetation were greater bulrush, common cattail, reed grass and sedge. The most abundant submerged macrophytes were northern watermilfoil, Richardson pondweed, stonewort, and large-sheath pondweed. Sago pondweed, Yellow pond lily, and arrowhead are also present.

A survey was conducted in Wabamun Lake in November 2002 to determine if discharges from the ash lagoon for the Wabamun Power Plant and the Wabamun Lake Water Treatment Plant had an impact on the distribution of benthic invertebrates in the lake (Stantec 2003). A total of 128 taxa of benthic invertebrates were identified, typical of fauna generally found in shallow, fairly productive lakes in Alberta. Survey results indicated some effects in the areas of the discharges when compared to background areas in the lake. Overall, the differences in the area of the lake influenced by the ash lagoon discharge were slight and not indicative of a toxic effect; however, signs of mild enrichment were apparent. In the area of the water treatment plant discharge, there were significant differences, which may have been related to the different water quality of the discharge but also to differences in substrate and the presence of macrophytes.

Wabamun Lake is also well known as an important site for birds and long favoured by birders (see e-bird for a list of 173 species recorded on or around the lake). In particular, the lake supports a colonial nesting Western Grebe population, a species of special concern vulnerable to human disturbance. Common loons are also sensitive to disturbance and appear to be declining across Canada.

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Wabamun Lake is also home to a number of fur-bearers (muskrat, beaver) and other small mammal species. Sightings of deer, moose and coyotes are common; bats, black bears and a number of other mammals may also be present. Many of these species occupy the mixed wood forest stands around the lake which include Aspen, Poplar and white spruce forest and birch tree species, as well as an understory of shrubs that include Prickly wild rose, Beaked hazelnut, Red osier dogwood, Low-bush cranberry, Green alder and Saskatoon. Ground Covers might include Wild sarsaparilla, Dewberry, Common pink wintergreen and Bedstraw. In wetter areas, sedges and reed grass predominate.

In recent years, residents have become concerned about a perceived decline in biodiversity in and around the lake. Efforts to document both past and present biodiversity are being undertaken. In 2019, in conjunction with ALMS, the WWMC conducted an aquatic plant survey. In the near future, the WWMC, working with AEP, hope to analyze all the phytoplankton and zooplankton samples that have been gathered as part of past monitoring efforts, in order to better understand potential changes to the Wabamun Lake food web.

Invasive Species

Native biodiversity can be negatively affected by invasive species. Purple Loosestrife is already present in the watershed (infestation control measures were taken by Parkland County in 2012 at Rich's Point). Other invasive plants in the watershed include Himalayan Balsam, Common Tansy and Scentless Chamomile. Additionally, flowering rush is a pervasive problem at nearby Lake Isle. With its high boater traffic, there is considerable concern regarding potential zebra and/or quagga mussel introduction. The 2013 State of the Watershed Report recommended more monitoring for the presence of invasive species as well as more public education. While there is an interprovincial program to intercept and inspect boats entering the Province, the risk remains that a contaminated boat or boats may slip through the border and contaminate the lake. There is currently no known effective method of mitigating mussels, once they have been introduced into a lake system.

Invasive species such as Flowering Rush, Quagga and Zebra mussels, and Scentless Chamomile can affect lake health.

What can we do about it?

In order to achieve the objective of maintaining or improving biodiversity, a number of strategies and actions are identified below and in the Ten Year Workplan (Appendix 3).

Wabamun Lake WMP Goal: Healthy Aquatic Ecosystems & Biodiversity

Objective: Biodiversity is maintained or improved and the occurrence or spread of invasive species in the watershed is prevented or mitigated.

Strategy: Reduce or eliminate opportunities for invasive species to enter the watershed.

Strategy: Monitor for invasive species, inventory them where they occur, and remove them using the appropriate methods, protocols, etc.

Strategy: Ensure a sustainable fishery.

Strategy: Improve knowledge about and appreciation for biodiversity and its habitat in the watershed, particularly for species at risk. See https://abinvasives.ca/wp-content/uploads/2018/04/Grow-Me-Instead.pdf.

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Goal: Wise Land Use

Much of the natural land cover that once existed within the Wabamun Lake watershed has already been lost through the conversion of lands for agriculture, mining and settlement. Hence it is important that, going forward, we make land use decisions carefully, with the health of the lake as a litmus test to how well we are doing. Good decision making requires good information, shared by all such that policies and plans are aligned by well-informed decision-makers.

Land Use

What is the issue?

Land cover (i.e., the vegetation associated with natural forests, grasslands, etc.) and land use (e.g. agriculture, residential development, roads, etc.) influence water interception, retention, evapotranspiration and run-off. Hence, they influence lake condition, including the state of water quality, quantity, and aquatic ecosystem health. Land managers understand the value of retaining natural cover (sometimes called 'green infrastructure' in relation to the goods and services it provides) in order to balance growth and development with watershed health and sustainability.

What do we know about it?

The Wabamun Lake watershed is a mix of natural and man-made landscapes (Figure 6). About a quarter of the watershed is made up of waterbodies, including Wabamun Lake as well as number of smaller lakes, ponds, wetlands and streams. Another quarter still remains in natural cover, mostly deciduous forest with small amounts of mixed and conifer forests, shrub and grass lands. Almost half of the basin is in agriculture (including tilled land for crops and pastures for livestock grazing) and mined lands that will eventually revert to agriculture. A small amount of the watershed is developed with built infrastructure (urban areas and subdivisions, transportation and utility corridors, oil and gas wells, etc.). Several types of land uses are discussed in more detail below.

Recreation

Wabamun Lake is popular for year-round recreational activities and is one of the most heavily used lakes in the province, with a number of parks, camps, Recreational Vehicle (RV) sites, docks, moorings, boat launches and other amenities to support this use. While the number of visitors to the lake each year is unknown, provincial park statistics show 7,000-8,000 Occupied Campsite Nights and another approximately 25,000 day use party visits at Wabamun Provincial Park annually from 1996 – 2004. With Edmonton a rapidly growing urban centre with more than a million people less than an hour away, recreational pressure on the lake will likely continue to increase in the future.

Recreational activities in and around the lake include boating, swimming, fishing, bird and wildlife watching, hiking, camping and golfing. To support these activities, there are five sailing clubs, two marinas and several boat launches. Off the lake, the Paul First Nation operates the 18-hole Ironhead Golf and Country Club on reserve land. The 9-hole Pineridge Golf and RV Resort is located in Seba Beach.

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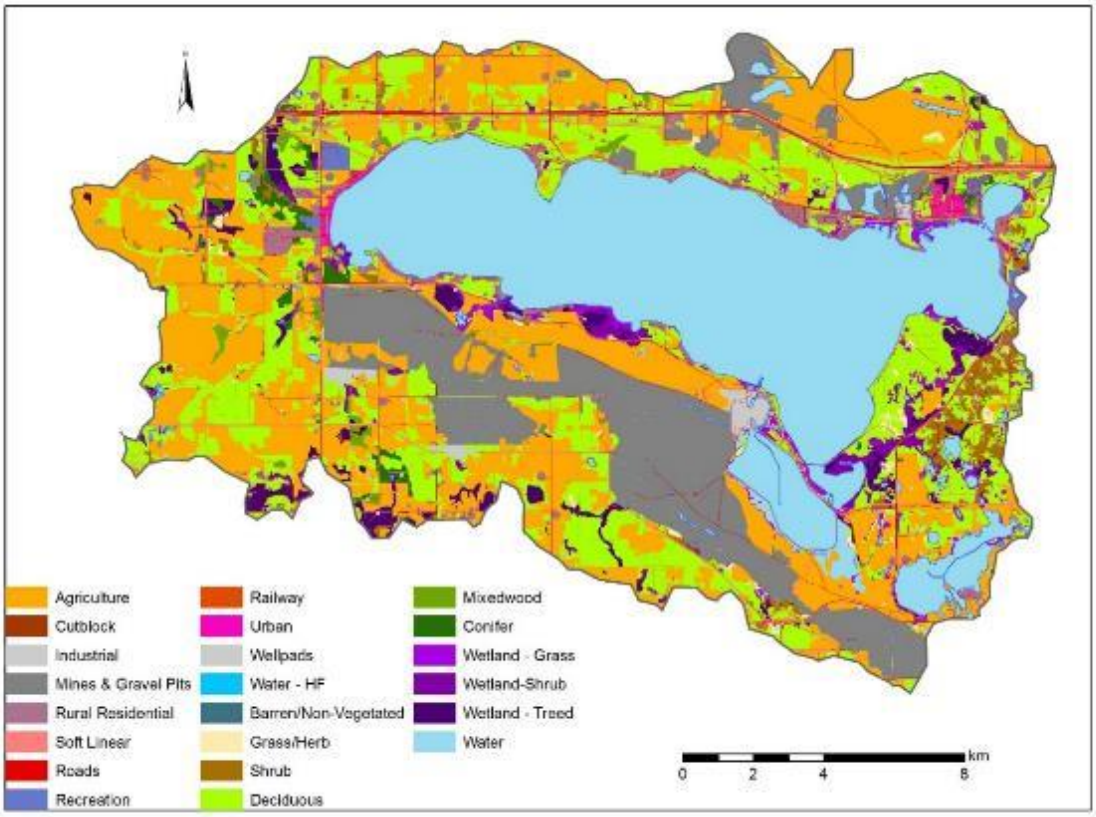

Figure 6. Land uses in the Wabamun Lake watershed. (Developed by ABMI)

To accommodate visitors, there are several campgrounds and resorts around the lake. Wabamun Lake Provincial Park, operated by AEP, is located on the north-eastern shore, near the Village of Wabamun, bordering the Yellowhead Highway. It includes a good portion of the shoreline of Moonlight Bay, where swimming and other activities are popular at the man-made beach. This park supports overnight camping, day-use and group use facilities with 301 campsites, playground areas, picnic shelters, a pier and boat launch. Kokanee Springs RV Resort in Seba Beach has 170 sites. In addition, there are 124 seasonal RV sites available at Pineridge Golf Course and 252 seasonal RV sites at Shadybrook Resort in Seba Beach.

Finally, there are a number of outdoor education camps including the Eldon and Sarah Tanner Youth Camp (LDS), Bissell Centre Moon Light Bay Camp, YWCA's Camp YoWoChAs, and Camp Oselia Children's Camp operated by the Ukrainian Catholic Eparchy of Edmonton. Each of these camps has residential dorm facilities, such as kitchens, washroom and shower facilities, and some also have additional campsite spaces.

While visitors enjoy a number of on- and near-shore activities such as swimming, picnicking, birdwatching, etc., the lake is particularly well-known for motorized and non-motorized boating opportunities, particularly during summer weekends. On the lake, too many boaters can be a safety issue. Boaters can also disturb wildlife, especially fish and waterfowl, and their habitat, particularly

during sensitive periods such as spawning or nesting. Motor boat wakes can cause erosion of shoreline habitat. They can also pollute the lake with boat fuel, sewage and garbage. Wabamun Lake currently is regulated by the Federal *Vessel Operations Regulations Act* (Federal) with 12 km/hour speed zones indicated by signs. There are also areas where vessels are prohibited.

Gaining access to the lake is also an important issue. Boat launches and vehicle parking areas must be adequate to manage demand. Wabamun currently has limited boat launch capacity, with a number of informal boat launches being used around the lake.[30] The launch at Seba Beach was closed in 2015 due to safety concerns and site limitations (i.e. too shallow, limited parking). To ease congestion, Parkland County has approved funding for the Sundance Boat launch (on Range Road 53 on the south shore) to be developed and in use by 2021. Additionally, the Village of Wabamun is adding a third lane to their boat launch. The provincial park also maintains a boat launch and has recently increased parking capacity. Docks and mooring can also be an issue, particularly where boats are moored illegally. In general, any such structures situation on Crown lands require permits. (For information on regulations around this topic, see https://www.alberta.ca/lakeshores.aspx.) Future planning might consider the use of community docks.

Other activities, such as swimming and picnicking, also need appropriate infrastructure to ensure safety. To guide the development of future recreational opportunities, Parkland County has developed a Parks, Recreation and Culture Master Plan. This plan identified the need to enhance more water-based recreational opportunities in the county. It also identifies the potential for further park and trail development on the southwest shore under the Highvale Area Structure Plan.

Wabamun Lake Boat Studies

In 2013, Parkland County commissioned the *Lake Wabamun Boat Launch Study*. This report identified 20 boat launch sites around the lake. However, only two sites (Wabamun Lake Provincial Park and Village of Wabamun) are formally developed sites with full amenities including parking for up to 232 vehicle/boat units at a time. The remaining 18 sites are informal with fewer amenities (and some like Seba Beach and Sundance Power Plant were closed prior to or after the report was commissioned). This report also showed that the boat launch in the Village of Wabamun is the most utilized and almost half of all users are from communities east of the Lake (i.e., Edmonton, Spruce Grove, etc.). Additionally, there is a desire among residents to improve/increase facilities at Seba Beach and Sundance. Finally, this report noted that although there is no universally acceptable formula for determining the carrying capacity of lakes in Alberta, using a gradation ranging from a minimum standard of 6 hectares per boat to a preferred standard of 16 hectares per boat, the lake could accommodate 470 to 1254 boats at once.

In 2015, a subcommittee of the WWMC also looked at the capacity for motorized watercraft activity on Lake Wabamun. Utilizing a standard of 1 boat per 15 to 25 water surface acres, their report cited a boat capacity of 1000 - 1100 boats. Unfortunately, the number of boats utilizing Wabamun Lake at any given time is currently unknown. With the development of dedicated lake boat launch facilities, a more accurate census of boat population could be determined for future assessments. In the meantime, in 2018, Parkland County Council voted to begin construction of the $2,000,000 boat launch on the south side of Wabamun Lake, near the Sundance power plant. Construction is expected to begin in 2020. Parkland County has posted a draft design of the launch site on its website.

[30] See parkland county website Wabamun Lake Boat Access

Residential Development

While the majority of visitors only come for a day or two, some choose to live seasonally or year-round at the lake. While most of the Wabamun watershed lands come under the jurisdiction of Parkland County, a number of small independent communities are found around the shoreline. Adding up both seasonal and permanent residents, the WLSLUP estimated a population of about 3,500 in the Wabamun watershed. For the most part, these villages are already largely built out and now are mostly dealing with re-development; an exception being new lots made available through the completed Phase 1 (Osprey Residential) of the Village of Wabamun's Discovery Wharf project. The Village guides future commercial, residential and recreational use of this area via its Waterfront Area Structure Plan which strives to balance environmental values in this area of high bird and other biodiversity with other social and economic values.

Residential cottage development and re-development in the uplands surrounding the lake can erode soils and lead to accelerated sedimentation. It also affects the amount of impervious surface, particularly as smaller, older buildings are redeveloped with larger footprints, which in turn, affects the volume and rate of surface water run-off, especially during large precipitation events. Finally, run-off can introduce contaminants (like fertilizers and pesticides) collected along the way to the lake. In 2004, Schindler recommended more stringent guidelines for cottage development around the lake. Currently, each municipality has its own development process for activities within its jurisdictional boundaries.

As the Province eliminated the ability to form Summer Villages in 1995, the formation of any new lakeshore communities (i.e., subdivisions) will likely occur under County jurisdiction. Parkland County, which has jurisdiction over approximately half of the lakeshore, currently manages such development via its Municipal Development Plan (MDP) and Land Use Bylaw (LUB). The MDP provides a long-term vision, providing an idea of how much lakeshore will be developed over time. Several sections of the LUB affect lakeshore development. In particular, the Lakeshore Residential District section outlines conditions for development of small existing lakeshore parcels (limiting parcel coverage to a maximum of 40%). Additionally, the Lake Wabamun Flood Plain Overlay section describes conditions for development in the floodplain.

Parkland County is currently in the process of developing Intermunicipal Development Plans (IDP) with each of its neighboring jurisdictions. The IDP with Betula Beach is completed and sets a good example of a commitment to collaborative watershed management for future agreements. IDPs will also be reviewed every five years, providing the opportunity to address watershed issues as they arise.

Once established, communities also need a supply of water for drinking and domestic use, and they need to deal with septic waste. For the most part, communities in the Wabamun watershed receive their water supply from a regional network, from groundwater wells, or they operate a cistern and have treated water delivered. Similarly, most communities have a wastewater system in place to meet the needs of their residents. More and more, these are also tied to a collection system (e.g., the Capital Region Sewage Treatment Facility), either directly, or indirectly via a waste transfer station. As part of

Parkland County's "Healthy Lakes" Program, inspections of existing sewage systems on lakeshore properties were offered to residents in 2019.

Finally, with residential development comes the need for all-weather roads and utility corridors (for electricity, natural gas, etc.). These linear disturbances add to the overall footprint, alter hydrology, and can also add to sediment and contaminant loading in the lake and its tributaries. They also increase the risk of potential spills and other contamination events. Informal recreational trails around settlements, particularly where off-highway vehicle use in stream beds occurs, can also add to nutrient loading.

Going forward, lakeshore communities will have to look at best practices for reducing nutrients in residential areas, with focus on urban development controls to reduce surface runoff, preserve natural areas, and enhance green infrastructure within the communities surrounding the lake. Low impact development principles should be used to minimize and compensate for changes in water flow and entrained nutrients. Additionally, future *Water Act* Approvals for storm water should consider nutrients (dissolved as well as associated with sediment) in their approval processes.

Municipality	Length (%) of Lakeshore	Permanent Population (2016)	**Drinking Water**	Wastewater
Parkland County (including Fallis, 27 lakeshore sub-divisions and other private and county lands)	Total: 35,599 m (52.9%) Subdivisions and Hamlets only: 13,892 m (20.6%)	Fallis 54 Ag residences 158 Subdivisions 300	Largely private systems (wells, dugouts, cisterns, etc.)	largely use private holding tanks trucked to Entwistle lagoon.
Paul First Nation	13,787 m (20.5%)	Pop. ~ 1100	West Inter Lake District (WILD)	On site treatment
Village of Wabamun	3,005 m (4.5%)	Pop. 682	WILD Phase 1	Treatment lagoons north of Hwy 16, discharge annually to NSR tributary
Summer Village of Seba Beach	4,060 m (6.0%)	Pop. 169	Future WILD Phase 3	Lagoon, evaporation
Summer Village of Lakeview	848 m (1.3%)	Pop. 30		Holding tanks; Hauled to Entwistle lagoon
Summer Village of Betula Beach	853 m (1.3%)	Pop. 16		
Summer Village of Kapasiwin	1,559 m (2.3%)	Pop. 10		
Summer Village of Point Alison	1,577 m (2.3%)	Pop. 10		
Crown Land (including Wabamun Lake Provincial Park)	6,012 m (8.9%)		Park has a Groundwater well	Onsite lagoon discharged annually to NSR tributary
Total	67300 m (100%)			

Mining

The Wabamun Lake watershed has two surface strip coal mines. Whitewood Mine opened in 1962 and was closed in 2010 with reclamation of the entire 1,900-hectare (ha) site completed (but with a portion of the area still in the approvals process for a reclamation certificate[31]). End-land use includes agriculture, recreation, commercial and wildlife/wetland habitat (see the Beaver Creek Conservation Site or East Pit Lake Conservation Area).[32] Monitoring of ground and surface water, erosion, vegetation, etc. is ongoing. Additionally, between 2002 and 2010, the Wabamun Power Plant was closed and subsequently reclaimed (315 ha restored to parkland, industrial and some residential use for the Village of Wabamun and Parkland County future growth).

Highvale Mine, the largest surface strip mine in Canada at 12,600 ha, has been in operation since 1970 with seven pits[33] in various stages of mining. The mine produces about eight million tonnes of low-sulphur-content thermal grade coal that is provided to Sundance, Keephills, and Keephills 3 thermal generating plants. TransAlta plans to convert its coal fired plants to natural gas by 2030. Reclamation is ongoing with 1,566 ha of land reclaimed to date. Future land uses (Figure 7) are guided by Parkland County's Highvale End Land Use Area Structure Plan (2016). Public consultation is an important component of land use planning and should be used to inform future updates of this and other area structure plans around Wabamun Lake.

Schindler *et al* 2004 suggested that the mines should be "reclaimed to original natural cover as much as possible" in order to avoid negatively affecting lake health. However, to accommodate socio-economic and environmental values for the area, mine lands will be reclaimed to a mix of agriculture, wetland and wildland natural areas, with consideration for managing run-off and limiting erosion and sedimentation. Monitoring is required to measure changes and their impacts on the lake and its watershed.

If the same general pattern of reclamation is followed as occurred at the Whitewood mine, reclaimed Highvale lands will be recontoured, covered with topsoil, planted with cereal crops (oats, barley) at first, then forage (hay, alfalfa) and eventually grazed by livestock. Fertilizer and mulch will be used where needed to boost production and deal with any erosion issues. Throughout the reclamation timeline, TransAlta will monitor agricultural production, ground and surface water, erosion, vegetation and weeds to demonstrate the capability of the reclaimed land.

Once a reclamation certificate is received, lands are eventually leased, then sold by TransAlta to agricultural producers and others. Also at this time, development comes under County jurisdiction with its associated planning and permitting processes. In time, agricultural lands may become subdivided for country residential and other development. While the Whitewood mine would appear to have been reclaimed successfully, and may provide a template, note that the Highvale mine is much (almost 7x) larger than Whitewood and includes a significant portion of the area south of Wabamun Lake.

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[31] For information on what is required for a reclamation certificate, see https://www.aer.ca/documents/forms/ReclamationCertificate_EPEAApprovedActivities-Checklist.pdf

[32] As per Parkland County's Whitewood Mine Conceptual Scheme and bylaw 2018-25 to redistrict the area.

[33] Pits 03 – 09, however, note that pits 08 and 09 are largely outside of the Wabamun Lake watershed.

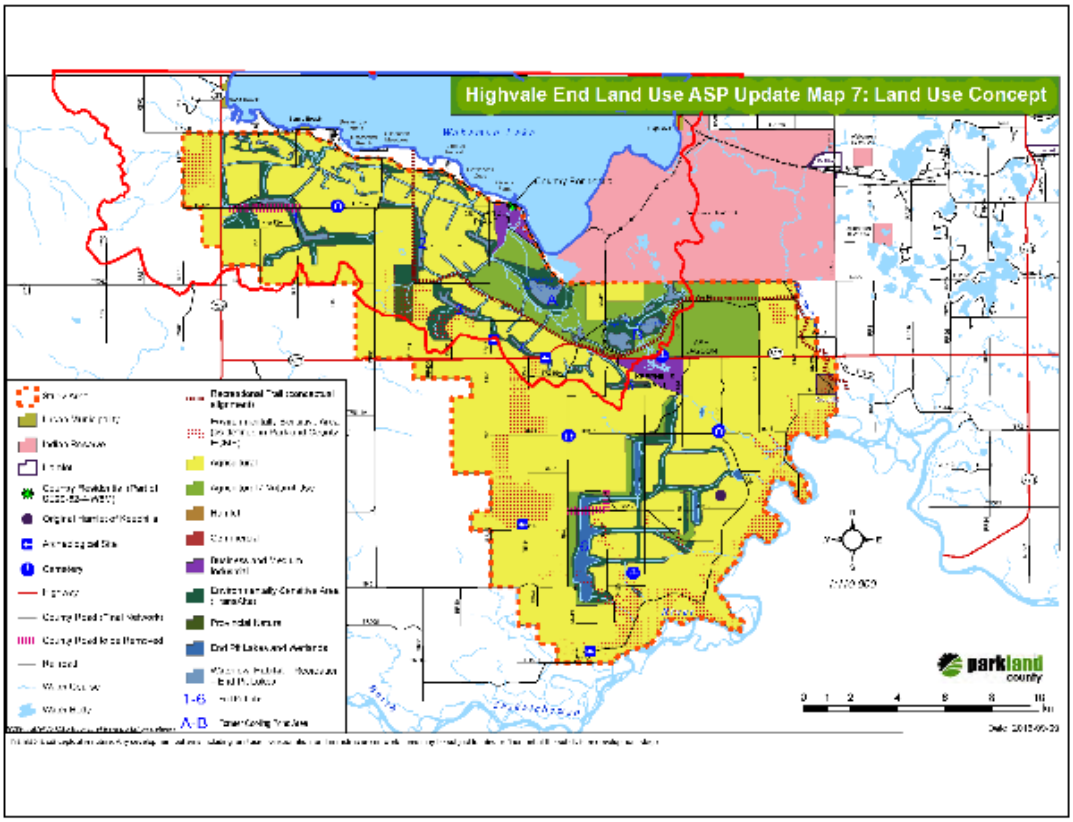

Figure 7. Map of Highvale End Land Use Area Structure Plan.

Agriculture

With a good portion of the Wabamun watershed already in agricultural production, and with agricultural lands about to increase over the next two decades via mine reclamation, this sector has the potential to be a large influence on the watershed. Issues affecting lake health that can arise from agriculture include clearing of forested lands that leads to erosion; soil management (erosion and sedimentation), the use of fertilizers and pesticides, and manure management.

Currently, agricultural lands within the Wabamun watershed include approximately 18,944 ha.[34] This also includes a portion of the Jack Pine Provincial Grazing Reserve which is estimated to have the capacity for 413 head of cattle. Stock watering on the reserve is achieved by dugout or water trough; significant streams are fenced off from cattle; no fertilizer is used; hence there is likely little overall nutrient loading to Wabamun Lake from the reserve.

Other agricultural lands in the watershed are estimated to carry about 1100 cattle, 105 horses; no commercial hog, poultry or sheep. Altogether, annual livestock manure production is estimated for the watershed at 1144 kg/ha. Most livestock operations are a mile or more from the lake with little connection to watercourses; manure is spread to hay or pasture land so again, it is believed that there is

[34] Jan 2014 report to the WWMC by Jack Latham.

little nutrient loading to Wabamun Lake from this activity although this might vary depending on timing with potentially higher phosphorus levels in creeks and diffuse runoff in spring and during storms.

Currently, the County's Municipal Development Plan limits where Confined Feeding Operations can occur (no new operations are permitted in the Wabamun watershed). To guide future expansion in this sector, Parkland County has commissioned the "Future of Agriculture Study (2016)" and the Agricultural Service Review (2018). Additionally, the Edmonton Metropolitan Regional Board is developing an Agricultural Master Plan that will include Parkland County.

Reclamation of Mined Lands to Agricultural Lands

With a significant portion of the Wabamun watershed already made up of agricultural lands, and with both the Whitewood and Highvale mines being reclaimed largely to agriculture, this land use has the potential to impact lake health negatively if not managed appropriately. Additionally, agricultural lands throughout the watershed can also be used for a number of other 'discretionary' activities (as per the County's Land Use Bylaw), or they may be sub-divided and re-districted over time, further affecting lake health, depending on the disturbance, loss of natural cover and buffers, post-development run-off rates, erosion and contaminant control requirements, etc. Tuininga *et al.* (2015) modeled several development scenarios for the Wabamun watershed and determined that if the Highvale mine areas was converted equally to agriculture and forested land, the percentage (%) change in Total Phosporus load would be about 6%.

For the most part, the conversion and development of agricultural lands in the Wabamun watershed is managed through Parkland County's Planning and Development processes. In particular, long range planning documents, such as the County's Technical Growth Study, inform decision-making. Additionally, documents like the area structure plan and land use bylaw attempt to balance development *"with landscape connectivity, water quality and quantity, and other environmental considerations"*, and development on lands adjacent to a waterbody may trigger the need for a biophysical assessment or other requirements.

However, there is currently no mechanism to assess and manage the cumulative impact of each single, successive land use development on lake health[35]. Additionally, there is limited opportunity for 'non-affected' advocates for lake health (a public good) to participate in development approval and appeal processes for private landowners (i.e., no one speaks for the lake[36]). This reinforces the importance of good planning in order to put protections in place before development occurs as well as the importance of developing a watershed management plan and integrating its elements into municipal planning documents.

[35] An example of a mechanism used by some jurisdictions for managing cumulative effects of development through a regulatory process would be setting a daily total nutrient loading limit.

[36] For a good article on the value of watershed stewardship groups, see this paper.

Other Land Uses

Although transportation and oil and gas activities only represent a small percentage of land uses in the Wabamun watershed, their impact on the lake can be large, as witnessed by the 2005 train derailment and subsequent spill. Both Highway 16 and the Canadian National Railway (CNR) main line run through the watershed, as does a natural gas pipeline and the Trans Mountain Pipeline (oil).

Interestingly, in the event that a spill into the North Saskatchewan affected the City of Edmonton's source drinking water, Wabamun Lake is identified as a short-term alternative supply for the city. Fortunately, Alberta has a coordinated provincial and municipal emergency response system that hopefully would mitigate any such events in the future.

Environmentally significant areas (ESA) are also an important land use that can provide a number of social (e.g. recreation), economic (e.g. tourism) and environmental (e.g. headwaters protection) benefits. Parkland County has mapped its significant areas, as per its Environmental Conservation Master Plan. The Wabamun watershed includes 11 ESA - the largest being the lake itself, followed by the Jackpine Grazing Area. Though much smaller in size, the Fallis Slope, Wabamun Creek and Wildlife Point ESAs are notable as areas that are highly sensitive to disturbance. While ESA designation does not stop development, where development is proposed in or adjacent to a ESA, a Biophysical Assessment may be required.

The Alberta Conservation Association (ACA) also has several conservation sites in the area. The Parkland Conservation Area includes a 160 acre site 1.6 km south of Hwy 16 just west of Wabamun Lake. This site is mainly aspen forest, with black spruce and tamarack bogs, small wetlands and an unnamed lake. It is jointly managed by ACA and the Alberta Fish and Game Association (AFGA). At 54.5 acres, the Wabamun North Shoreline Conservation Site, a mix of shoreline and upland habitat, is managed by AFGA and TransAlta. And finally, the East Pit Lake Conservation Area is a 312 acre day-use recreation area directly north of Wabamun. This site includes several hiking trails and a lake with Rainbow Trout. It is managed by AEP, AFGA, County of Parkland, TransAlta, and the Stony Plain Fish and Game Association.

What can we do about it?

All together, there are a number of land uses in the Wabamun watershed that can affect lake health. There are also a number of areas where it is beneficial to protect existing natural cover. To achieve the objective of retaining natural land cover and mitigating land use, a number of strategies and actions are identified below and in the Ten Year Workplan (Appendix 3).

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Wabamun Lake WMP Goal: Wise Land Use

Objective: To the extent possible, natural land cover is retained and land use does not impair lake or watershed health.

Strategy: To the extent possible, conserve existing native cover through the use of statutory and voluntary tools such as ESA dedication, environmental reserve, land conservation trusts, etc.

Strategy: Balance public access and a quality lake experience with aquatic ecosystem health.

Strategy: Minimize any impacts of residential lake shore and backshore development and redevelopment on lake and watershed health.

Strategy: Monitor coal mine reclamation to ensure a change in land use does not impair lake and watershed health.

Strategy: Minimize the impacts of agriculture and country residential on lake and watershed health.

Strategy: Minimize the impact of industrial, transportation, and other development on lake and watershed health.

Policy and Planning

What is the issue?

Water is a public (Crown) resource and as such, we expect it to be managed by our government on our behalf. That is, water management in Alberta is the shared responsibility of federal, provincial and municipal governments, who are often assisted/informed in their work by stakeholders and the public. Additionally, waterbodies are affected by the human activities that occur on and around them. Hence the need to include public and private land and resource managers in lake management.

Unfortunately, no one entity is solely accountable for lake or watershed health. Hence there is a need to integrate policy, planning and practices between decision-makers such that everyone, collectively, is doing their part to ensure lake health. In theory, this level of alignment between governments, stakeholders, land managers and the public sounds feasible and in fact, is succeeding in many jurisdictions. However, without concerted effort, a plan to guide actions, and a feedback mechanism to inform performance, gaps in lake management can occur. Users of Wabamun Lake want to be assured that this level of cooperation is occurring; they want to know who is responsible for managing what; and they want to know it is working to safeguard lake health.

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What do we know about it?

The Wabamun Lake Watershed Management Plan was developed within the current framework of federal, provincial, and municipal legislation and policies. Below is a brief outline of the authorities relevant to Wabamun Lake.

Government of Canada

Although they do not have a large presence in Alberta, the federal government does have a responsibility for fish habitat, species at risk, navigable waters, public safety, railway and boating regulations. They also recognize the *United Nations Declaration on the Rights of Indigenous Peoples* and have a number of polices and legislation related to indigenous communities that consider the Wabamun watershed as traditional territory. The Paul First Nation Reserve is located on the east shores of Wabamun Lake and the Alexis Nakota Sioux Nation and Enoch Cree Nation also have traditional land within the watershed. Metis Local 55 also recognizes this area.

Government of Alberta

The Government of Alberta, through several Ministries and agencies, is responsible for development and activities that occur on the bed and shore of the lake, protecting wildlife and endangered species, protecting ground and surface water resources, air quality, agricultural practices, energy resource extraction, and provincial parks.

The provincial government's *Water for Life*: *Alberta's Strategy for Sustainability* (2003) sets the direction for water management in the province. The strategy in general, and water management specifically, are achieved through the application of several pieces of legislation including the *Water Act*, *Public Lands Act*, *Environmental Protection and Enhancement Act*, *Municipal Government Act*, *Land Surveyors Act*, sewage regulations, etc. Policy pieces like the Alberta Wetland Policy and Climate Leadership Plan are also significant. At an operational level, the GOA has directed its regulatory staff to consider watershed management plans when reviewing development projects in affected areas. The GOA is also responsible for a number of science and monitoring pieces key to managing water bodies in Alberta.

Another key GOA policy is the Land Use Framework (LUF), an approach to managing Alberta's land and natural resources to achieve long-term economic, environmental and social goals, that includes the development of regional plans. The *Alberta Land Stewardship Act* provides the legal basis for this work. The North Saskatchewan Regional Plan, when completed, will establish land-use management objectives for the area. Municipal plans, including the Edmonton Metropolitan Regional Board (EMRB) Capital Growth Plan, will have to adhere to the regional plan.

NSWA IWMP

Another regional document, the NSWA *Integrated Watershed Management Plan for the North Saskatchewan River* (2012) provides advice to both provincial and municipal governments on how to achieve *Water for Life* and other watershed management goals in the North Saskatchewan watershed.

EMRB Capital Region Growth Plan

Working together as the Edmonton Metropolitan Regional Board, the City of Edmonton and those municipalities surrounding it including Parkland County developed the Capital Region Growth Plan, *Re-imagine. Plan. Build.* (2016). The plan includes an environmental goal "*to protect natural living systems and environmental assets"* to be achieved by practicing "*wise environmental stewardship and promoting the health of the regional ecosystem, watersheds, airsheds, and environmentally sensitive areas."* This document identifies several mechanisms for integrated planning for growth and development, service delivery, etc. but is not yet specific to the management of water, lakes, recreation, etc.

Parkland County

As per its website, Parkland County recognizes that the lakes within its boundaries are important for recreation, tourism, environmental diversity, potable water and family and community life. They also recognize that with an increasing population (expected to grow from 32,097 in 2016 to 73,000 by 2041), more pressure will be placed on Parkland County lakes. Thus, they recognize the need to balance the environment with residential and business growth, tourism and recreation for a balanced community.

Parkland County is governed via a number of policy and planning documents including a municipal development plan, land use bylaws, area structure plans, sub-division plans, etc. It is also currently in the process of developing Inter-municipal Development Plans with its neighboring jurisdictions. Finally, the county also has commissioned a number of reports, inventories (e.g., wetlands), master plans (e.g., Environmental Conservation Master Plan) that guide the management of county lands including the Hamlet of Fallis and approximately 27 sub-divisions around Wabamun Lake. Also prepared as a guidance document, the County's, *Wabamun Lake Subwatershed Land Use Plan* (WLSLUP) was completed with the purpose of providing a guide to coordinate regulatory and non-regulatory land use decision-making in the watershed based on the needs of the community (Stantec 2015).

Parkland County's Wabamun Lake Sub-watershed Land Use Plan

Accepted as information by Parkland County Council in November 2016, the WLSLUP provides guidance to the county when making land use decisions within the Wabamun Lake watershed. The plan vision is *"A multi-stakeholder land use plan that, as a component of an integrated watershed plan, will improve the health and resiliency of the Wabamun watershed and sustain our communities through the improved stewardship of our land and water."*

The plan strives to achieve the following five outcomes:

1. Our land use practices protect the environment.
2. Our land use practices provide economic opportunities that support the people and health of our watershed.
3. Reduce the environmental impacts of development.
4. Coordinated governance.
5. Our stewardship programs inspire us to action.

Villages

The Village of Wabamun and the five Summer Villages (i.e., Betula Beach, Kapasiwin, Lakeview, Seba Beach and Point Allison) around the lake all have jurisdiction over subdivision of land, land use and development within their respective municipal boundaries. Although all municipalities must follow a formal development process, the specific rules and regulations governing land use and development can be different for each municipality, as found within their governing documents.

What can we do about it?

To integrate policy and planning between authorities such that there is improved communications and greater scrutiny on activities that could affect lake health, a number of strategies and actions can be carried out as per the objectives and strategies below. This work could be the future focus of the Wabamun Lake WMP Steering Committee, coordinating policies and bylaws such that they are lake and watershed wide.

WABAMUN LAKE WMP GOAL: WISE LAND USE

Objective: Policies and plans are aligned between authorities and regulatory bodies such that development does not impair lake watershed health.

Strategy: Educate lake users about boating, fish habitat and other federal rules and regulations applicable to Wabamun Lake.

Strategy: Raise awareness of the need for and participate in regional discussions and planning for future growth in recreational demand.

Strategy: Promote municipal collaboration on key policy and plan development to ensure such documents and actions support lake and watershed health.

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Informed Decision-making

What is the issue?

Although a great deal has been learned about Wabamun Lake and its watershed over the past century, data gaps remain and there is still more to know. In fact, several reports have included recommendations to collect further information. As well, lake conditions change over time, hence ongoing monitoring and assessment are an important part of lake watershed management. However, filling information gaps requires capacity. Additionally, some coordination of information gathering is desireable, to ensure cost-effectiveness and to avoid redundancies.

What do we know about it?

In addition to a stakeholder group, Schindler also recommended that a parallel technical advisory group be put in place to coordinate research efforts. Currently, there are a number of entities carrying out different research or monitoring projects around the lake. TransAlta completed a Biophysical Assessment of Wabamun Lake as a part of its ongoing regional biomonitoring program. EPCOR and AEP monitor water quality at a number of sites upstream of the City of Edmonton, including at the mouth of Wabamun Creek. AEP, through the ALMS LakeWatch program, will continue to collect data on lake water quality and invasive species. While such individual efforts are valuable, the value could be enhanced via a coordinated program of information gathering and sharing.

What can we do about it?

To ensure decision-makers are well informed about lake health, a number of strategies and actions are identified below and in the Ten Year Action Plan (Appendix 3) .

WABAMUN LAKE WMP GOAL: WISE LAND USE

Objective: Knowledge needed to manage a healthy Wabamun Lake watershed is gathered and made available to decision-makers.

Strategy: Identify, prioritize and fill information gaps.

Strategy: Find innovative ways to communicate learnings to decision-makers.

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Goal: Engaged Stewards

Although provincial, municipal and Indigenous governments have a strong role to play in watershed management, indivduals, including private landowners and recreation seekers, also have a role to play in ensuring lake watershed health. Hence it is important that such individuals are well-informed and know how to be good stewards.

Education

What is the issue?

In 2006, the Wabamun Watershed Management Council (WWMC) was formed as a means to give citizens representative of lake communties a voice in protecting the lake. Since then, the WWMC has successfully carried out a number of educational and stewardship projects and responded to a number of specific issues around the lake. However, the WWMC is a volunteer not-for-profit entity and has limited capacity to advocate/be the voice for lake health. Funding and potential volunteer burn-out also influence stewardship and education efforts.

What do we know about it?

To leverage its work, the WWMC often partners with local authorities (County, villages, etc.) as well as conservation agencies such as the Alberta Conservation Association (fisheries), Alberta Fish and Game Association, Alberta Lake Management Society, Nature Alberta, etc. It also encourages all individual lake users to be good stewards by providing information via its website, newsletters, door-to-door campaigns, workshops, etc.

Additionally, there are a number of other education and outreach programs that can inform lake users. The Government of Alberta manages the *Respect Our Lakes* program. Parkland County also promotes a stewardship ethic and promotes stewardship knowledge and tools by sponsoring the ALUS, Green Acreages, and other programs.

What can we do about it?

To promote education…

WABAMUN LAKE WMP GOAL: ENGAGED STEWARDS

Objective: Residents and visitors are knowledgable about how they can lessen their impact and contribute to lake health.

Strategy: Educate lake users, including residents and visitors, about how they can be good stewards and use beneficial practices to reduce their impact on lake and watershed health.

Stewardship

What is the issue?

In 2006, the Wabamun Watershed Management Council (WWMC) was formed as a means to give citizens representative of lake communties a voice in protecting the lake. Since then, the WWMC has successfully carried out a number of educational and stewardship projects and responded to a number of specific issues around the lake. However, the WWMC is a volunteer not-for-profit entity and has limited capacity to advocate/be the voice for lake health. Funding and potential volunteer burn-out also influence stewardship and education efforts.

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What can we do about it?

To promote stewardship such that the community surrounding the lake as well as visitors to the area share a collective responsibility, and have the knowledge and tools, to be the best stewards of the Wabamun watershed, a number of strategies and actions can be taken.

WABAMUN LAKE WMP GOAL: ENGAGED STEWARDS

Objective: The community shares its collective responsibility to be the best stewards of the Wabamun Lake watershed and stewardship programs inspire individual and collective action.

Strategy: Provide stewards with tools and opportunities to build awareness and knowledge, gain skills, and implement stewardship actions.

Plan Implementation

Lake watershed management is complex and there are many activities that can be undertaken to protect lake health. However, for a plan to be actionable, limited resourcing and capacity issues also have to be considered as they may constrain plan implementation. Hence it is important that:

a) a sound implementation governance structure is put in place;

b) priorities are carefully weighed and matched with capacity (e.g. money, people, time, etc.);

c) collaborations come together to leverage resources; and

d) performance measures are used to ensure priority actions to address issues of the highest risk to lake health are effective over time.

A sound governance structure should include continuation of the Wabamun Lake WMP steering committee (SC). This committee should retain its current members and could be enlarged to include additional key parties as they are identified as potential leads and partners for the various strategies and actions in the plan. Evolving roles and responsibilities of the SC could be spelled out in a renewed Terms of Reference. At a minimum, the SC should meet quarterly (as called by the co-chairs) to share information and guide plan implementation. The SC might liaise from time to time with other lake initiatives such as the Lakes of Parkland County, GOA *Respect Our Lakes* program, Alberta Lake Management Society, etc. It might also commission technical reports to fill information gaps, as they are identified.

Key risks facing Wabamun Lake include:

- Invasive species
- Blue-green algae blooms
- Nutrient overload from residential development, loss of riparian filter function, and agricultural intensification all without corresponding mitigative actions to control run-off
- Climate change
- Cumulative effects

In thinking about priority issues and actions, the SC requested that there be a focus on actions that, where possible, have an existing mechanism to be implemented: that is, they can be expedited through operational decisions and existing budgets at the provincial, municipal and Indigenous government levels, or through existing stewardship initiatives. They also advised that resources be put where the problems (i.e., risks) are greatest and/or where the biggest gains could be made. Hence in developing strategies and actions, we have attempted to identify the highest priorities under goals and objectives presented earlier in this document, as well as the partners required to implement such actions. Briefly, these priority areas include:

- Maintaining a collaborative WMP implementation governance structure with a representative Steering Comittee;
- Continuing to build on WWMC educational activities with an initial focus on invasive species, riparian health and agricultural BMPs;

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- Setting up a robust water quality monitoring program that discerns trends and informs decision-makers;
- Restoring shoreline riparian function;
- Continuing to align provincial, municipal and Indigenous policies, plans and processes (e.g., fertilizer and pesticide bylaws, septic bylaws and building and development requirements) that promote watershed health.

Priority areas of focus are outlined in red in the Ten Year Workplan (Appendix 3). Note that actions are also further divided into time frames of 1) existing activities that should be continued from 2020 – 2029 2) new activites that could be implemented relatively easily in the next three years (2020 – 2023) and 3) more challenging activities that will take some time and resources to address over the longer term.

Finally, as an important component of any plan, performance measures should also be identified and publicly reported on regularly by the SC to ensure WMP actions are leading to success. Additionally, the SC should revisit the plan from time to time (e.g. every 5 years) to ensure actions are still relevant to prevailing issues or adjusted to meet changing conditions. Reporting can include successes and challenges in implementing the plan, as well as actual improvements to the lake's ecological integrity. A key to success will be to maintain and support partnerships to collect the relevant data and to do the evaluations at the desired frequency.

In Summary / Conclusion

Despite being a large, well-used recreational waterbody, Wabamun Lake, with a small catchment area and the weir at the outlet, doesn't experience much flushing flow, so whatever goes in it, stays there for a long time. Over eons, nutrients and other contaminants have built up in the lake's sediments. In addition to these rich sediments, growth and development and climate change are also likely affecting the lake, making ideal conditions for cyanobacteria (blue-green algae) and other aquatic plant growth.

Unfortunately, there is no easy one-step solution to keeping additional nutrients from entering the lake. Hence, everyone must do their part, no matter how big or small the task. For only through cumulative action, can significant change occur. Fortunately, over the past 100 years or more, a number of entities and mechanisms have been put in place to support this work. Hopefully, if well utilized, they will see our enjoyment of Wabamun Lake continue for at least another 100 years.

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Appendices

Appendix 1. Past and Present Wabamun Lake Watershed Management Plan Steering Committee Members

Member Organization	Represented by:
Alberta Environment and Parks	Arin Macfarlane-Dyer
North Saskatchewan Watershed Alliance	Leah Kongsrude, Breda Muldoon, Petra Rowell, Dave Trew
Parkland County	Peter Vanna, Krista Quesnel
Summer Village of Point Alison	Jim O'Brien
Summer Villages of Betula Beach, Lakeview, Kapasiwin and Seba Beach	Sue Evans
TransAlta	Shannon Leggo, Ken Munch, Ken Woollard, Stacey Lauder
Village of Wabamun	Shawn Patience
Wabamun Watershed Management Council	Stan Franklin, Neil Fleming

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Appendix 3. Ten-Year Workplan (With priority areas of focus in red)

Objective	Strategies	Current activities that should be continued 2020-2029 / Lead	New activities that are relatively easy to implement 2020 - 2023 / Lead	Longer-term actions that will require new resources, organization 2024-2029 / Lead	Performance Measure
Goal: Good Water Quality					
Current surface water quality is maintained or improved throughout the watershed.	Undertake adaptive management by developing, monitoring, and reporting on surface water quality goals that inform management action.	Encourage the continuation of existing monitoring and sampling programs / ALMS, TransAlta, Alberta Health, Beach Operators	Develop surface water quality goals for the lake and its tributary streams. /SC, AEP, ALMS	Building on existing monitoring programs, coordinate annual lake monitoring and periodic stream monitoring to evaluate if surface water quality goals are being met. / Wabamun Technical Committee (including AEP, ALMS, AHS, Beach Operators, etc.)	Surface water quality objectives for aquatic ecosystem health and recreation are met.
	Improve our understanding of current and future sources of nutrient and contaminant loading through models, studies, etc.		Building on Tuininga (2015) or other information, model changes to water addition and nutrient load as mined lands are reclaimed to agriculture as per the current approved TransAlta Highvale Mine reclamation plan. Model effects on P loading of more land reclaimed to forest, wetlands, native pasture versus cropping, etc. / SC, AEP, TA, academia	Investigate other issues related to water quality such as how to reduce internal sediment load, how to improve flushing flows, etc. /SC, academia	
Lake users are knowledgeable about and able to adapt to lake levels, which fluctuate with natural variability, thereby	Educate lake users about lake level variability and potential for flood and drought.	Monitor and communicate lake water levels to residents and users. /AEP, WWMC, municipalities, Paul First Nation	Use the floodplain map to educate residents and promote flood emergency preparedness. /WWMC, municipalities, Paul First Nation		Lake levels fluctuate within the range of natural variability without incurring property
	Improve understanding of current and future lake level variability to		Improve lake water balance calculation by collecting precipitation data at two sites	Improve understanding of the impact of the weir, beaver dams, vegetation, TA supplement, and	

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contributing to lake health.	inform users and managers.		and establish lake outflow measurements on Near real-time basis when possible or on average daily basis with time step similar to the lake level measurements. / AEP, WWMC, volunteers	other factors on lake level. / AEP, SC, TA	damage or loss.
Objective: Groundwater quantity and quality is maintained and protected for human consumption and recognized as a component of surface water quantity and quality.	Educate groundwater users about well maintenance and how to reduce risk of well contamination.	Encourage regular testing and maintenance of domestic drinking water wells by hosting the Working Well program and providing residents with other educational materials. / Villages, County	Provide information and incent landowners to properly abandon and decommission unused wells through programs such as Parkland County's Green Acreages program. /Villages, County		Number of well owners that test their well regularly. # of well owners that have attended a Working Well Workshop. # of well owners that have shock-chlorinated their well. # of development decisions that have considered GW.
	Improve understanding of groundwater in the Wabamun Lake watershed including accurate estimate of groundwater fluxes (inflow and outflow) for the lake to improve our understanding for water balance models.	TransAlta provide presentations to residents on GW understanding in the area		Encourge researchers to collect and analyze data from the GOA well database, well drilling reports, Alberta Health database, etc. to improve understanding of areas of high groundwater use (well density), recharge rates, groundwater chemistry, surface water interactions, etc./ academia	
	Manage land use development in consideration of impacts to groundwater and the potential for gw-sw	Undertake groundwater vulnerability mapping and use tools such as			

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	interactions and contamination pathways.	policies, environmental reserve dedication, development requirements, the Biophysical Assessment Process, etc.to inform development decisions near key recharge and discharge areas in order to protect them from contamination and incompatible land uses. /AEP, Villages, County			
	Understand the impact of the Highvale mine reclamation on local groundwater flows.	Continue to monitor and report on groundwater flows throughout the reclamation process. /TransAlta			
Goal: Healthy Aquatic Ecosystems and Biodiversity					
Aquatic ecosystem health is maintained or improved.	Conserve, and where degraded, restore wetlands and riparian areas in the Wabamun Lake watershed.	Continue to support and encourage participation in programs like ALUS, Green Acreages, Living by Water, etc. / municipalities, WWMC	Using the riparian assessment and wetland inventories, identify potential sites and incent/assist landowners via existing programs (ALUS Canada) to undertake conservation and restoration. / WWMC, municipalities	Review statutory documents to ensure policies support the Alberta Wetland Policy, bylaws are protective of shorelines and wetlands, and tools (e.g. reserves, setbacks, zoning, enforcement) are used appropriately to protect these areas. / municipalities	Percent of lakeshore with intact riparian area increases

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	Select, monitor and periodically assess indicators in a state of aquatic ecosystem health report.		Review the 2013 state of indicators and determine if they are still appropriate. / SC, AEP	Periodically re-do the Wabamun state of assessment to report on lake health and compare indicators over time. / SC, AEP	State of indicators are maintained or improve over time
Biodiversity is maintained or improved and occurrence or spread of invasive species in the watershed is prevented or mitigated.	Reduce or eliminate opportunities for invasive species to enter the watershed.	Promote the GOA Aquatic Invasive Species program and municipal invasive species and weed programs / municipalities, AEP, Paul First Nation	Ensure existing invasive species educational materials are made available to residents and lake visitors. /WWMC, municipalities, Paul First Nation		Presence or absence of invasive species.
	Monitor for invasive species, inventory where they occur, and remove them using the appropriate methods, protocols, etc.	Continue to monitor for invasive mussels and other invasive species. / ALMS, WWMC, municipalities	Encourage/educate residents to report sightings of invasive species to AEP via the AIS Hotline (1-855-336-BOAT) line, or via AISC EDDMapS Alberta. / WWMC, municipalities		
	Ensure a sustainable fishery.	Set fishery objectives and monitor, assess and report on. / AEP, ACA	Develop educational tools to manage expectations and ensure anglers understand issues (e.g., mercury levels). / AEP, AH, WWMC	Restore the small unnamed fish-bearing creek in south Seba Beach and other areas of key fish habitat. / ACA, WWMC	
		Encourage residents and other anglers to provide input to GOA fisheries consultation processes. / WWMC	Reduce recreation and industry-related fish mortality by promoting best practices. / AEP, ACA WWMC		
	Improve knowledge about and appreciation for biodiversity and its	Organize biodiversity surveys and/or encourage	Develop a checklist series (birds, fish, aquatic plants,	Encourage academic analysis of existing biota collected from lake samples. / academia	Biodiversity is maintained.

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	habitat in the watershed, particularly for species at risk.	the public to contribute to existing programs such as ABMI's NatureLynx, e-bird, Loon Watch, etc.). /WWMC	etc.) for the Wabamun watershed. /WWMC Analyze all the phytoplankton and zooplankton samples that have been gathered as part of past monitoring efforts, in order to better understand potential changes to the Wabamun Lake food web. / WWMC		Species at risk are recovered.
		Continue implementing the Western Grebe recovery plan. / AEP	Use education to promote good near shore (littoral zone) and on-water recreational practices to limit impact on wildlife and habitat. / WWMC, municipalities		
Goal: Wise Land Use					
To the extent possible, natural land cover is maintained or improved and land use does not impair lake or watershed health.	To the extent possible, conserve existing native cover through the use of statutory and voluntary tools such as regulations, bylaws, zoning, easements and conservation tools.	Using ESA, wetland, riparian and other map overlays, provide conditions during ASP development and at sub-division such as requiring proponents to submit a biophysical assessment and using environmental reserve,	Update the Highvale Mine ASPafter appropriate consultation. / Parkland County		% of natural land cover in the watershed

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		development setbacks, etc. to protect native cover. / municipalities			
	Balance public access and a quality lake experience with aquatic ecosystem health.	Manage boating capacity and safety by developing the Sundance boat launch and addressing informal boat launches. / County	Work with RCMP, provincial Conservation Officers and municipal bylaw officers to increase public awareness and compliance with applicable boating and other laws. / Enforcers		
	Minimize the impacts of residential lake shore and backshore development and redevelopment on lake and watershed health by encouraging self reporting for landowners in a floodplain, encouraging naturalized processes for re-builds ex: willow staking, contouring with materials on site and enforcing the *Public Lands Act.*	Continue to develop and implement cosmetic pesticide and fertilizer bylaws. County, villages	Use maps, signage and other communication tools to show where bed and shore, 1:100 floodplain, and existing environmental reserves are, and discourage residents from encroaching on these areas or undertaking offshore modification such as dredging, beach development, fill importation etc. except for the maintenance of existing developed sites (e.g. beaches, launch and pier channels) as regulated via the *Water Act./* County, Villages	Assess stormwater discharge around the lake and potential control and prevention measures. /SC, County, Villages	
		Promote low impact development along the lakeshore by	Implement LID practices & policy in relation to stormwater management.		

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		discouraging new builds or re-builds that substantively increase historical footprint using policy and bylaws for percent of lot cover/ impervious surfaces; etc.			
		Revisit the list of discretionary land uses for Ag designated lands adjacent to a waterbody.			
	Monitor coal mine reclamation to ensure a change in land use does not negatively affect lake and watershed health.	Use adaptive management to ensure the discontinuance of TA water supply and the Highvale mine reclamation are successful and do not negatively impact lake and watershed health. /TA	Provide input to updates of the Highvale ASP (every 5 years starting in 2021). / SC, WWMC		
	Minimize the impacts of agriculture and country residential on lake and watershed health.	Continue to implement the County sewage strategy to eliminate contamination risk by providing septic	Enforce AOPA and encourage the use of BMPs (through ALUS, Green Acreages and other programs) in order to reduce nutrients, manure, pesticides, etc. in runoff. /County, AAF, ALUS	Work to phase out non-conforming land users over time (existing oil and gas well and aggregate mining) within 800 metres of the legal bank of Wabamun Lake, as per the WLSLUP. / County	

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		system education, inspections and maintenance, and incentives to transition to self-contained systems through the Green Acreages program.			
	Minimize the impact of industrial, transportation, and other development on lake and watershed health.	Consider *Environmentally Significant Areas* and other mapped sensitive features when reviewing resource extraction or other development proposals. Provide regulators ESA data overlays. County, AER, AEP	Minimize impact of transportation by ensuring best practices for road maintenance, use of salt, emergency preparedness, etc. County		
Policies and plans are aligned between authorities and regulatory bodies such that development does not impair lake watershed health.	Educate lake users about boating, fish habitat and other federal rules and regulations applicable to Wabamun Lake.		Encourage DFO to have a stronger presence on Wabamun Lake. / SC		TBD
	Raise awareness of the need for and participate in regional discussions and planning for future growth in recreational demand.	Continue to participate in the EMRB in order to provide a watershed lens to regional land use	Recognize the need for regional recreational lake management planning in the NSRP. / AEP		

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		and recreational planning / County			
	Promote municipal collaboration on key policy and plan development to ensure such documents and actions support lake and watershed health.	Continue to meet regularly, develop IDPs, align policies, etc. / County, villages			
Knowledge needed to manage Wabamun Lake watershed is gathered and made available to decision-makers.	Identify, prioritize and fill information gaps.		Establish a Wabamun Watershed Technical Committee to identify and prioritize information needs and communicate findings to decision-makers. / AEP, WWMC, ALMS, Paul First Nation, municipalities, industry	Develop and implement a long-term monitoring program for the lake that can 1) detect long term changes in water quality/ quantity and 2) Can be used to determine the impact of surrounding land use on the lake. Wabamun Technical Committee	To be determined.
	Find innovative ways to communicate learnings to decision-makers.	Continue to build the WWMC website as a parking lot for all Wabamun Lake information.	Make presentations about lake issues/solutions to municipal councils. / SC		
Engaged Stewards					
The community shares its collective responsibility to be the best stewards of the Wabamun Lake watershed and stewardship	Educate lake users, including residents and visitors, about their lake and how they can be good stewards, using beneficial practices to reduce their impact on lake and watershed health.	Continue to support and connect the WWMC Education Committee to existing initiatives such as the GOA Respect Our Lakes program, Love your Lake, etc. / SC,	Develop and implement an education and outreach plan that identifies audiences, tools and information on several key themes such as shoreline restoration, invasive species identification, alternatives to fertilizers and pesticides, good septic	Educate residents about good practices to reduce their impact. Conduct Living by Water shoreline and home assessments and incent restoration via Green Acreages grants. WWMC NA	

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programs inspire action.		WWMC, AEPEducation committee	management, boating safety, etc. / WWMC, AEP		
	Provide stewards with tools and opportunities to build awareness and knowledge, gain skills, and implement stewardship actions.	Continue to support existing Wabamun Lake programs like ACA Kids can Catch day.	Introduce new stewardship tools such as National Secchi Dip Day, Loon Lakes Survey, NatureLynx, etc. / WWMC, municipalities.	Where gaps exist, develop new tools such as case studies, workshops, etc.	
		Continue to support a representative Wabamun Lake WMP Steering Committee that meets regularly to oversee WMP implementation./SC	Encourage residents to educate themselves and participate in land use planning consultation processes, particualry for mine reclamation.		

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