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WIZARD LAKE

Wizard Lake State of the Watershed Report 2012

WIZARD LAKE WATERSHED AND LAKE STEWARDSHIP ASSOCIATION

Wizard Lake Watershed & Lake Stewardship Association

RR 4, Site 2, Box 50, Calmar, AB, T0C 0V0 ~ 780-389-3336
stewardship@wizardlake.ca

Prepared by Aquality Environmental Consulting Ltd.

for the Wizard Lake Watershed and Lake Stewardship Association

Aquality

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

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Letter from the Chair

August 2012

To readers of the Wizard Lake State of the Watershed Report,

The Wizard Lake Watershed and Lake Stewardship Association (WLWLSA) is a small group of dedicated board members and membership who believe that Wizard Lake is precious and must be protected. Our mission is to work towards enhancing and protecting the sustainability and enjoyment of Wizard Lake for the benefit of all users and watershed inhabitants.

Wizard Lake is a small lake, and it is located 40 minutes from Edmonton's metropolitan population of over one million people. If there is not careful stewardship by the residents, users and County decision makers, it faces the overwhelming threat of over-use and over-development, to the detriment of the watershed and beautiful lake we enjoy today.

Five years ago, LeVerne Ellsworth recognized that a crucial step in protecting Wizard Lake was to commission a State of the Watershed report. It is thanks to careful piloting from LeVerne and Carole Ellsworth, who are board- and founding members of the WLWLSA, that the money was painstakingly raised, progress was tracked, input sought, information shared, and that the report is finally complete, a crucial milestone of which all members of the WLWLSA can be very proud.

Thank you to the other board members who were there at the inception of this report and supported its commission, and who are still volunteering their time and effort on the WLWLSA board: Chris Daniel, Kate Daniel, Ruth Kolodychuk and Walter Kolodychuk. Also, our thanks to Aquality for their professionalism and willingness to work with our uncertain financial progress.

A State of the Watershed report includes the history of the watershed, its features, issues and concerns, evaluates the condition of the resources and determines the impact of human activity. The purpose of the report is to serve as a reference guide to help County decision makers and Environmental groups to make informed decisions regarding land and water management and conservation. It serves as the foundation on which to measure success and to build an action plan to guard and improve the state of our watershed.

In addition, our hope is that all residents, users and stakeholder groups will recognize their personal ownership for the healthy future of Wizard Lake, and use this information to help them understand their particular roles and responsibilities as individual stewards of Wizard Lake.

Hope to see you around enjoying beautiful Wizard Lake.

Sincerely,

Laverne Faulkner

Chair, Wizard Lake Watershed and Lake Stewardship Association

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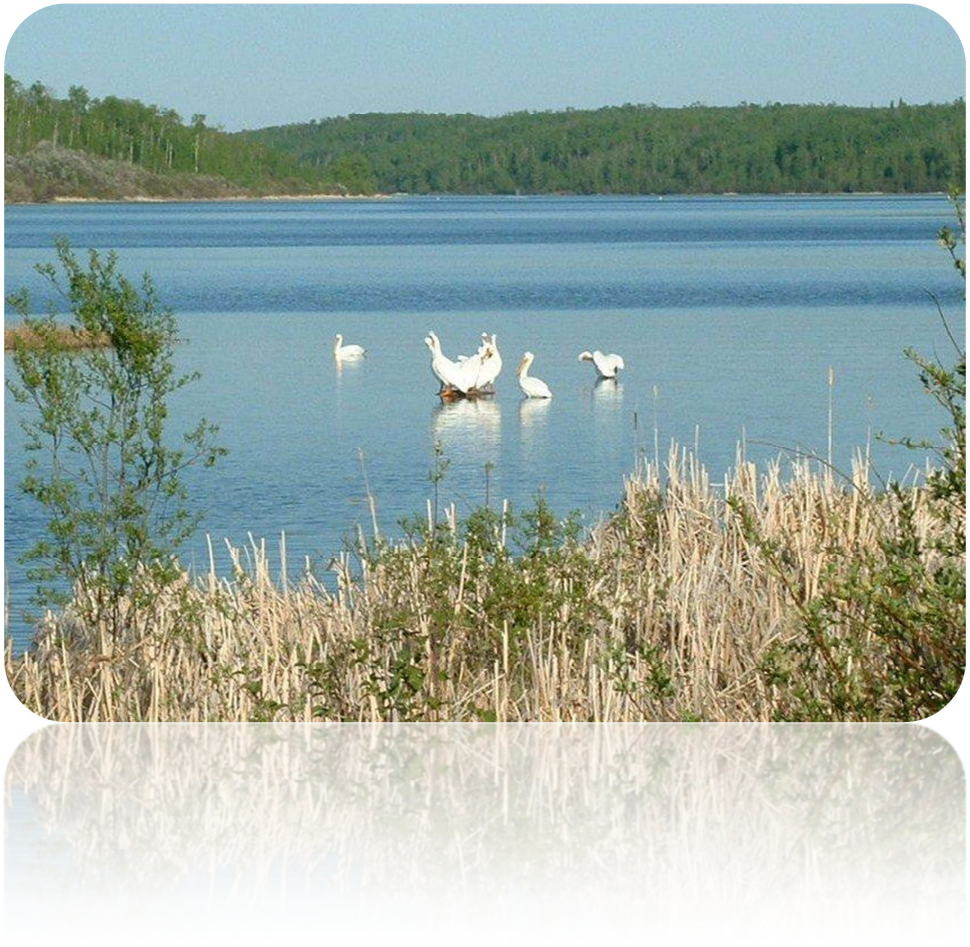


Introduction

Introduction

Wizard Lake is a small lake located approximately 60 km southwest of the City of Edmonton, lying along the border between Leduc County and the County of Wetaskiwin. It is a small basin lying within the Strawberry Creek sub-basin of the North Saskatchewan River watershed (North Saskatchewan Watershed Alliance, 2005), emptying into the North Saskatchewan approximately 5 kilometers west of Devon via Conjuring Creek. Poorer soils than much of the surrounding landscape have contributed to the high amount of intact natural land cover compared to the surrounding region, as much of the land is not suitable for intensive agricultural production. The lake itself lies in a relatively steep-sided valley, which, combined with the rolling topography of the immediate vicinity, may have served to reduce the amount of residential development of the shoreline compared to other lakes in the region.

The First Nation's name for the lake translated to "Lizard Lake," but the lake was referred to as "Conjuring Lake" up until the 1960s. The shores of the lake were first homesteaded in the early 1900s, and a sawmill briefly operated on its shores only to be closed when an expected railway line was not constructed (Mitchell and Prepas, 1990). Coal mines have periodically been active at a number of locations, but no coal mining currently occurs within the watershed. Residential development on the lake since initial settlement has been modest, restricted to isolated areas of the lake shore due to both the steepness of the shore in the immediate vicinity of the lake, and to management plans and policies put in place to limit growth to sustainable levels.

Owing to its proximity to the City of Edmonton, Wizard Lake is a popular recreational lake in the region. It is popular for fishing, boating, and a wide variety of other water sports, and boasts popular camping areas. The recreational appeal of the lake resulted in different pressures on the environment from various groups of users, including water skiers and other power boat operators, canoeists and anglers, and local residents. These conflicting pressures have resulted in the proposal and partial implementation of several plans for the lake, including posting of speed limits and proposals to divide the lake into separate usage zones, and restrictions on the amount of development that will be allowed.

In addition to its recreational value, Wizard Lake and the associated habitats have been recognized as a regionally significant Environmentally Sensitive Area, providing important fish and wildlife habitat. It boasts a large basin size relative to the lake area, and a large proportion of the basin remains intact relative to the surrounding landscape.

The struggle to strike a balance between various forms of development, increased recreational access, and protection of the natural environment have resulted in increasing conflict between stakeholders in the future of Wizard Lake.

Purpose of Report

The purpose of this State of the Watershed report for Wizard Lake is to summarize the current knowledge of the watershed pertaining to land-use, water quality, water quantity and biological characteristics, in order to comment on the environmental integrity of the watershed. This report has been created primarily for the Wizard Lake Watershed and Lake Stewardship Association (WLWLSA), but also for other watershed stakeholders, including residents, recreational users, regulators, policy makers, industry and non-governmental organizations. The report will provide the background information that is required for improved municipal district management decisions by regulators, policy makers, landowners and industrial users. Specifically, it is designed to answer the following questions:

- What is the condition of the Wizard Lake Watershed?
- What data/knowledge gaps exist?
- What steps can be taken by local governments, residents, the WLWLSA, and other stakeholders to prevent future impacts to, mitigate existing impacts of, or restore impacted or lost ecosystems?

Scope of the Report

The geographic scope of this State of the Watershed report is the Wizard Lake Watershed in northwestern Alberta. The Watershed is located at the border between Leduc County and the County of Wetaskiwin, about 60 km southwest of Edmonton (Figure 1). The watershed encompasses an area of about 32 km^2 (Agriculture and Agri-Food Canada, 2008). As part of the Leduc County's Wizard Lake Area Structure Plan (2010), the northern portion of the watershed boundary was re-delienated using updated topographical information. The updated boundary closely follows the previous boundary over most of its length, except that a rectangular region extends approximately 1 km further north from the previous boundary in the vicinity of 3,10–T048-R27-W4M, to the west of Enchantment Valley (Figure 1). Similarly, a re-delineation of the southern boundary is in progress by the County of Wetaskiwin (WLWLSA, pers. comm.). However, because much of the data used in this report is provided based on the boundaries of the PFRA dataset, and because a finalized updated boundary is not available for the southern half of the watershed, the earlier boundary will be used for the presentation of most information in this report.

This report provides information on the counties, lake water quality/quantity, land-use and the potential effects of resource and land-use practices. Each section of this report is intended to provide and summarize known social, physical and environmental information. The report considers the physical aspects of the entire watershed, first at a broad scale and then on specific land and water resources. The report also identifies the jurisdictions of the various Federal, Provincial and Municipal regulators in an effort to decipher roles and mandates. The report then outlines how state of the watershed reporting fits into the greater context of watershed management planning in Alberta under Alberta Environment's *Water Strategy: Water for Life* and identifies legislation and policies affecting watershed management in Alberta. A special emphasis has been placed upon the role of this document in future

planning and stewardship activities in the Wizard Lake Watershed, by all present and future stakeholders and stewards.

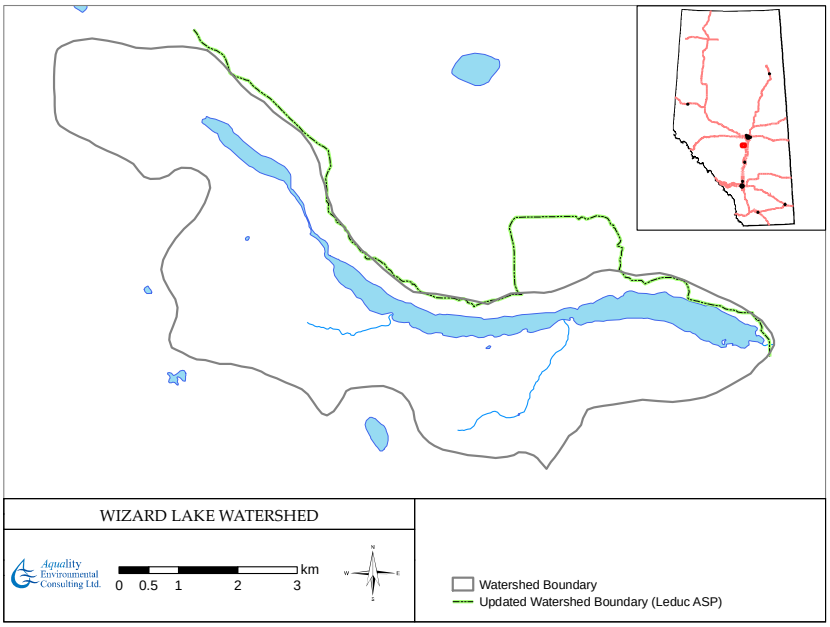


Figure 1. Location of the Wizard Lake watershed in Alberta. Green line represents the new northern watershed boundary determined by Leduc County (2010).

Legislation and Regulation

Federal Government

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

The *Fisheries Act* is the guiding act that enables Fisheries and Oceans Canada to protect fish and fish habitat. Fish habitat by definition includes spawning grounds and nurseries, rearing, food supply and migration areas on which fish depend to carry out their life processes. It is the mandate of the Department of Fisheries and Oceans to preserve healthy marine and freshwater aquatic ecosystems in support of scientific, ecological, social and economic interests. The *Fisheries Act* prohibits any activity that results in the harmful alteration, disruption or destruction (HADD) of fish habitat, protects fish populations from pollution and recommends mitigation measures where loss of habitat is unavoidable.

Work carried out near a fish-bearing watercourse must have the approval of Fisheries and Oceans Canada. Failure to comply with the Act may result in fines or imprisonment.

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

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

Provincial Government

The Government of Alberta is committed to sustainable development through an integrated resource management (IRM) approach to protect the environment and manage Alberta's resources. IRM requires a comprehensive, interdisciplinary approach to the management of water, timber, air, public land, fish, wildlife, range, oil, gas and mineral resources. The Alberta Government initiated the development of a province-wide comprehensive strategy called *Water for Life: Alberta's Strategy for Sustainability* in 2001. The purpose of the strategy was to identify short-, medium- and long-term plans to manage effectively the quantity and quality of the province's water systems and supply. The three main goals of the strategy are to ensure that Albertans have a safe and secure drinking water supply, healthy aquatic ecosystems and reliable and high-quality water supplies for a sustainable economy (Alberta Environment, 2003). The provincial government uses both the *Water Act* and the *Environmental Protection and Enhancement Act* (EPEA) to enforce regulations regarding the preservation of Alberta's water supplies.

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

More recently, the Government of Alberta introduced the *Alberta Land Stewardship Act* ("ALSA") on April 27, 2009. ALSA provides the legislative framework to support Alberta's Land-Use Framework

("LUF"), which is a comprehensive strategy to guide the management of public and private lands and natural resources across Alberta.

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

Municipal Governments

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

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

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

Legislation/Policy	Description
Federal *Fisheries Act* – Department of Fisheries and Oceans Canada (DFO)	Regulates and enforces on harmful alteration, disruption and destruction of fish habitat in Section 35.
Canadian Environmental Protection Act (CEPA) – Environment Canada (EC)	Aimed at pollution prevention and the protection of the environment and human health to contribute to sustainable development.
Canadian Environmental Assessment Act – Canadian Environmental Assessment Agency	Requirement by federal departments, agencies and certain Crown corporations to conduct environmental assessments for proposed projects and activities before providing federal support to the project.
Canada Water Act – Environment Canada (EC)	Aimed to ensure that water issues of national significance are conserved, developed and managed.
Canada Wildlife Act –Environment Canada (EC)	Designed for the creation, management and protection of wildlife areas for wildlife research activities, or for conservation or interpretation of wildlife.
Navigable Waters Protection Act (NWPA) – Transport Canada (TC)	Aimed to protect the public right of navigation by prohibiting the building or placement of any "work" in, upon, over, under, through, or across a navigable water without the authorization of the Minister of Transport.
Species at Risk Act – Environment Canada (EC), Parks Canada, Department of Fisheries and Oceans Canada (DFO)	Provides legal protection of wildlife species and the conservation of biological diversity.
Migratory Birds Convention Act – Canadian Wildlife Service (CWS)	Aimed to protect and conserve migratory birds, both as individuals and populations, as well as their nests.

Provincial *Water Act* – Alberta Environment (AENV)	Governs the diversion, allocation and use of water. Regulates and enforces actions that affect water and water use management, the aquatic environment, fish habitat protection practices and in-stream construction practices.
Provincial *Environmental Protection and Enhancement Act* (EPEA) – AENV	Management of storm water, contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement.
Provincial *Land Stewardship Act* – Sustainable Resource Development (SRD)	This act supports the Land Use Framework, which is a comprehensive strategy to guide the management of public and private lands and natural resources in Alberta.
Provincial *Agricultural Operations Practices Act* (AOPA) – Natural Resources Conservation Board (NRCB)	Regulates and enforces on confined feedlot operation and environment standards for livestock operations.
Provincial *Municipal Government Act* (MGA) – Municipal Affairs	Provides municipalities with authorities to regulate water on municipal lands, management of private land to control non-point sources, and authority to ensure that land use practices are compatible with the protection of aquatic environment.
Provincial *Public Lands Act* – Sustainable Resource Development (SRD)	Regulates and enforces on activities that affect Crown-owned beds and shores of waterbodies and some Crown-owned uplands that may affect nearby waterbodies.
Provincial *Safety Codes Act* – Municipal Affairs	Regulates and enforces septic system management practices, including installation of septic field and other subsurface disposal systems.
Regional Health Authorities Act – Alberta Health	RHA have the mandate to promote and protect the health of the population in the region and may respond to concerns that may adversely affect surface and groundwater.
Wildlife Act – SRD	Regulates and enforces on protection of wetland-dependent and wetland-associated wildlife, and endangered species (including plants).
Provincial Parks Act & *Wilderness Areas, Ecological Reserve and Natural Areas Act* – SRD and Community Development	Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas.
Provincial Wetlands Policy	This policy will be used to protect wetlands and mitigate losses through a "No Net Loss" policy.
Land Use Bylaws (Municipal)	The bylaw that divides the municipality into land use districts and establishes procedures for processing and deciding upon development applications. It sets out rules that affect how each parcel of land can be used and developed and includes a zoning map.
Area Structure Plans (Municipal)	Adopted by Council as a bylaw pursuant to the *Municipal Government Act* that provides a framework for future subdivisions, development, and other land use practices of an area, usually surrounding a lake.
Municipal Development Plans	The plan adopted by Council as a municipal development plan pursuant to the *Municipal Government Act*.

Existing Plans and Policies

At the municipal level, there are currently several applicable policies. Because of its location along the boundary between two counties, separate policies may apply to the north and south shores of the lake, implemented by Leduc County and the County of Wetaskiwin, respectively.

A Management Plan for Wizard Lake was prepared in 1980 (Edmonton and Battle River Regional Planning Commissions, 1980). The Plan outlined a management philosophy based on minimizing development near existing or potential coal, oil, and gas reserves to allow for future energy development, limitations on residential or other development on lands suitable for agriculture, the protection of existing fish and wildlife resources, and limitations on recreational development due to the relatively small size of the lake. The plan adopted an overall integrated use approach, attempting to balance land use between agriculture, protection of coal deposits, and sustainable residential development.

The Leduc County Municipal Development Plan (1999) includes provisions for development of lakeshore resorts (including the communities around Wizard Lake), based on the principles of development within carrying capacity, the minimization of impacts on the lakeshore, the protection of public access to the lake, and the conservation and protection of the natural environment and recreational areas.

Wetaskiwin's 1999 Wizard Lake Management Plan focuses to a great extent on minimizing the impacts of nutrient pollution into the lake, including targets for septage management, the maintenance of riparian vegetation, the control of nutrient runoff from agricultural operations, and the management of nutrient runoff residential and recreational/commercial properties. It also includes goals for the management of recreational traffic, especially boating, on the lake, and the preservation of the fisheries in Wizard Lake.

Leduc County has prepared a more recent Area Structure Plan for Wizard Lake (2010). The ASP is guided by three primary vision statements:

1. The plan area shall remain a place where natural environment and agriculture is cherished and protected.
2. The area is a place with a strong sense of community and identity. The plan shall help build on those strong values.
3. Wizard Lake is a place for recreation. The plan shall strive to make this area healthier and safer.

The ASP promotes development in the area that is specifically geared towards the protection of the natural environment, the preservation of the area's historical identity and character, and promoting sustainable development and recreation.

Under the County of Wetaskiwin's (2010) Municipal Development Plan, the intended land use intensity of Wizard Lake is classified as "Low-impact Development." This categorization is applied to lakes that can accommodate low impact and small scale development on the lakeshore, and which may be suitable for wildlife habitat and wilderness conservation.

Public Perception and Concerns

Concerns about Wizard Lake and its watershed have been presented from a variety of sources.

The membership of the Wizard Lake Watershed and Lake Stewardship Association present the following as major stewardship concerns for the lake:

- Water quality problems from sewage, algae, pesticides, agricultural runoff
- Recreational use and lake public safety and enjoyment
- Bed and shore health (e.g. loss of buffer zones, shoreline erosion)
- Loss or damage to wildlife and fish habitat

Additionally, extensive public consultation was performed during the development of Leduc County's Wizard Lake Area Structure Plan. Concerns raised with respect to the lake included:

- Concerns about the amount and type of boat use on the lake, boating facilities, the impact on the natural environment and safety of lake users.
- Need more regulated boat use – reduced numbers, limit types.
- Need to see more boats for fishing, which has been reduced over the years because of the amount of speed boat activity.
- Issues related to private property damage - need more regulation and enforcement around the lake, pertaining to trails, parks and open space uses.
- Trespassing using quads, dirt bikes, and skidoos is an issue consistent among residents and farmers.
- Need to see more stewardship of the watershed and an increase in land based recreational use to offset the amount of boating on the lake – such as trails, nature walks, hiking, cross country skiing, lake swimming, canoeing, kayaking and cycling.

Topics discussed at the Wizard Lake ASP Focus Group on recreation:

- Buffer zones/setbacks
- Impacts on agriculture
- Involvement of Wetaskiwin County
- Existing agricultural businesses and alternative methods for agriculture
- Need for the County to conduct a study on water levels and quality of Wizard Lake
- Solutions for existing conditions caused by nutrient dumping & water quality education
- Improvement of current services for resort residential subdivisions
- Redevelopment of existing residential areas
- Development Guidelines: Character areas (cluster country residential) and infrastructure
- The Hamlet

- Trail system
- Boat access to Wizard Lake & boat safety
- Jubilee park expansion

The various planning and policy documents discussed previously were also guided by issues raised by residents and other stakeholders. However, the issues listed above include the vast majority of multi-stakeholder issues that have arisen to date.

Methods

Methods

Indicators of Environmental Quality

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

1. relevant - able to educate the public about the ecosystem;
2. straightforward;
3. easy to understand;
4. reliable - the information the indicator provides is trustworthy; and
5. timely - the information is available while there is still time to act.

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

1. Land use:
    - Urban, Rural and Recreational Developments;
    - Agricultural and Livestock Operations;
    - Oil and Gas Activities;
    - Linear Developments;
    - Wetland Loss; and
    - Riparian Health.
2. Water quality:
    - Nutrients;
    - Metals;
    - Bacteria;
    - Parasites; and

- Pesticides.

3. Water quantity:
    - Lake Levels and Withdrawals;
4. Biologicals:
    - Land Cover

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

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

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

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

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

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

highway – 16 m; 4-lane paved undivided highway – 32 m; paved divided highway – 40 m; unimproved road – 8 m).

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

Riparian health – Riparian health assessments have been performed by various agencies and are generally based on those done by Cows and Fish, i.e., based on their inventory and assessments protocols. The ratings provided in this report follow those of the agencies that have performed the riparian assessments, e.g., Cows and Fish, ACA, ASRD.

Total phosphorus – Total phosphorus (TP) concentration < 0.05 mg/L was deemed "good", from 0.05-0.10 mg/L was deemed "fair" and > 0.10 mg/L was deemed "poor". The cut-off concentration for the "good" rating for TP follows the CCME Protection of Aquatic Life (PAL) guideline of 0.05 mg/L (CCME, 1999, 2001).

Total nitrogen – Total nitrogen (TN) concentration < 1.0 mg/L was deemed "good", from 1.0-1.5 mg/L was deemed "fair" and > 1.5 mg/L was deemed "poor". The cut-off concentration for the "good" rating for TN follows the CCME Protection of Aquatic Life (PAL) guideline of 0.05 mg/L (CCME, 1999, 2001).

Total metals – Due to the potentially severe impacts of metals to aquatic organisms, total metal concentrations exceeding CCME Protection of Aquatic Life guidelines (CCME, 2001) were deemed "poor".

Bacteria – *E. coli* counts from 0-100 CFU/100 mL were deemed "good" and counts > 100 CFU/100 mL were deemed "poor". The cut-off concentration follows CCME Agriculture/Irrigation guidelines (*E. coli* concentration of 100 CFU/100 mL) (CCME, 1999).

Parasites – If any parasite concentrations exceeded Health Canada drinking water guidelines, a rating of "poor" was given.

Pesticides – If any pesticide concentrations exceeded CCME PAL guidelines (CCME, 1999), a rating of "poor" was given, otherwise, a rating of "good" was given.

Minimum flow – No reduction in water flow is deemed "good", a reduction in water flow up to 15% was deemed "fair" (resulting in intermediate chronic impacts on fish populations due to a reduction in habitat availability for intermediate periods) and a reduction in flow > 15% was deemed "poor" (resulting in high chronic or instantaneous impacts on fish populations due to a reduction in habitat availability for prolonged periods) (Clipperton et al., 2003).

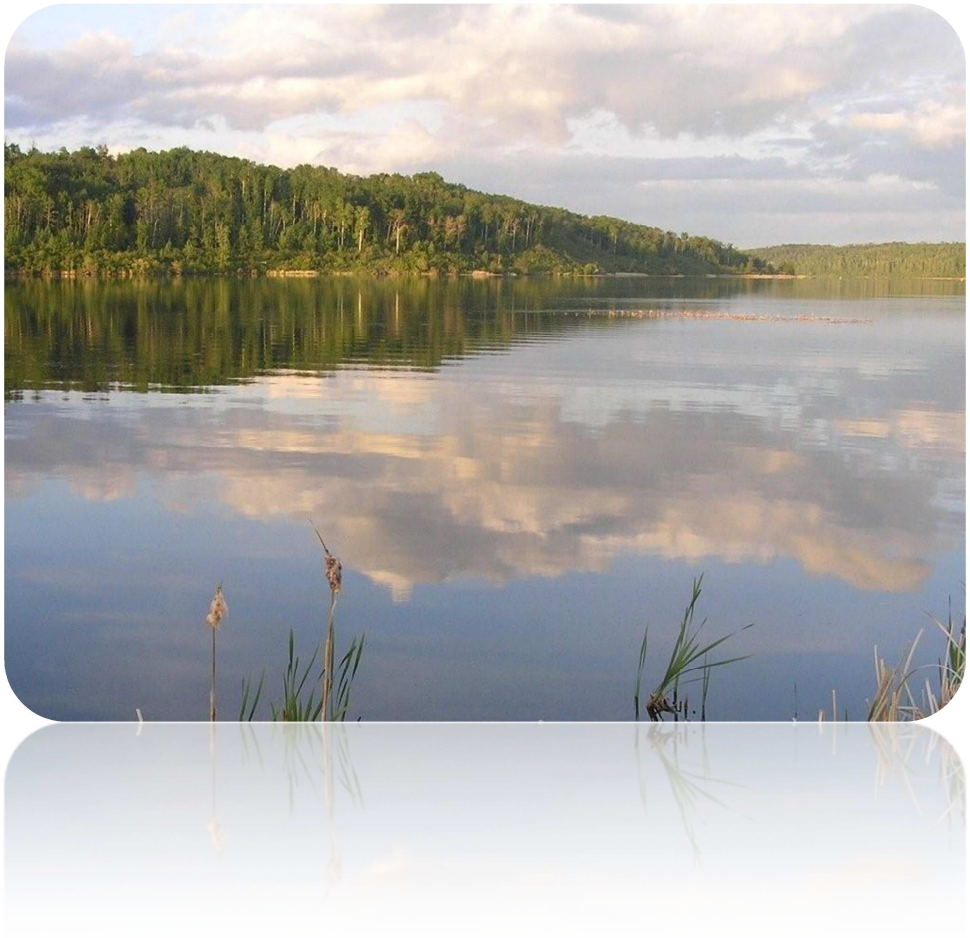
Land cover – Combined land cover values for wetlands, grasslands and all forested areas > 50% was deemed "good", 25-50% was deemed "fair" and < 25% was deemed "poor".

Data Collection

Data used in the development of this report come from Alberta Environment and Water (formerly Alberta Environment), Alberta Sustainable Resource Development (ASRD), the Alberta Geological Survey, Geobase, Altalis, Alberta Culture and Community Spirit, the Prairie Farms Rehabilitation Administration (PFRA), Agriculture and Agri-Food Canada (AAFC), Environment Canada (EC), Geogratis, and/or Geobase (Table 2), and may be subject to copyright and/or licensing restrictions. Other sources of data are referred to throughout this report and consist of reports from federal and provincial governments, non-governmental agencies, municipalities, industry and scientific literature. The most recent and publicly-available data were used to generate all maps in this report.

Table 2. Data sources for maps generated for this report.

Map	Data source
Agricultural intensity	Statistics Canada (2006) and Agriculture and Agri-Food Canada (2007)
Cattle density	Statistics Canada (2006) and Agriculture and Agri-Food Canada (2007)
Groundwater licenses	Alberta Environment (2011)
Land cover	Natural Resources Canada (2009b)
Linear developments	Natural Resources Canada (2009a)
Manure production	Statistics Canada (2006) and Agriculture and Agri-Food Canada (2007)
Natural Subregions	Alberta Tourism, Parks and Recreation (2006)
Non-contributing drainage area	GeoBase Canadian Digital Elevation Model (Natural Resources Canada, 2007)
Oil/natural gas wells	Natural Resources Canada (2007)
Surface water licenses	Alberta Environment (2011)
Topography	GeoBase Canadian Digital Elevation Model (Natural Resources Canada, 2007)
Waterbodies	CanVec Hydrography layer (Natural Resources Canada, 2009a)
Watershed boundaries	Agriculture and Agri-Food Canada (2008)
Wetland cover	CanVec saturated soils layer (Natural Resources Canada, 2009a)



State of the Wizard Lake Watershed

State of the Wizard Lake Watershed

General Watershed Characteristics

The Wizard Lake watershed is located approximately 60 km southwest of the City of Edmonton, lying along the border between Leduc County and the County of Wetaskiwin. It is a small drainage basin lying within the Strawberry Creek sub-basin of the North Saskatchewan River watershed (North Saskatchewan Watershed Alliance, 2005), emptying into the North Saskatchewan approximately 5 kilometers west of Devon via Conjuring Creek. The lake itself lies in a relatively steep-sided valley (Figure 3), and owing to the unfavorable topography, much more of the watershed is under natural cover (such as forests and wetlands) than much of the land in the region. Elevations range from 846 m above mean sea level on the southern edge of the basin, to approximately 784 m at the lake surface.

The Wizard Lake watershed has a total area of 3,221 hectares, extending approximately 13 km in an approximately northwest-to-southeast orientation. The watershed is approximately 1.6 kilometers wide at its narrowest point, and 3.4 kilometers at its widest. The watershed has a moderate to large area relative to the size of the lake, with an area ratio of approximately 12:1.

Figure 2. Wizard Lake in winter.

Wizard Lake proper has a surface area of approximately 248 hectares across two separate basins connected by a narrow channel (Figure 3). The larger east basin is the primary body used for recreational activities, as the narrow, shallow channel limits boat access. The total channel length of the two basins is approximately 11.5 km, and the lake reaches a maximum width of approximately 550 m at the eastern end near the outlet and a minimum width of approximately 140 to 150 m near the mid-

point of the east basin (depending on water levels). The lake reaches a maximum depth of 11 m, with an average depth across the whole lake of 6.2 meters (Mitchell and Prepas, 1990). The littoral zone (the shallow, shore-adjacent portions of the lake where light can penetrate) extends out to a depth of approximately 4.1 m, and takes up roughly a third of the lake's surface area (Mitchell and Prepas, 1990).

The lake is fed by several tributaries, including two flowing into the southern edge of the lake that are classified as permanent by Natural Resources Canada (Natural Resources Canada, 2009a), and drains to the North Saskatchewan River via Conjuring Creek. Owing to its large basin:lake surface area ratio, Wizard Lake has a short hydraulic residence time on the order of 13 to 14 years (the average amount of time water will spend in the lake); other popular regional lakes such as Pigeon, Gull, and Wabamun have much longer residence times due to their relatively smaller basins, so they have lower potential for rapid filling and flushing (Alberta Environmental Protection, 1998).

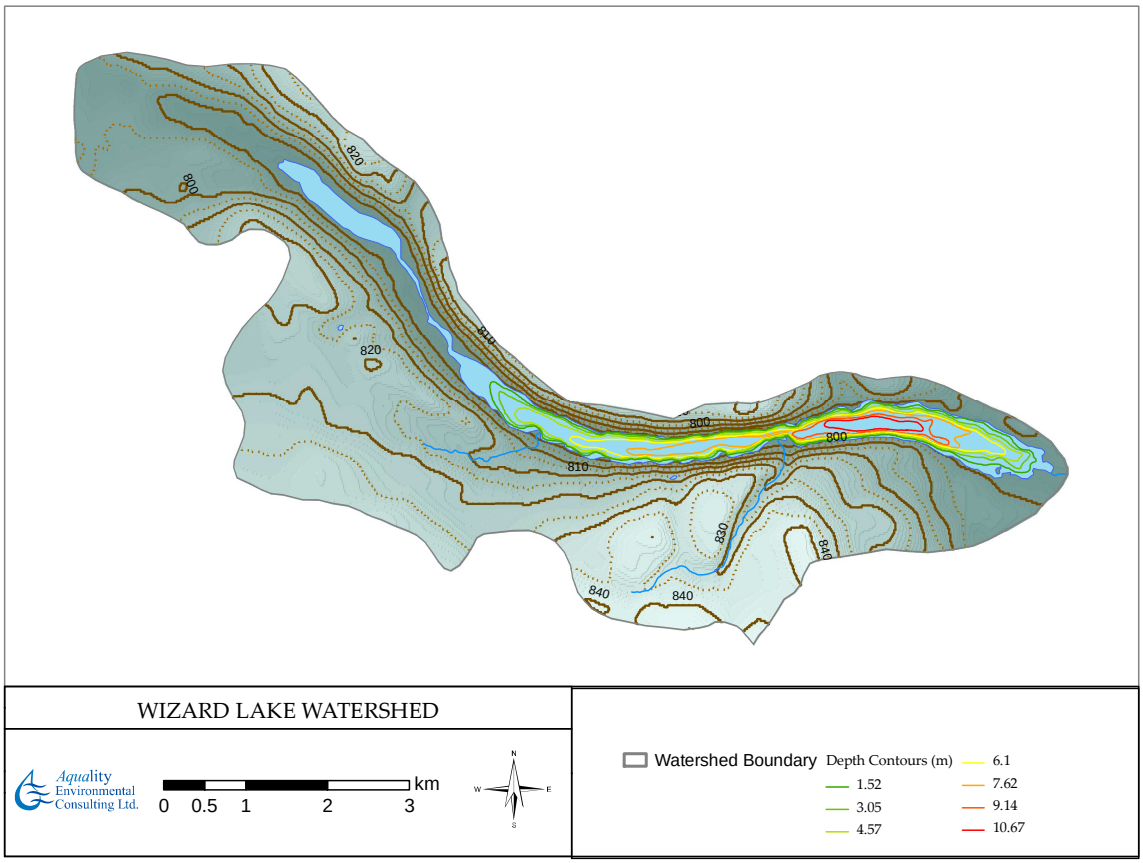


Figure 3. Elevation and bathymetric (depth) contours for Wizard Lake and surrounding watershed. Data from Natural Resources Canada (2009a) and Alberta Geological Survey (2008).

Natural Regions and Subregions

The Wizard Lake watershed lies across the boundary of the Boreal Forest and Parkland Natural Regions in Alberta (Natural Regions Committee, 2006; Figure 4). The Natural Regions classification was adopted by the Government of Alberta to represent ecosystem and biodiversity elements of importance to protected areas. The classification system emphasizes the overall landscape pattern, which mainly reflects climate, but in other cases may predominantly reflect geological and soil factors. The purpose of the Natural Regions classification is to account for the entire range of natural landscapes and ecosystem diversity and is related primarily to ecosystem and biodiversity conservation.

The area of the Wizard Lake watershed consists of approximately 90% Boreal Forest (Dry Mixedwood Natural Subregion) in the western portion of the watershed, with the remaining approximately 10% consisting of Parkland (Central Parkland Natural Subregion) in the extreme eastern-most area of the watershed. However, given the scale of the watershed relative to the scale of the Natural Regions, and the fact that the Natural Region Boundaries are artificial distinctions on a continuously varying landscape, it is likely that the watershed consists almost entirely of an intermediate between these two regions.

Boreal Forest Natural Region - Dry Mixedwood Subregion

The Boreal Forest Natural Region is the largest in Alberta and consists of broad lowland plains and discontinuous but locally extensive hill systems. The presence of extensive wetlands is a major characteristic of the Boreal Forest Natural Region. Bogs, fens and swamps are abundant and marshes are locally prevalent. The Natural Region has been divided into six Subregions, of which only one, the Dry Mixedwood Natural Subregion, occurs in the Wizard Lake Watershed.

The Dry Mixedwood Natural Subregion is the second-largest Natural Subregion in Alberta. Elevations range from 200 m along the Peace River in the extreme northeast part of the Natural Subregion to 1,225 m west of Sundre and adjacent to the Lower Foothills Natural Subregion. The dominant terrain types are level to gently undulating glacial till or lacustrine plains. Gray Luvisols are the dominant soils on uplands; Gleysols and Organic soils are dominant in wetlands. Aspen forests with mixed understories of rose, low-bush cranberry, beaked hazelnut and Canada buffaloberry are typical on uplands. Treed, shrubby or sedge-dominated fens occupy about 15% of the Natural Subregion. Jack pine stands occur on dry, well- to rapidly-drained glaciofluvial and eolian precipitation are higher in the southern part of this Subregion than in the Peace River area. Growing degree-days are highest in the Peace River area. The prevalence of early to mid-seral aspen forests in the Dry Mixedwood Natural Subregion, and the relative scarcity of white spruce compared to the adjacent Central Mixedwood Natural Subregion, might be in part due to a higher incidence of lightning-caused fires in the Dry Mixedwood (Natural Regions Committee, 2006).

Parkland Natural Region - Central Parkland Subregion

The Parkland Natural Region consists primarily of level to undulating land, underlain mainly by glacial till. The natural vegetation is dominated by extensive grasslands, interspersed with remnant willow shrublands and aspen stands. As a result of the rich character of the deep soils formed on till, much of this Natural Region is under cultivation for cropland. The Parkland Natural Region is broken down into

three different subregions, of which only one, the Central Parkland Natural Subregion, occurs in the Wizard Lake watershed (Natural Regions Committee, 2006).

The Central Parkland Natural Subregion consists of a broad arc of highly fertile land in central Alberta. Elevations range from 500 m near the Alberta-Saskatchewan border to 1,250 m near Calgary. The dominant terrain types are undulating glacial till plains and hummocky uplands. Black Chernozems are the dominant soils in grassland areas, with Dark Gray Chernozems and Luvisols under aspen forests. Across the entire Natural Subregion, only about 5% remains in native vegetation. These remnant areas consist primarily of grasslands dominated by rough fescue, Western porcupine grass, and northern wheatgrass interspersed with a wide variety of forbs, and aspen forests with mixed understories of rose, beaked hazelnut and saskatoon. The Central Parkland Natural Subregion has slightly warmer mean annual temperatures than the Dry Mixedwood Natural Subregion, with precipitation generally peaking from June to August. This combination of a warm and relatively long growing season with adequate precipitation, as well as rich, deep soils, makes the area highly productive as cropland (Natural Regions Committee, 2006).

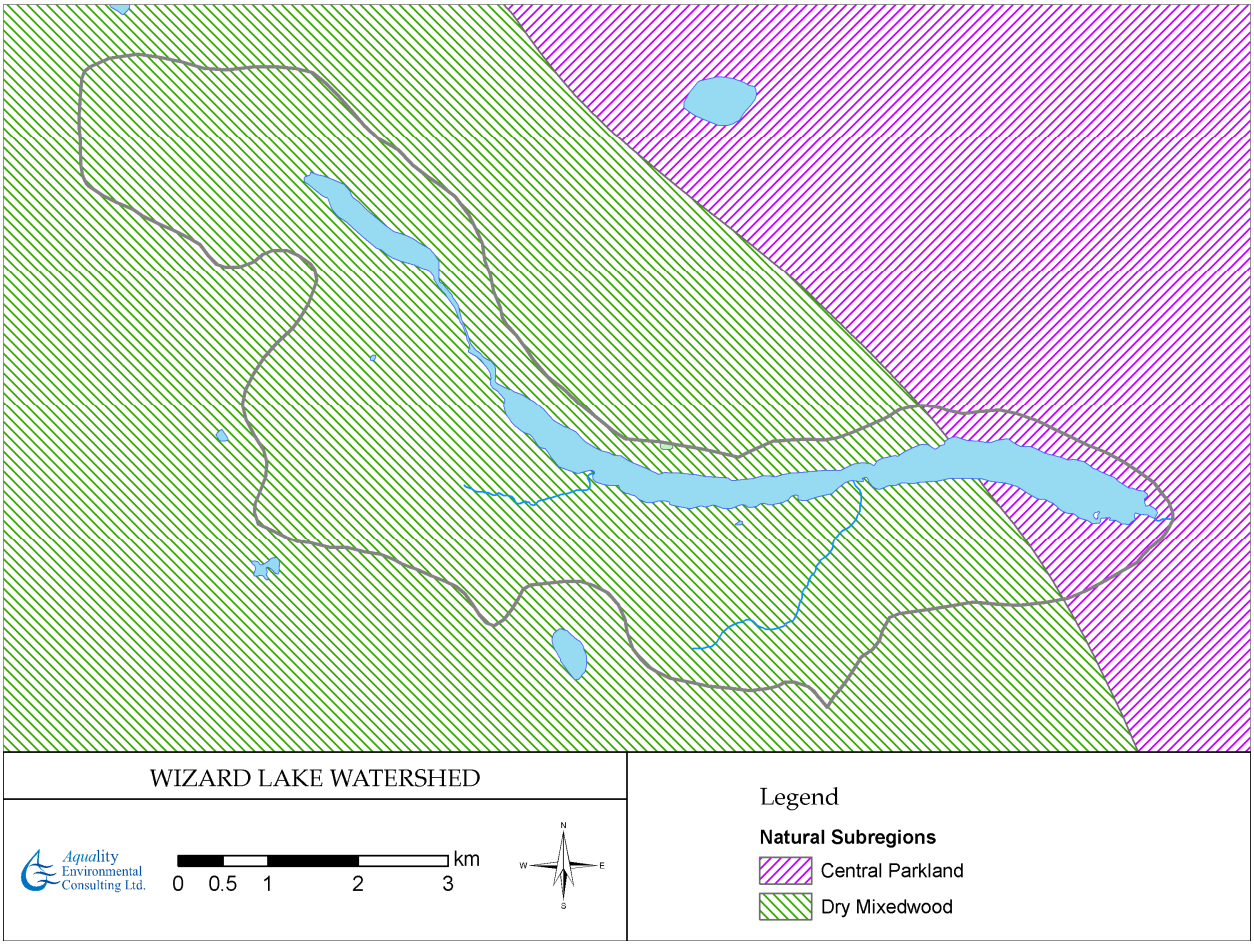


Figure 4. The Natural Subregions of the Wizard Lake watershed (Alberta Tourism, Parks and Recreation, 2006).

Geology

The surficial geology of the Wizard Lake study area reflects the action of the most recent ice advance, in which the Laurentide Ide Sheet extended from the northern regions of the continent. Surficial deposits in the area consist primarily of glacial moraines between 0 and 10m thick with a flat to undulating topography. Deposits at the very eastern-most edge of the watershed are dominated by ice-contacted fluvial deposits, formed by deposits of till within streams flowing through and under the glacial ice sheets (Alberta Geological Survey, 2009). The basin as a whole is the result of a channel through the underlying bedrock; during the last glacial recession, meltwater eroded away the surface till, resulting in a steep, sheltered valley (Mitchell and Prepas, 1990; Natural Resources Canada, 2009a).

The bedrock geology of the Wizard Lake watershed consists primarily of sandstone, siltstone, and mudstone, with thin beds of limestone, coal, and tuff. These bedrock deposits come mostly from the upper Paskapoo bedrock formation (Alberta Geological Survey, 2009). The Paskapoo formation is Tertiary Period deposit composed primarily of non-marine sedimentary rocks including primarily calcareous mudstone, siltstone and sandstone, with subordinate beds of limestone, tuff, and coal. The watershed boundary may extend to the boundary between the Paskapoo and the Scollard Formation (Cenozoic Era, Tertiary Period, Tertiary-Cretaceous Epoch), which is composed primarily of dark sandstones and mudstones with thick coal beds.

Climate

The climate in the Wizard Lake watershed is sub-humid and continental with short, cool summers and long, cold winters (Natural Regions Committee, 2006). The nearest Environment Canada reporting site for which climate normals are available is located at Calmar. The mean annual temperature is 2.9°C, with an average growing season temperature (May-September) of 13.5°C. The area has an average annual precipitation of 520.9 mm, with approximately 70% of that falling from May to September (Environment Canada Canadian Climate Normals, 1971-2000). The area experiences approximately 1430 growing-degree-days annually.

Land Use

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

- Urban, Rural and Recreational Developments;
- Agricultural and Livestock Operations;
- Oil and Gas Activities;
- Linear Developments;
- Wetland Loss; and

- Riparian Health.

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

Urban and Rural Developments

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

The Wizard Lake watershed contains 6 main population centers: Enchantment Valley (comprising approximately 73 residences), Wizard Lake Estates (16 residences), Butterfly Cove (8 residences), Curilane Beach (A – 18 residences and B – 51 residences), Wizard Heights (40 residences), and Wizard Ridge (12 residences). A neighbourhood park is available at Enchantment Valley, and public access is provided at Jubilee Park, the northwest end at RR275, Curilane A and Wizard Heights.

Under the Wetaskiwin County Municipal Development Plan, the Wizard Lake area has been categorized as “Low-impact Development” in order to minimize the impacts of rural and urban development.

Recreation

Recreational developments are those developments that do not support permanent residency, but may experience heavy traffic during certain periods for recreational activities such as boating, fishing, or camping.

Two campgrounds/ recreational facilities are located in the Wizard Lake watershed. Jubilee Park is a public campground located on the northeast edge of the lake. The facility is maintained by Leduc County, and provides 33 powered sites, 67 natural sites, and 12 picnic sites, with beach, shower, boat launch, and various other facilities (Leduc County, 2009). Bentley’s Family Campground is a privately run campground located on the central portion of the north shore of the lake, which has been running since 1998. The facility has approximately 60 sites available, up from 15 when the campground was opened (A Bentley, pers. comm.).

Wizard Lake is subject to heavy recreational boating usage, and boating traffic and safety have been an ongoing concern for decades. Surveys of boat usage were conducted in 1979 in connection with the development of the Wizard Lake Management Plan (Edmonton and Battle River Regional Planning Commissions, 1980), by the Wizard Lake Water Ski Club in 1998, and by the WLWLSA in 2008. In 1979, estimated boat usage was 76 boats on the water during daylight hours. In 1998, the peak number of boats on the water was 61, though surveys of residents, ski club members, and Jubilee Park staff suggested the potential for up to 250 boats having access to the lake at any given time (Leduc County and Wetaskiwin County, 1998). The survey conducted in 2008 showed an average of 84 and a maximum

of 123 boats on the water on 4 weekend days between June 28th and August 17th (Wizard Lake Watershed and Lake Stewardship Association, 2008). In all cases, peak numbers of boats on the water exceeded an estimated carrying capacity of approximately 50 boats, based on an assumed requirement of 10 acres per boat.

Estimates of recreational carrying capacity were performed using the methods of Jaakson (1990), which suggested that the maximum safe density of boats on the lake for all usage types is approximately 52 total. However, because of the narrow nature of the lake and the associated high shoreline to lake area ration, even less of the lake's surface area may be available for many boating activities. This suggests that the lake may frequently be over capacity for recreational boating, creating potential safety and environmental hazards.

Figure 5. Water skier on Wizard Lake.

In response to boating pressure and concerns over public and environmental safety, the 1980 Wizard Lake Management Plan recommended 12 km/h speed limits offshore from Jubilee Park and at the west end of the lake in the vicinity of Wizard Heights. These recommendations were then implemented in the *Boating Restriction Regulations* by Transport Canada. Updates to the *Regulations* in 1998 included both speed limits and boating prohibitions in posted areas. The draft 1998 Wizard Lake Management Plan (Leduc County and Wetaskiwin County, 1998) notes that various speed limits are in place on the lake, including 40 mph (approximately 65 km/h) across the entire lake, 8 mph (approximately 13 km/h) in the vicinity of Jubilee Park and the west end of the lake beyond Wizard Heights, and 10 km/h within 30 meters of the shore. The 40 mph and 8 mph speed limit zones must be posted in order to be enforceable under the *Regulations*, while the near-shore 10 km/h speed limit is enforceable regardless of whether or not it is posted.

More broadly, as a result of a growing economy and increasing population base, province-wide pressures on the landscape have increased considerably over the past decade. Consequently, the Government of Alberta has developed new *Land Use* and *Parks Planning Frameworks* (Government of Alberta, 2008). The goals laid out by the *Land Use Framework* will guide future parks planning at regional and provincial levels in the province of Alberta to enhance visitor experiences and conserve Alberta's ecosystems (Alberta Tourism, Parks and Recreation, 2008b).

Agricultural Development

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

Due to the very small size of the watershed, precise statistics about agricultural activities are impossible to obtain from the Canadian Census of Agriculture, because the size of the reporting unit for the census is larger than the watershed itself. Approximations could be made based on the proportional area of each reporting unit comprising the watershed, but these assume that the activities reported are evenly distributed across the unit, which is generally not an accurate assumption. The Canadian Census of Agriculture is provided at the greatest resolution interpolated to the Soil Landscapes of Canada; the Wizard Lake watershed spans two reporting units, but makes up less than 5% of the area of each. Values for indicators related to agricultural activity will be determined, but with the strong cautions about the accuracy and precision of the results.

Based on the 2006 Census of Agriculture (Statistics Canada, 2006), there were an estimated 16 farms in the Wizard Lake watershed. Farms in the watershed cover an estimated area of 1559 ha (Table 3). Over half of the agricultural activity in the Wizard Lake watershed is believed to involve oilseed, grain, and/or pulse crops, and/or with cattle production (Statistics Canada, 2006).

Table 3. Agricultural land use in the Wizard Lake watershed in 2006 (Statistics Canada, 2006).

Land Use	Area (ha)	Proportion of agricultural land (%)
Crop land	1559	52.8%
Other	327	11.1%
Natural pasture	427	14.4%
Tame/seeded pasture	606	20.5%
Summer fallow	36	1.2%
Total	2955	

Agricultural intensity, expressed as the percent land cover used as croplands, generally ranges from 25-50% in the White Zone and is considered moderate for that region in the Wizard Lake watershed (Statistics Canada, 2006).

The Wizard Lake watershed contains an estimated 1,500 cattle and calves, 1,100 poultry animals (including chickens and turkeys), and 350 hogs. All other livestock species each have less than 100 units within the watershed (Statistics Canada, 2006). Manure production is dominated by production from cattle. Total manure production from all sources across the watershed is estimated to be approximately 15,613 tons annually, or approximately 4800 kg / ha annually (Statistics Canada, 2006). However, these numbers are likely to be significant overestimates of the actual densities in the watershed; the total area of productive agricultural land within the watershed is much less than in the surrounding areas, and these densities are based on what amount to regional estimates due to the scale of the available data.

Table 4. Estimated livestock populations in the Wizard Lake watershed in 2006 (Statistics Canada, 2006).

Livestock Species	Number of livestock
Cattle and calves	1,495
Poultry	1,104
Pigs	350

Oil, Gas, and Mining Activities

Oil and gas exploration and extraction activities are very common throughout the province of Alberta. With oil and gas development there can be a number of associated impacts, including loss of wetlands, habitat fragmentation, increased water use and surface water and groundwater contamination (Alberta Centre for Boreal Studies, 2001).

A total of nine petroleum wells are reported for the Wizard Lake watershed, with no surficial pipelines reported at the 1:50,000 scale (Figure 6; Natural Resources Canada, 2011). The 1998 draft Wizard Lake Management Plan (Leduc County and County of Wetaskiwin, 1998) includes additional information on the locations of abandoned oil wells, but these do not show up in more recent datasets of surface features. Abandoned wells are generally not considered to be a severe issue to overall watershed health (Leduc County and County of Wetaskiwin, 1998).

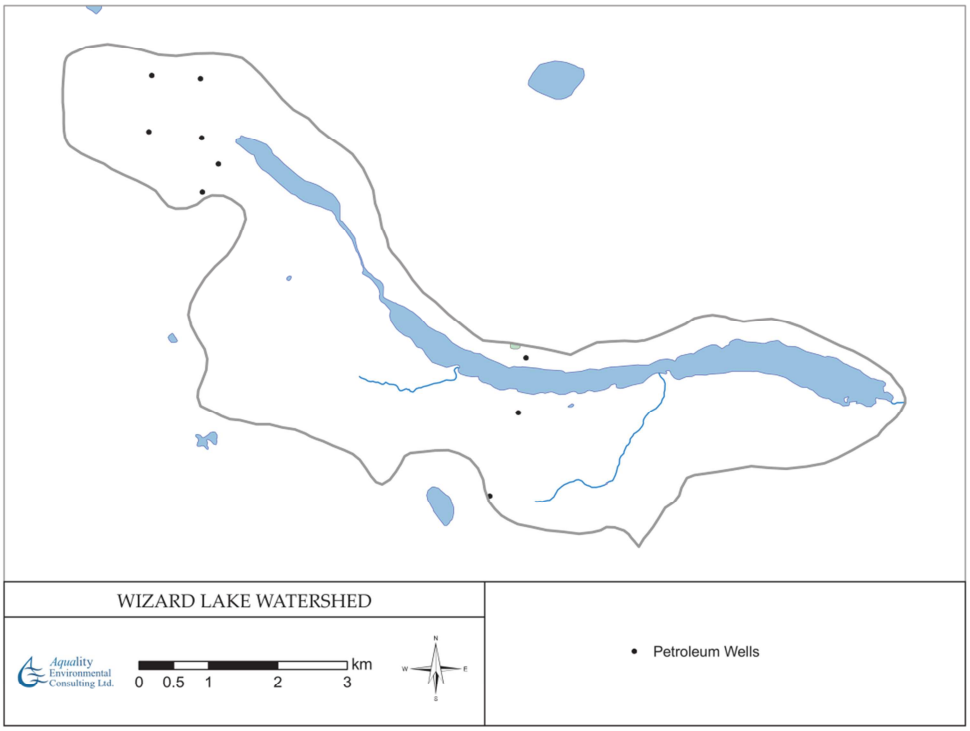


Figure 6. Petroleum wells in the Wizard Lake watershed.

Numerous subsurface pipelines, most of which are or were previously owned and operated by Imperial Oil, are known to bisect the lake in the vicinity of the narrowest point of the larger east basin (Figure 7). These cross the lake at the narrowing in the central portion of the east basin (near NW and SW-T048-R27-W4M). Many of these are no longer active and are currently being left in place as per current legislation; however, during future development or subdivision, the lengths of pipeline under the affected lands may be removed and the land reclaimed (Alberta Association of Municipal Districts and Counties, 2006; Leduc Rep, 2009).

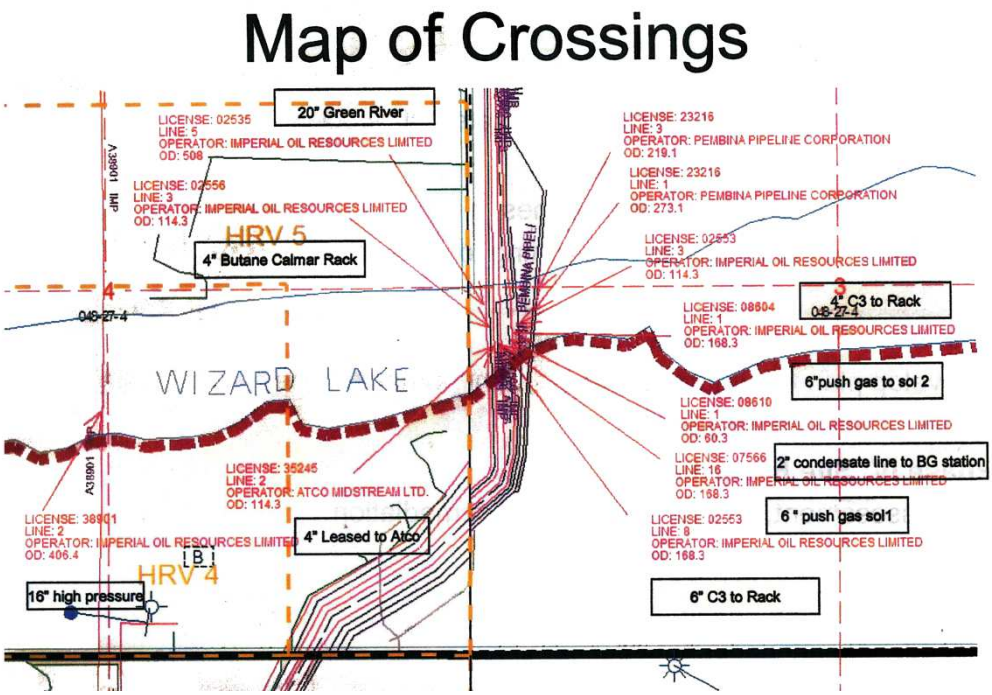


Figure 7. Petroleum pipeline crossings under Wizard Lake. From hard copy presentation provided by WLWLSA.

Historically, the Paskapoo and Scollard formations within the watershed have been mined for coal, which occurs in seams of varying depth and thickness. A total of six underground coal mines were reported as of 1960, all of which were abandoned after that time. Several open prospect pits were located along the banks of Wizard Lake. Mining operations at these sites have not continued, due to seams of unreliable thickness and yield. There are currently no active coal dispositions within the Wizard Lake watershed (Alberta Energy, 2010); however, various municipal plans and lake management plans have proposed limited development in areas where known coal beds occur, in order to allow for potential future extraction (Edmonton and Battle River Regional Planning Commissions, 1980).

Coal bed methane (CBM) is natural gas that is found within coal formations. It has received attention recently as an additional source of energy; however, it brings with it potential environmental impacts, some of which are similar to conventional oil and gas exploration and production endeavors. Conversely, some potential impacts it brings with it are new, including an increased intensity in wells, compressors, pipeline infrastructure and completion and production of natural gas from formations above the base of groundwater protection. Some CBM wells are estimated to produce over 65,000 L of waste water per day (Lennon, 2008). In addition, common to oil, gas and unconventional gas (CBM and Shale gas) production is the risk of groundwater contamination through fracturing. Fracturing results from pumping fluids or gases into bedrock formations at high rates and pressures to 'fracture' the bedrock and increase gas or oil production. Fracturing fluids may contain toxic or carcinogenic compounds, which may leach into groundwater sources and pose a threat to human health through contaminated drinking water (Natural Resources Defense Council, 2002).

Linear Developments

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

The only linear development class reported in the Wizard Lake watershed at the 1:50,000 scale are roadways, which have a total length of 26.6 km (Natural Resources Canada, 2009a) and make up an estimated 1.3% of the total land base. Most of these are located in the southern and eastern region of the watershed (Figure 8). These data do not include the smaller roadways associated with the lakeshore population centers. However, such roadways are generally associated with more drastic changes in land use and cover, so their effects on contiguous land cover is generally negligible.

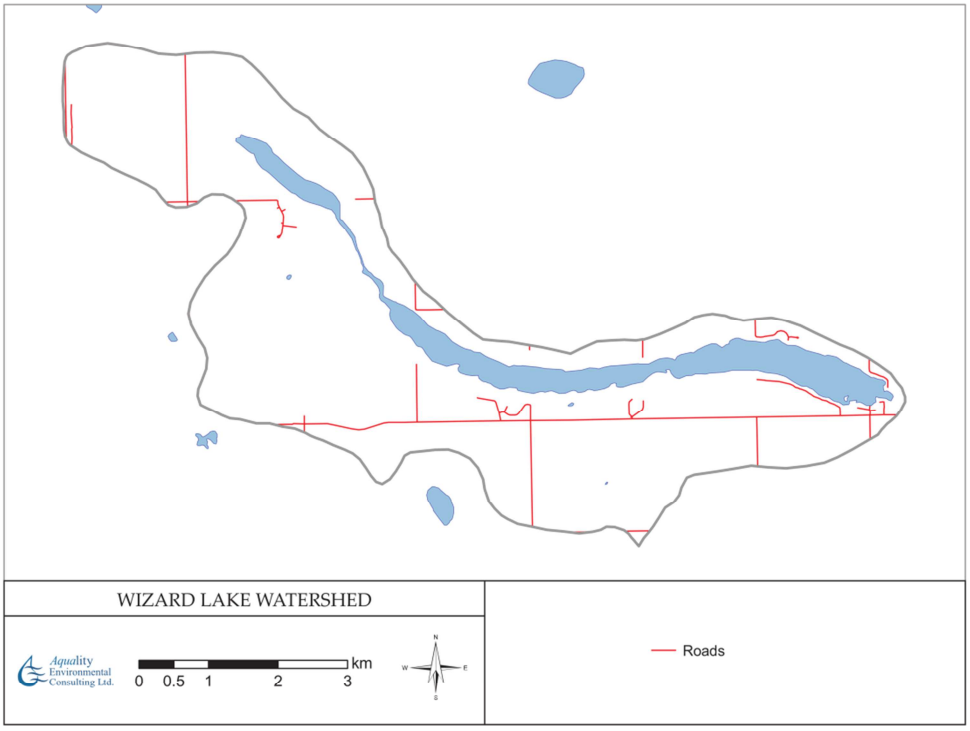


Figure 8. Linear developments in the Wizard Lake watershed (Natural Resources Canada, 2009a)

Wetland Loss

Wetlands serve many functions in the natural landscape including water storage, flood attenuation, wildlife habitat, groundwater recharge and general water quality improvements (e.g., nutrient uptake, degradation of pesticides, sediment retention). Additionally, wetlands provide a cost effective and sustainable alternative to engineered water treatment options. The loss of wetlands to development and/or agriculture can be deleterious to surface and groundwater quantity and quality.

The entire Wizard Lake watershed is located in the White Zone of Alberta. Wetlands have historically been quite common within the White Zone, but significant wetland area has been lost due to drainage for agricultural and development activities (Strong et. al, 1993). Across the entire Dry Mixedwood Natural Subregion, peatlands cover about 9.3% of the, wherein tree-, shrub- and graminoid-dominated fens are the dominant peatlands. Patterned fens, while present, are rare. In addition, bogs, marshes and shallow open water wetlands occur in this Subregion (Vitt et al., 1996). Based on the 1:50,000 scale saturated soils layer (Natural Resources Canada, 2009a), the total area of saturated soils landforms within the Wizard Lake watershed is approximately 228 ha, or approximately 7.1% of the land base of the watershed (Figure 9). Based on more detailed land cover data, wetlands make up approximately 12.6% of the land base in the Wizard Lake watershed (Table 8. Summary of land cover types in the Wizard Lake watershed (Natural Resources Canada, 2009b).,Figure 24; Natural Resources Canada, 2009b).

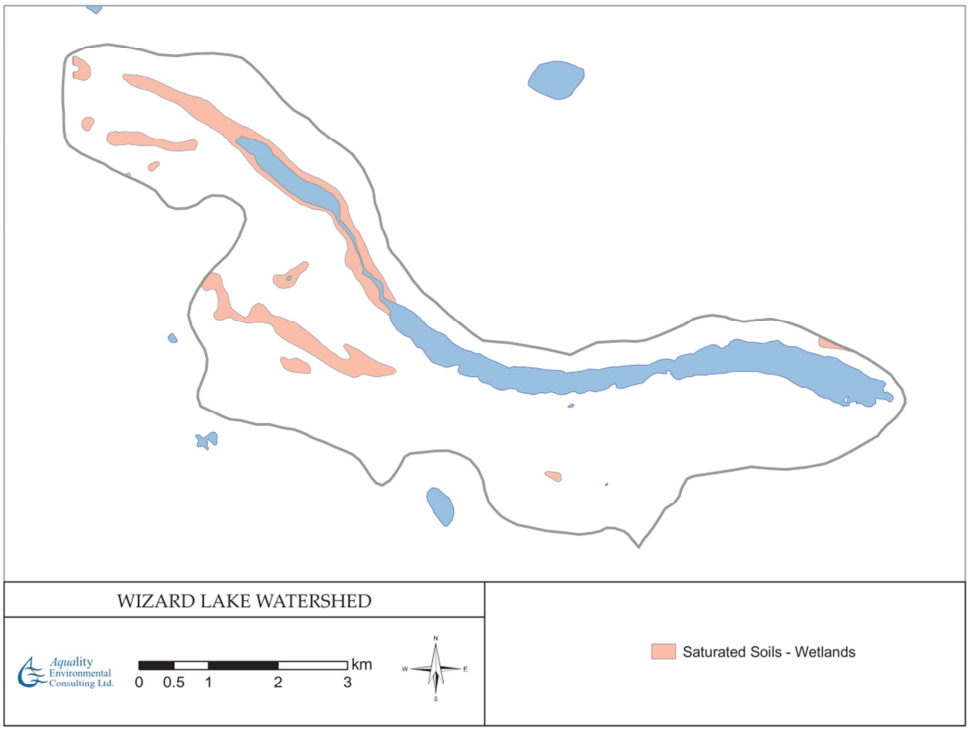


Figure 9. Saturated soil landform cover in the Wizard Lake watershed (Natural Resources Canada, 2009a).

Wetland loss or degradation has certainly occurred in the Wizard Lake watershed, although the extent is unknown. Impacts to wetland in this region are associated primarily with development activities and agricultural operations.

Riparian Health

Riparian areas are an important transition zone between uplands and water. They act as buffer zones, protecting water quality and attenuating floods. Contaminants are adsorbed onto sediments,

assimilated by vegetation and transformed by soil microbes into less harmful forms. They have long been proven effective in reducing nutrients, sediments and other anthropogenic pollutants that enter surface waters via overland and subsurface flow.

We could not locate any data on riparian health for any waterbody in the Wizard Lake watershed.

Water Quality

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

- Nutrients and Routine Parameters;
- Metals;
- Bacteria;
- Parasites;
- Pesticides; and
- Point Source Pollutants.

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

Data on water quality were provided by Alberta Environment and Water, with data available (with varying degrees of completeness for various parameters) from 1972-2010 (Alberta Environment and Water, 2012). Additionally, ongoing water quality testing has been carried out under the Alberta Lake Management Society's LakeWatch volunteer lake monitoring program for a variety of biological, chemical, and physical parameters (ALMS, 1998, 2006, 2009a-b, 2010, 2011). Where applicable, data from the LakeWatch Program have been included in these analyses as well.

Nutrients and Routine Parameters

Nitrogen (N) and phosphorus (P) are essential nutrients for most aquatic plants. As a result, excess nutrients can lead to eutrophication, i.e., an excessive amount of aquatic plant and phytoplankton growth. Concomitant with increased plant and phytoplankton growth, oxygen levels may become significantly reduced in the water column, which may negatively impact aquatic organisms, including fish. In addition, excessive phytoplankton growth, particularly of cyanobacteria, can lead to the release

of toxins into the water column, which may be harmful to aquatic organisms, waterfowl, livestock and humans.

Total nitrogen (TN) concentrations exceed Alberta Surface Water Quality (ASWQ) guidelines for the Protection of Freshwater Aquatic Life (FAL) guidelines for the vast majority of samples collected. Concentrations of TN ranged from 0.5 to 2.5 mg/L, with an overall average of 1.35 mg/L, compared to a guideline value of 1.0 mg/L. Total phosphorus (TP) concentrations are also well in excess of ASWQ guidelines for the majority of samples collected, though the frequency of exceedance is lower than for TN. Concentrations of TP ranged from 0.001 to 0.3 mg/L, with an overall average of 0.059 mg/L, compared to the guideline value of 0.05. Across the entire record, there was no significant trend in concentrations of either TP or TN (Figure 10 and Figure 11).

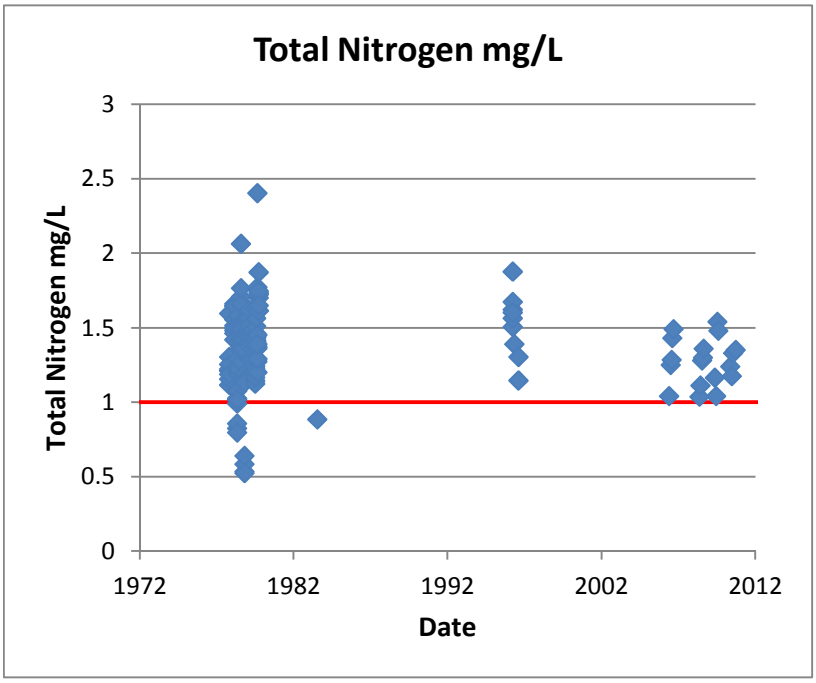


Figure 10. Total nitrogen concentrations in Wizard Lake. Red line is the ASWQ guideline of 1.0 mg/L. Data from Alberta Environment and Water (2012).

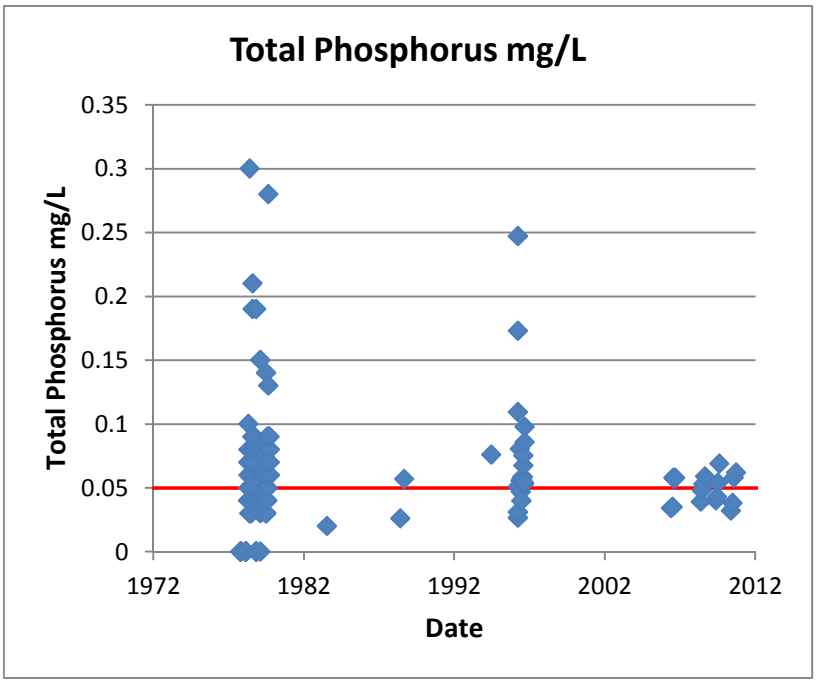


Figure 11. Total phosphorus concentrations in Wizard Lake. Red line is the ASWQ guideline of 0.05 mg/L. Data from Alberta Environment and Water (2012).

A preliminary theoretical phosphorus supply was calculated for Wizard Lake by Alberta Environmental Protection (Table 5; Alberta Environmental Protection, 1998). Over 60% of the total estimated phosphorus load coming into the lake from external sources was due to surface runoff, with the majority of that component contributed by human-influenced lands (including cleared or agricultural areas as well as residential areas). Internal loadings from sediment are believed to be of a comparable magnitude to external loadings.

Table 5. Theoretical phosphorus supply for Wizard Lake

Source	Rate of Input (kg/year)	% of Total Input
Surface Runoff:	437	64%
Forested/Bush	164	24%
Cleared/Agricultural	184	27%
Urban/Cottages	89	13%
Sewage	193	28%
Precipitation/Dustfall	50	8%
Total External Load	620	100%
Internal Loading from sediment	581	
TOTAL	1261	

Various other parameters have been collected as part of Alberta Environment and Water's monitoring programs; these are summarized in Table 6. The various nutrient parameters are generally somewhat

elevated compared to guidelines, but within the range expected for lakes in the region, both due to anthropogenic effects and the naturally rich soils in the settled region of the province. Chlorophyll-a concentrations, a measure of density of algae in water, indicate that the lake is eutrophic, and are in agreement with other assessments of trophic status conducted by the Province (Alberta Environment, 2009).

Concentrations of dissolved oxygen were generally moderate, with reduced values tending to occur in the winter under ice cover, and at the lower depths of the lake; however, the data did not suggest severe risks of winterkill. Iron concentrations generally exceeded guidelines, but the soils and groundwater in central Alberta tend to be very high in naturally occurring iron. Average fluoride concentrations exceeded CCME CEQG FAL guidelines, but are well below the World Health Organization maximum recommended drinking water concentration of 1.5 mg/L (World Health Organization, 1993).

Table 6. Nutrient, Routine and Physical Water Parameters for Wizard Lake. Data from Alberta Environment and Water (2012)

Parameter	CCME/ASWQ FAL Guideline	Average	Minimum	Maximum
Ammonia mg/L	varies	0.069	0	0.88
NO_3 & NO_2 mg/L		0.052	0	0.545
Total Nitrogen mg/L	1.0 mg/L	1.36	0.523	2.402
Total Phosphorus mg/L	0.05 mg/L	0.059	0	0.3
Total Dissolved Phosphorus mg/L		0.027	0	0.16
chlorophyll-a mg/m^3		20.5	0.4	87.4
Total Organic Carbon mg/L		9.6	2	30
Secchi Disk Transparency m		2.01	0.1	6
pH	6.5 – 9.0	8.18	6.89	9.2
Specific Conductance (Field) µs/cm		325	110	1050
Dissolved Oxygen mg/L	6.5 – 9.5 mg/L	6.28	0.01	12.4
Total Hardness $CaCO_3$ mg/L		107	84	506
Bicarbonate mg/L		218	184	555
Total Dissolved Solids mg/L		181	145	519
Chloride mg/L	120 mg/L	4.1	3	11
Fluoride mg/L	0.12 mg/L	0.13	0.08	0.8
Sulphate mg/L		2.6	0	26
Calcium mg/L		36.9	24.8	155
Iron mg/L	0.3 mg/L	3.5	0	134
Magnesium mg/L		9.1	4	29
Potassium mg/L		5.0	3.5	6.8
Sodium mg/L		29.1	13	39.4

In addition to the monitoring carried out by Alberta Environment, WLWLSA has also carried out water quality sampling on several tributaries flowing into Wizard Lake, in consultation with Alberta

Environment and Water (Teichreb, 2007, 2010, 2011; Table 7). Those studies found that the inflows to Wizard Lake have much higher concentrations of nutrients, especially phosphorus, than the lake itself. The outflow at Conjuring Creek had comparable concentrations to the Lake, suggesting that nutrients from the inflows are being stored in the lake and may contribute to future nuisance algal blooms.

Figure 12. Sampling of a tributary to Wizard Lake.

Table 7. Wizard Lake tributary water quality sampling dates. From Teichreb, 2007, 2010, 2011.

Name	Location	2007 Sample Date	2010 Sample Date	2011 Sample Date
Inflow 1	At RGE RD 275	April 11	May 24	April 13
Inflow 2	Near Wizard Heights subdivision	April 16	Not sampled	April 26
Inflow 3	At TWP RD 480 – 1.5km west of RGE RD 272	April 16	May 24	April 13
Inflow 4	At TWP RD 480, 0.2km west of RGE RD 271	March 27	May 24	April 13
Tributary A	At RGE RD 271, 0.8km south of TWP RD 480 d/s of farm	March 27	Not sampled	April 13
Tributary B	At RGE RD 271, 1.0km south of TWP RD 480 u/s farm	March 27	May 24	April 13
Conjuring Creek	Wizard Lake Outflow (Weir)	Not sampled	Not sampled	April 26
Wizard Ridge Estates Drainage		Not sampled	Not sampled	April 26

Blue-green algae, also called cyanobacteria, are a class of photosynthetic bacteria sometimes found in fresh water bodies. Under certain conditions, they can form nuisance blooms that are hazardous from both human and environmental health perspectives. In addition to the issues generally associated with eutrophication as a result of algal growth (decreased light penetration and visibility, anoxic conditions due to decay), cyanobacterial also produce toxins that can cause illness or even death in humans and other animals. The toxins produced by blue green algae were detected on 14 of the 17 occasions that they were tested for by Alberta Environment and Water (2012), with an average concentration of 0.12 µg/L. No guidelines are available for these toxins in Alberta, but the World Health Organization (2003) provides a provisional guideline for drinking water of 1 µg/L. In July and August of 2011 the lake was closed to recreational activities due to a blue-green algae bloom.

Metals

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

Metals data were not collected from Wizard Lake as part of Alberta Environment and Water's ongoing water quality monitoring programs (Alberta Environment and Water, 2012).

Bacteria

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

Data on bacteria were not collected as part of Alberta Environment and Water's monitoring programs (Alberta Environment and Water, 2012). However, information on fecal coliform concentrations was collected by Alberta Health Services from 2004 to 2011 as part of their beach testing program. Guidelines for fecal coliforms include the CCME CEQG Guidelines for Irrigation Water of 100 CFU/100 mL, and for Recreation and Aesthetics of 200 CFU/100 mL (based on a 5-sample geometric average). Fecal coliform concentrations exceeded the Irrigation guideline on four occasions: August 2006, July 2007, June 2008, and July 2011 (Figure 13). The sample from June 2008 also exceeded the guideline for Recreation and Aesthetics, but follow-up samples did not show elevated concentrations.

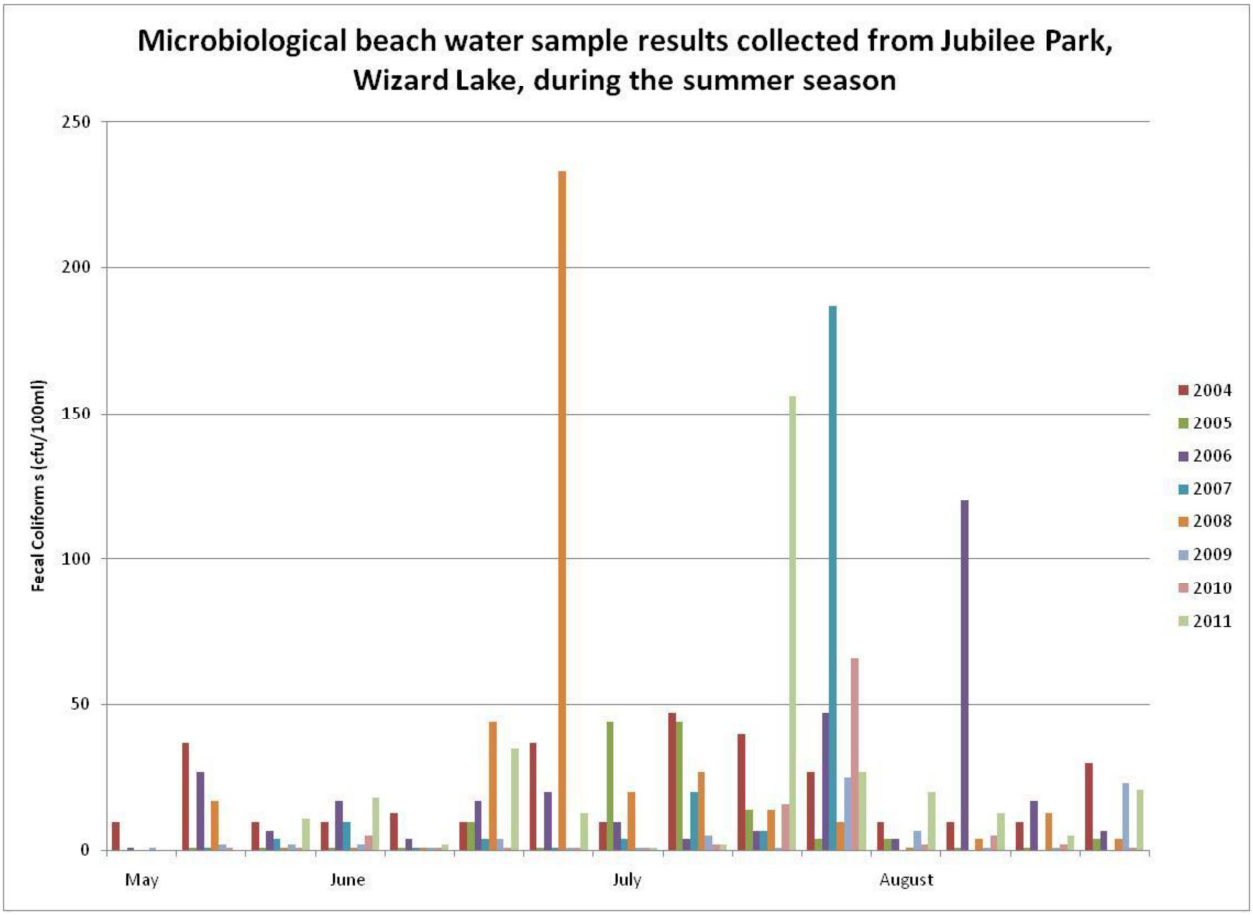


Figure 13. Beach testing data for fecal coliforms from Jubilee Park on Wizard Lake, 2004 – 2011 (Alberta Health Services, 2011)

Parasites

Parasites generally include microbiological organisms such as *Cryptosporidium* (the micro-organism responsible for the parasitic disease cryptosporidiosis) and *Giardia lamblia* (the micro-organism responsible for the parasitic disease giardiasis, or beaver fever).

Parasite data have been collected from the outflow at Conjuring Creek, but not from Wizard Lake proper. Samples collected from 1998 to 2005 showed up to 6400 *Cryptosporidium* oocysts per 100 L, and over 46,000 *Giardia* cysts per 100 L (Alberta Environment and Water, 2011). US EPA guidelines for drinking water are 0 oocysts/cysts per 100 L for *Cryptosporidium* and *Giardia* in treated drinking water, respectively (United States Environmental Protection Agency, 2012). Controlled laboratory studies with volunteer human subjects have shown that as few as 30 *Cryptosporidium* oocysts are sufficient to cause illness (DuPont et al., 1995). Consumption of as few as 10 *Giardia* cysts can cause infection (Mukherjee et al., 2011). However, water can generally be effectively treated for these parasites by simple filtration for use in drinking water (LeChevallier et al., 1991).

Pesticides

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

Pesticide data were not collected from Wizard Lake as part of Alberta Environment and Water's ongoing water quality monitoring programs (Alberta Environment and Water, 2012).

Point Source Pollutants

The National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling. It is a key resource for (1) identifying pollution prevention priorities, (2) supporting the assessment and risk management of chemicals, and air quality modeling, (3) helping develop targeted regulations for reducing releases of toxic substances and air pollutants, (4) encouraging actions to reduce the release of pollutants into the environment, and (5) improving public understanding (NPRI, 2009). The NPRI provides information on point source releases of pollutants from a variety of operations, including waste water treatment plants (WWTP), stormwater outfalls and industry. Point source releases of pollutants to aquatic ecosystems include nutrients, solids, pharmaceuticals, metals, solvents, hydrocarbons, salts, as well as other chemicals used in processing or manufacturing industries.

No releases within the Wizard Lake watershed were found in the NPRI database. It may be possible for regional airborne releases to fall within the Wizard Lake watershed, but without detailed study the impact of any such releases is not known.

Water Quantity

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

- Volume;
- Contributing Areas to Drainage;
- Allocations; and
- Groundwater.

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

Lake Levels

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

Alberta Environment (Government of Alberta, 2009) has been monitoring water levels in Wizard Lake since 1968 (Figure 14). There has been no clear trend in water levels, which have varied between 783.5 m above sea level (a.s.l.) and 784.7 m a.s.l. over the period of record, exhibiting a moderate degree of variability. Water levels fell to their lowest levels in 2008 to 2009, but have started recovering as of 2010. Concerns have been expressed regarding the effects of water withdrawals (both ground and surface water) on lake levels, but various municipal and management plans have expressed the intention of limiting development to within the carrying capacity for the area (Edmonton and Battle River Regional Planning Commissions, 1980; Leduc County and County of Wetaskiwin, 1998;). Little information is available on the contribution of groundwater to lake levels, so the true effects of groundwater withdrawals on lake levels is currently unclear (Alberta Environmental Protection. 1998).

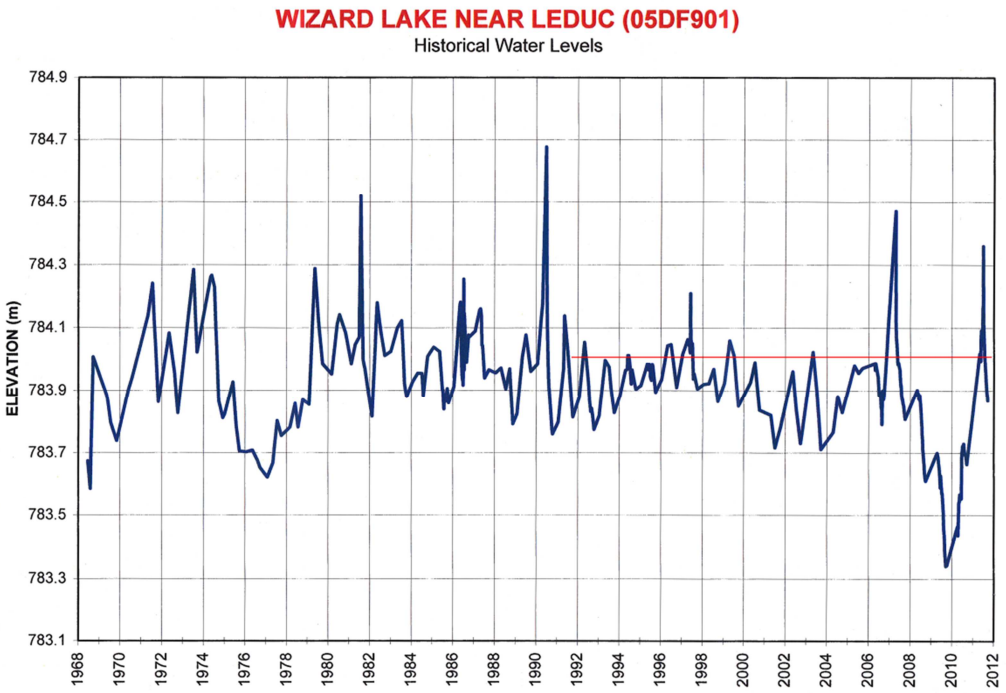


Figure 14. Water levels in Wizard Lake, 1968-2010 (Government of Alberta, 2009). Red represents the elevation of the weir crest, with the onset of operations in 1991.

Figure 15. The weir at the upper end of Conjuring Creek.

Weir

A weir has been in operation at the headwaters for Conjuring Creek (the downstream-most point of the Wizard Lake watershed) since 1991. Prior to its construction, there were concerns with fluctuating water levels in the lake itself, as well as flooding downstream along Conjuring Creek (County of Leduc, 2011). The weir was installed to regulate lake levels, with the crest of the weir established at 784 m above mean sea level. Lake levels appear to have been much more stable since the weir began operating (Figure 14). The weir incorporates a fish ladder to allow the passage of fish during the annual spring spawning period for Northern Pike, and is kept open when fish are observed below the weir.

Contributing Areas to the Wizard Lake Watershed

Contributing drainage areas to a watershed are those areas from which water is capable of eventually flowing out of the watershed. Non-contributing drainage areas, on the other hand, are isolated "sink" areas that do not drain out of the watershed, such as wetlands, depressions, and other low areas that do not have a channel or slope connecting them with other water bodies. Virtually the entire area of the Wizard Lake watershed contributes to drainage, with only a small number of sinks located in the west and south of the lake (Figure 16). This high contributing area is a result of the steep valley sides, narrow basin, and the resulting lack of flat areas and potholes where water will only drain internally.

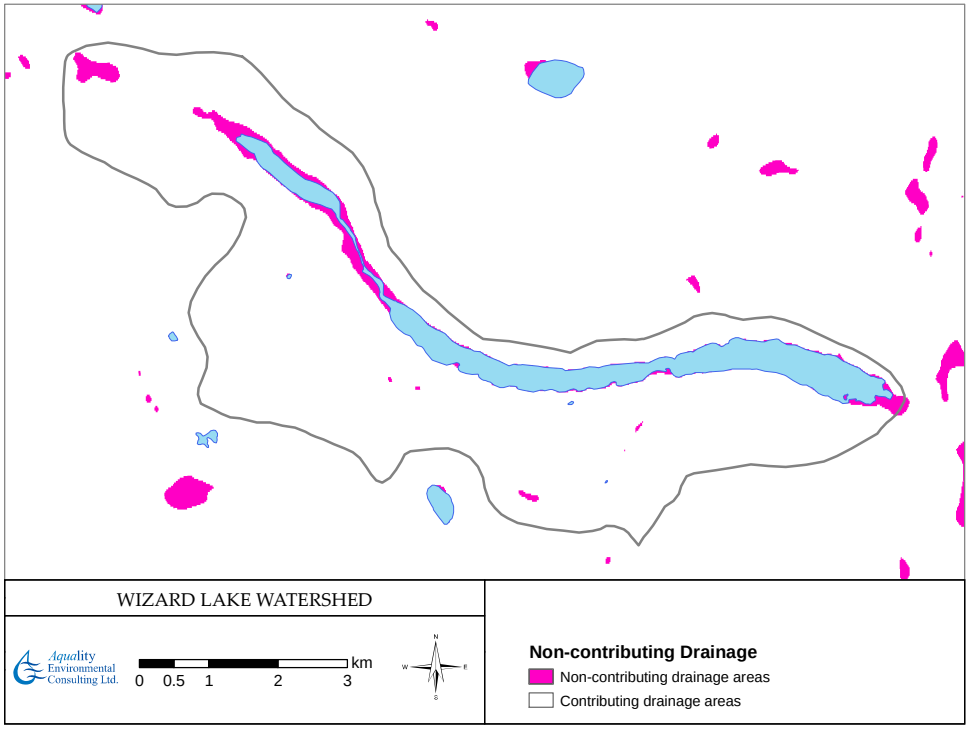


Figure 16. Non-contributing drainage areas in the Wizard Lake Watershed (Natural Resources Canada, 2007).

Water Allocations and Diversions

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

Surface Water Allocations

There are a total of 21 current surface water licenses in the Wizard Lake watershed boundary, with an additional 16 licenses found in the immediate vicinity – these latter licenses are included because licenses are located based on the center of the owners property, and so may actually represent diversions within the watershed. The total maximum annual diversion from all of these surface water licenses is 1,918,446 m^3. The majority of licenses fall under the Registry category (for licensing traditional agricultural water uses), with only a single license issued for each of the categories of Stock Watering, Lake Stabilization, and Flood Control. Maximum diversion volumes, however, are completely dominated by Lake Stabilization, with over 99% of diversion volumes in and around the watershed taken up by the single license within that category.

All of these license categories have no requirement for return flow i.e. all diverted water is expected to be lost from the system. However, licensees do not necessarily use all of their allocated volume, and no reporting of consumed water volumes is required for licenses other than in the Stabilization category. Therefore, these numbers likely overestimate the consumption of groundwater in the vicinity of the Wizard Lake watershed.

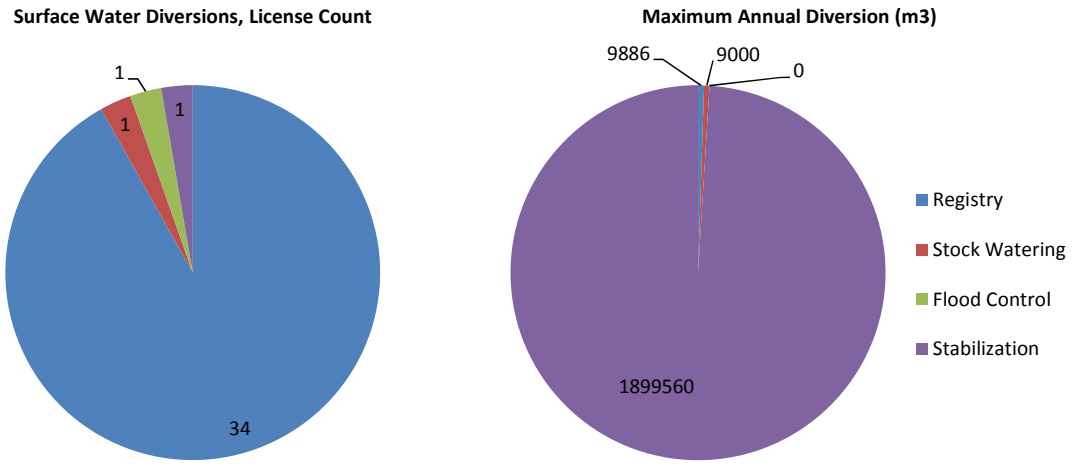


Figure 17. Surface water diversions: total number of licenses (left) and maximum annual diversion volume (right). Note that diversion volume for flood control is zero.

Groundwater Allocations

There are a total of 14 current groundwater licenses in the Wizard Lake watershed boundary, with an additional 31 licenses found in the immediate vicinity – these latter licenses are included both because licenses are located based on the center of the owners property, and also because groundwater boundaries are not necessarily equivalent to their surface water counterparts. The total maximum annual diversion from all of these groundwater licenses is 95,683 m^3. The majority of licenses fall under the categories of Registry (27) and Stock Watering (13), with the remaining licenses for Lake Stabilization (2), Recreation (2), and Drainage (1). Maximum diversion volumes are dominated by Stock Watering, Drainage, and Registry, with lesser volumes allocated to the other license categories.

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

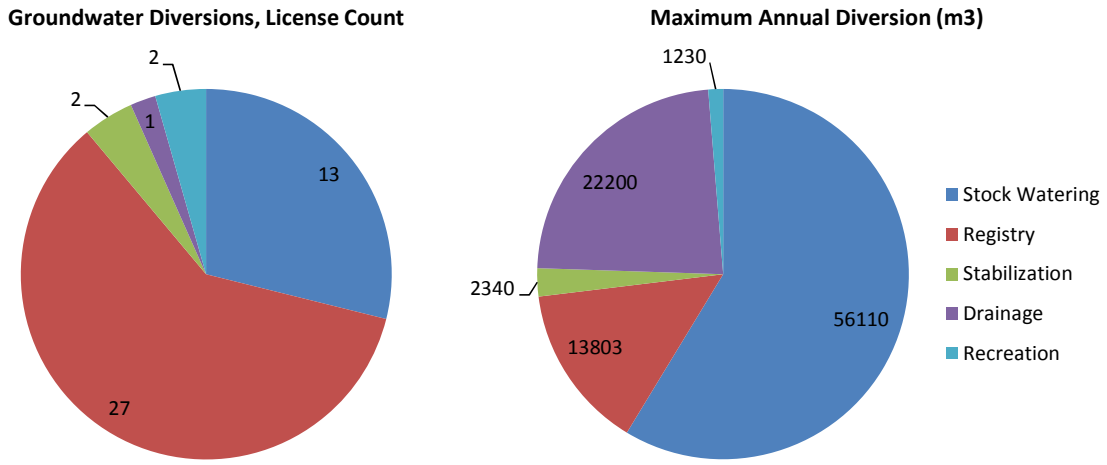


Figure 18. Ground water diversions: total number of licenses (left) and maximum annual diversion volume (right).

Groundwater

No detailed groundwater assessment has been conducted for the Wizard Lake watershed specifically; however, the area has been included in assessments made by Hydrogeological Consultants Ltd. (HCL, 1999, 2008), and in a more recent study of groundwater along the Edmonton-Calgary corridor by the Government of Alberta (2011). Groundwater recharge is the process by which water moves downwards from surface water to groundwater supplies, while groundwater discharge is the process by which water moves upwards from groundwater sources to either surface waters (from shallow aquifers) or to shallow groundwater supplies (from deep aquifers).

For local (shallow) groundwater supplies, the portion of the watershed north of Wizard Lake generally shows moderate potential to low potential for recharge, while the portion to the south of Wizard Lake shows moderate discharge potential (Figure 19; Government of Alberta, 2011). For regional (deeper)

groundwater supplies, most of the watershed has low to moderate recharge potential (Figure 20). However, the lands lying directly under much of the lake have moderate potential for deep groundwater discharge. Significant groundwater discharge areas have also identified around the smaller western basin, on the south shore just to the west of Wizard Heights, and on both sides of the lake at the narrowing of the eastern basin. Taken together, these results suggest that groundwater sources may be important contributors to Wizard Lake, though their relative magnitude in comparison to other water sources is unknown.

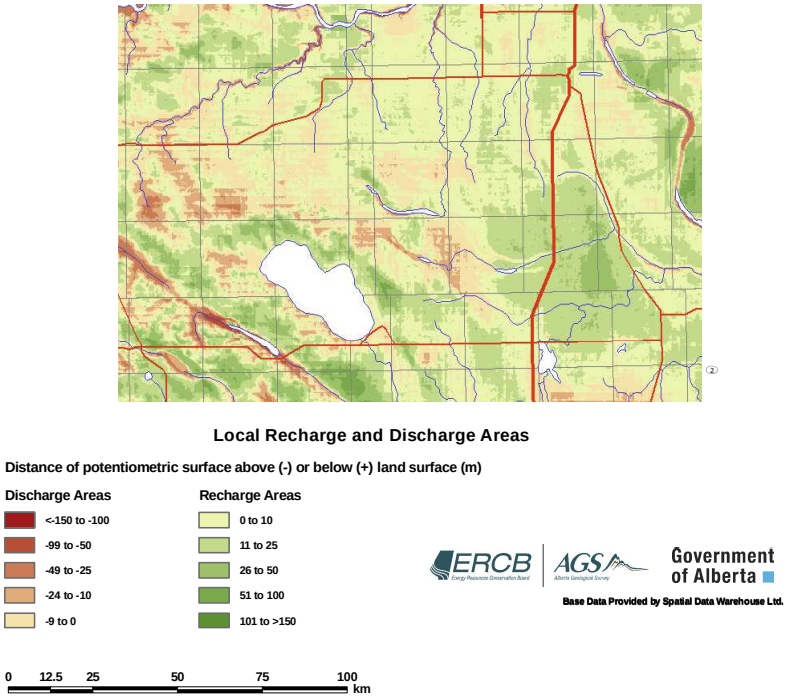


Figure 19. Groundwater recharge and discharge to local (shallow) groundwater supplies in the Wizard Lake region. From Government of Alberta, 2011.

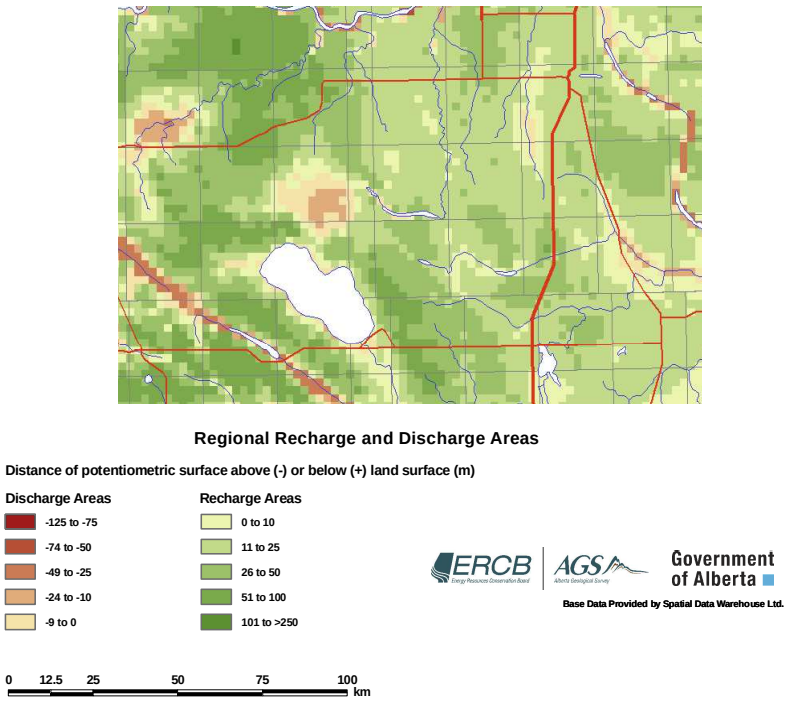


Figure 20. Groundwater recharge and discharge to regional (deep) groundwater supplies in the Wizard Lake region. From Government of Alberta, 2011.

Biological Indicators

Bioindicators are biological (plant and animal) data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of such data can be linked to water quality, quantity and ultimately to overall health of the Wizard Lake watershed. Four metrics were used as biological indicators in the Wizard Lake watershed:

- Wildlife Biodiversity;
- Fish;
- Land Cover; and
- Species at Risk.

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

Wildlife Biodiversity

Wildlife inventories to determine the biodiversity within the watershed will indicate changes in environmental conditions (e.g., habitat fragmentation, loss of nesting and breeding sites, nutrient

enrichment, etc.). A loss of biodiversity can cause an ecosystem to become less stable and more vulnerable to environmental change. A change in diversity may also affect nutrient cycling and/or energy flow through the ecosystem.

The Alberta Biodiversity Monitoring Institute maintains a network of monitoring stations across the province for scientific and management purposes. None of the AMBI stations lie within the boundaries of the Wizard Lake watershed, and the nearest site with data is approximately 100 km from the watershed boundary.

Figure 21. A White-tailed Deer on the shore of Wizard Lake.

No comprehensive reports on wildlife biodiversity were available for the Wizard Lake Watershed. Although the larger basin provides poor waterfowl habitat due to steep banks and heavy recreational usage, the smaller western basin of the lake is known to be locally important for waterfowl breeding, and also supports some beaver and muskrat population. The intact, contiguous forested areas around the lake provide habitat for upland species common in the Parkland region of central Alberta, including White-tailed Deer, Ruffed and Sharp-tailed Grouse. Species classified at various levels of risk under the *Species at Risk Act* (Species at Risk, 2009), as well as species and communities considered important under the Alberta Conservation Management Information System (Alberta Tourism, Parks, and Recreation, 2012), are known to occur regionally, but confirmed occurrences within the water shed could not be found. More details on species at risk are presented later in this report.

Fish

Inventories of fish populations may show increases or declines through introductions or changes in environmental conditions. Indicator species sensitive to environmental pollution may show areas of concern through their absence, while others may show similar with their presence. Invasive species, if present, will indicate areas of concern requiring future monitoring.

Wizard Lake contains Northern Pike, White Sucker, Yellow Perch, and Spottail Shiner (Mitchell and Prepas, 1990), as well as Burbot (WLWLSA, pers. comm.). Many of these species have been confirmed by other sources (V. Buchwald, pers. comm.), but no detailed population studies are available. Walleye were also stocked in Wizard Lake in 1949 – 1951, and 1953 (V. Buchwald, pers. comm.), and reportedly again in 1980 (WLWLSA, pers. comm.) but to date there have been no reports of this species being caught there. Alberta Sustainable Resource Development does not currently maintain a stocking program for Wizard Lake (ASRD 2006-2009). Wizard Lake is a popular local sportfishery, and angling pressure has become an issue to fisheries in water bodies across the province. Increases in angling pressure are likely as population densities and recreational usage of the lake continue to grow.

Critical spawning habitat is known to exist at each end of the main body of Wizard Lake, in the shallow-water habitat at the narrowing between the smaller west and larger east basin, and just upstream of the weir at the outlet (V. Buchwald, as cited in Leduc County and Wetaskiwin County, 1998). The weir located at the outlet on Conjuring Creek may present an impediment to fish migrations into and out of the lake; however, the weir incorporates a fish ladder and the license of operation specifies that the control gate must be monitored and operated to allow the movement of Northern Pike during the annual spring spawning period (Alberta Environmental Protection, 1996). Northern Pike spawning habitat has also been noted at the inlet creek approximately ¼ mile to the west of Wizard Heights (WLWLSA, pers. comm.), though it is not known whether this area constitutes an important spawning habitat for Northern Pike populations in the system.

Figure 22. Northern Pike caught on Wizard Lake.

Land Cover

Land cover is the type of vegetation, or lack thereof, covering the landscape. Inventory of vegetation populations may show increases or declines through introductions or changes in environmental conditions. Indicator species that are sensitive to environmental pollution may show areas of concern

with their absence, while others may show areas of concern with their presence. Changes in land cover can indicate a change in land use and identify areas that need restoration, are at risk of erosion and/or areas with rare plant species that need protection. Land cover is a separate measurement from land use, even though these two terms are sometimes used interchangeably.

Figure 23. Wizard Lake in Autumn.

Based on land cover data from Natural Resources Canada, the Wizard Lake watershed is covered primarily by forage, cropland, and treed areas, which make up approximately 70% of the land base. (Natural Resources Canada, 2009b). Overall, less than half of the watershed's total area is in land cover classes that are considered to be non-natural (Agriculture – cropland, Agriculture – pasture/forage, Developed, and Exposed/Barren Land). This is less than the provincial average for the White Zone of Alberta, likely a result of the undulating terrain and poor-than-average soils within the watershed making agriculture difficult. Urban and rural development has also been restricted in areas close to the lake by the relatively steep slopes compared to the surrounding landscape. The flat areas in the southern portion of the basin may be suitable for development and may experience future development pressure, although the distance from the lake may reduce the desirability of such properties and slow development.

Table 8. Summary of land cover types in the Wizard Lake watershed (Natural Resources Canada, 2009b).

Name	Area (ha)	Percent Cover

Agriculture - cropland	175	5.43 %
Agriculture - pasture/forage	969	30.1 %
Herbs	104	3.24 %
Coniferous forest - dense	77	2.41 %
Broadleaf forest - dense	1092	33.9 %
Wetland - treed	133	4.15 %
Wetland - shrub	272	8.46 %
Water	384	11.9 %
Exposed/barren land	5.1	0.16 %
Developed	4.6	0.14 %

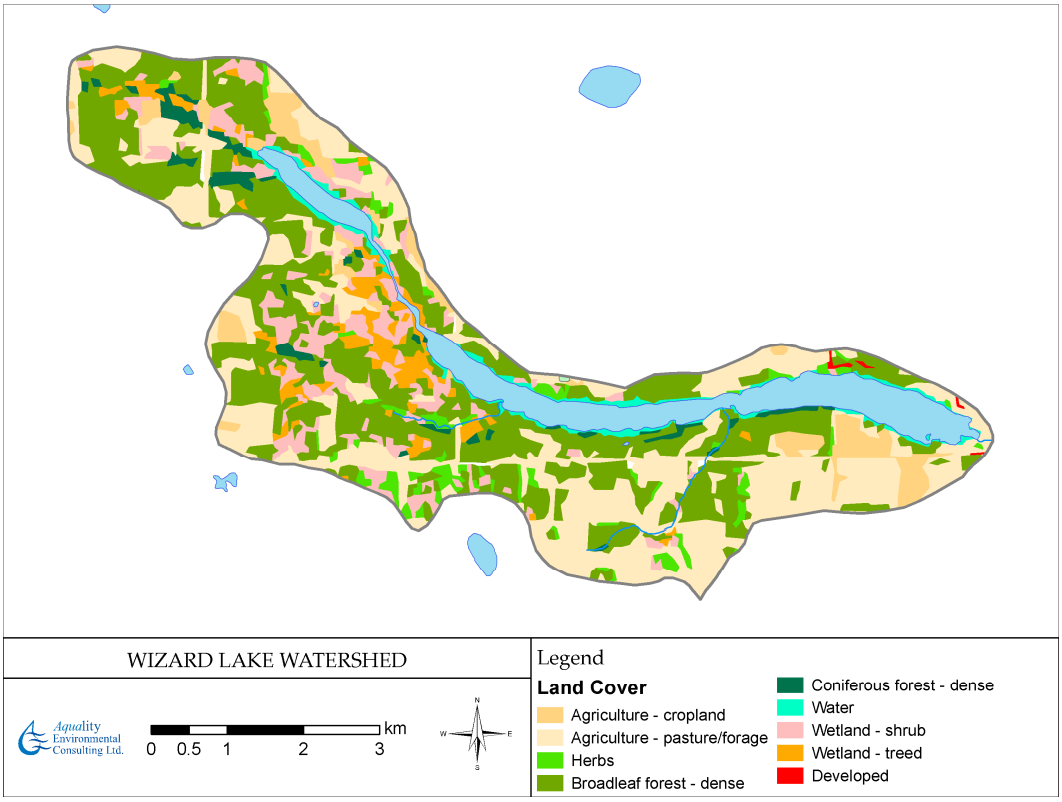


Figure 24. Distribution of land cover in the Wizard Lake Watershed (Natural Resources Canada, 2009b).

Species at Risk

Identifying species at risk and their habitat requirements will help to determine sensitive areas and level of protection required. The *Species at Risk Act* (*SARA*) was introduced in June 2003 to provide legal protection of wildlife species and conservation of biological diversity. The Act aims to prevent Canadian indigenous species, subspecies and distinct populations from becoming extinct or extirpated (locally extinct), to provide for the recovery of endangered or threatened species and encourage the management of other species to prevent them from becoming at risk. Currently, there are 363 species

listed as either endangered (169 species), threatened (110 species) or of special concern (84 species) (Species at Risk, 2009).

The Wizard Lake watershed is potentially home to one endangered species (Piping Plover, *Charadrius melodus circumcinctus* subspecies), three threatened species(Loggerhead Shrike, *Lanius ludovicianus excubitorides* subspecies; Peregrine Falcon *Falco peregrines anatum* subspecies; and Sprague's Pipit, *Anthus spragueii*), and two species of special concern (Yellow Rail, *Coturnicops noveboracensis*, and Monarch butterfly *Danaus plexippus*). There are limits to the level of detail provided by the SARA registry, and without on-the-ground surveys, it is impossible to definitely determine whether a particular species is present. However, these are all species whose estimated range lies within 20 km of Wizard Lake. The provincial Endangered Species Conservation Committee under the auspice of Alberta Sustainable Resource Development's Alberta's Species at Risk Program recognizes a number of additional species that "may be at risk" or as "sensitive" within the North Saskatchewan River watershed. Several of these species may be classified as "species of special concern", "endangered" or "threatened" in the future (Fish and Wildlife Division, 2008).

The loggerhead shrike is a threatened species that inhabits a wide variety of open habitats, including grasslands, sagebrush stands, pastures, agricultural areas and thinly wooded areas with small trees and shrubs where it can nest and forage. This shrike has a preference for small bushy trees and dense or thorny bushes. Its habitat choices are still poorly understood, as many apparently suitable sites are left unused. Suitable habitats for breeding, migration and wintering have declined and continue to decline. Habitat loss is primarily due to the conversion of native grasslands to agricultural land and the degradation of the remaining grasslands. Pesticides are one of the major factors that have contributed to population declines. Sharp declines of the loggerhead shrike *excubitorides* subspecies population have been shown to coincide with the period during which organochlorine pesticides (e.g., DDT) were used in Canada and the United States, in part to combat grasshoppers, which are a key source of food for loggerhead shrikes nesting in the Prairie Provinces. Since this bird is a predator at the top of the food chain, pesticides accumulate in its body every time it eats prey that has itself absorbed pesticides. These chemicals may be the cause of developmental delays in juveniles, the thinning of eggshells and smaller clutch sizes. Although organochlorines are no longer used, they remain in the environment and the effects of new pesticides are unknown. Moreover, the decline of the prey base related to the use of pesticides and habitat fragmentation may also be major factors. Collisions with automobiles are believed to be another major cause of mortality of both juvenile and adult loggerhead shrikes that build their nests and hunt near roadways. The predation rate on adults, eggs and nestlings also appears to be higher near roads and hedges, which attract predators. Finally, juvenile birds are also vulnerable to cold temperatures and heavy precipitation (Species at Risk, 2008).

Peregrine falcon anatum Subspecies is a threatened bird. The habitat requirements of the peregrine falcon can be divided into three components: (1) the nest site: nests are usually scrapes made on cliff ledges on steep cliffs, usually near wetlands, including artificial cliffs such as quarries and buildings; (2) the nesting territory: the area defended around the nest prevents other pairs from nesting within 1 km or more, ensuring adequate food for all nesting pairs and their young; the density of nests tends to be related to food availability; (3) the home range: the extended, non-defended area in which the

peregrines hunt for additional food and which can extend to 27 km from the nest; peregrines prefer open habitats such as wetlands, tundra, savannah, sea coasts and mountain meadows, but will also hunt over open forest. The major cause of decline of peregrine falcon populations was the presence of agricultural pesticides, especially organochlorine compounds, in the environment. These compounds cause egg-shell thinning, egg breakage, reduced hatching success, reduced brood-size and reduced breeding success. Since peregrine falcons are at the top of the food chain, their tissues accumulate a great deal of these substances. Organochlorine contamination is no longer a major limiting factor for peregrines. Current threats include the small population size and the diminishing quality of habitat. Locally, peregrines may be affected by destruction of breeding sites and breeding areas, or by human intrusion near nest sites (Species at Risk, 2008).

The piping plover is an endangered bird that nests just above the normal high-water mark on exposed sandy or gravelly beaches. On the prairies, nesting occurs on gravel shores of shallow, saline lakes and on sandy shores of larger prairie lakes. Seeps also provide important foraging habitat on the Prairies. The most important limiting factor for the piping plover *circumcinctus* subspecies is loss of habitat due to human use of beaches and the consequent disturbance of nesting sites. Dogs and cats prey on the eggs and young, as do gulls and raccoons initially attracted to the nesting areas by picnickers' garbage. On the Prairies, cattle and horses trample nests, and chicks can be trapped in deep hoof prints. Changes in water levels due to recreational or building activities, dams and seasonal storms also threaten the nesting sites of this subspecies (Species at Risk, 2008).

Sprague's pipit is a threatened bird that prefers native grassland and is rarely found in cultivated lands, or in areas where native grasses have been replaced with introduced forages. In general, pipits prefer native vegetation of intermediate height and density, with moderate amounts of litter. Such areas tend to occur where habitats are lightly to moderately grazed, or where fires periodically remove vegetation. Areas of suitable habitat must be >150 ha to be attractive as breeding sites for this species. Current information suggests that at least 75% of native grasslands on the Canadian prairies have been lost to cultivation. This has greatly reduced the availability of suitable habitat for Sprague's pipit. Among the other factors which may also reduce habitat suitability are (1) intensive grazing, which removes vegetation and may cause reproductive failure due to disturbance and trampling of nests, (2) haying, (3) fragmentation of habitat and (4) reduction in fire frequency, which encourages encroachment of woody vegetation and promotes excessive growth of vegetation and accumulation of litter. The use of pesticides to control grasshoppers may also impact Sprague's pipit populations, since grasshoppers are an important food item for the adults and nestlings during the breeding season. The most significant 'natural' limiting factor for the species is probably drought, which affects nesting habitat and possibly food supply at the local level (Species at Risk, 2008).

The yellow rail is a bird of special concern that is typically found in marshes dominated by sedges, grasses and rushes, where there is little or no standing water (generally 0-12 cm water depth), and where the substrate remains saturated throughout the summer. They can be found in damp fields and meadows, on the floodplains of rivers and streams, in the herbaceous vegetation of bogs and at the upper levels (drier margins) of estuarine and salt marshes. Nesting habitats usually have a dry mat of dead vegetation from previous growing seasons. The loss and degradation of wetlands due to

agricultural and human development is the greatest threat to this species throughout its breeding range. On the wintering grounds, habitat loss has been so extensive that the wintering range may no longer be contiguous, and the yellow rails are becoming largely restricted to a narrow band of coastline. Coastal marshes are threatened throughout the Gulf States (Species at Risk, 2008).

The monarch butterfly is an insect of special concern. In Canada, it exists primarily wherever milkweed (Asclepius spp.) and wildflowers (such as goldenrod, asters, and purple loosestrife) exist. This includes abandoned farmland, along roadsides and other open spaces where these plants grow. Environmental conditions and loss of breeding habitat pose threats to all monarch butterflies. In the Prairie provinces, habitat disturbances from agricultural practices and residential land conversions reduce suitable habitat for monarch butterflies. In addition, the widespread and increasing use of herbicides poses a significant threat to the caterpillars that require the milkweed and the adults that require nectar-producing wildflowers (Species at Risk, 2008).

Data Gaps

Data Gaps

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

Land Use Indicators

Urban and Rural Developments

Urban and rural developments include all permanent population centers including cities, towns, villages, and rural subdivisions. Data on the population centers are up-to-date based on current area structure and municipal development plans. However, because of the small size of these centers in the watershed, they are not presented as part of the Alberta provincial census as only towns and larger centers are reported.

Recreational Developments

Recreation includes both recreational developments (infrastructure such as boat launches, campgrounds, etc.), and the actual recreational activities undertaken at a location. Information on boating usage was provided by WLWLSA from a period of two summer weekends, and is believed to be at least somewhat representative of boating density on the lake. Average boat counts likely overestimate average density across all days (such as weekdays and off-season), but may underestimate peak densities.

Agricultural Development

Livestock, manure production and agricultural intensity data are based on the 2006 Agriculture Census and data from Agriculture and Agri-Food Canada (2007). These datasets are complete for the Wizard Lake watershed, i.e., there are no data gaps. More recent data from the 2011 Agriculture Census have not yet been released to the public.

Oil and Gas Activities

Data on well and major surface pipelines are complete, i.e., there are no data gaps. Some information on the status of the subsurface pipelines crossing Wizard was available, but information on future pipeline abandonment and decommissioning are not available as they will depend on business strategies of the corporations involved, whether future oil and gas activity may result in the possible re-commissioning of these pipelines, and whether or not they are petitioned by individual landowners to remove abandoned sections of pipeline.

Linear Developments

Linear development data originate from Natural Resources Canada (2009a) and are complete, i.e., there are no data gaps. The resolution of these data are fairly coarse relative to the size of the watershed,

however, so they may exclude smaller scale developments and developments that have occurred since the last time the data were updated.

Wetland Loss

A comprehensive wetland inventory has not been completed for the Wizard Lake watershed. To date, limited data are available on wetland distribution, classes, coverage and loss in the watershed. Both provincial and federal have undertaken wetland mapping initiatives that will encompass the entire province, such as the Canadian Wetland Inventory by Environment Canada, Canadian Space Agency, Ducks Unlimited Canada and the North American Wetlands Conservation Council. However, the watershed is not in one of Ducks Unlimited Canada's Priority Areas, so the completion of the inventory for this region will likely take significant time. This inventory will not examine historical distributions in order to quantify wetland loss; however, at this stage, quantifying the current state of wetlands in the watershed should be a priority. The absence of a detailed wetland inventory represents a significant data gap, and the development of comprehensive wetland inventories should be included in future studies.

Riparian Health

No comprehensive studies of riparian health are available, either for the basin as a whole or for the lake shore in particular. This represents a significant data gap, as the health and integrity of riparian areas strongly influences the health and integrity of the associated aquatic ecosystem. This lack of information may be especially important for Wizard Lake, as it is a small headwaters basin fed primarily by small and/or intermittent streams; such watercourses are capable of contributing significant amounts of pollutants relative to the volume of water that they carry.

Water Quality Indicators

Nutrients and Routine Parameters

Data on nutrients and routine water quality parameters are available from 1972-2010; however, some gaps in the historical record do exist. The sporadic collection of data make determining long-term trends or patterns difficult, but sufficient data exist to assess the general status of the lake.

Metals

Metals data were not available as part of Albert Environment and Water's monitoring programs; this represents a data gap for the watershed. Industrial and commercial developments in the watershed are relatively low, so risk of metals pollution via direct runoff is somewhat reduced; however aerial deposition, natural occurring metals, and other sources may also contribute.

Bacteria

Bacteria data collected as part of Alberta Health Services beach testing program are available from 2004 for much of the open water season. This frequency of collection is sufficient for assessing bacterial conditions in the lake, as bacteria do not build up in a water body over time in the same way that compounds such as nutrients or metals may. There are no current data gaps for bacteria, though long-term historical trends cannot be addressed with the available data.

Parasites

No data on *Cryptosporidium* or *Giardia* are available for the watershed. This represents a significant data gap, especially because of the high concentrations of parasites found in the outlet watercourse immediately downstream of the lake.

Pesticides

No data on pesticide concentrations are available for the watershed. This represents a significant data gap, as these compounds are easily transportable from surrounding agricultural and residential lands. Pesticides are relatively frequently found in surface waters of the settled region of the province, though concentrations may vary widely between water bodies and from year to year (Palliser Environmental Services Ltd. and Alberta Agriculture and Rural Development, 2008).

Water Quantity Indicators

Lake Levels and Withdrawals

Lake level data have been collected since 1968 and are complete i.e. there are no data gaps.

Information on licensed water withdrawals available from the province is complete. However, not all licenses require reporting of withdrawals, consumption, or losses, so actual diversions from ground and surface water sources may not be reflected by licensed diversion volumes. Moreover, not all withdrawals (e.g. limited traditional agricultural uses and household uses) require licenses, so not all withdrawals from the watershed are accounted for.

Biological Indicators

Land Cover

Land cover data is complete for the most recently available coverage (circa 2000), so no significant data gaps exist for this indicator. More recent data would be useful for addressing changes in land cover and use, but such datasets are quite labour-intensive to produce, and are completed at long intervals.

Detailed data on other biological indicators (e.g. fish and wildlife populations) are limited for the Wizard Lake watershed, and are generally restricted to either snapshots from a single point in space and time, or to assessments performed at a regional level.

Discussion, Conclusions, and Recommendations

Discussion

Land Use

Urban, Rural, Recreational, and Agricultural Developments

Overall, the density of urban and rural developments in the watershed is low relative to other areas within the North Saskatchewan River watershed, as there is limited population in small communities, and there are continuing policies to restrict residential developments. There are only a few recreational developments (campgrounds, parks, boat launches, etc.), but recreational pressure on the lake is very high as a result of the appealing surroundings and the proximity to a major urban center. Agricultural development of the watershed is limited by the steep terrain in many areas, as well as the relatively low-productivity soils.

Overall, the total area taken up by urban, rural, recreational, and agricultural development is approximately 36% of the land base of the watershed, which is lower than much of the surrounding region. However, as noted in previous sections, much of the pressure on Wizard Lake is due to recreational activities, such as boating, that do not depend on a high degree of developed infrastructure. Recreational activities present a significant risk to the lake and watershed, from both human safety and environmental integrity perspectives. The lake is likely at or over capacity for recreational boating under average conditions; however, the greatest risks to human and environmental safety will come during peak usage. As a result, this indicator receives only a "**fair**" rating. Additionally, it should be recognized that development is an ongoing process, and that further irreversible loss of natural land cover to development may result in a degradation of the health of the Wizard Lake watershed and an accompanying reduction in its rating for land cover.

Annual manure production calculated for the watershed is high (4,800kg/ha) and so the watershed receives a rating of "**poor**". However, as discussed previously, the density of agricultural operations within the watershed is much lower than in the surrounding region from which these figures were calculated. There is therefore considerable uncertainty in this figure, although ultimate densities are likely much lower.

Oil and Gas Activities

A total of 9 active petroleum wells were found within the watershed, at an average density of 0.003 wells / ha. This density is low relative to much of the rest of the North Saskatchewan River watershed, and results in a rating of "**good**" for this indicator. Although several petroleum pipelines run under Wizard Lake, many of these are abandoned or decommissioned, and are not expected to provide a significant risk to watershed health. The density of oil and gas activities tends to be highly clustered as a result of the distribution of exploitable oil and gas reserves, so it is unlikely that oil and gas activity will approach the levels seen in other areas of the surrounding landscape.

Linear Developments

There are a total of 26.6 km of linear developments in the watershed, encompassing an estimated area of 0.42 km^2, or 1.3% of the land base of the watershed. This results in a rating of "**good**" for this parameter. This is also a significantly lower density of linear developments than the rest of the Strawberry sub-basin of the North Saskatchewan River watershed (of which the Wizard Lake watershed is a part), where densities averaged approximately 4% of the land base.

Wetland Loss

Historical inventories of wetland density are not available at the scale of the Wizard Lake watershed, so no rating can be given for this indicator. There has been clearing of land for agricultural and residential development, suggesting that some loss of wetlands has occurred. However, because the intensity of land-clearing is lower than in the surrounding region, it is likely that the Wizard Lake watershed has been less impacted by wetland loss than the surrounding landscape. Wetlands fill a wide variety of important roles on the landscape, providing stabilization of water levels, recharge groundwater sources, and provide habitat for a wide variety of organisms.

Riparian Health

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

Water Quality

Nutrients and Routine Parameters

Average concentrations of total nitrogen were 1.35 mg/L and total phosphorus were 0.059 mg/L, resulting in a score of "**fair**" for both parameters. These are based on the CCME CEQG FAL guidelines of 1.0 mg/L for total nitrogen and 0.05 mg/L for total phosphorus. In both cases, the nutrient parameters exceeded guidelines, but not excessively and not to the same degree seen in other water bodies in the region.

Wizard Lake is classified as eutrophic based on chlorophyll-a concentrations, which tend to show strong correlations with nutrient concentrations. The lake periodically suffers from algal blooms, which can be aesthetically displeasing and pose significant threats to both human and aquatic ecosystem health. Reductions in nutrient inputs from any source may help to reduce the frequency of these events, and improve the health of the lake.

Metals

Detailed data on metals concentrations were not available for the Wizard Lake watershed, so no score can be provided for this indicator.

A variety of metals may be a concern in surface waters in Alberta, as a wide variety of sources exist. In some cases, natural background concentrations of certain metals are high in both surface and groundwater sources (e.g. iron, aluminum), and little can be done to reduce concentrations. However, elevated concentrations of other metals more often come from anthropogenic sources, and may significantly impede the functioning of aquatic ecosystems.

Bacteria

Average concentrations of fecal coliforms fell below the guideline of 100 CFU/mL, resulting in a score of "**good**" for this parameter.

Potential sources of fecal bacteria to the lake include leakage from residential wastewater systems, pet waste, swimmers, agricultural runoff, and illegal dumping of sewage from recreational vehicles. The actual source is not known from these data, and distinguishing between sources is difficult, costly, and beyond the scope of the monitoring carried out by Alberta Health Services. Reductions in their concentrations generally require the concerted application of best management practices in both agricultural and residential areas.

Parasites

Data on the concentrations of parasites (*Cryptosporidium* and *Giardia*) were not available from the Wizard Lake watershed proper, so no score can be provided for this indicator.

However, they were detected at high concentrations immediately downstream of the outlet on Conjuring Creek, so there appears to be a good possibility that they may be detected within the lake itself. *Cryptosporidium* and *Giardia* could pose a significant problem if drinking water is obtained from surface water sources in the watershed, and may also pose a threat to the health of recreational users of lake when accidental ingestion may occur.

Pesticides

Data on the concentrations of any pesticides were not available from the Wizard Lake watershed proper, so no score can be provided for this indicator. However, pesticides are frequently detected in surface water bodies within Alberta, so they may be present and detectable in future monitoring. Sources of pesticides include runoff from both agricultural and residential areas. Due to a recent provincial ban on combined fertilizer-herbicide products for residential use, it is expected that the contribution of pesticides from residential sources will decline in coming years. However, the residential pesticide use still has the potential to be a significant problem, given the high value placed on properties adjacent to water bodies.

Water Quantity

Lake Levels and Withdrawals

Wizard Lake has historically shown moderate variability in water levels, enough so that residents expressed significant concerns and a weir was installed to regulate levels. Since the installation and onset of operation of the weir, variability has been substantially lower than in the preceding period.

Withdrawals of water from both surface and groundwater sources are relatively low, compared to other sub-basins in the North Saskatchewan River watershed. This indicator therefore receives a rating of "**good**."

However, because of increasing population and economic growth, there is increasing pressure on water supplies from residential, commercial, industrial, and agricultural sources, resulting in a growing risk to water supplies across the province. Because licensing of allocations is carried out at the scale of major basins, there is the possibility that new licenses may not be permitted (as happened in the South Saskatchewan River basin), even if local supplies are not under heavy pressure.

Biologicals

Land Cover

Much of the Wizard Lake watershed remains under natural cover types, with forested and wetland areas making up approximately 50% of the total land base. Agricultural and other anthropogenic land cover types make up approximately 36% of the land base, with the remainder dominated by open water bodies. Overall, the Wizard Lake watershed receives a score of "**good**" for this indicator. These figures are much better than the rest of the Strawberry Creek sub-basin of the North Saskatchewan River, where more than 50% of the land base is taken up by pasture alone. A high percentage of natural cover types can contribute strongly to watershed health, providing wildlife habitat and corridors, protecting the land base from erosion, and acting as a filter in riparian areas and preventing pollutants from entering surface waters. Changes in land cover as a result of human population growth or increased human activities, however, may put the watershed at risk in the future if protections for natural areas are not put into place and enforced.

Conclusions

The overall condition of the Wizard Lake watershed is rated as good, though there is considerable uncertainty for some parameters. Five of the indicators used in this report received a rating of "**good**", two received a rating of "**fair**", one received a rating of "**poor**", and five could not be assessed due to a lack of data (Table 9).

The areas of greatest concern in the watershed include water quality, agricultural activity, and residential and recreational development.

Table 9. Summary of indicator ratings.

Indicator	Rating	Description
Land Use		
Urban, rural, recreational, and agricultural development	**"FAIR"**	Anthropogenic development accounts for only 36% of the land base; however, this likely underestimates problem because of high recreational pressure without high development
Manure production	**"POOR"**	4,800kg/ha annual manure production; however, this likely overestimates problem due to regional nature of data available
Oil and Gas Activity	**"GOOD"**	Low petroleum well density of 0.003 wells / ha
Linear Developments	**"GOOD"**	Linear developments account for only 1.3% of land base, low relative to surrounding region
Wetland Loss	-	Insufficient data available for rating
Riparian Health	-	Insufficient data available for rating
Water Quality		
Nutrients and Routine Parameters	**"FAIR"**	Nitrogen and phosphorus exceed water quality guidelines, but by less than 50%
Metals	-	Insufficient data available for rating
Bacteria	**"GOOD"**	Average concentrations of fecal coliforms fall below water quality guidelines
Parasites	-	Insufficient data available for rating
Pesticides	-	Insufficient data available for rating
Water Quantity		
Lake Levels and Withdrawals	**"GOOD"**	Low withdrawals relative to other NSR sub-basins
Biologicals		
Land Cover	**"GOOD"**	More than 50% of basin under natural land cover types

Water quality in Wizard Lake does not appear to be as impeded as in other lakes in the region. However, nutrient concentrations are fairly high, resulting in periodic algal blooms and at least one lake closure in recent years. Bacterial concentrations are generally moderate, but occasionally exceed guidelines. They are considered a moderate risk because of the uncertainty regarding the density of agricultural activity in the watershed, and due to the possible contribution of improperly operated residential wastewater systems. As recreational pressure on the lake continues to grow, additional problems may arise from the illegal dumping of sewage from recreational vehicles, which can contribute both fecal bacteria and high concentrations of nutrients to surface waters.

Due to a lack of information on metals, pesticides, and parasites, there is a substantial amount of uncertainty about water quality in Wizard Lake. All three of these indicators can have significant human health impacts, either through recreational contact with contaminated water or through consumption, and metals and pesticides can also have significant impacts on aquatic ecosystem health.

Based on land cover data, the extent of agricultural activity in the watershed is less than in the surrounding region. However, regional densities of livestock and manure, and the related clearing of land to provide forage, are very high. Thus, issues with agricultural in the basin tend more towards risk of future expansion and impacts, rather than present-day problems. Agricultural activity has certainly had an impact on watershed health, but magnitude of these effects is lower than in other local basins.

Current Area Structure Plans, Municipal Development Plans, and Lake Management Plans have all made recommendations or taken steps to limit development on the lake shore to sustainable levels, which may help to reduce pressure on the lake from residential and recreational users. However, this approach can do little to limit pressure from recreational users that are not residents, as public access to the lake is readily available and many recreational users come from the surrounding urban centers.

Recommendations

There is limited information on several key indicators of watershed health used in this report: wetland densities and loss rates, riparian health, and water quality (specifically metals, pesticides, and parasites). Where possible, future studies should be performed to address these data gaps.

Periodic water quality sampling for metals, pesticides, and parasites (in addition to those parameters currently tested) would help to determine if significant threats to human and environmental health exist from these parameters. Even if these parameters are not addressed by regular sampling from Alberta Environment and Water, occasional sampling by municipalities or stewardship groups including the WLWLSA could complement existing monitoring programs. For most of these parameters, management of elevated concentrations comes down to the implementation of best management practices, such as runoff and erosion control from agricultural and industrial settings, modernization and maintenance of septage and sewage management systems, limiting fertilizer and pesticide application around water bodies, and the protection and restoration of riparian areas. The implementation of these practices should be encouraged regardless of whether further water quality data is collected; however, it is frequently easier to convince stakeholders to do so when data demonstrating the risks can be presented.

A lack of information on the health and integrity of riparian areas in the watershed is a concern, as riparian areas perform a wide variety of protective functions for aquatic ecosystem health. Through the Cows and Fish Program, the Alberta Riparian Habitat Management Society carries out detailed health and integrity assessments on water-adjacent properties. However, the assessment methods used are extremely labour-intensive, and resources available for assessments are limited. Other less-intensive methods exist, such as aerial videographic or aerial photographic assessments; these provide a much lower level of detail, but may suffice for a rapid initial assessment of riparian integrity. Because current planning documents limit development around the lake shore both in total development area and in proximity to the lake, information on the integrity of riparian health will be mostly useful for planning conservation, restoration, and other stewardship activities.

A more thorough study of the past and present distribution of wetlands within the watershed would help to determine how impacted the watershed is, and would assist in future planning activities. Wetlands are protected from alteration or destruction under the provincial *Water Act*, and a new provincial Wetland Policy is currently under development. A current inventory of wetlands can be a substantial aid to future land use planning, and an inventory of previously drained or otherwise impeded wetlands can assist in mitigation and restoration activities.

Based on previous surveys, the lake is at or over capacity for many types of recreational boating activity. Direct limitations on the number of boats that can access to the lake may be difficult, due to the public nature of navigable water bodies in Canada. Restricted activity zones and posted speed limit zones are viable options for reducing safety risks, and effectively increasing the carrying capacity of the lake for recreational boating; however, this may limit power boat-related activities on the lake. Although some user groups may favour this option, it must be recognized that all users are stakeholders in the lake.

In addition to human safety issues, high recreational usage of the lake can also threaten the aquatic environment. From an aquatic ecosystem health perspective, limiting numbers of recreational users and reducing boating speeds would reduce the risks associated with shoreline erosion and disturbance of sediment, elevated fishing pressure, fuel spills, and increased loadings of garbage, sewage, and other contaminants in the lake and watershed as a whole.

The information contained in this report should be used as a baseline against which to compare future changes within the watershed. Stewardship activities aimed at improving the health of the watershed should focus on mitigating the effects of those indicators that did not have a rating of "good", either through the implementation of best management practices or through direct restoration of affected areas. It is equally important, however, to ensure that a "good" ranking for a particular indicator is not taken to mean that development that has an effect on these indicators could or should proceed without care. The preservation and conservation of aspects of the Wizard Lake watershed that are currently in "good" condition is critical for maintaining the long-term health of the lake.

The mandate and responsibility for protecting the Wizard Lake watershed is shared by a large number of entities, including federal, provincial, and local governments, residents and recreational users, and stewardship groups. Efforts should be made to encourage all of these groups work together to secure the future of Wizard Lake, both through long-term planning for the area, and ensuring that development and other activities adhere to current and future plans. While the responsibility for enforcement of laws, laws, regulations, and plans generally falls to various levels of government, it is critical that residents and other stakeholders maintain their involvement and ensure that issues within the watershed are not ignored.

The Wizard Lake watershed is currently in fair to good condition, especially considering the status of the surrounding landscape and the other popular lakes in the region. This same quality of environment that it provides makes it a draw for increasing residential development and recreational usage, which may threaten its integrity. The inherent biophysical characteristics of the watershed (such as terrain, limited soil capability, and a large watershed:lake area ratio) may have a mitigating effect of human impacts to the watershed. However, if steps are not taken to manage development and recreational usage, the environmental quality of the watershed is at risk of decline. Furthermore, while policies and bylaws are in place to protect the environment of the Wizard Lake watershed, these must be followed and enforced for protection to occur; ignoring such tools may result in the degradation of Wizard Lake in the future.

Continued lake and watershed planning, especially the ongoing coordination of planning and development policies of Leduc County and the County of Wetaskiwin, are necessary to ensure the preservation of the Wizard Lake watershed.

Bibliography

Bibliography

Abraham, C. 1998. Wizard Lake hydrological and meteorological data. Report 5DF 98-061, Water Sciences Branch, Alberta Environmental Protection, Edmonton, Alberta.

Agriculture and Agri-Food Canada. 2007. Soil Landscapes of Canada, version 3.1.1. Agriculture and Agri-Food Canada, Ottawa, Ontario. Online at: http://sis.agr.gc.ca/cansis/nsdb/slc.

Agriculture and Agri-Food Canada. 2008. PFRA Watershed Project - Incremental Gross Drainage Area. Prairie Farms Rehabilitation Administration, Agriculture and Agri-Food Canada, Regina, Saskatchewan.

Alberta Association of Municipal Districts and Counties, 2006. Resolutions database 6-06F: Removal of Abandoned Pipelines. Alberta Association of Municipal Districts and Counties, Nisku, Alberta.

Alberta Centre for Boreal Studies. 2001. Fact Sheet - The Oil and Gas Industry in Alberta: Drilling and Production. Alberta Centre for Boreal Studies, Edmonton, Alberta.

Alberta Energy. 2010. Interactive Coal Map. Alberta Energy, Edmonton, Alberta. Online at: http://www.energy.alberta.ca/OurBusiness/1072.asp.

Alberta Environment and Water. 2012. Water quality data. Monitoring and Science Division, Alberta Environment and Water, Edmonton, Alberta.

Alberta Environment and Water. 2011. Status of Alberta Lake Levels. Alberta Environment and Water, Edmonton, Alberta.

Alberta Environment. 2010. Alberta water well information database. Edmonton Alberta. Online at: http://environment.alberta.ca/01314.html.

Alberta Environment. 2009. Trophic State of Alberta Lakes. Alberta Environment, Edmonton, Alberta.

Alberta Environmental Protection. 1998. Water Quality of Wizard Lake. Prepared by P. Mitchell, Alberta Environmental Protection, Edmonton, Alberta.

Alberta Environmental Protection. 1996. License to Divert and Use Water Pursuant to the Water Resources Act No. 18305. Alberta Environmental Protection, Edmonton, Alberta.

Alberta Geological Survey. 2009. Geology of Alberta. Edmonton, Alberta. Online at http://www.ags.gov.ab.ca/default.shtml.

Alberta Geological Survey. 2008. Wizard Lake, Alberta - Bathymetry (GIS data, line features). Edmonton, Alberta.

Alberta Health Services. 2011. Environmental Public Health Beach Water Monitoring Program: Jubilee Park, Wizard Lake, Leduc County. Alberta Health Services, Environmental Public Health. Edmonton, Alberta.

Alberta Lake Management Society (ALMS). 1998. Lake Watch: 1996 Volunteer Lake Monitoring Program. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/DwnldDocs/LakeWatchRpts/LkWtchRpt96.pdf

Alberta Lake Management Society (ALMS). 2006. Lakewatch Wizard Lake 2006 Report. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/userfiles/2006-LakewatchReport-Wizard.pdf

Alberta Lake Management Society (ALMS). 2009. Lakewatch Wizard Lake 2008 Report. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/userfiles/WizardLake_2008Final_Sept09.pdf

Alberta Lake Management Society (ALMS). 2009. Lakewatch Wizard Lake 2009 Report. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/userfiles/WizardLake2009.pdf

Alberta Lake Management Society (ALMS). 2010. Lakewatch 2010 Wizard Lake Report. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/DwnldDocs/LakeWatchRpts/2010/Wizard_Lake_Report_10.pdf

Alberta Lake Management Society (ALMS). 2011. Lakewatch 2011 Wizard Lake Report. Alberta Lake Management Society, Edmonton, Alberta. Available online at http://www.alms.ca/DwnldDocs/LakeWatchRpts/2011/Wizard%20Lake.pdf

Alberta Sustainable Resource Development. 2006-2009. Stocking Report. Alberta Sustainable Resource Development, Fisheries Management Information System, Edmonton, Alberta.

Alberta Tourism, Parks, and Recreation. 2012. Alberta Conservation Information Management System (ACIMS). Edmonton, Alberta. Available online at http://albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-(acims).aspx

County of Wetaskiwin. 1999. Wizard Lake Management Plan. County of Wetaskiwin, Wetaskiwin, Alberta.

County of Wetaskiwin. 2010. Municipal Development Plan. County of Wetaskiwin, Wetaskiwin, Alberta.

Edmonton and Battle River Regional Planning Commissions. 1980. Wizard Lake management plan: A summary of regulations and policies. Joint report by the Edmonton and Battle River Regional Planning Commissions.

Fish and Wildlife Division. 2008. Report of Alberta's Endangered Species Committee: June 2006. Fish and Wildlife Division, Alberta Sustainable Resource Development, Edmonton, Alberta. 44 p.

Government of Alberta. 2011. Edmonton-Calgary Corridor Groundwater Atlas. Energy Resources Conservation Board and Alberta Geological Survey, Government of Alberta, Edmonton, Alberta.

Jaakson, R., Buszynski, M. D. and Botting, D. Carrying capacity and lake recreation planning. The Michigan Riparian, 1990, pp. 11-12, 14.

LeChevallier MW, Norton WD and Lee RG. 1991. Occurrence of *Giardia* and *Cryptosporidium* spp. in surface water supplies. Applied and Environmental Microbiology 57(9): 2610-2616.

Leduc County, 2009. Leduc County website. Online at http://www.leduc-county.com/.

Leduc County. 1999. Leduc County Municipal Development Plan. Leduc, Alberta.

Leduc County and Wetaskiwin County, 1998. Wizard Lake Management Plan 1998, Draft for Public Discussion. Joint plan developed by Leduc County and Wetaskiwin County.

The Leduc Rep, 2009. Stewardship vital to Wizard Lake. Newspaper article in the Leduc Rep, Leduc, Alberta.

Lennon, L. 2008. Coalbed Methane: Economic Boon or Environmental Boondoggle? Montana State University, Bozeman, Montana. Online at: http://serc.carleton.edu/research_education/cretaceous/coalbed.html.

Mitchell, P.M. and E.E. Prepas. 1990. Atlas of Alberta Lakes. The University of Alberta Press, Edmonton, Alberta.

Mukherjee S, Pennardt A, Sheridan BJ, Hökelek M, Fennelly G, and Johnston MH. 2011. Giardiasis. MedScape Reference. Online at http://emedicine.medscape.com/article/176718-overview.

Natural Resources Defense Council. 2002. Hydraulic Fracturing of Coalbed Methane Wells: A Threat to Drinking Water. 7 p. Online at http://www.earthworksaction.org/pubs/200201_NRDC_HydrFrac_CBM.pdf.

Natural Resources Canada. 2009a. Geogratis – CanVec Digital Cartographic Reference. Department of Natural Resources, Ottawa, Ontario.

Natural Resources Canada. 2009b. Land Cover, circa 2000-Vector. Natural Resources Canada, Earth Sciences Sector, Mapping Services Branch, Centre for Topographic Information. Sherbrooke, Quebec.

Natural Resources Canada. 2007. Geobase – Canadian Digital Elevation Model. Department of Natural Resources, Ottawa, Ontario.

Natural Resources Defense Council. 2002. Hydraulic Fracturing of Coalbed Methane Wells: A Threat to Drinking Water. New York, New York, United States of America.

North Saskatchewan Watershed Alliance (NSWA). 2005. North Saskatchewan Watershed Report 2005 – A Foundation for Collaborative Watershed Management. Prepared by Aquality Environmental Consulting Ltd., Edmonton, Alberta.

Palliser Environmental Services Ltd. and Alberta Agriculture and Rural Development. 2008. Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds. Palliser Environmental Services Ltd., Mossleigh, Alberta, Canada. 81pp.

Species at Risk. 2009. Species at Risk Public Registry. Gatineau, Quebec. Online at: http://www.sararegistry.gc.ca.

Statistics Canada. 2008. 2006 Census. Statistics Canada, Ottawa, Ontario. Online at: http://www12.statcan.ca.

Strong, W.L., B.K. Calverley, A.J. Richard and G.R. Stewart. 1993. Characterization of Wetlands in the Settled Areas of Alberta. Alberta Environmental Protection.

Teichreb, C. 2007. Wizard Lake 2007 tributary monitoring. Alberta Environment, Edmonton, Alberta.

Teichreb, C. 2007. Wizard Lake historical water quality assessment. Alberta Environment, Edmonton, Alberta.

Teichreb, C. 2010. Wizard Lake 2010 tributary monitoring. Alberta Environment, Edmonton, Alberta.

Teichreb, C. 2011. Wizard Lake 2011 tributary monitoring. Alberta Environment, Edmonton, Alberta.

United States Environmental Protection Agency. 2012. Basic Information about Pathogens and Indicators in Drinking Water. United States Environmental Protection Agency, Washington, DC.

World Health Organization. 2003. Cyanobacterial toxins: Microcystin-LR in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. World Health Organization, Geneva, Switzerland.

World Health Organization. 1993. Guidelines for Drinking Water Quality, Second edition, volume 1, recommendations. World Health Organization, Geneva, Switzerland.

Glossary

Aerobic: In freshwater systems, an environment that contains oxygen.

Aeolian: Geological landforms or processes associated with wind action.

Anaerobic: In freshwater systems, an environment that is devoid of oxygen.

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

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

Arable: Land fit to be cultivated as by plowing or tilling.

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

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

Colluvial: Refers to loose deposits of rock accumulated by gravity, generally at the bases of hills or cliffs.

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

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

Dissolved Oxygen: A measurement of the amount of oxygen available to aquatic organisms. Temperature, salinity, organic matter present, BOD and COD affect DO solubility in water.

Ecological Integrity: See Environmental Integrity.

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

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

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

Ephemeral Wetland: A wetland that temporarily holds water for part of the year in some years. Using the Stewart and Kantrud (1971) classification, these would be classes I – III, with class I being very

temporary and often farmed right through in all but the wettest years and III containing typical emergent vegetation, like cattail, but drying up in mid-summer.

Epilithic: Refers to growth on the surface of rocks and stone, especially of algal or planktonic growth on stream/riverbed rocks.

Epiphyton: A complex community of plants and algae that live on the surface of other plants and animals.

Eutrophic: Refers to aquatic environments that have abundant nutrients and high productivity. In waterbodies such as lakes, ponds and slow-moving rivers, oxygen levels below the surface layer may be depleted. Opposite of oligotrophic (CCME, 1999).

Eutrophication: The natural and/or anthropogenic processes by which the nutrient content of natural waters is increased, generally resulting in an increase of biotic productivity and biomass (CCME 1999).

Exceedence: A sample, event, or sampling period for which a measurement exceeds a specified guideline or limit.

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

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

Five-Year Running Average: The sum of the previous five years' quantities in a set divided by five. Expressing an average in this manner eliminates individual between-year variation, making data easier to understand.

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

Forest Management Area: An agreement between the Alberta government and a company to enable that company to enter on forest land for the purpose of establishing, growing and harvesting timber in a manner designed to provide a perpetual sustained yield. Unlike timber quotas or timber permits, FMAs require long-term forest management planning and public consultation by the companies.

Forest Management Unit: The defined area of forest located in the Green Area designated by the Alberta government to be managed as a unit for wood fibre production and other renewable resources.

Gastroenteritis: Inflammation of the stomach lining membrane and intestines that is marked by flu-like symptoms, including nausea, vomiting, diarrhea and abdominal cramping, and is typically caused by a virus (as the Norwalk virus) or a bacterium (as *E. coli*).

Fluvial: Refers to geological processes associated with glacial streams and rivers.

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

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

Guidelines: Generic numerical concentrations or narrative statements that are recommended as upper limits to protect and maintain the specified uses of air, water, sediment, soil or wildlife. These values are not legally binding (CCME, 1999).

Hardness: The concentration of all metallic cations, except those of the alkali metals, present in water. In general, hardness is a measure of the concentration of calcium and magnesium ions in water and is frequently expressed as mg/L calcium carbonate equivalent (CCME, 1999).

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

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

Lentic: Waterbodies consisting of standing or still water.

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

Linear Regression: A statistical test to determine whether there is a linear relationship between two variables, and how strong that relationship is.

Lotic: Waterbodies consisting of flowing water.

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

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

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

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

Morphometry: The measurement of the shape of a lake, usually with depth contours.

Multi-Barrier Approach: An integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health.

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

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

Oligotrophic: Refers to aquatic environments that have scarce nutrients and low productivity. Opposite of eutrophic (CCME, 1999).

p or p-value: In statistics, the probability (out of 1.0) that an observation occurred by chance. Values less than 0.05 are generally considered to indicate a statistically significant result.

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

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

Pelagic: Open-water areas of lentic systems that receive enough sunlight for net photosynthesis to occur. Also used as a descriptor of organisms that are commonly found in or prefer such areas.

Periphyton: A complex mixture of algae, cyanobacteria, heterotrophic microbes and detritus that is attached to submerged surfaces in most aquatic ecosystems.

Permanent Wetland: A wetland that retains water for most of the year in most years. Using the Stewart and Kantrud (1971) classification, these would be class IV or V (lakes).

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

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

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

Polygon: A term used to describe a riparian inventory site area.

Pugging: Raised mounds in soil resulting from large animals walking through soft or moist soil.

Reach: A section of stream, river, lake or wetland with similar physical and vegetative features and similar management influences.

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

Salinity: In fresh waters, the salinity is the sum of the ionic composition of the eight major cations (calcium, magnesium, sodium and potassium) and anions (carbonate, sulfate, chloride and nitrate) in mass or milli-equivalents per liter (Wetzel, 1975).

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

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

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

Soluble Reactive Phosphorus: A measure of the inorganic (dissolved) phosphorus in a solution.

Standard: A legally enforceable numerical limit or narrative statement, such as in regulation, statute, contract or other legally binding document, that has been adopted from a criterion or objective (CCME 1999).

Stratigraphy: The study of rock, soil or lake sediment layers (strata), especially the distribution, deposition and age of sedimentary rocks or lake sediments.

Taxon: In biology, a taxonomic category or group, such as a phylum, order, family, genus or species.

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

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

Total Dissolved Solids: Portion of dissolved solids that passes through a 2.0 µm filter (National Standard Methods, 1998).

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

Total Kjeldahl Nitrogen: A measure of the nitrogen concentration in a solution, as the sum of organic nitrogen and ammonia nitrogen (National Standard Methods, 1998).

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

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

Total Residue: Material left behind after evaporation of a sample and oven drying (National Standard Methods, 1998).

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

Total Suspended Solids: The portion of dissolved solids that are retained by a 2.0 µm filter (National Standard Methods, 1998).

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

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

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