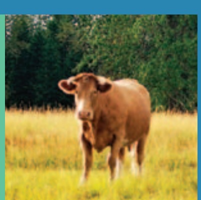
# North Saskatchewan Watershed Alliance

Painting by Jim Visser, NSWA Member

# State of the North Saskatchewan Watershed Report 2005

*A Foundation for Collaborative Watershed Management*



The NSWA gratefully acknowledges the funding and in-kind support of our project partners

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# State of the North Saskatchewan Watershed Report 2005

*A Foundation for Collaborative Watershed Management*

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*A Foundation for Collaborative Watershed Management*

**Prepared for:**
**NORTH SASKATCHEWAN WATERSHED ALLIANCE**

**Prepared by:**
***AQUA*LITY ENVIRONMENTAL CONSULTING LTD.**
**Edmonton, Alberta**

**in association with:**
**LILLEY ENVIRONMENTAL CONSULTING INC.**
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# on the road to sustainability...

For the past three years, the NSWA has been working on behalf of North Saskatchewan watershed stakeholders to collect and collate key information on our watershed. This report describes present conditions and will act as a guide for our decisions and actions into the future. Our State of the Watershed Report is the first of its kind to be initiated by a multi stakeholder organization, collecting information into one document, using the geographical boundary of the North Saskatchewan Watershed in Alberta as its scope. The process of collecting data, reports and the knowledge of experts in our watershed has been both challenging and rewarding. As the Watershed Planning and Advisory Council for the North Saskatchewan, we are committed to state of the watershed reporting well into the future.

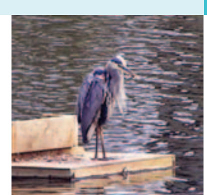
Using the best available data provided by our partners, the health of the watershed rates as 'generally fair'. While this may be considered a passing grade by some - a 'very good' or 'excellent' outcome is far more desirable. The recommendations in this report will require serious consideration if we are to tip the scales in a more positive direction. This report serves as a foundation; a starting point from which to channel our partnerships and resources to create a more sustainable watershed for future generations. As such, the *State of the North Saskatchewan Watershed 2005* is an asset for the NSWA, and all decision-makers in the watershed, as we embark on our integrated watershed management planning process.

We have a unique opportunity here in Central Alberta. Our watershed and the river it serves remains sufficiently intact to still allow wise and sustainable decisions regarding their future management. We have not yet made commitments our river, and its watershed, cannot keep. We have the opportunity to make choices that will meet societal needs, while ensuring the ecological integrity of the watershed. This is our task, and this is our responsibility. A healthy watershed, in many ways, serves as the very foundation of our human needs. This State of the Watershed Report is a "call for action". It challenges us to accept and act upon the important responsibility we have to the systems that sustain us.

Tracy Scott
*NSWA President, 2004/5*

Sharon Willianen
*NSWA Manager*







**Acknowledgments**

Due to the length and magnitude of this project, both in development and completion, there have been many NSWA members involved with the project direction. The NSWA has tracked membership of this Steering Committee over time. Current management apologizes for any omissions in this list.

The report would not have been possible without the efforts of many individuals and organizations. This project was conceived at a meeting in Edmonton on November 15, 2001. The following individuals met to discuss the current project: Christine Della Costa (FEESA; now Inside Education); Bruce McCulloch (Fisheries and Oceans Canada); Dave Trew, Anne Marie Anderson, Ed Bulger, Hamid Namsechi, Sal Figliuzzi, Jason Boisvert, Douglas Thrussell (Alberta Environment); Cherie Westbrook, Jamie Wuite (Alberta Agriculture, Food and Rural Development); Ron Bjorge, Kevin Tripp (Alberta Sustainable Resource Development); Adele Mandryk (then NSWA Manager); and Cindy Shepel (EPCOR Water Services). Through the efforts of NSWA Manager Adele Mandryk, terms of reference were created and funds were raised to start the project.

NSWA partner agencies are largely responsible for the donation of digital data products and guidance, without either of which this project would not have been as successful. The following should be recognized: Andy Lamb from Alberta Environment; Richard Escott, Jason Vanrobaeys, Nolan Becker, David Gibbens and Shannon Hall from Agriculture and Agri-Food Canada – PFRA; Tim Martin and Jamie Wuite from Alberta Agriculture, Food and Rural Development; Kevin Tripp and Phil Mackenzie from Alberta Sustainable Resource Development; and Tracy Scott, Nicole Hopkins and David Kay from Ducks Unlimited Canada. Special thanks go to Ducks Unlimited Canada for the donation of a GIS workstation and server space during 2003/2004. Significant technical support was provided to this project by Nicole Hopkins at the Edmonton DUC office.

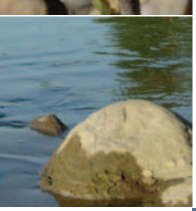
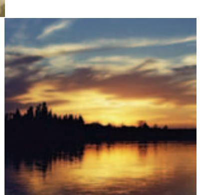
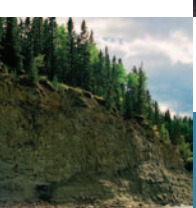
Other NSWA partners provided timely riparian health data for inclusion into this report including Lorne Fitch and Kelsey Spicer-Rawe (Cows and Fish), Kristin York (AESA – Counties of Leduc and Wetaskiwin), Blake Mills (Alberta Conservation Association) and Andrew Schoepf (Alberta Fish and Game Association).

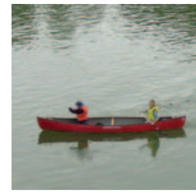
NSWA members were instrumental to the success of the public outreach component of this project. The NSWA would like to thank the Rocky Riparian Group, Delaney Anderson (AESA – Smoky Lake and St. Paul Counties) of the Bonnie Lake Sustainability Association, and Michael Dell of Trout Unlimited Canada, and Locke Girvan and Doug Marvin of Strathcona County for their promotion of the Public Open Houses.

The Steering Committee members who have overseen this project are recognized for their efforts. Committee members have included Kerry Brewin, Ernie Ewaschuk, Peter Denney, Richard Escott, Gail Feltham, Paul Goodman, Jordan Kuschminder, Adele Mandryk, Bruce McCulloch, Diana Rung, Tracy Scott, Cindy Shepel, Doug Thrussell, Susan Tiege, Beth Michener, Ross Wein, and Carol Wilson.

Finally, the NSWA Membership is to be thanked for their ongoing support. NSWA members determine project work. This report is to be recognized as a foundational document for the Integrated Watershed Management Plan.



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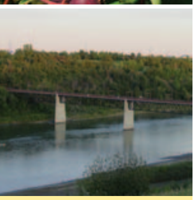





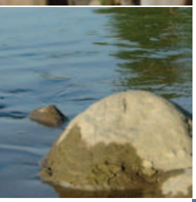
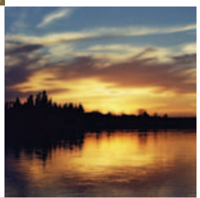


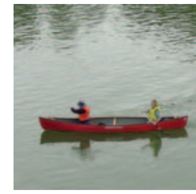


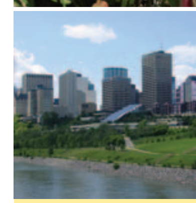













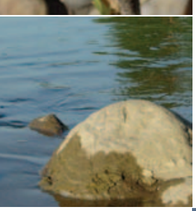
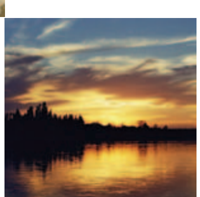
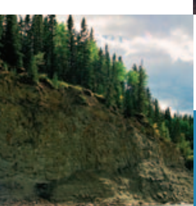

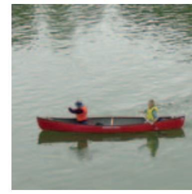




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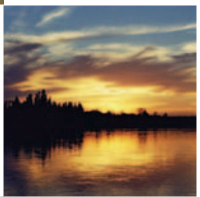
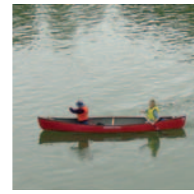
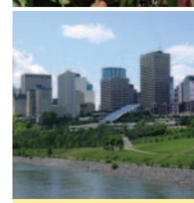


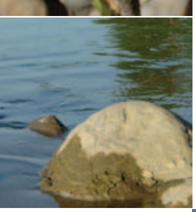



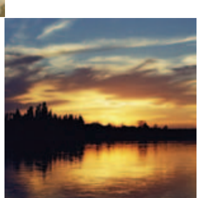


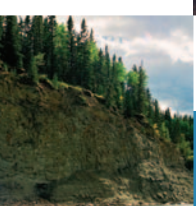


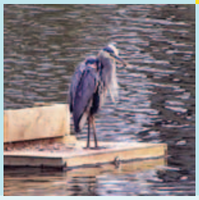




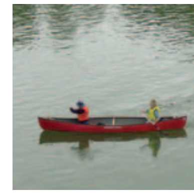


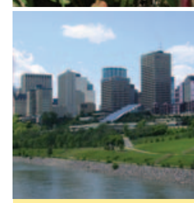




## Chapter 1.0

# Executive Summary




# 1.0 EXECUTIVE SUMMARY

## 1.1 BACKGROUND

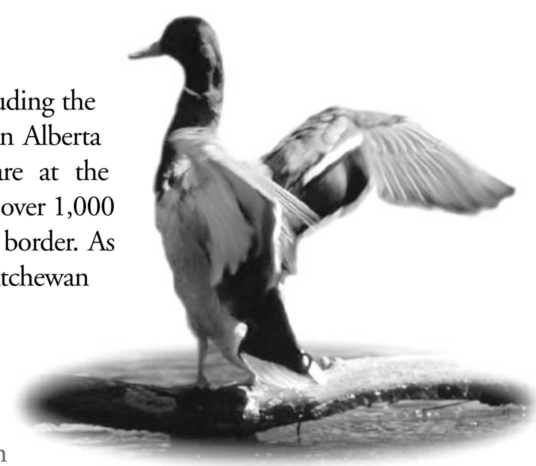
The North Saskatchewan Watershed Alliance (NSWA) identified a "State of the Watershed" report as one of its key initiatives to better understand the current status of the watershed and to provide a baseline from which an Integrated Watershed Management Plan could be prepared (NSWA Business Plan, 2000).

The NSWA's vision is a watershed where ecological integrity is the foundation for environmental, cultural, social and economic decision-making. Actions taken and policies followed will result in the wise use and management of the North Saskatchewan Watershed in Alberta. This includes actions to protect and improve water quality and ecosystem function and taking a multi-barrier approach to source water protection. The NSWA has recently been appointed by Alberta Environment as the Watershed Planning and Advisory Council (WPAC) for the North Saskatchewan Watershed in Alberta. Through this designation, the Alberta government has sanctioned the NSWA's responsibility to prepare a watershed management plan that requires as a foundation, the current state of the watershed.

This document reports on the state of the watershed within Alberta by each of its 18 subwatersheds that are based on highest order tributary. The report quantifies land uses and comments on land use, water quality and environmental integrity in the North Saskatchewan Watershed. The report provides a "snapshot in time" and is not intended to demonstrate long-term changes in land use, water quality or show historical trends. The report will be revisited in the future to determine if implementation of the Integrated Watershed Management Plan (IWMP) has made a change to the watershed health indicators both studied in this report and those determined in the future.

To actively engage watershed stakeholders, and to gain a better understanding of current public concerns and issues within the watershed, a public participation program was implemented. The program included disseminating information about the NSWA and the project through the production of information panels that were displayed in various locations throughout the watershed in the summer of 2003. These were followed up with three public open houses held in Rocky Mountain House, Sherwood Park and Elk Point, Alberta. Issues and concerns were obtained from verbal and written comments recorded during the open houses. Water quality, quantity (drought), land use practices and the industrial use of water were the most frequently mentioned concerns.

## 1.2 WATERSHED OVERVIEW



This scope of this report is the entire North Saskatchewan Watershed within Alberta; including the main stem, the Battle River and Sounding Creek. The North Saskatchewan Watershed in Alberta drains 80,000 km2, approximately 12.5% of Alberta's landmass. The headwaters are at the Saskatchewan Glacier in the Columbia Icefields in Banff National Park and the river flows over 1,000 kilometres through five natural regions from its headwaters to the Alberta/Saskatchewan border. As part of the Nelson River Basin, the North Saskatchewan River joins with the South Saskatchewan River in the province of Saskatchewan and eventually empties into Hudson Bay.

Water quality in the North Saskatchewan River changes as one moves downstream due to inputs from natural and anthropogenic; point and non-point sources. Nutrients (notably phosphorus), bacteria and pesticides typically increase. Dissolved oxygen decreases downstream of larger urban populations.





Land uses in the watershed include agriculture, resource exploration and extraction, forestry, recreation, urban centres and country residential development. The vast majority of human population in the watershed lives in the greater Edmonton area. The headwaters of the watershed are sparsely populated and remain primarily in a natural state within National Parks.  Land uses such as seismic activity, pipelines, service infrastructure, road networks, forestry related activities, powerlines and other resource exploration and extraction activities occur in the Green Zone (crown land) and all have a cumulative effect on watershed health.

Water use along the North Saskatchewan River and its tributaries includes human consumption, waste assimilation, hydroelectric power generation, oil and gas extraction, mining, and agriculture. Several villages, towns, and cities in the watershed have either wastewater treatment plants or wastewater lagoons that discharge treated effluent into the North Saskatchewan River or its tributaries.

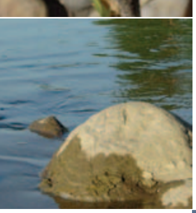
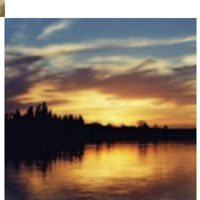
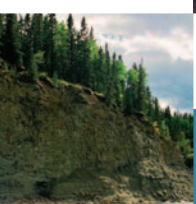
The North Saskatchewan Watershed includes about 3,600 kilometres of streams. Approximately one-half, mostly in the upper reaches, are suitable for trout and other cold water species. Downstream the river becomes warmer and the fish community shifts towards cool and warm water game fish such as walleye, pike, goldeye, mooneye and sauger. Lakes are not plentiful and lake fishing opportunities are somewhat limited. The larger cool water lakes primarily contain pike, perch, lake whitefish, and walleye.

### 1.3 INDICATORS

Fifteen indicators were chosen at a May 2002 workshop attended by NSWA partner experts to represent and describe watershed health. Indicators fall into four broad categories. Within these categories, the following indicators and metrics were used to guide data collection.








Metrics chosen for the State of the North Saskatchewan Watershed Report.

| Indicator Category | Metric |
|---|---|
| Land Use | Riparian health |
| | Linear development (roads, seismic, pipelines, etc.) |
| | Land use inventory |
| | Livestock density |
| | Wetland inventory |
| Water Quality | Surface water quality index (AENV model) |
| | *E. coli* |
| | Phosphorus (TP, SRP) |
| | Pesticides |
| Water Quantity | Water allocations by sector |
| | Groundwater extraction |
| Biological Indicator | Aquatic macrophytes |
| | Fish (population estimates) |
| | Vegetation types (Alberta Vegetation Inventory) |
| | Benthic invertebrates |



Significant knowledge gaps exist for some indicators initially chosen for this report. Few systematic assessments of bioindicators have been performed, and those that exist have not been converted to a compatible (digital) format for use in this report. Assessment of watershed health based on these is therefore limited. The Recommendations section of the report addresses how this might be resolved in the future.

## 1.4 WATERSHED SUMMARY

### 1.4.1 Headwater Subwatersheds

The headwater subwatersheds of Cline, Brazeau, Ram and Clearwater share features that are critical to source water quantity and quality in the watershed. The presence of glaciers, mountain snowpack, forests and natural wetlands ensure the supply of water to tributaries and the river main stem for the large population of the Edmonton area, especially during periods of low runoff. Glacial flour in headwater streams and rivers creates a naturally turbid environment for aquatic life.

Forest and perennial vegetation loss can place risks on this area's ability to continue to store and deliver water. Minimizing linear disturbance and uncontrolled access related to industry including resource exploration and extraction, along with sustainable forest practices in these areas will benefit forest structure, cold water fisheries productivity and natural biodiversity. These practices will also ensure that good quality water continues to flow to downstream reaches and users.

Should ranching or other agricultural activities increase in the headwaters of the watershed, contributions of manure, pesticides and fertilizers should be regularly monitored. Management practices to protect riparian areas and minimize water quality impacts should be followed in these critical areas.



Water quality data indices are calculated in only a few locations in the watershed, and in the interest of source water protection, sound knowledge of flows and chemistry will become even more important in the future. Abraham Lake and the Brazeau Reservoir provide hydroelectric power generation and their dams augment winter flows for downstream residents, agriculture and industry. The headwaters are a key recreational and tourism area and as increasing activity has the potential to disturb landscapes (ski hills, golf courses, resort development) this could place more risk on watershed integrity at its source. While this area is very important in terms of source water protection, the largest basic digital (Geographic Information System - GIS) data gaps exist here.

**1.4.2 Middle Reach Subwatersheds**

Compared to the headwaters, the subwatersheds in the central region of the watershed in Alberta have more agricultural activities, manure production, and urbanization. These land uses have the largest impact on overall watershed health. This area includes the Modeste, Strawberry, Sturgeon, Beaverhill and White Earth subwatersheds. Change in land uses from agriculture and natural landscapes to urban and industrial land uses increases the susceptibility of groundwater resources, surface water resources, soils, crops and native vegetation to absorb the impacts of natural and anthropogenic events such as drought, flooding, industrial spills and urban stormwater run-off. NSWA members have raised resource extraction in these subwatersheds, (gravel and coal) as an issue of concern.

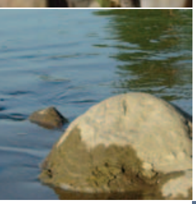
Currently, human impacts on the watershed are addressed through treatment processes and the assimilative capacity of the North Saskatchewan, Sturgeon, Vermilion and Battle Rivers. Retention and restoration of riparian health and intact, functional wetlands are critical in providing good water quality and storing water on the landscape for the benefit of the entire watershed. The cumulative impact of land disturbance needs to be better addressed on a regional scale in this area of the watershed.

**1.4.3 Eastern Subwatersheds**

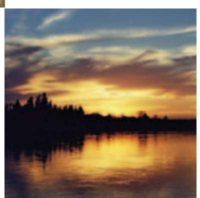
Water quantity and water quality impacts from the City of Edmonton concern the residents downstream in the northeast portion of the watershed. The Frog, Vermilion, Blackfoot and Monnery subwatersheds have some of the most altered landscapes in the watershed. This has impaired natural functions related to water storage, groundwater recharge, flood attenuation and base flow contributions to creeks and rivers. Livestock densities in these subwatersheds are moderate which implies livestock and manure management are very important considerations. The NSWA suggests that riparian health and wetland restoration should be future areas of focus to restore sustainability in these eastern reaches.

**1.4.4 The Battle Subwatersheds**

The Battle River subwatershed is comprised of the Bigstone, Paintearth, Iron, Blackfoot and Ribstone Creek basins. Having no mountain headwaters to provide a steady supply of glacial and snowpack meltwater, this area relies solely on spring runoff and rain events for most main stem flows. Land and water management practices in the Battle subwatersheds must ensure the sustainability and ecological integrity of this area.



Decreased flows in recent years have impacted municipal and industrial reservoirs along the Battle. There are significant areas of the subwatershed with high agricultural intensity, high livestock density, altered wetlands, poor water quality and low tree cover. Areas of recharge (wetlands) and contributions to river base flows by groundwater become increasingly important in these non-glacier fed watersheds. The results of riparian health assessments along the Battle River and its tributaries suggest that it is becoming important to fully assess the impacts of various land use practices.






### 1.4.5 The Sounding Subwatershed

In the southeast portion of the North Saskatchewan basin, most of the Sounding Creek subwatershed has the unique municipal designation of 'Special Areas'. These areas all experienced severe soil erosion during the Depression and drought of the 1930's. As a result, this subwatershed has unique jurisdictional and watershed challenges. It is considered a closed basin by provincial and federal governments, because it rarely flows into the Battle River at its confluence in Saskatchewan. Less than 1% of the subwatershed has tree cover and livestock densities are moderate.

## 1.5 CONCLUSIONS

Fifteen indicators of watershed health were selected and ranked by a panel of experts and members of the NSWA for each of the 18 subwatersheds. These indicators were summarized and have yielded a subjective health rating. The overall health of the entire North Saskatchewan Watershed is generally fair (on a scale of excellent, good, fair and poor) and includes some subwatersheds where ecosystem function is significantly impaired by human activity. Through an adaptive process, the NSWA should re-evaluate these indicators based on the current report for relevance, and focus future data collection efforts and state of the watershed reporting where data gaps have been identified and indicators refined.

For the indicators where data were available and through the assessment methods used, the watershed is most healthy in the 4 headwater subwatersheds which include the Cline, Brazeau, Clearwater and Ram. East of the headwaters, where livestock density, human activity and populations are greatest, health tends to decline. Generally, the health of a subwatershed is worse in those subwatersheds where land use is more intensive and where riparian health scores and wetland cover are lowest.

Disturbances of note include the Capital Region's impacts on the river main stem from treated wastewater and stormwater outfalls. For example, the Alberta Surface Water Quality Index drops downstream of Edmonton due to increases in both *E. coli* counts and phosphorus concentrations. However, the impact of the City has been lessened considerably by the recent improvements in wastewater treatment technology (tertiary treatment including biological nutrient removal) and is anticipated to improve as the City of Edmonton moves forward with proposed stormwater treatment strategies.

The impacts of high agricultural intensity in the Bigstone, Iron, Ribstone, Blackfoot, Vermilion, Frog, Beaverhill, Modeste, Strawberry, Sounding and Paintearth subwatersheds may be reflected in higher phosphorus values, lower riparian health scores and lower wetland densities. In these subwatersheds, water quantity will continue to be an issue, as will water quality given the results of these indicators.

Pesticides were detected in several subwatersheds, but concentrations did not exceed the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. "*Based on the research and monitoring work conducted, the risk of water quality degradation appears to be significant for areas of the province where intensive agriculture is practised, as measured by fertilizer or herbicide inputs or by animal unit density*" (CAESA, 1999). However, several types of pesticides identified do not have established guidelines.

Existing or available data on biological indicators (aquatic macrophytes, fish population estimates, vegetation types and benthic invertebrates) and water quantity were least available for this study, and therefore not adequate to properly assess watershed health. Pharmaceuticals (animal and human) were found to be of concern to NSWA members. Their effects on humans and aquatic life are not well known or documented in the watershed and this presents a data gap for future consideration.





The NSWA, as Watershed Planning and Advisory Council for the North Saskatchewan River watershed in Alberta, will continue to lead State of the Watershed reporting in this watershed. It will also undertake integrated watershed planning by involving its members and watershed stakeholders in an ongoing, adaptive management and planning process. This State of the Watershed Report is a foundational document to be used by the NSWA to initially characterize and evaluate the overall health and issues of concern in this watershed.

As all major watersheds in this province are unique, this new approach to planning and growth while considering the limitations of watersheds creates an opportunity. The North Saskatchewan Watershed, with a relative abundance of water compared to some other Alberta watersheds, is still able to effectively consider the needs of the aquatic, riparian and other hydrological systems as part of its future management planning. Through the IWMP the NSWA in consultation with the residents and stakeholders in the watershed, must decide on the balance between society's needs, and the needs of the natural systems which support social, environmental and economic health. It is hoped that this document, and future reports of this kind will provide an assessment of just how well our planning, implementation and actions improve the 'state of the watershed'.

## 1.6 RECOMMENDATIONS

The following recommendations are a result of report data analysis, NSWA member and public comments, examining the needs of future State of the Watershed Reports and information required for wise use and management of the North Saskatchewan Watershed. These recommendations are for the review and consideration by NSWA members, NSWA partners and watershed stakeholders. The recommendations are:

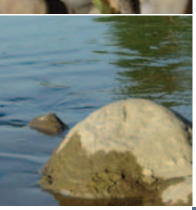
**i.** To support municipal government initiatives that promote wise use and management of their portion of the watershed such as urban sustainability initiatives (Smart Growth), conservation planning, riparian area protection zones, wetland restoration and upgrades to wastewater and stormwater treatment.

**ii.** To encourage municipal governments to incorporate watershed function in planning and development policy reviews. Riparian areas, native and perennial tame vegetation, and wetlands are key elements in watershed protection. The NSWA should work with and encourage municipalities to develop and implement land use policies that protect these features.

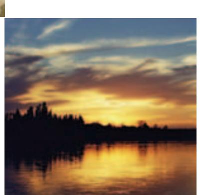
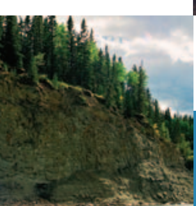
**iii.** To discuss with the federal, provincial and municipal governments the provision to the public of digital data collected and created with public dollars. A major constraint of this project was obtaining digital data from government and the lengthy process that this required.

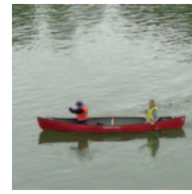
**iv.** To encourage the federal, provincial, municipal governments and Non-government Organizations (NGO's), industry and others, to undertake a review of their respective non-digital data sources and translate these to geo-referenced digital data for the purpose of GIS layer completeness (i.e. water quality and fisheries data).

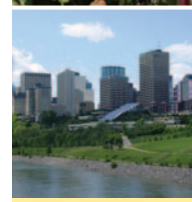




**v.** To create a water quality working group to identify all agencies and volunteer organizations currently collecting water quality information in the watershed to ensure that monitoring efforts are adequate to address watershed health. This could be accomplished through a series of workshops or forums. This group could also share water quality data and ensure a consistent approach to data collection, and create a water quality report using existing data from throughout the basin. This would have value in further understanding the watershed's water quality not based solely on the Alberta Surface Water Quality Index (ASWQI).



**vi.** To encourage the provincial government and research organizations to systematically assess a suite of biological indicators in order to properly evaluate this aspect of watershed health. Alternatively, the NSWA should consider an initiative to collect biological indicator data that were absent from this report.

**vii.** To work with the Cows and Fish Program, and other riparian assessment experts, to develop a collective GIS-based riparian assessment process that is objective, universal, unconstrained by sharing issues and more accessible to the public. As a component of this, the NSWA should consider undertaking a thorough review of acceptable riparian buffer widths for all land uses, and determine best practices to be consistently incorporated into government land management practices and policies.

**viii.** To gain a better understanding of the cumulative impact of land disturbance, comprehensive assessments of provincial river basins should be a component of the province's 'state of the environment' reporting.

**ix.** To work with other Watershed Planning and Advisory Councils on adopting a consistent wetland classification system and scale (e.g. Stewart and Kantrud or Cowardin) to be used throughout the province. The NSWA should then encourage and support conservation groups and agencies to collect wetland digital data using this consistent classification system.

**x.** To undertake with other agencies and partners a comprehensive wetland resource inventory, including drained wetlands, as a key component of a complete land use inventory for the North Saskatchewan Watershed. This is an essential tool that would enable planners to effectively address source water protection, water storage and restoration needs in the watershed. A priority for the inventory would be areas of medium to high agricultural intensity and land drainage.



**xi.** That the provincial government develop and implement a Wetland Policy through the Alberta Water Council that effectively addresses both wetland loss and restoration.

**xii.** To encourage the province and research organizations to undertake research in the area of glacier recession and snow pack change in the North Saskatchewan Watershed. This research should then be linked to climate change models for predictive scenarios.

**xiii.** To encourage and support the province to fund groundwater quantity and quality assessments for major groundwater sources in the watershed. This should include an assessment of groundwater quantity to ensure adequacy and scale of existing data.

**xiv.** To support and encourage federal and provincial governments to continue to invest in research of emerging issues such as waterborne human and livestock pharmaceuticals. Research should focus on beneficial management practices to decrease their concentrations at the source (such as livestock waste and municipal wastewater treatment facilities) and increase proper disposal.

**xv.** To encourage all levels of government to support and promote management practices that result in increased biodiversity in the watershed.

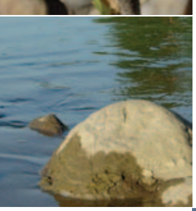
**xvi.** To develop a system to record and track improvements to watershed protection and continue to evaluate the effects of these improvements through regular state of the watershed reporting.

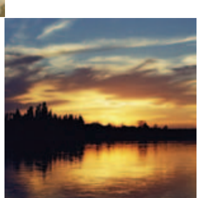


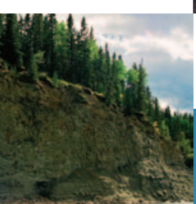
**xvii.** The indicators of watershed health used in this study were selected and ranked by the NSWA. NSWA should re-evaluate these indicators based on the current report for relevance, and encourage the focus of future data collection efforts by all partners in the watershed, where data gaps have been identified.

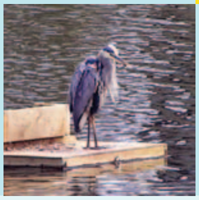
**xviii.** In future 'State of Watershed' reporting, the impact of resource extraction practices needs to be assessed relative to watershed health.





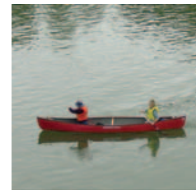


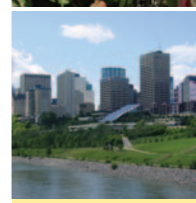



## Chapter 2.0

# Report Overview



## 2.0 REPORT OVERVIEW

A state of the watershed report is a current account of an entire watershed that identifies knowledge gaps within the watershed. The following state of the North Saskatchewan Watershed report was prepared for the North Saskatchewan Watershed Alliance (NSWA) using most recently available data that quantifies land-use categories and comments on water quality, water quantity and environmental integrity in the North Saskatchewan Watershed. Indicators of watershed health were determined with the assistance of partner experts which became the focus of data collection. Spatial data, using a geographic information system (GIS), were collected where possible. The four main indicator categories were water quality, water quantity, land use and biological indicators. Another aspect of this report was issue identification which will affect socio-economic decision making.

Watershed management decisions are becoming increasingly complex and require timely and relevant information from State of the Watershed reports. The NSWA subscribes to the multibarrier approach to source water protection. This is the first State of the Watershed report of this scale to be completed in Alberta, and is the NSWA's largest undertaking to date. This report will provide background information necessary for the development of an Integrated Watershed Management Plan (IWMP) for the North Saskatchewan Watershed in Alberta. Integrated Watershed Management is a comprehensive, multi-resource management planning process that involves all stakeholders in the watershed who come together to identify the resource issues and concerns. Stakeholders will also develop and implement a watershed plan with solutions that are environmentally, socially and economically sustainable.



## 2.1 PURPOSE OF REPORT

The purpose of this state of the watershed report is to summarize the current knowledge of the North Saskatchewan River watershed pertaining to land-use, water quality, water quantity, fisheries, and select biological indicators to comment on the environmental integrity of the North Saskatchewan Watershed. This report has been created for all NSWA members and other watershed stakeholders such as residents, regulators, policy makers, industry and non-governmental organizations. The report will provide some background knowledge that is required for improved watershed management decisions by regulators, policy makers, landowners and industrial users. Specifically, this report will:

1. Inform and raise awareness of the current state of the North Saskatchewan wateshed in Alberta.
2. Comment on the value of watershed protection, ecological health, and the state of the watershed.
3. Make recommendations based on observed conditions and information needs for sustainable management of the watershed.
4. Encourage independent studies of watershed functioning in areas where little data exists.
5. Provide the basis for predictive analyses and other information necessary to develop an Integrated Watershed Management Plan for the North Saskatchewan Watershed in Alberta.

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 (Government of Alberta 1999). IRM of water resources requires a comprehensive, interdisciplinary approach to the management





of water, timber, air, public land, fish, wildlife, range, oil, gas and mineral resources. Water management planning is formalized in the *Framework for Water Management Planning* (Alberta Environment 2001) which outlines the processes and required components for water management planners. The Framework states that the foundation for water management planning is a baseline State of the Watershed report. This report is intended to provide the baseline data required for the NSWA IWMP. Definitions for highlighted terms found throughout this report can be found in Section 8.0 Glossary.

## 2.2 SCOPE OF REPORT

The geographic scope of this State of the Watershed report is the watershed boundaries of the North Saskatchewan River within Alberta. The North Saskatchewan River within Alberta is broken down into 18 Subwatersheds: Cline, Brazeau, Ram, Clearwater, Modeste, Sturgeon, Strawberry, Bigstone, White Earth, Beaverhill, Paintearth, Vermilion, Frog, Iron, Monnery, Blackfoot, Ribstone and Sounding, each named for their highest order tributary into the North Saskatchewan River main stem (Figure 1). The scale that was used to break down the Subwatersheds was arbitrarily chosen. The Battle River Subwatershed (which includes the Bigstone, Paintearth, Iron, Blackfoot and Ribstone) and the Sounding Subwatershed are included in the North Saskatchewan River watershed, although they join the North Saskatchewan River in Saskatchewan rather than in Alberta.

The scope of data collected and used in this report was constrained to recent water quality and water quantity reports, land use data provided from NSWA partners, and select data pertaining to our biological indicators (Table 1). When data was readily available, trends over time that were related to our indicators were summarized and presented in this report. However, State of the Watershed reporting provides only a "snapshot in time" and is not intended to demonstrate long-term changes in land use, water quality or show trends over time. This report does not include historical analysis, but rather presents the most recent data that was available. Indicators were previously selected by our partner experts to determine what variables would be summarized to gauge the State of the Watershed, and ultimately predict watershed health.


## 2.3 NSWA BACKGROUND

The North Saskatchewan Watershed Alliance (NSWA) is a non-profit society whose purpose is to protect and improve water quality and ecosystem function in the North Saskatchewan Watershed within Alberta. Formed in 1999, the NSWA believes that an ecosystem approach coupled with an inclusive, collaborative process is the most effective way to find a balance between human needs and watershed integrity.

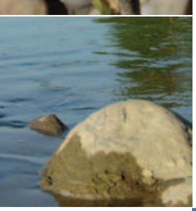
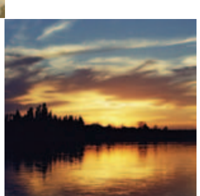
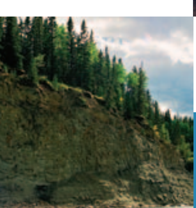
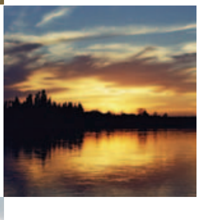




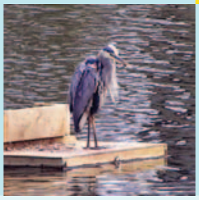

**Figure 1:** The 18 subwatersheds that comprise the North Saskatchewan Watershed in Alberta.










## Chapter 3.0

# The North Saskatchewan in Alberta





## 3.0 THE NORTH SASKATCHEWAN IN ALBERTA

### 3.1 WATERSHED OVERVIEW

Wherever you are on earth, you are in a watershed. Most of the rain and snow falling outside your window will eventually find its way to a local waterbody - rolling downhill across the land, forming rivulets and joining small streams, and finally emptying into a river or lake. That area of land or "gathering ground" from which water drains to your local waterbody is *your watershed.*

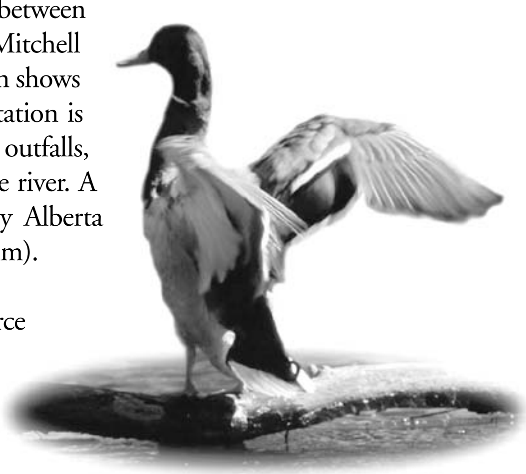
In 2001, the North Saskatchewan Watershed Alliance (NSWA) prepared a background report that described the North Saskatchewan Watershed (Perrin 2001). The following overview of the watershed uses information from that report as well as other material as referenced. For a more detailed description of subwatershed land use refer to Perrin (2001).

The North Saskatchewan Watershed in Alberta drains 80,000 km$^2$, approximately 12.5% of Alberta's landmass. The river has its origin at the Saskatchewan Glacier in the Columbia Icefields in Banff National Park and flows over 1,000 kilometres from its headwaters to the Alberta/Saskatchewan border. The elevation of the North Saskatchewan River is 1,390 m above sea level at the Saskatchewan Crossing near the park boundary, and slopes to just 500 m above sea level at the border with Saskatchewan. It joins with the South Saskatchewan River in Saskatchewan east of Prince Albert, flows into Lake Winnipeg in Manitoba and eventually empties into the Hudson Bay via the Nelson River. As part of the Saskatchewan River Basin, the North Saskatchewan River is subject to the 1969 Master Agreement on Apportionment, which states that Alberta must allow 50% of the natural flow of rivers to flow into Saskatchewan, must meet a minimum flow requirement whenever flow is above that minimum and can account for this on an annual basis.



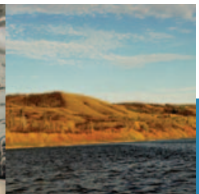
Water quality in a river system tends to change as you move downstream due to inputs from both natural and human-caused point and non-point sources. Nutrients (notably phosphorus), bacteria and pesticides typically increase while dissolved oxygen decreases downstream of larger urban populations.

Flow in the North Saskatchewan River is regulated by two headwater dams, the Bighorn on the main stem near the mouth of the Bighorn River, and the Brazeau on the Brazeau River. The net effect of these impoundments is to redistribute flow to a higher average flow in the winter and lower average flow in the summer. Without these dams, the City of Edmonton would face water shortages for consumption and waste assimilation at certain times of the year. Three tributaries contribute 66% of the increase in flow between Whirlpool Point and the Saskatchewan border—the Ram, Clearwater and Brazeau Rivers (Mitchell 1994). An analysis of recorded river flow at Hydat Station 05df001 at the City of Edmonton shows a trend of decreasing flow in the river main stem over the past century (Figure 2). This station is downstream of water treatment plant intakes and upstream of wastewater treatment plant outfalls, so it shows increased water use, but doesn't show that most of this water is returned to the river. A naturalized flow study of the North Saskatchewan River is currently being prepared by Alberta Environment, which is due to be published in December 2004 (Doug Thrussell pers. comm).



Land use in the North Saskatchewan Watershed in Alberta includes agriculture, resource exploration and extraction, forestry, recreation, and urban centres. The upper part of the watershed is sparsely populated and remains in a primarily natural state within National Parks. The vast majority of human population in the watershed lives in the greater Edmonton area.





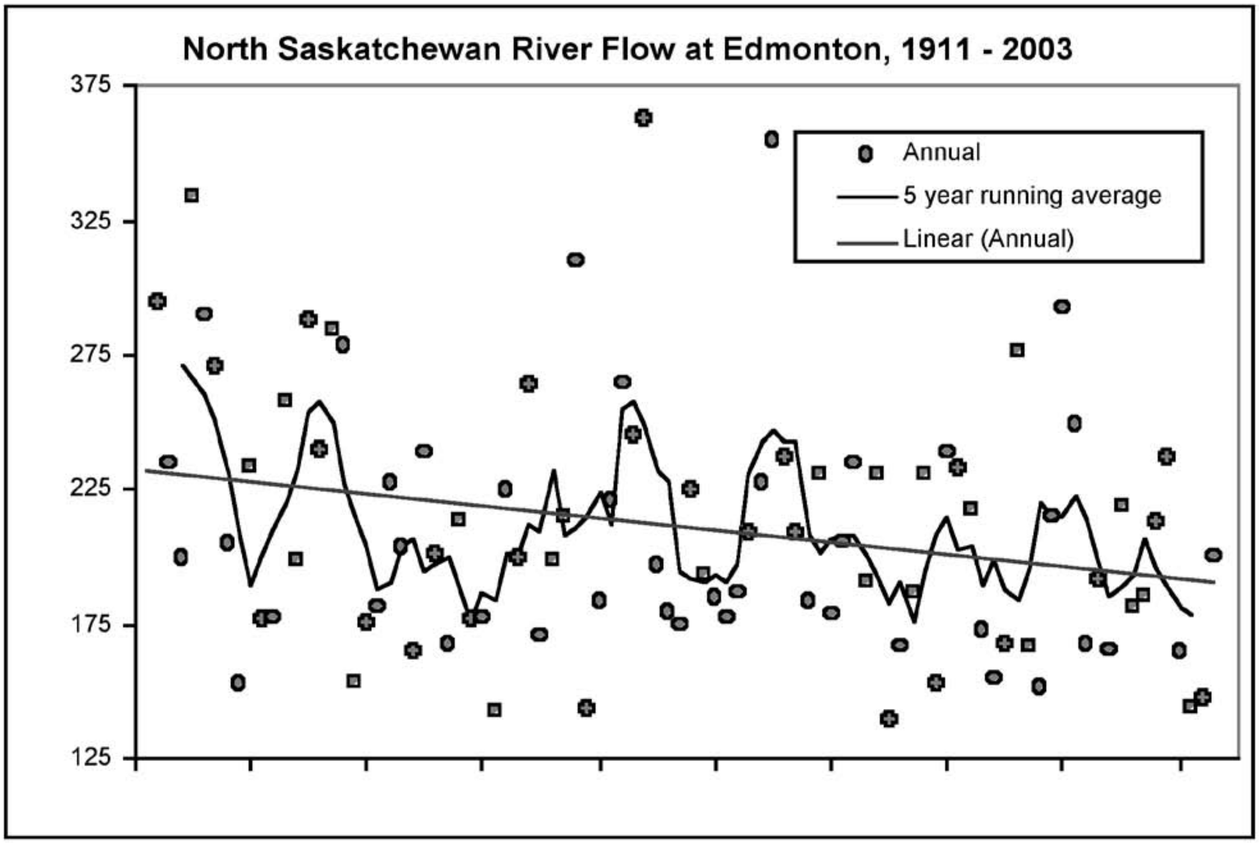
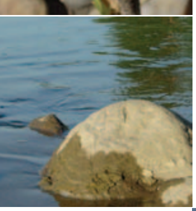
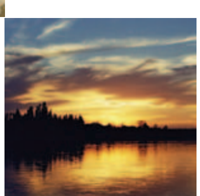



**Figure 2:** North Saskatchewan River flows at the City of Edmonton (HYDAT Station 05DF001) for 1911 to 2003 as recorded by EPCOR Water Services.

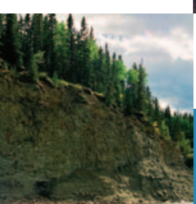


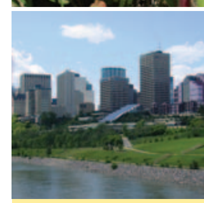
Water use along the North Saskatchewan River and its tributaries includes human consumption, hydro-electric generation, oil and gas extraction, mining, and agricultural uses such as livestock watering and some irrigation. Several villages, towns, and cities in the watershed have either wastewater treatment plants or wastewater lagoons that discharge their treated effluent into either the North Saskatchewan River or tributaries to the river.

The Battle River originates at Battle Lake, traverses central Alberta and flows 1,100 kilometres to enter the North Saskatchewan River near the Battlefords in Saskatchewan. The Battle River drains approximately 40% of the North Saskatchewan River watershed in Alberta. Because the Battle River is fed by groundwater and surface runoff from local snowmelt and rain rather than from glacial meltwater, it only contributes 3% of the water that flows into the North Saskatchewan River. Land use in most of the Battle River watershed is agriculture-intensive and there is a significant amount of coal mining for locally produced power.



There are eight provincial Grazing Reserves in the North Saskatchewan Watershed. These reserves are public lands that provide summer pasture for Alberta's farmers and ranchers. The reserves also are used for recreational activities, oil and gas production, and firewood cutters. The North Saskatchewan Watershed has ten provincial parks, three national parks, three ecological reserves, two wilderness areas, eighteen First Nation's reserves, and one Métis settlement.





The North Saskatchewan Watershed, including the drainage basins of the Ram, Clearwater, Brazeau and Battle Rivers, has an estimated 3,600 kilometres of streams. Approximately one-half are suitable for trout and other cold water species. The cold water habitat is located mainly above the junction of the Clearwater and North Saskatchewan Rivers and in the upper half of the Brazeau drainage. Downstream of this area, the river gradually becomes warmer and the fish community shifts towards cool water and warm water game fish such as sturgeon, walleye, pike, goldeye, mooneye and sauger.

Lakes are not plentiful in the watershed and lake fishing opportunities are somewhat limited. Stocked cold water lakes in the headwaters and numerous pothole lakes in the central part of the watershed provide the best opportunities for trout fishing. The larger cool water lakes primarily contain pike, perch, lake whitefish, and walleye.

## 3.2 NATURAL REGIONS IN THE NORTH SASKATCHEWAN WATERSHED

The North Saskatchewan and Battle Rivers traverse five natural regions within Alberta – the Rocky Mountain, Foothills, Boreal Forest, Parkland and Grassland natural regions (Figure 3). 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 others cases reflects the predominance of 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.

Brief descriptions of the five natural regions and relevant sub-regions are given below. For more detail, the reader should refer to Achuff (1994).



### 3.2.1 Rocky Mountain Natural Region

The Rocky Mountain Natural Region is underlain primarily by upthrust and folded bedrock. This region is the most rugged topographically. Elevations drop from west to east, from 3700 m along the Continental Divide to 1500 to 1000 m in river valleys. Three natural sub-regions reflect changes in environmental conditions dues to changes in altitude.

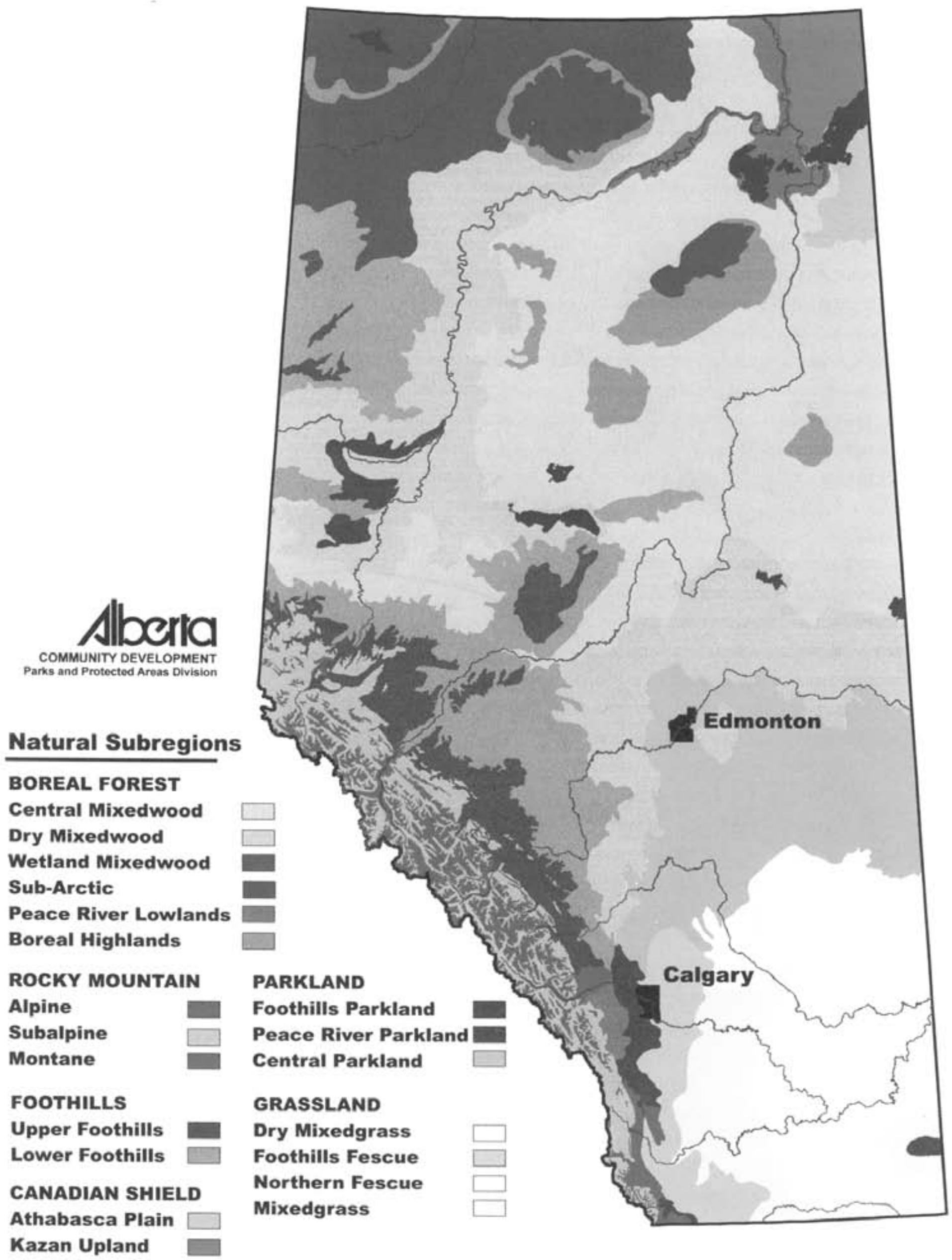



**Figure 3:** Natural Subregions map of Alberta. Figure courtesy of Alberta Community Development Parks and Protected Areas Division.




**3.2.1.1 Alpine Subregion**

The Alpine Subregion includes all areas above the tree line. Materials generally are residual bedrock and colluvium often on steep slopes. Extensive areas of unvegetated bedrock occur. The mean May to September temperatures is approximately 6°C and frost-free periods are rare. Mean annual precipitation ranges from 420 to 850 mm. Much of this subregion has no soil. Alpine vegetation typically forms a complex mosaic in which microclimatic variations are reflected in marked changes in dominant species.

**3.2.1.2 Subalpine Subregion**

The evaluation of the Subalpine Subregion ranges from about 2300 m to around 1600 m. Morainal materials occupy the majority of the subregion with colluvial and residual bedrock materials frequent at higher elevations. Fluvial and glaciofluvial deposits are common along stream valleys. The mean annual temperature ranges from -1°C to 3°C with a mean July temperature of about 15°C. Below freezing temperatures occur in all months. Total annual precipitation ranges from 460 mm to more than 1400 mm. Winter precipitation is higher in this subregion than in any other with often more than 200 cm of snowfall. Soils vary widely, reflecting the great diversity in parent materials and ecological conditions. The Subalpine Subregion is often divided into two portions: a Lower Subalpine characterized by closed forests of lodgepole pine, Engelmann spruce and subalpine fir and an Upper Subalpine with spruce-fir closed forests and open forests near the tree line. At lower elevations, lodgepole forests cover extensive areas following fire. Engelmann spruce and subalpine fir forests typically occur on higher, moister sites that have not been subject to fire. Open forests in the Upper Subalpine are transitional to the treeless Alpine Subregion above. Dominant trees include Engelmann spruce, subalpine fir, and whitebark pine. High elevation grasslands occur in the Subalpine Subregion.



**3.2.1.3 Montane Subregion**

The Montane Subregion occurs primarily in the major river valleys. The landforms of the major valleys are primarily fluvial and glaciofluvial terrace and fans with smaller areas of glaciolacustrine, aeolian and morainal deposits. Sandstone outcrops are typical. Elevations range from 1000 to 1350 m. Chinooks are characteristic of this subregion. The mean temperature for May to September is approximately about 12°C, with a mean July temperature of 15°C. There are approximately 70 frost-free days per year and the mean annual precipitation is approximately 600 mm with a range of 300 to 1280 mm. The landscape is characterized by a pattern of open forests and grasslands. Characteristic tree species include Douglas fir, limber pine and white spruce.

**3.2.2 Foothills Natural Region**

The Foothills Natural Region is transitional between the Rocky Mountains Natural Region and the Boreal Forest Natural Region. It consists of two Subregions, the Upper Foothills and the Lower Foothills.

**3.2.2.1 Upper Foothills Subregion**

The Upper Foothills Subregion occurs on strongly rolling topography along the eastern edge of the Rocky Mountains. The upper elevation limit is about 1500 m. Bedrock outcrops of marine shales and non-marine sandstones are frequent. Morainal deposits are common over bedrock throughout much of the area. The subregion has a mean annual precipitation of approximately 540 mm, with approximately 340 mm occurring between May



and September. The mean May to September temperature is 10°C to 12°C. Upland forests are nearly all coniferous and dominated by white spruce, black spruce, lodgepole pine, and occasionally subalpine fir. Lodgepole pine forests occupy large portions of upland sites and black spruce dominates on wet sites.

#### 3.2.2.2 Lower Foothills Subregion

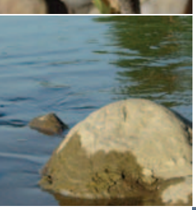
The Lower Foothills Subregion is generally rolling topography created by deformed bedrock along the edge of the Rocky Mountains. Elevations range from approximately 1250 m to 1450 m. Surficial materials are commonly morainal veneer over bedrock. Extensive organic deposits occur in valleys and wet depressions. Mean annual precipitation averages 465 mm, of which two-thirds falls between May and September. The mean May to September temperature is 11°C to 13°C. The forests reflect the transitional nature of the subregion in which mixed forests of white spruce, black spruce, lodgepole pine, balsam fir, aspen, balsam poplar and paper birch occur. Lodgepole pine communities are perhaps the best indication of the lower boundary of the Lower Foothills Subregion. The upper boundary is marked by the occurrence of nearly pure coniferous forest cover. Black spruce forests occur on moist upland sites and fens are common in much of the subregion.

### 3.2.3 Boreal Forest Natural Region

The Boreal Forest Natural Region is the largest in Alberta; however, most of this natural region occurs north of the North Saskatchewan Watershed. The region 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 region has been divided into six subregions, but only the Dry Mixedwood Subregion occurs in the North Saskatchewan Watershed.



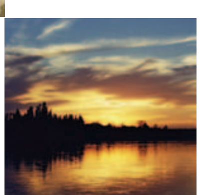
#### 3.2.3.1 Dry Mixedwood Subregion

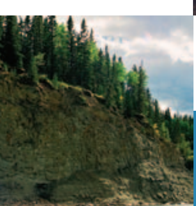


The Dry Mixedwood Subregion is characterized by low relief and level to undulating terrain. Surficial materials are mostly till with some areas of aeolian dunes and sandy outwash plains. The Cooking Lake moraine east of Edmonton is a separate portion of the subregion. The climate of the subregion is subhumid, continental with short, cool summers and long, cold winters. The mean May to September temperature is approximately 13°C and the growing season 90 days. Annual precipitation averages 350 mm, with June and July being the wettest months. Winters are relatively dry with approximately 60 mm of precipitation. Aspen is an important tree species in the subregion, occurring in both pure and mixed stands. Balsam poplar frequently occurs with aspen on the moister sites. Over time, white spruce and, in some areas, balsam fir can be expected to increase or replace aspen and balsam poplar as the dominant species; however, frequent fire seldom permits this to occur and pure deciduous stands are common in the southern part of the subregion. Dry, sandy sites are usually occupied by jack pine forests. Peatlands are common and may be extensive.

### 3.2.4 Parkland Natural Region

The Parkland Natural Region forms a broad transition between the drier grasslands of the plains and the coniferous forests of the Boreal Forest and Rocky Mountain natural regions. The Parkland Natural Region consists of three subregions; Central, Peace River, and Foothills, the latter of these does not occur in the North Saskatchewan Watershed. The subregions are separated on the basis of geographical location and major floristic differences. The Parkland Natural Region is the most densely populated region in Alberta and settlement has changed much of the native vegetation from aspen groves and grasslands to cultivated land.







#### 3.2.4.1 Central Parkland Subregion

Surficial deposits in the Central Parkland Subregion range from intermediate-textured hummocky and ground moraines to fine-textured glaciolacustrine deposits and coarse outwash. Elevations range from just over 500 m to around 1100 m. Numerous permanent streams cut across the subregion, and lakes and permanent wetlands are scattered throughout. Many of the lakes and wetlands naturally are slightly to strongly alkaline. The mean annual temperature is 2°C with a May to September average of 13°C. The frost-free period averages 95 days. The mean annual precipitation is 350 to 450 mm, with the May to September precipitation averaging 300 mm. Within the Central Parkland Subregion, the vegetation changes from grassland with groves of aspen in the south to aspen parkland to closed aspen forest in the north. The two major forest types in the subregion are trembling aspen and balsam poplar on moister sites in depressions and in the northern part of the subregion. Both are characterized by a dense, lush, species-rich understory. The grassland vegetation of the 'parks' is the same as that of the Northern Fescue Subregion described below.

In Alberta, the Central Parkland Subregion is one of the most productive waterfowl areas; however, only about 2% of this landscape is formally protected in parks or other conservation areas. The area's deep, rich soils and reliable moisture have largely been converted to productive farmland. It is now the most heavily impacted and fragmented ecoregion in Alberta, with only 5 - 8% remaining in its natural state (Nature Conservancy of Canada 2004).

### 3.2.5 Grassland Natural Region

The Grassland Natural Region is a flat to gently rolling plain with a few major hill systems. Most of the bedrock is covered with extensive, thick glacial till deposits. The Grassland Natural Region contains four subregions: Dry Mixedgrass, Mixedgrass, Northern Fescue, and Foothills Fescue, separated primarily on the basis of climatic, soils and vegetation. Only the Northern Fescue and Foothills Fescue subregions occur in the North Saskatchewan Watershed.

#### 3.2.5.1 Northern Fescue Subregion

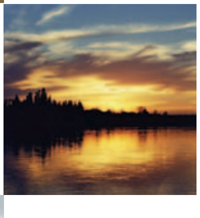
The Northern Fescue Subregion is characterized by gently rolling terrain, commonly low-relief ground moraine and hummocky moraine. The mean May to September temperature is 14°C and the frost-free period is about 90 days. Mean annual precipitation is approximately 400 mm, with mean May to September precipitation of approximately 280 mm. The vegetation is dominated by rough fescue.

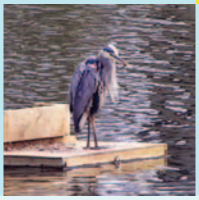
#### 3.2.5.2 Foothills Fescue Subregion

The Foothills Fescue Subregion occurs largely on the outwash deposits of the foothills. Elevations are higher in this subregion than in the Northern Fescue Subregion. The climate differs from the Northern Fescue Subregion in having a greater frequency of Chinooks and thus, a milder winter climate. There also is more snowfall in later winter and early spring with the majority of precipitation falling during the growing season. The mean annual precipitation is approximately 500 mm with 290 mm falling between May to September. The mean May to September temperature is 11 to 13°C and the mean annual temperature is 3°C. The average frost-free period is 90 days. Grasslands are dominated by rough fescue, Idaho fescue, and oat grass.



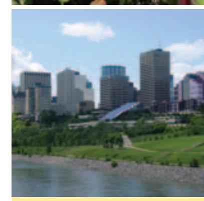


# Chapter 4.0
# Methodology



## 4.0 METHODOLOGY

### 4.1 INDICATORS BACKGROUND

Indicators and their metrics have become a useful regulatory tool and there is considerable information on the use of indicators. Indicators can be region-specific, system-specific or seasonal. For example, stream metrics are useful indicators for flowing water but not for detection of habitat changes in wetlands. The large geographical scale of this project also presents a challenge. Indicators must be useful throughout the watershed, or have a significant relevance to a portion of the watershed (e.g. *E. coli* in areas of higher human or livestock populations). Where possible, measures had to apply to the sub-watershed level to assist in future management decisions, which will be made at the local level.

The selection of indicators is not an exact science. There are several indicators and metrics that can be used for any given analysis. Our selection of indicators is based on an expectation that they will be useful in the next stage of the project – an integrated watershed management plan and because they are expected to indicate potential management issues that should be addressed in the integrated watershed management plan. For example, water quality and riparian health are measures that can be affected by land use changes or changes in land management practices.

### 4.2 INDICATOR DEVELOPMENT

NSWA's partner experts from government, industry, and non-government organizations met in Edmonton in May 2002 to determine a suite of indicators for use in the current state of the watershed report. The one-day workshop resulted in a master list of many indicators and several metrics for each indicator. As well, data sources for both the indicators and the metrics were identified for further information gathering purposes. As the master list of indicators was compiled, it became obvious that the selected indicators fell into one of four broad categories — land use, water quality, water quantity, or biological indicators.



### 4.3 METRICS

The challenge of choosing metrics for use on a watershed scale is in selecting a parameter that is applicable or that appears throughout the watershed. For example, the headwaters of the North Saskatchewan River are found in the Montane Natural Region in Banff National Park, and the river flows over several ecotypes before its departure into Saskatchewan in the Dry Mixedwood Natural Region. Ideally, the selected indicator would occur in all regions from the headwaters downstream. The 15 indicators in Table 1 and their respective metrics were chosen, based on the recommendations by the workshop group.

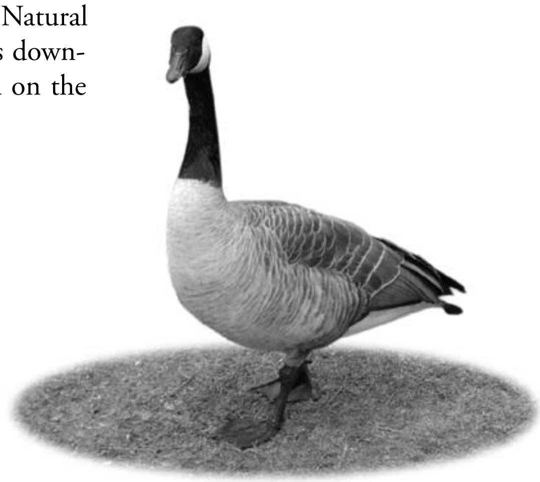






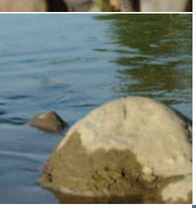
**Table 1 :** Metrics Chosen for Report.

| Indicator Category | Metric |
|---|---|
| Land Use | Riparian health |
| | Linear development (roads, seismic, pipelines, etc.) |
| | Land use inventory |
| | Livestock density |
| | Wetland inventory |
| Water Quality | Surface water quality index (AENV model) |
| | *E. coli* |
| | Phosphorus (TP, SRP) |
| | Pesticides |
| Biological Indicator | Aquatic macrophytes |
| | Fish (population estimates) |
| | Vegetation types (Alberta Vegetation Inventory) |
| | Benthic invertebrates |

Several other key pieces of data are included in this report in addition to the selected indicators. These data provided background and contextual information that augment the other measures. They are:

- stream flows and discharges
- surface water and groundwater use
- effluent point sources and inputs
- population distribution
- land classification
- protected areas
- fertilizer and pesticide sales
- description of biota



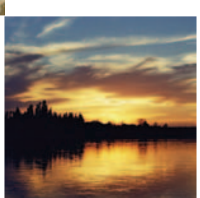


With the above as a guide, the data were collected based on the indicators and metrics listed above.

## 4.4 INDICATOR DETAILS

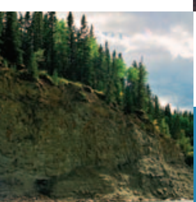
### 4.4.1 Land Use Metrics

Changes in land use patterns reflect major development trends such as forested lands converted to agriculture and agricultural lands developed and lost to urban development. Land use changes and the subsequent changes in land use practices will impact both the quantity and quality of waters in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 4.4.1.1 Riparian Health Inventory

Riparian areas are the important transition zone between uplands and surface water bodies. These areas perform several critical watershed functions and benefits such as trapping sediments and







filtering nutrients and pollutants, providing fish and wildlife habitat, aiding in erosion control, forage and hay production, improving water quality, and storage and slow release of water. Riparian areas in Alberta only make up 4% of the province's total area, but approximately 80% of fish and wildlife species depend on riparian areas for reproduction, food and cover (ARHMP Cows and Fish 1999). One of the best examples of comprehensive riparian work in the North Saskatchewan Watershed is the Vincent Lake Working Model. The Vincent Lake Working Model is a story of riparian health education, awareness and action. The details of the work completed by this group can be found in the Frog Subwatershed overview and online at www.healthyshorelines.com

A riparian health index has been developed by the Alberta-based Cows and Fish Program (www.cowsandfish.org) to examine vegetation, soil parameters, and hydrology of an area to reflect the adequacy of land use practices (Table 2). The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. The Cows and Fish inventory is based on an American model. It can be used by riparian resource management professionals to capture benchmark data, examine details of the plant community and structure, and for monitoring purposes. It is an important tool for examining the health of riparian areas, collecting baseline information, and for evaluating the impact of management changes over time.

Riparian health assessments are a rapid survey of an area and a quick calculation of relative health that compares a site's current condition to its potential. Health assessments can be undertaken for streams and small rivers, large rivers and lakes, and wetlands. While the inventory does not address water quality specifically, sites that are significantly disturbed will have a higher probability of impacting the surrounding waterbody. The inventory arrives at an overall health category for a riparian area which is identified by a health score. The ratings are:



**Table 2:** Cows and Fish riparian health score categories and score ranges.

| Health Category | Score Ranges | Description |
|---|---|---|
| Healthy | 80-100% | Little to no impairment to riparian functions |
| Healthy, but with problems | 60-79% | Some impairment to riparian functions due to management or natural causes |
| Unhealthy | <60% | Severe impairment to riparian functions due to management or natural causes |

Cows and Fish have completed riparian health assessments on 1,085 sites in Alberta including sites in the North Saskatchewan River watershed. Of all the riparian areas assessed in Alberta, 18% were considered "healthy," 52% were considered "healthy but at risk," and 30% were considered "unhealthy." Cows and Fish conduct riparian health assessments at the request of a community, watershed organization or individual and these sites are not randomly chosen. In the North Saskatchewan Watershed, assessments have been made across a diversity of sites, in terms of both health and system type. Sites were selected based on a combination of representative sampling (air photo stratification of habitat types) and interest-based sampling (landowners who request an inventory on their land). Some assessments may skew their representation from interest-based sampling, but in general the work in the North Saskatchewan Watershed has been a fairly even between the 2 sampling methods.

**4.4.1.2 Linear Development**

Recently, landscape ecologists have been studying the impacts from linear developments such as seismic activity, and





oil and forestry roads. For example, similar amounts of timber are removed in Alberta from seismic operations as is removed by the entire forest industry (Schneider 2002). From 1979 to 1995 an average of 57,750 km/year of seismic lines were approved in the Green Zone of Alberta (Alberta Centre for Boreal Studies 2001). As of 1999, the total length of seismic lines cut in the Green Zone was 1.5 million km (Alberta Environmental Protection 1998). However, unlike the forest industry, seismic operators are not required to reforest the lines that they cut and regeneration is slow (MacFarlane 1999, Revel et al. 1984). Because of inadequate regeneration, seismic activities result in a progressive loss of mature forest and alteration of forest structure. In subwatersheds with high rates of seismic activity, the cumulative loss of habitat may be substantial (Schneider 2002).

Quantifying linear development will help us understand potential changes in water quality and fish and wildlife populations that might result from resource extraction practices. For example, wildlife corridors can be altered by roads and watersheds can have their drainage patterns and water quality altered by increases in compacted surfaces.

#### 4.4.1.3 Land Use Inventory

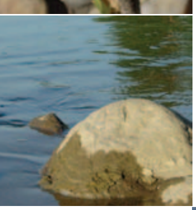
A land use inventory quantifies natural landscape types, natural processes and land use practices. Quantification of land use types will allow us to calculate development in the watershed (timber extraction, oil lease lands, and natural disturbances such as forest fires). In addition, areas of undisturbed lands are quantified (such as wetland, river, lake and park areas). The land use inventory may be linked to land use changes and used to explore changes in water quality and quantity, fish and wildlife populations and riparian health.

#### 4.4.1.4 Livestock Density / Manure Surrogate



A subcomponent of the agricultural sector's dynamics is the category of livestock density, which is typically expressed as the number of head of livestock per unit area. Areas of higher livestock density within a subwatershed can have greater impacts on downstream aquatic systems. Results from a recent study by Alberta Environment show that streams that drain land farmed with high intensity have higher nutrient concentrations, dissolved nutrients, mass loads, fecal bacteria and total dissolved phosphorus than streams that drain land farmed at medium or low intensity (Anderson et al. 1998). Alberta Agriculture, Food and Rural Development studies have shown that surface water in watersheds with high agricultural activities are more susceptible to enrichment from phosphorus and contamination from pesticides and fecal coliforms (CAESA 1998).

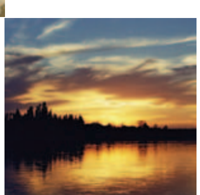
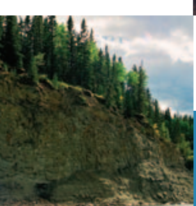




Manure production on Provincial soil polygons (in tonnes) is used as a surrogate for livestock density (Figure 4). Manure production information was available from Statistics Canada's 1996 Census of Agriculture. The data were broken down for Alberta on the basis of existing Alberta soil polygons by PFRA (Hiley and Lindwall 1998). A limitation of this data is that the polygons used do not correspond exactly to sub-watershed boundaries and therefore provide only a rough estimate of manure production within the actual sub-watershed. Manure production within these soil polygons is presented in tonnes per soil polygon.

#### 4.4.1.5 Wetland Inventory

A subcomponent of the land use inventory is an inventory of wetlands. Wetlands serve many functions in the natural landscape including water storage, flood attenuation, evaporation, wildlife habitat, groundwater recharge and general water quality improvement. The loss of wetlands and their function to agriculture and other development can have significant negative impacts on water quantity and quality. Several wetland inventory datasets exist and we present wetland GIS inventory data from Agriculture and Agri-Food Canada (PFRA), Alberta Sustainable Resource Development's hydrological features and inventory data from Ducks Unlimited Canada.

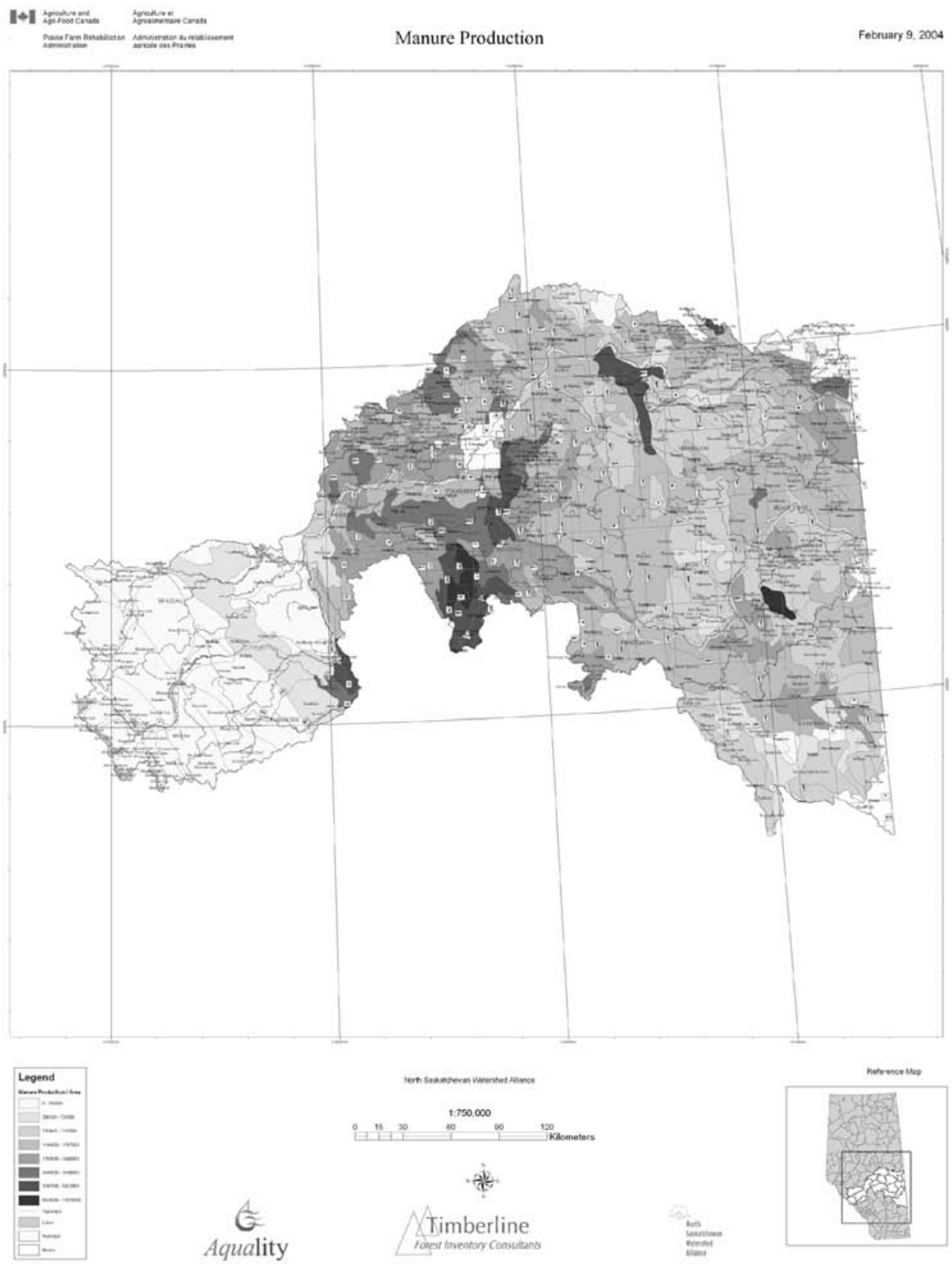



**Figure 4:** Manure production in the North Saskatchewan Watershed by soil polygon data.



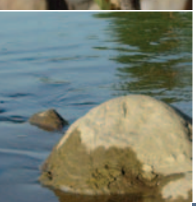
### 4.4.2 Water Quality Metrics

Water quality changes over time can indicate a change in the state of the watershed. Changes in water quality may be brought about by changes in land use or land management practices, landscape disturbance, and natural events. The following activities can significantly impact water quality: logging, mining, wetland drainage, dredging, dam construction, agricultural runoff, industrial and municipal effluents, land erosion, road construction and land development. Many other human activities and natural processes can impact surface and groundwater quality.

The North Saskatchewan River is monitored in Alberta at several sites. Whirlpool Point, the headwater site in Banff National Park, is monitored by Parks Canada and Environment Canada and a long-term dataset exists for this station (1972-present). Two other Environment Canada sites exist at Lea (Jubilee) Park (in Marsburg) and where the river crosses Highway 17, near the Alberta-Saskatchewan border. As the river flows through the City of Edmonton, water is treated and distributed by EPCOR Water Services to Edmonton and surrounding communities and wastewater is treated at City of Edmonton and Capital Region's treatment plants, and returned back the river. Stormwater from the City is also released back to the river, either directly or following treatment processes.

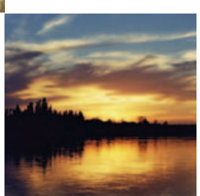
The North Saskatchewan River water quality is most intensely monitored around the City of Edmonton. The City of Edmonton, Alberta Environment, EPCOR Water Services and the Capital Region have an extensive Environmental Monitoring Program. This program was originally developed because the river is now used largely as the drinking water source and the wastewater recipient for the City of Edmonton and the greater Capital Region. Alberta Environment undertakes comprehensive water quality monitoring in the North Saskatchewan River at Long Term River Network (LTRN) stations at Devon and Pakan.



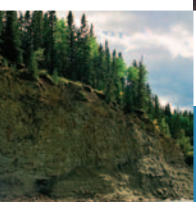


Several other agencies collect water quality data within the North Saskatchewan Watershed. These include Alberta Agriculture, Food and Rural Development under the Alberta Environmentally Sustainable Agriculture (AESA) program, Agriculture and Agri-Food Canada —Prairie Farm Rehabilitation Administration (PFRA), Riverwatch and the Alberta Lake Management Society (ALMS) under its Lakewatch program.

While AESA and PFRA water quality monitoring programs focus mainly on agricultural watersheds in Alberta, data will be presented where available within the North Saskatchewan Watershed. ALMS collects, analyzes and publishes its lake water quality data gathered under the Lakewatch program for several lakes in the watershed (www.alms.ca). Lakes with data available will be identified throughout this report. Although it was published in 1990, the Atlas of Alberta Lakes (Mitchell and Prepas 1990) contains information on 20 lakes within the North Saskatchewan Watershed and may be consulted for detailed background information and historic water quality data. Riverwatch monitors river water quality at three sites within the North Saskatchewan Watershed (www.riverwatch.ab.ca). These three sites include four stations along the river near the Town of Drayton Valley, and sixteen stations within the City of Edmonton. Finally, other water quality and quantity data collected by industry, volunteer watershed groups or consultants has not been considered in this report, but may be available and relevant to watershed groups.

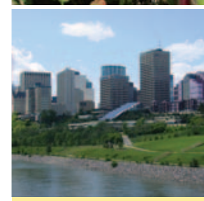


Little data exists on groundwater sources and quality. However, Alberta Environment, Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada, the Alberta Geological Survey or your local municipality should be contacted for any information on groundwater aquifers within the North Saskatchewan Watershed.



A full listing of watershed groups active in the North Saskatchewan Watershed and throughout



Alberta appears on . Where these volunteer watershed groups exist within a sub-watershed, they are identified. The following are water quality metrics that were chosen for this Report.

#### 4.4.2.1 Alberta Surface Water Quality Index

The Alberta Surface Water Quality Index (Alberta Environmental Protection 1996) was developed to mathematically combine a number of variables into one easily understood rating system. The Index summarizes chemical, biological, and physical data into a simple composite descriptor of water quality. Results can be used to compare water quality conditions at multiple locations and over time at a particular location. The Index is not meant to replace the conventional scientific process of analyzing and interpreting water quality data, but does provide a simple "snap-shot" of yearly water quality conditions in various areas of the province.

The formula used for the Alberta Surface Water Quality Index was developed in parallel with the Federal CCME Water Quality Index (CCME 2001) and the mathematics behind both are identical. The index incorporates three factors representing key aspects of water quality: the number of variables not meeting objectives (scope); the number of times objectives are not met (frequency); and the amount by which objectives are not met (amplitude). The overall index value is based on the mean of four sub-indices that are calculated for metals, nutrients, bacteria, and pesticides or other combinations of water quality parameters that are ranked 'Excellent', 'Good', 'Marginal', 'Fair', or 'Poor'.

The overall Alberta Surface Water Quality Index is based on the average of four sub-indices that are calculated for metals (up to 22 variables), nutrients (6 variables, including oxygen and pH), bacteria (2 variables), and pesticides (up to 17 variables). The objectives for the variables in the first three groups are drawn from guidelines listed in Surface Water Guidelines for Use in Alberta (Alberta Environment 1999). Variables in the fourth group (pesticides) are evaluated based on whether or not they can be detected in a water sample. The conservative approach for pesticides was adopted because some do not yet have official guidelines and, unlike metals, nutrients, and bacteria, pesticides do not occur naturally in the environment. This approach is valuable in assessing cumulative impacts of most land-use disturbances, and point and non-point source pollution throughout Alberta. Pollutants specific to a particular industry (i.e. arsenic and mining) can be included in the index to address the impacts of a specific industrial impact.



While Alberta Environment monitors surface water quality at many river and lake locations, only data collected as part of the province's Long-term River Network (LTRN) are used for the Index. The Index values are calculated annually for each site based on monthly data collected between April of one year and March of the next. Many Index sites are selected to represent conditions upstream and downstream of major urban areas or other development. This is the case for the LTRN sites within the North Saskatchewan Watershed, with a site upstream of Edmonton at Devon, and a site downstream of Edmonton at Pakan.

The Alberta Surface Water Quality Index is included as a provincial performance indicator in the Alberta Government's Annual Report, "Measuring Up," published by the Ministry of Finance each June. The Index also appears in the Ministry of Environment's "Annual Report" and "Business Plan". Alberta Environment uses the Index to evaluate the goal of bringing water quality downstream of developed areas in line with upstream conditions, while maintaining or improving water quality at all sites over the long-term.



### 4.4.2.2 Escherichia coli *(E. coli)*

Escherichia coli is one of three bacteria commonly used to measure direct contamination of water by human or other mammalian wastes. These are a group of bacteria associated with the feces of warm-blooded animals. Waters that are polluted may contain several different disease-causing organisms, commonly called pathogens. Enteric pathogens, those that live in the human intestine, can carry or cause a number of infectious diseases. Contact or consumption by humans and other animals may result in gastroenteritis. Environmental quality guidelines exist for *E. coli* in drinking, agricultural and recreation water and for aesthetic purposes. Due to the short survival time of these organisms outside of an animal's body, the impacts of these pathogens can be short-lived or episodic following larger precipitation events.

### 4.4.2.3 Phosphorus Concentrations (Total and Soluble Reactive)

Phosphorus is a nutrient required for the growth and development of animals and plants. In aquatic systems, phosphorus typically is the limiting nutrient and, when added to aquatic systems, enriches productivity. Other changes, including increased macrophyte (large aquatic vegetation) growth, algal blooms, decreasing water clarity and fish kills, may result from excessive phosphorus inputs to aquatic systems. Environmental quality guidelines exist for phosphorus to protect water quality for aquatic life, recreation and livestock watering (CCME 1999). Phosphorus is an accepted nutrient surrogate and can be measured by Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP); an estimate of phosphate. Changes in phosphorus concentrations in aquatic systems can be linked to changes in land use, land use activities and management practices. Phosphorus concentrations are directly comparable between similar systems (i.e. lakes or rivers) and both snapshot and trend information are valuable.

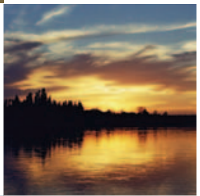


### 4.4.2.4 Pesticides

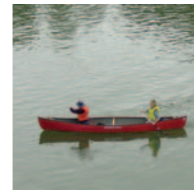
Peticides are a group of chemicals including herbicides, insecticides, rodenticides and fungicides. They are used for many purposes including pest control and aesthetics in urban areas, golf courses, and in forestry and agricultural production. Pesticides are a common contaminant of streams and dugouts in high intensity agricultural areas of Alberta (CAESA 1998). Herbicides were detected in 54 of 112 dugouts sampled in 1994 and 10 of 14 dugouts sampled in 1996 in Alberta (CAESA 1998). Pesticides can be linked to land use, land use activities and management practices.

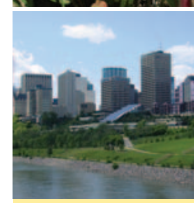
Herbicide, insecticide and fungicide production on Provincial soil polygons (in tonnes) were used as a surrogate for pesticide application (Figures 5a, 5b and 5c). Herbicide, insecticide and fungicide production information was available from Statistics Canada's 1996 Census of Agriculture. Like the manure data, these data were broken down for Alberta on the basis of existing Alberta soil polygons by PFRA (Hiley and Lindwall 1998). A limitation of this data is that the polygons used do not correspond exactly to sub-watershed boundaries and therefore provide only a rough estimate of manure production within the actual sub-watershed. Pesticide production within these soil polygons is presented in tonnes per soil polygon.

### 4.4.3 Water Quantity Metrics



Water quantity is important to maintain riparian health. Healthy riparian areas provide high quality aquatic habitat, have functions that are related to water quality, are essential for the treatment and production of drinking water, and are essential for the treatment of discharged wastewater (i.e. assimilation capacity). Irrigation, industry, recreation and livestock production all depend on a minimum amount of water. The minimum flow requirements of all users (including the needs of



the aquatic organisms) are expressed by studies on Instram Flow Needs (IFN), a new approach in aquatic science that is now being developed in Alberta. Water quantity is necessary for many recreational activities, and the public is quick to respond in the absence of expected quantities of water in the environment and for their personal use.

HYDEX is an inventory database of Environment Canada's streamflow, water level, and sediment stations (both active and discontinued) throughout Canada. The database contains station information including location, equipment, and type of data collected.  is Environment Canada's database of computed data for HYDEX stations and includes data on daily and monthly means of flow, water levels and sediment concentrations (for sediment sites). For some sites, peaks and extremes also are recorded. The data are collected by regional offices **and** updated once each year. This update generally occurs in mid-summer for the previous year (e.g. summer 2004 for 2003 data). Each year, a new HYDAT  is produced that updates the previous CD-ROM. Data from many stations is also available on Alberta Environment's website (http://www3.gov.ab.ca/env/water/GWSW/quantity/).

The North Saskatchewan River has been monitored at 128 flow gauging stations on the river, some since 1908 (Figure 6). Of the sixty-six currently active stations, 23 have real-time data available on the Environment Canada website (Environment Canada 2004a). HYDAT 2001 is the latest Water Survey of Canada flow dataset.  This can be downloaded from the Environment Canada website (Environment Canada 2004b). Available HYDEX stations and HYDAT data will be identified for each sub-watershed in this report.
The following are water quantity metrics that were chosen for this Report.





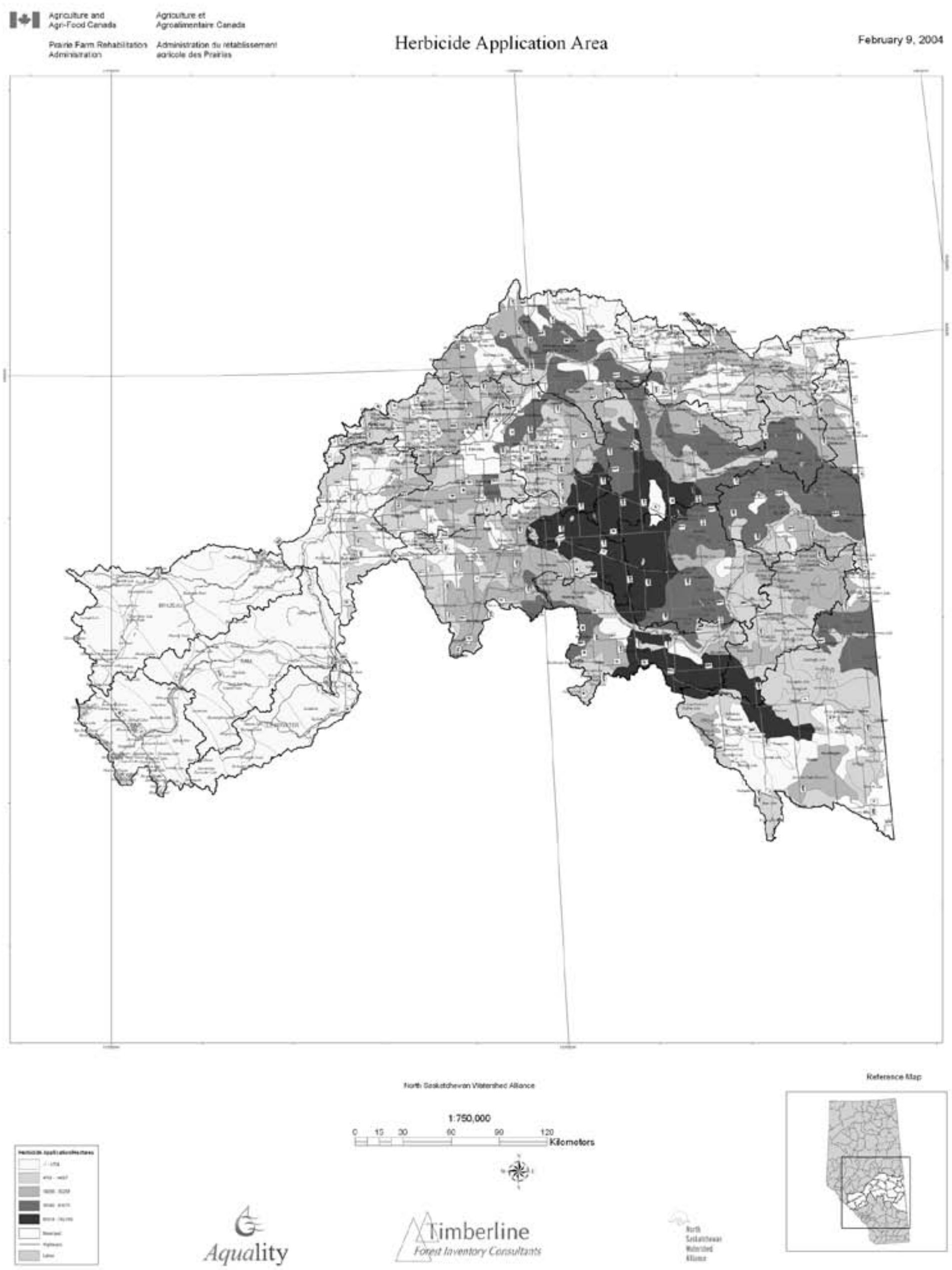




**Figure 5a:** Herbicide production in the North Saskatchewan Watershed by soil polygon data.

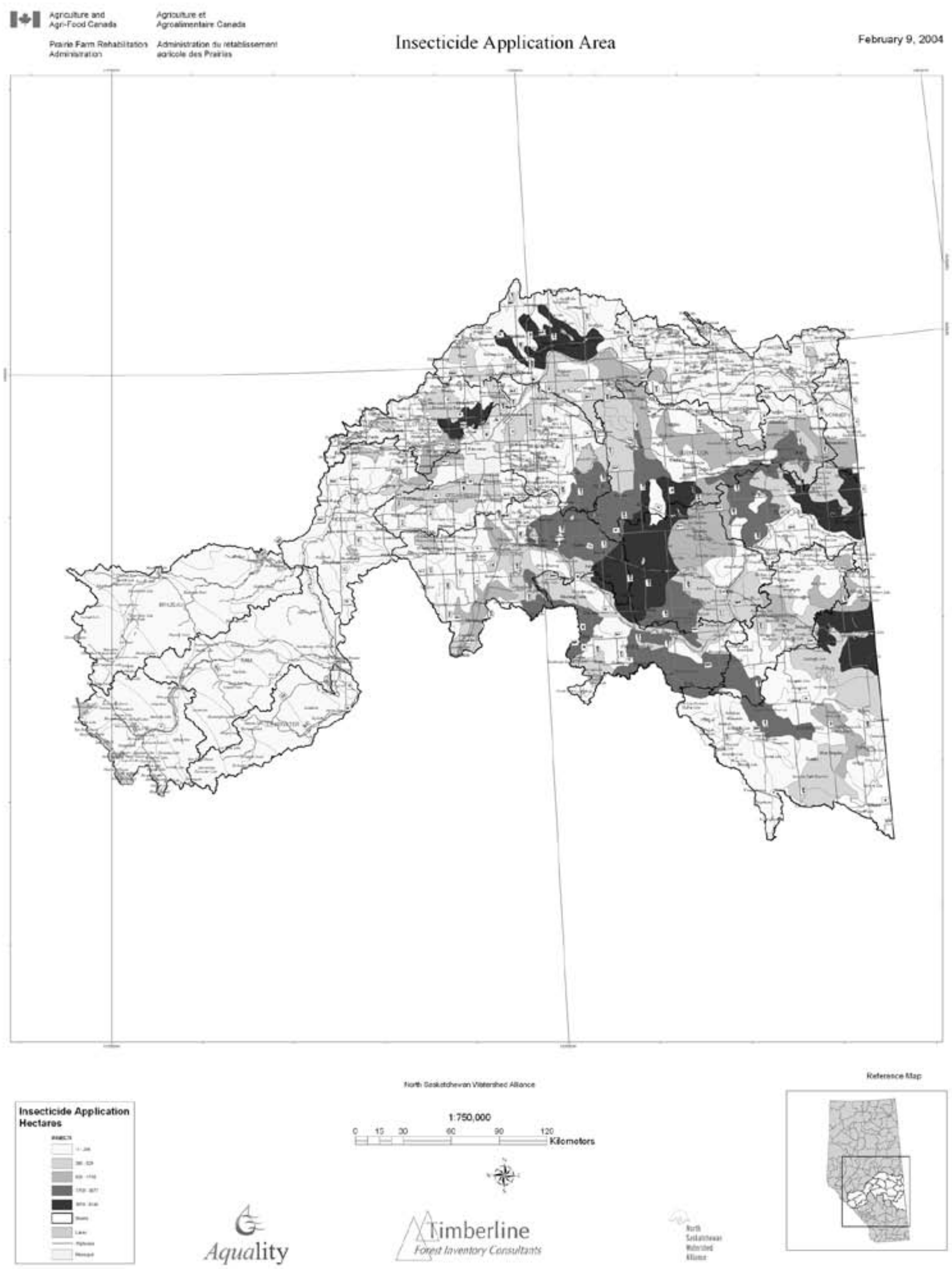



**Figure 5b:** Insecticide production in the North Saskatchewan Watershed by soil polygon data.

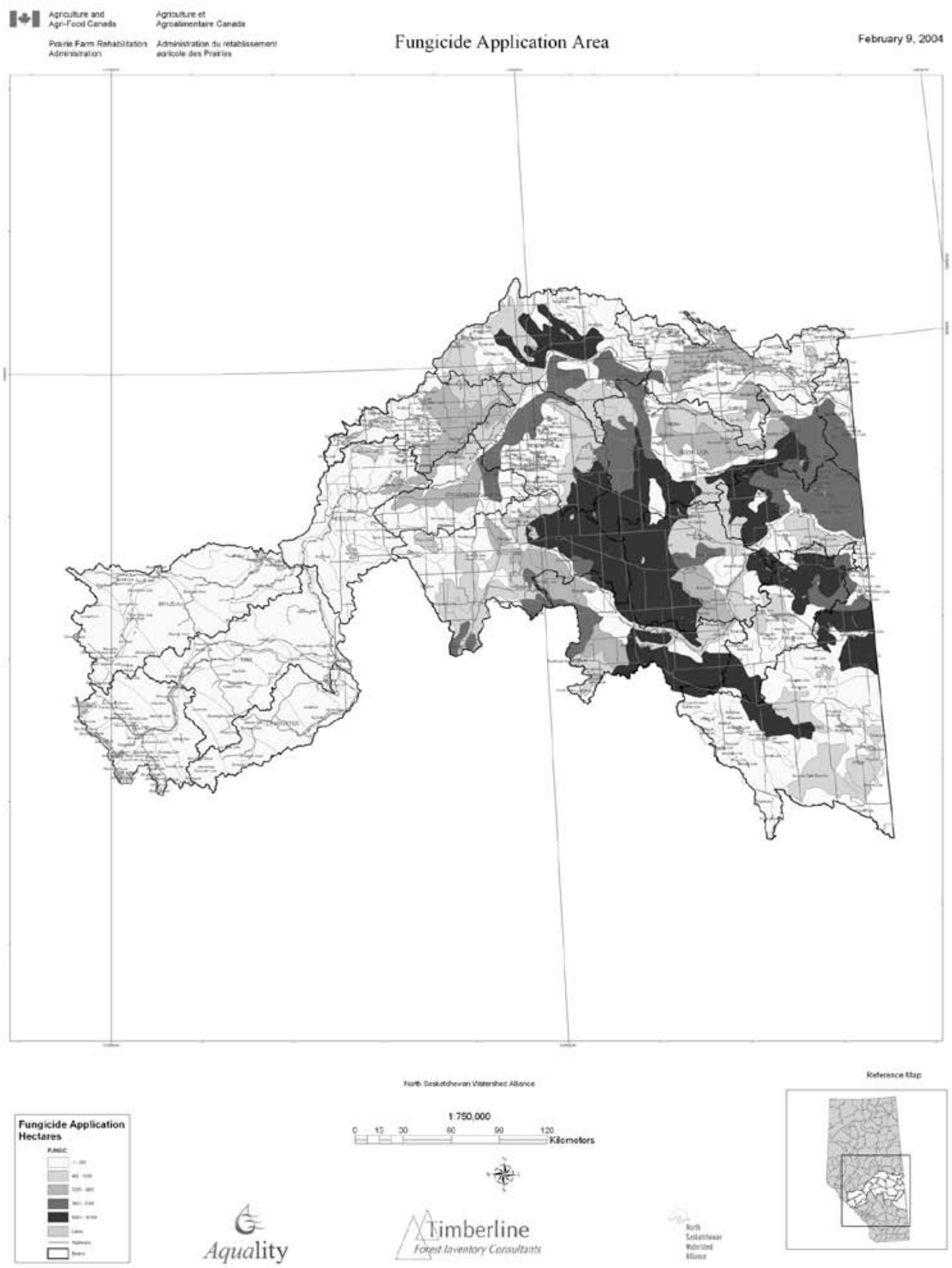
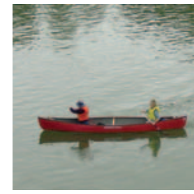
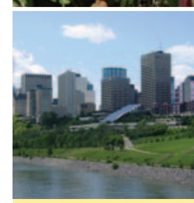



**Figure 5c:** Fungicide production in the North Saskatchewan Watershed by soil polygon data.

**Figure 6:** North Saskatchewan Watershed hydrometric (water flow gauging) stations. *Please see pocket or the pdf file on the CD ROM for map.*



### 4.4.3.1 Water Allocations by Sector

Surface water withdrawal permits for the watershed are identified by user sector (agriculture, municipal, industrial) along with information on licenses for the top ten users of surface water. This information is used along with water flow data to show areas of potential future constraints on surface water availability, which can have implications on development.

### 4.4.3.2 Groundwater Extraction

Groundwater withdrawal permits for the watershed are identified by user sector (agriculture, municipal, industrial) along with information on licenses for the top ten users of groundwater. This information may be used along with groundwater flow data to show areas of potential future constraints on groundwater availability, which could have implications for development.

### 4.4.4 Biological Indicator Metrics

Biological Indicators are biological (plant and animal) data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of these organisms can be linked to water quality, quantity and ultimately to watershed health.

### 4.4.4.1 Aquatic Macrophytes

Aquatic macrophytes are large aquatic plants, which can be rooted, submersed, emergent or sessile. Their growth is directly related to the availability of phosphorus in aquatic systems. Excessive macrophyte growth or changes in species abundance and distribution may indicate decreased water quality, may have detrimental impacts on other aquatic organisms, and alter habitats and flow rates. Excessive growth may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



### 4.4.4.2 Fish (Population Estimates)

Inventories of selected fish populations may show increases or decreases through introductions or changes in environmental conditions. The presence and abundance of fish species may also be related to changes enviromental factors such as water quality or quantity. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show similar with their presence.

### 4.4.4.3 Vegetation Types

Inventories of flora 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.

### 4.4.4.4 Benthic Invertebrates

Benthic or bottom dwelling invertebrates can be sensitive to environmental changes, and are an important food source for higher trophic levels. Several invertebrate species such as mayflies and caddisflies are excellent indi-



cators of aquatic health. Alberta Environment has developed a "key" to the identification of the most common taxa of freshwater invertebrates occurring in the major rivers of Alberta. The key was prepared to accompany project materials on the biological monitoring of water quality (Anderson et al. 1983)

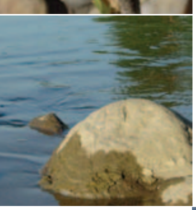
### 4.5 ASSESSING WATERSHED HEALTH

What constitutes a healthy watershed is a fundamental question that can be difficult to answer. A healthy watershed performs a number of functions that keep the ecosystem in balance, and when these functions are compromised, watershed health can be negatively affected. Resource and other types of human-influenced development need to be undertaken in ways that protect the ecological integrity of a watershed. If not, the functions we require of watersheds – primarily producing a safe and abundant water supply – become jeopardized. Watershed health will ultimately be determined by the users of watershed resources. While measuring "watershed health" is difficult, we can choose parameters as indicators that can represent elements of watershed health, such as water quality measures of nutrient concentrations. In this example, water quality is the indicator, and nutrient concentration is a specific measurement or "metric" of the water quality indicator.

Environmental indicators are general measures of environmental quality that can be used to show trends of environmental conditions. Their purpose is much like a performance measure, to show how well a system is functioning over time.

To be effective, and indicator must be:

- Relevant - able to show you something about the system that you need to know
- Straightforward
- Easy to understand
- Reliable - the information the indicator provides is trustworthy
- Timely - the information is available while there is still time to act

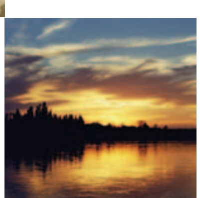


In addition, a good environmental indicator can simplify large amounts of complex information into a concise, easily understood format such as the Alberta Surface Water Quality Index (Alberta Environmental Protection 1996).

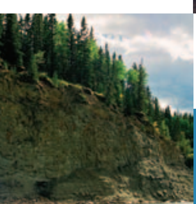
In order to report on watershed health, each indicator was examined individually, and determined if it was high or low, based on its occurrence across all 18 subwatersheds. The range of each metric (or measure of the indicator) was plotted and subjectively broken into a high, medium and low value for each. Where they exist, values from the scientific literature were used to assess their ability to impact the landscape, and thus watershed health. For example, the literature suggests that linear disturbance greater that 3% can significantly impact water quality. Based on the above assessment methods, the following rankings were used:

- Linear disturbance below 2% was considered good, between 2 and 3 percent was fair and above 3% was poor.

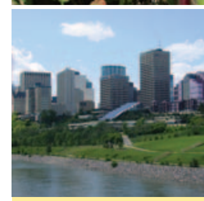
- Total phosphorus less than 100 ug/L was good, between 100 ug/L and 199 ug/L was fair and 200 ug/L was deemed poor.



- Livestock density that was low was deemed good, medium low and medium was deemed fair medium high and high was deemed poor.
- Land use disturbances of less than 50% disturbed lands were deemed good, between 50% and 89% fair, and greater than 90% poor.





- Riparian health rankings were already provided by Cows & Fish. The highest percentage ranking was used to rank the subwatershed. For example, in the Frog subwatershed there were more healthy riparian areas (46%) than any other ranking, therefore the watershed was deemed to have 'healthy' riparian areas.

- E. coli counts between 0 and 50 were deemed good, counts between 51 and 100 were deemed fair, and counts greater than 100 were deemed poor.

- Wetland coverage of greater than 10% in a subwatershed were deemed good, between 5% and 9% fair, and below 5% were deemed poor.

- Alberta Surface Water Quality Index ratings of good were deemed good, fair and marginal were fair, and poor were deemed poor.

- No systematic studies of aquatic macrophytes were done in any watershed. However, if studies found aquatic macrophytes, the overall health in the watershed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.

- No systematic studies of benthic invertebrates were done in any reach of the watershed. However, if studies found benthic invertebrates, the overall health in the wateshed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.

- No systematic studies of fish populations were done in any reach of the watershed. However, if studies found fish populations existed, the overall health in the wateshed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.



## 4.6 DATA COLLECTION

Digital data were assembled from a variety of freely-available sources such as agency internet websites, and where possible, through data-sharing agreements with NSWA partners. The focus for data collection was the indicators selected by the expert panel that represented water quality, water quantity, land use and biological indicators. Data-sharing agreements were established with Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada–PFRA and Ducks Unlimited Canada. Other sources of data are referred to throughout this report.

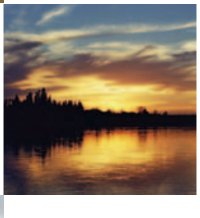
Digital datasets compiled for this project include:

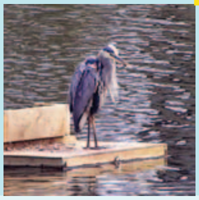
- Alberta Agriculture, Food and Rural Development Soils Data (AgraSid 3.0)
- ASRD Native Vegetation Project
- ASRD Base Features Data (Land Use, Water Hydrology, Parks and Protected Areas)
- PFRA Landcover Polygons, Generalized Landcover and Hydrology Layers (including wetlands)
- Natural Resources Canada Data (Hydro, Rail, Ecozones, Ecoatlas, Climate Changes, Soils Water, Radarsat, Soils, Water, Canada Land Inventory data)
- Ducks Unlimited Canada Wetland Habitat Inventory - Landsat Based Inventory (30m)
- Statistics Canada 2001 Census of Agriculture (Manure Production, Cropland, Summer Fallow and Unimproved/Improved Pasture Data). This was the only dataset that had to be purchased by the NSWA.







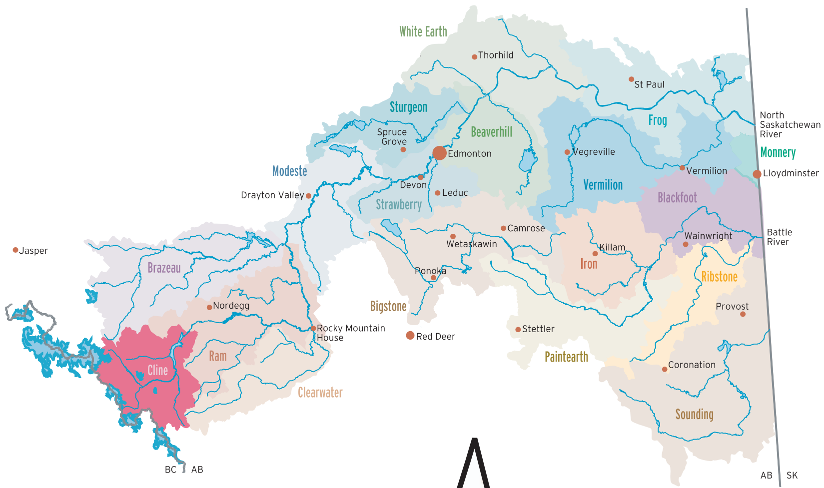



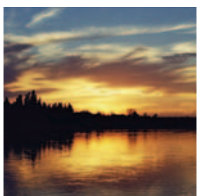



## Chapter 5.0

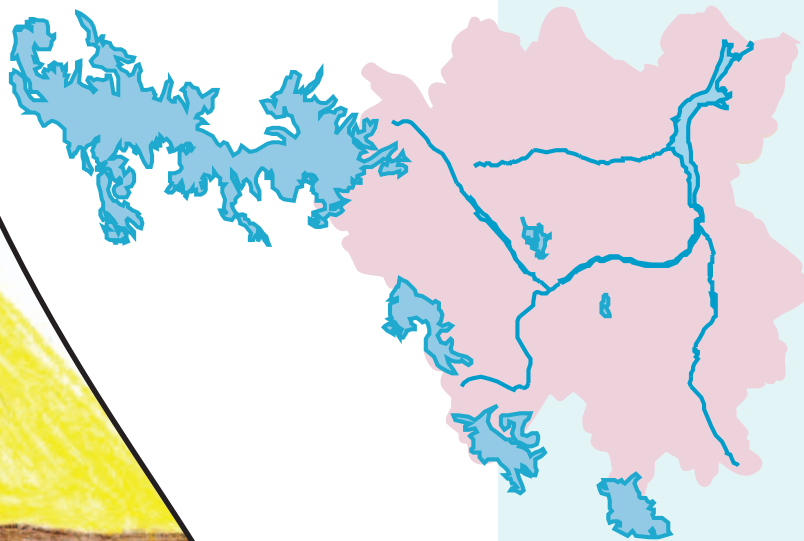
# State of the North Saskatchewan Subwatersheds

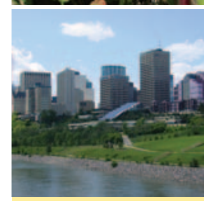
# Cline



Graham Ward
Age 10
Edmonton





## 5.0 STATE OF THE NORTH SASKATCHEWAN SUBWATERSHEDS

## 5.1 CLINE SUBWATERSHED

The eastern boundary of the Cline Subwatershed is the height of land that forms the Alberta/British Columbia border. This area is in the Rocky Mountain Natural Region and the climate is dry and windy, with moderate winter temperatures and increased winter precipitation. The Cline is in the municipal boundary of Clearwater County, and there are no towns in this Subwatershed. The Cline Subwatershed encompasses 378,629 hectares including 37,286 hectares of lakes and rivers and the Saskatchewan Glacier (in the Columbia Icefield) where the North Saskatchewan River originates.

The geology of the region is that of many rock glaciers and unvegetated bedrock. In higher elevations, the vegetation is sparse consisting of lichens on rocks and shallow soils. At lower elevations, the vegetation consists of lodgepole pine and Douglas fir forests and Engelmann spruce-fir forests.

There is a significant amount of recreational activity in the Subwatershed, particularly in the Abraham Lake area. Recreational activities include fishing, hiking, canoeing, skiing, rock climbing, and rafting.

Many of the indicators described below are referenced from the "Cline Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.1.1 Land Use

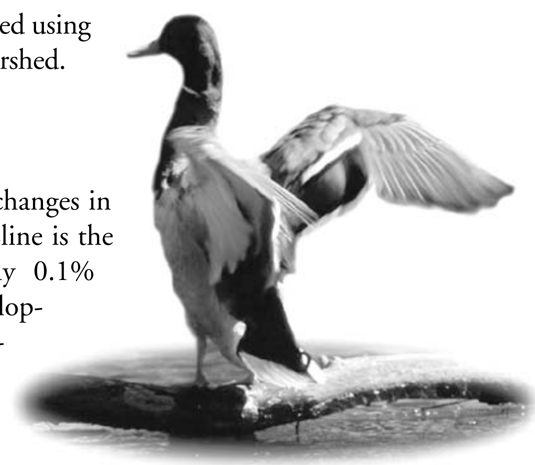
Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.1.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for any of the waterbodies in the Cline Subwatershed, so no conclusions can be drawn about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research in the Cline Subwatershed.

#### 5.1.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. The Cline is the least disturbed Subwatershed in the North Saskatchewan Watershed, with only 0.1% (365 ha) of the land area taken up by linear developments. The majority of these developments (63%) are roads of one form or another, mostly paved undivided roads and gravel roads. The remainder of the linear disturbance (37%) is cutlines and trails.



### 5.1.1.3 Land Use Inventory

An inventory of land use quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Forty-nine percent of the Subwatershed lies within Banff and Jasper National Parks and 22% in the Siffleur and White Goat wilderness areas. Provincial Forest Management Units comprise the remaining 29% of the Subwatershed. Most of the Subwatershed lies within protected areas. Within the above areas, icefields, lakes, wetlands and rivers cover 9.8% (37,286 ha) of the Subwatershed.

### 5.1.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production in the actual watershed. Based on the available information, livestock densities in the Cline Subwatershed are low. Manure production in the soil polygons that cover the Cline Subwatershed was estimated between 0 and 256,000 tonnes.

### 5.1.1.5 Wetland Inventory

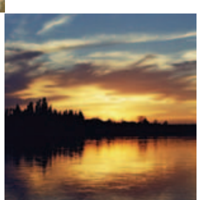
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Alberta Sustainable Resource Development base features hydrology data shows 122 hectares of wetlands in the Cline Subwatershed. Due to the low development in this Subwatershed, we can assume that most wetlands in this area are in a natural state, and highly functional.



### 5.1.2 Water Quality and Quantity

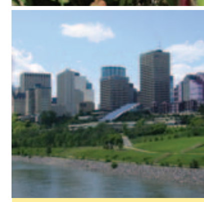
Water bodies in the Subwatershed include the North Saskatchewan River, Cline River, Siffleur River, McDonald Creek, Coral Creek, and Whiterabbit Creek. Some of the larger lakes and reservoirs in this Subwatershed include Abraham, Glacier, Peyto, Mistaya, Chephren and Pinto. The five largest icefields in the Subwatershed include the Columbia, Lyell, Freshfield, Mons and Wilson. The Columbia Icefield includes the Saskatchewan Glacier. The Bighorn hydroelectric dam operated by TransAlta Utilities Corporation creates Abraham Lake, which is the longest man-made lake in Alberta, and covers 35 $km^2$.

Water quality on the main stem of the North Saskatchewan River is monitored regularly by Parks Canada and Environment Canada at Whirlpool Point. One of the National Parks strategic goals is to provide an overview of status and trends in water quality in the three major watersheds originating in the mountains (North Saskatchewan, Athabasca and Bow Rivers). Monthly physical, nutrients, metals and flow data were obtained from 1970 to the present. CCME Water Quality Index (WQI) data are summarized by Environment Canada for 1983-2002 (Glozier *et al.* 2004).



For the 1983-2002 period, average river water quality at Whirlpool Point was found to be fair (calculated WQI = 64). A fair value (calculated WQI between 60 and 79) means that water quality is usually protected, but occasionally threatened or impaired by conditions that depart from natural or desirable levels. The five variables in non-compliance (in order of occurrence) were: total phosphorus, dissolved oxygen, fecal coliforms, dissolved arsenic, and total nitrogen. Similar headwater sites within the park boundaries on the Bow and Athabasca rivers both ranked much higher with a good rating (calculated WQI = 93).



The reason for Whirlpool Point's lower score relative to neighbouring Bow and Athabasca Rivers results from the parameters chosen to calculate the index. The high sediment load found in the North Saskatchewan River water contains particulate phosphorus from the natural weathering of phosphorus-rich bedrock. So, if a dissolved species of phosphorus (such as soluble reactive phosphorus, a measure of phosphate) had been used to calculate the Index, the Guideline would not have been exceeded and the Index score would have been higher (Nancy Glozier *pers. comm.*) Also exceeding the guidelines was dissolved oxygen concentrations, which average 8 mg/L in the river main stem. This is lower than the 9 mg/L set out in the published guidelines, and also reduce the WQI value. Naturally occurring fecal coliforms, arsenic and nitrogen which infrequently exceed the CCME's Guideline for the Protection of Aquatic Life are the other parameters which lower the WQI.

Water quantity on the main stem of the North Saskatchewan River is monitored regularly by Environment Canada at Whirlpool Point, a HYDEX station (05DA001). Water quantity is measured at nine other HYDEX stations (05DA002-05DA010), and one site has real-time online data (05DA009). Figure 7 shows the open water season hydrograph for the Mistaya River. This hydrograph is typical for a glacial meltwater dominated stream, with peak flows during the warm summer months, and little impact from spring runoff or summer storms. Flows in the Mistaya River are very predictable.



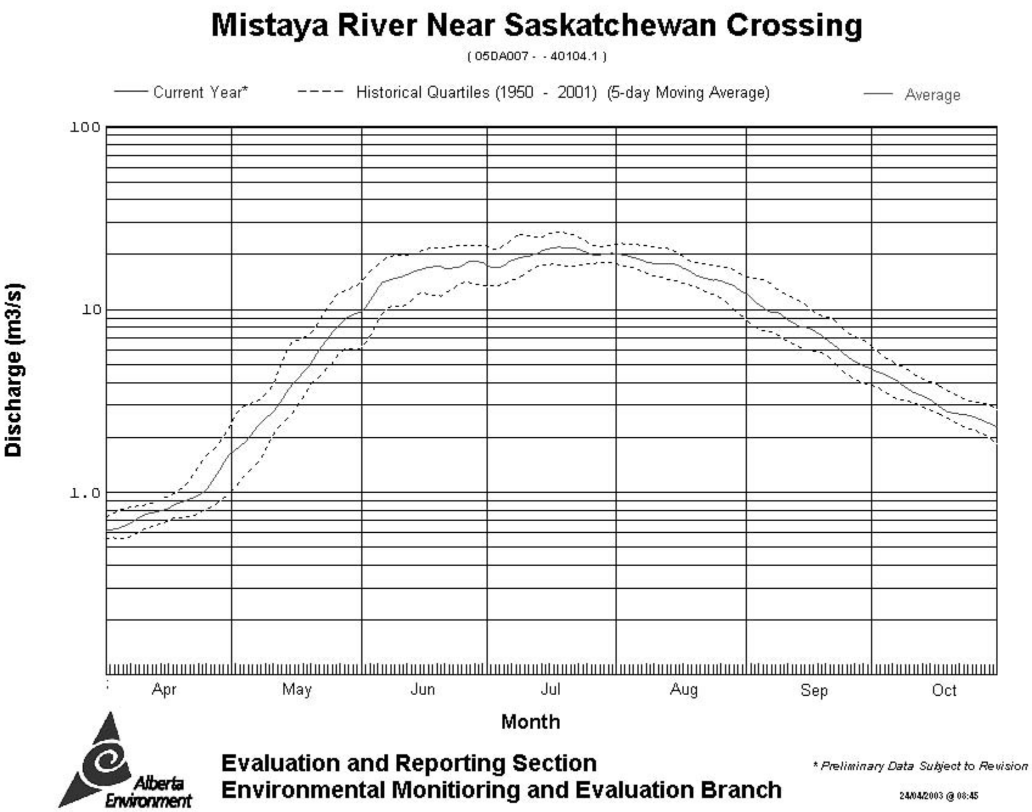
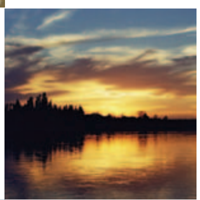



**Figure 7:** Mistaya River near Saskatchewan Crossing mean monthly discharge for the open water season (Station 05DA007).







### 5.1.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.1.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (e.g. wastewater outfalls) or non-point (e.g. general run-off) sources related to municipal development or land use practices. No published assessment of aquatic macrophytes was found for the Subwatershed, so we cannot make any conclusions about aquatic ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research in the Cline Subwatershed.

#### 5.1.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Fish species in this Subwatershed include cutthroat trout, mountain whitefish, lake trout and bull trout. Bull trout are the most widely distributed species and are found in most major tributaries and many lakes. Mountain whitefish are resident in the North Saskatchewan River and the lower reaches of many of the tributaries (Allan 1984).

Channel morphology of the North Saskatchewan River in this Subwatershed is highly variable. In some areas, channels are narrow and confined, while in other areas they are wide and extensively braided. Low temperatures, low concentrations of dissolved nutrients, low winter flows and channel instability reduce the productivity and quality of the cold water salmonid habitat in the river main stem and tributaries (Allan 1984). Therefore, natural features of the North Saskatchewan River can negatively impact fish populations in this Subwatershed.

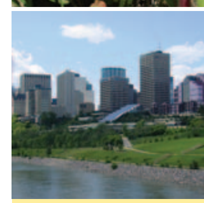
#### 5.1.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Cline is located in the Rocky Mountain Natural Region of Alberta. This region is split into 4 subregions; the alpine subregion, the lower subalpine, the upper subalpine and the montane subregion. The alpine subregion is typically unvegetated and lacking soil. The lower subalpine is composed mainly of lodgepole pine, Engelmann spruce, and subalpine fir, while the upper subalpine has spruce and fir closed forests, and open forests featuring Engelmann spruce, subalpine fir and whitebark pine. Lodgepole forests can be found at lower elevations. The montane subregion is composed of Douglas fir, limber pine, white spruce and grasslands. At higher elevations runoff occurs more quickly than compared to lower elevations where vegetation and soil absorb runoff and slow runoff velocity.

#### 5.1.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes in the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Cline Subwatershed, so no conclusions can be drawn about ecosystem health from this indicator. This data gap could be addressed in future research of Cline Subwatershed waterbodies.




### 5.1.4 Cline Summary

Using the chosen indicators, the Cline Subwatershed is the healthiest in the watershed, but significant data gaps exist that would allow us to better assess ecosystem health. It is a spectacular headwater area within the North Saskatchewan Watershed with 60% of its area in National Parks or wilderness areas. Because of the protected nature and the terrain of the Subwatershed, there is little linear development (mostly roads) and little or no cut-lines or seismic activity. With its rugged landscape, low level of disturbance and pristine wilderness, there is a significant amount of recreational activity in the Subwatershed. Livestock densities in the Cline Subwatershed are minimal.

Little development means that most of the aquatic ecosystems are unimpaired and likely in a natural, optimal functioning state. Water quality on the main stem of the North Saskatchewan River monitored by Environment Canada at Whirlpool Point was found to be only "fair" for the 1983-2002 period, while similar sites in the headwaters of the Bow and Athabasca rivers both received a "good" rating. These differences can be explained by the nature of the parameters that were used to calculate the WQI. Site-specific WQI parameters for Whirlpool Point may be required to accurately reflect the true state of the water quality at this site.

Water quantity is measured at ten stations in the Subwatershed: one site has real-time online data. These stations provide information for the operation of the Bighorn hydroelectric dam.

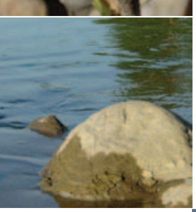
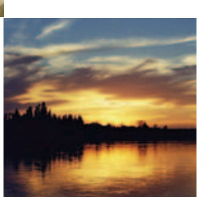
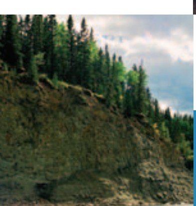
No detailed population assessments were found for fish species in the Subwatershed, nor was a systematic examination of riparian health, aquatic plants or benthic invertebrates found for the Subwatershed. These data gaps should be addressed in future research of the Cline Subwatershed.

In summary, there is little information related to several of the indicators required to assess ecosystem health for this Subwatershed. However, of the 5 indicators assessed, three were good, one was fair, and one was poor, yielding an overall subjective rating of good. Given the high percentage of this basin that lies in national parks and wilderness areas and the rugged terrain, there is little development and significant negative impacts are not anticipated. However, the potential impacts of forest harvesting on the Subwatershed should be examined.

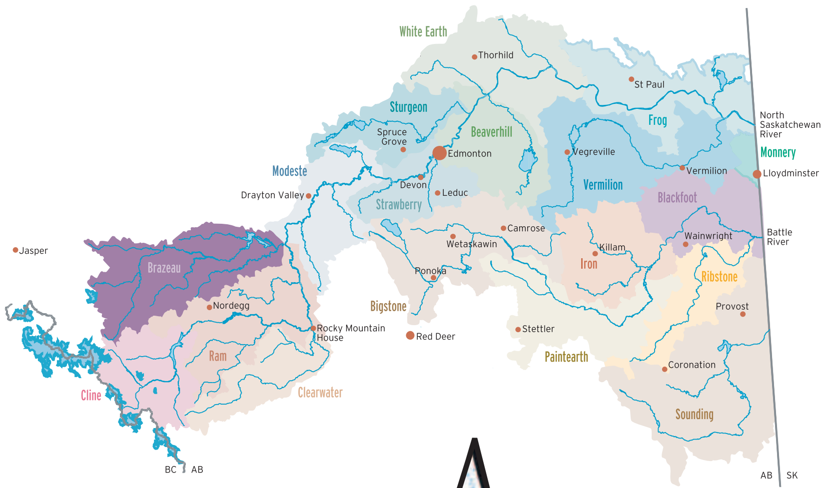


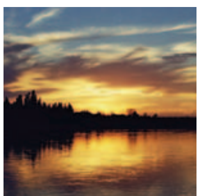


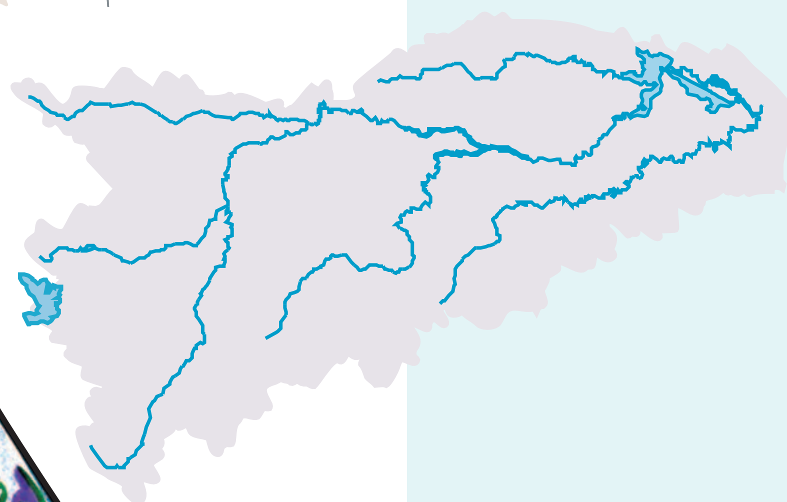


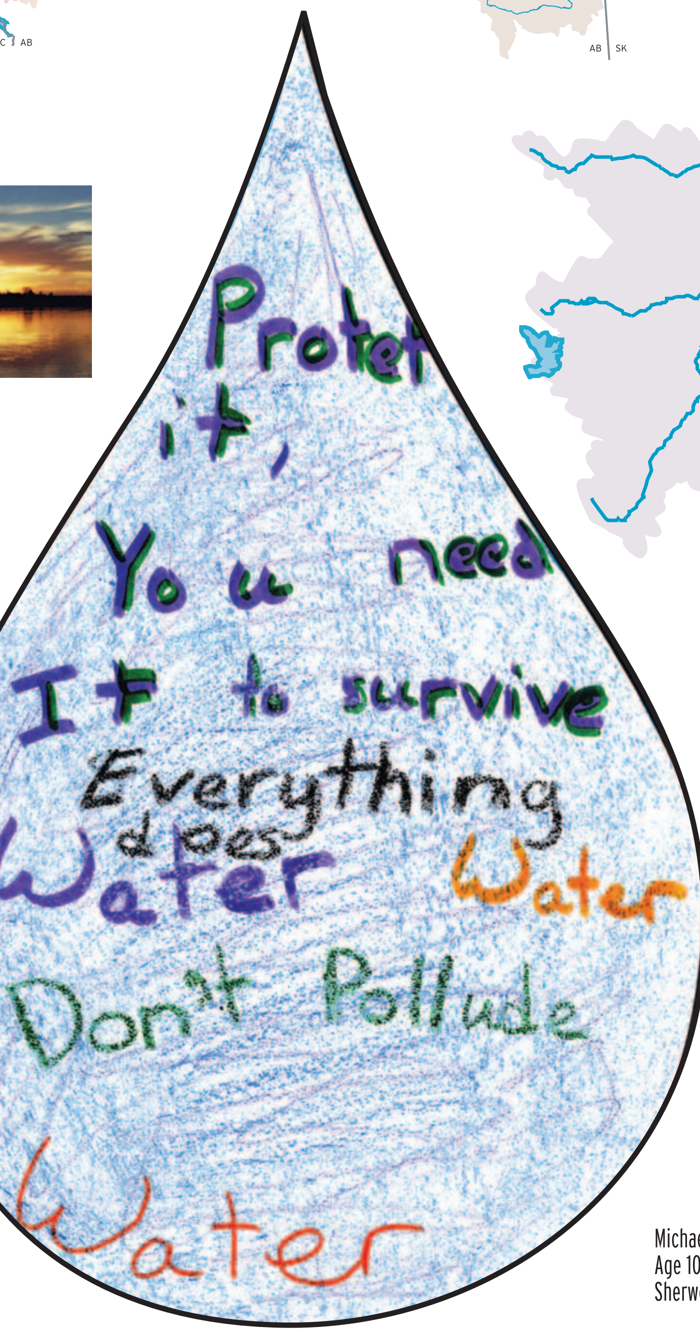




# Brazeau








Michaela Eifler
Age 10
Sherwood Park






## 5.2 BRAZEAU SUBWATERSHED

The Brazeau Subwatershed encompasses a biologically diverse area within parts of the Rocky Mountain and Foothills natural regions. The Subwatershed covers 689,198 hectares of land and includes 18,460 hectares of lakes, rivers, reservoirs and icefields. The Brazeau is in the municipal boundaries of Clearwater, Yellowhead and Brazeau Counties. The 5,000 hectare Brazeau Canyon Wildland Provincial Park, along with the 1,030 hectare Marshybank Ecological reserve, established in 1987, lie in the Brazeau Subwatershed. About 16.4% of the Brazeau Subwatershed lies within Banff and Jasper National Parks. The Subwatershed is sparsely populated, but includes the First Nation O'Chiese 203 and Sunchild 202 reserves. Recreation activities include trail riding, hiking, camping, hunting, fishing, and canoeing/kayaking.

Many of the indicators described below are referenced from the "Brazeau Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.2.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.2.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and can reflect changes in land use and management practices. No published assessment of riparian health was found for the Brazeau Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research in the Brazeau Subwatershed.

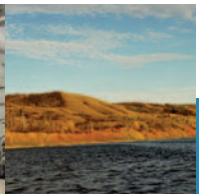
#### 5.2.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Of the land area in the Brazeau Subwatershed, 1.4% (9,315 ha) is taken up by linear development. The majority of this (63%) is cutlines. Roads of one form or another, unimproved or gravel roads (11.6%), truck trails (5.9%) and undivided paved roads (0.05%) cover the next largest portion of the watershed. Pipelines (15%) and transmission lines (4%) account for the remainder of the linear disturbance in the Brazeau Subwatershed.

#### 5.2.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Only 15% of this Subwatershed has been classified based on the PFRA Land Classification System. Of this, 105,419 hectares, 88% (93,247 ha) is classified as trees and 10% as "other lands". The remainder is grassland (2%, 1,914 ha) with small areas of forage and shrubs. Eighty-three percent of the Subwatershed is in provincial government forest management units (FMU).







In addition to the linear disturbances noted above, about 0.2% (1066 ha) of the Subwatershed area is affected by well sites and a smaller percentage, about 107 hectares, is used for various facilities including an air strip, gas plants, gravel pit, etc. While there is little industrial or urban land use in the Subwatershed, there are many mineral deposits including coal, oil and gas, limestone, and aggregates. There were many coal mines in operation in the first half of the 20th century. These are no longer active.

#### 5.2.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production in the actual watershed. Based on the available information, livestock densities in the Brazeau Subwatershed are low. Manure production in the soil polygons that cover the Brazeau Subwatershed was estimated at between 0 and 726,300 tonnes.

#### 5.2.1.5 Wetland Inventory

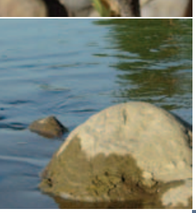
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. There was no information available on wetland area in the Brazeau Subwatershed; however, the Alberta Sustainable Resource Development base features hydrology indicated that only 2.6% (18,460 ha) of the Subwatershed was any form of water bodies.



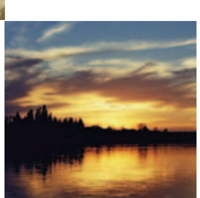
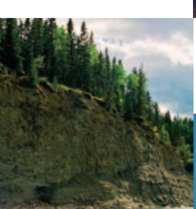
### 5.2.2 Water Quality and Quantity

Larger lakes and reservoirs in this Subwatershed include the Brazeau Reservoir, Brazeau Lake, Southesk Lake, Job Lake, Muskiki Lake, Leah Lake and Thunder Lake. Other waterbodies in the Subwatershed include the Brazeau, Elk, Blackstone, and Cardinal rivers, and Nomad, Ruby, Southesk, Chungo, Wawa, Rundle, Chimney, Thistle, Coast, Marshybank, and Brown Creeks. The Coronet Glacier is the largest glacier, and there are several smaller, unnamed glaciers in the Subwatershed.

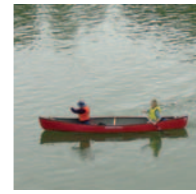




No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, sixty-nine total phosphorus samples and ten fecal coliform samples were collected along the Brazeau River from 1961-64, 1967-76, 1985-86 and 2003-04. The total phosphorus samples ranged from 0 to 3.1 mg/L, and averaged 0.226 mg/L. The fecal coliform samples ranged from 0 to 1 count/100 mL, and averaged 0.01 counts/100 mL. All fecal tests were well below the CCME Surface Water Quality Guidelines for Contact Recreation. There has been no sampling done for pesticides in the Brazeau Subwatershed.

Water quantity is measured at nine HYDEX stations (05DD001-05DD009): three have real-time online data (05DD004, 05DD007, and 05DD009). The Brazeau River and most of its upper tributaries exhibit typical mountain discharge regimes with over 50% of the total annual discharge occurring in June, July and August. The main stem of the North Saskatchewan River depends on glacial meltwater and groundwater for base flows and periods of low water extend from the fall through late spring (Allan 1984). The Brazeau Dam and hydroelectric plant on the Brazeau River form the Brazeau Reservoir, which is operated by TransAlta Utilities Corporation for hydroelectric power generation. Figure 8 shows a hydrograph typical of a glacial meltwater dominated stream, with peak flows during the warm summer months and some impact on flows from summer storms. Figure 9 shows an almost constant flow from the Cardinal River. Comparison of these two Rivers is difficult, as the scale for each differs.



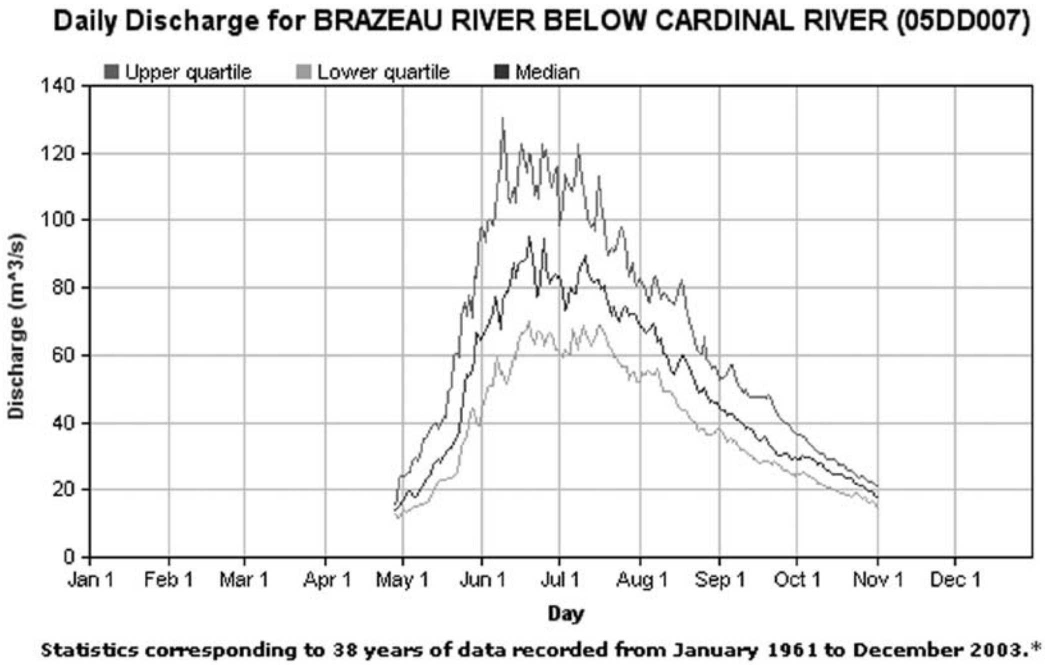



**Figure 8:** Brazeau River below Cardinal River mean monthly discharge (Station 05EA007).

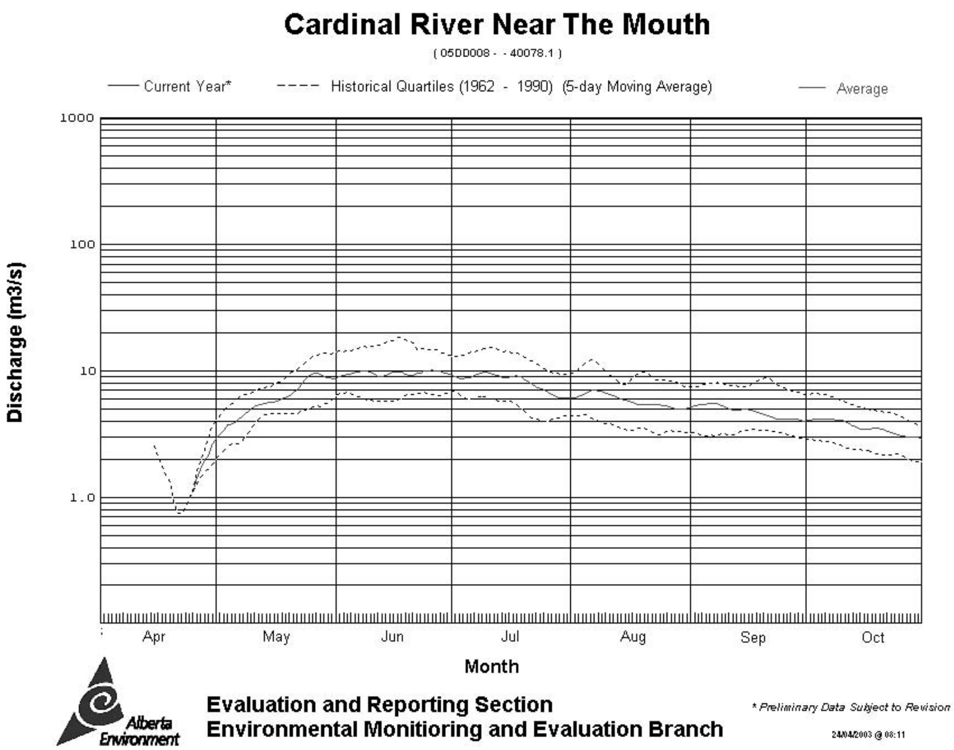
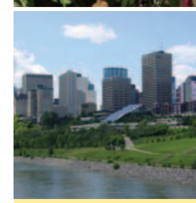



**Figure 9:** Cardinal River near the mouth mean monthly discharge for the open water season (Station 05DD008).







### 5.2.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.2.3.1 Aquatic Macrophytes

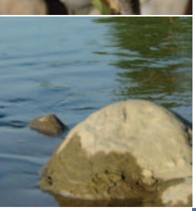
The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point sources (e.g. wastewater outfalls) or non-point (e.g. agricultural run-off) sources on the landscape. No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Brazeau Subwatershed, so we cannot make any conclusions about aquatic ecosystem health. This data gap could be addressed in future research of Brazeau Subwatershed waterbodies.

#### 5.2.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Two native salmonids, mountain whitefish and bull trout, are widely distributed throughout the Subwatershed. Northern pike have been noted in the lower Blackstone River system but are considered rare. The lower reach of the Nordegg River supports a mix of cold water salmonids, namely mountain whitefish and bull trout, as well as the occasional northern pike and walleye (Allan 1984).





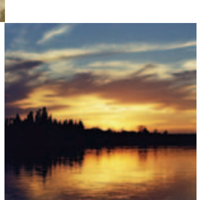
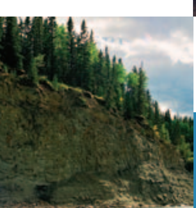


#### 5.2.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Brazeau is located partly in the Rocky Mountain Natural Region and partly in the Foothills Region of Alberta. The Rocky Mountain Natural Region is split into 4 subregions; the alpine subregion, the lower subalpine, the upper subalpine and the montane subregion. The alpine subregion is typically unvegetated and lacking soil. The lower subalpine is composed mainly of lodgepole pine, Engelmann spruce, and subalpine fir, while the upper subalpine has spruce and fir closed forests, and open forests featuring Engelmann spruce, subalpine fir and whitebark pine. Lodgepole forests can be found at lower elevations. The montane subregion is composed of Douglas fir, limber pine, white spruce and grasslands. Fens are very common in the lower foothills as well. Throughout most of the Subwatershed, the dominant species is lodgepole pine where fire occurs; white spruce is dominant where there has been no recent fire. Some risk to the Subwatershed may be attributed to a monotypic forest, which may be more susceptible to disease.

#### 5.2.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes in the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Brazeau Subwatershed, so we cannot make any conclusions about ecosystem health using this biological indicator. This data gap could be addressed in future research in this area.




### 5.2.4 Brazeau Summary

The Brazeau Subwatershed is a healthy Subwatershed, but significant data gaps exist. It is an important and scenic headwater area within the North Saskatchewan Watershed that has some land use disturbance, is sparsely populated and is mostly forested. There is low industrial or urban land use in the Subwatershed; however, 83% of the lands lie within a Provincial FMU. The impact of forestry in this Subwatershed could therefore be significant. The Subwatershed is an important destination for recreational users. Due to the altitude, rugged terrain and poor soils at the western portion of this Subwatershed, there is limited potential for agriculture. Because of this, Agriculture and Agri-Food Canada (PFRA) has only classified the land use of 15% of the eastern portion of the Subwatershed; and of that only 2% is grasslands. Available manure loadings suggest that livestock densities are low.

No published assessment of riparian health was found for the Brazeau Subwatershed. This data gap should be addressed, especially because a relatively high proportion of the Subwatershed's disturbance is due to forestry cutlines. In addition, a small area is affected by well sites and other oil and gas facilities. The impacts of these developments have not been assessed nor were the impacts of forest operations assessed for this report. The importance of this site for source water protection cannot be overemphasized, so frequent monitoring is recommended.

The available data showed no wetlands in the Brazeau Subwatershed. These data should be verified with other sources.

No long-term river water quality or groundwater quality information exists for this Subwatershed. Water quantity is measured at nine stations, three of which have real-time online data. These stations provide information critical to the operation of the Brazeau Dam and hydroelectric plant.



A systematic examination of water plants has not been completed in the Brazeau Subwatershed. A fish population assessment has not been done, nor were any published assessments of benthic invertebrates found for the creeks, rivers and streams of the Brazeau Subwatershed. As all three of the above metrics have been identified as important biological indicators, studies could be undertaken for lakes, reservoirs, creeks, streams and rivers in the Subwatershed to gain a better understanding of Subwatershed health.

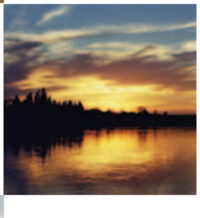
In summary, there has been little systematic assessment of the state of the Brazeau Subwatershed and there are significant data gaps, which should be addressed. However, of the seven indicators assessed, five were good, one was fair, and one was poor, yielding an overall subjective rating of good. Future studies should focus on the impacts of linear development and the potential conflicts between industrial activities - forest harvesting and oil and gas development – and recreational uses.



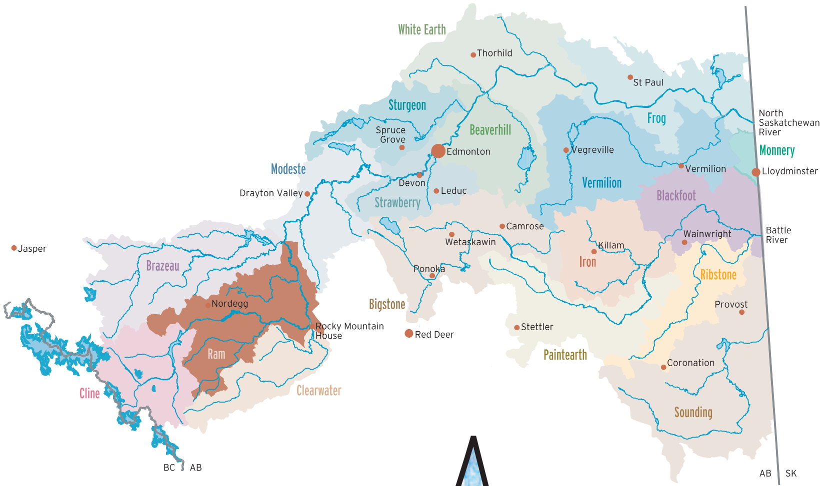


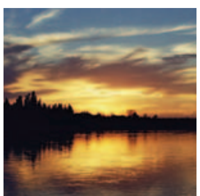


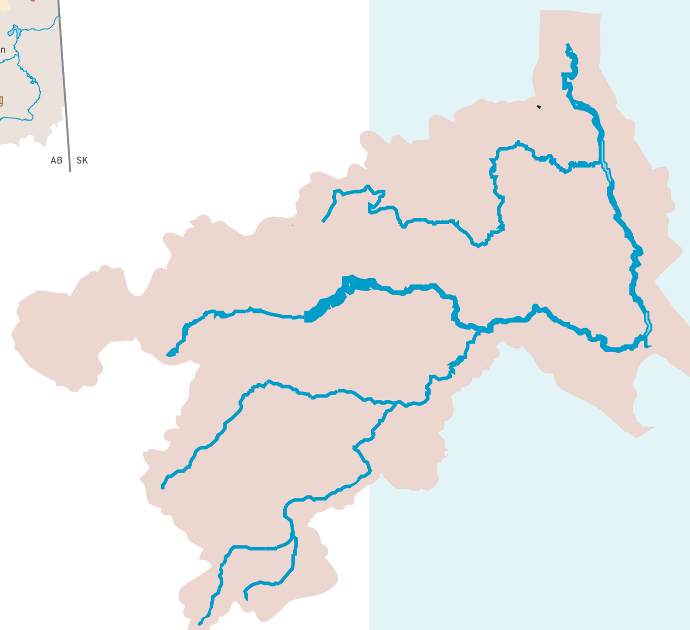



# Ram





Zoe Burgess
Age ?
Edmonton

## 5.3 RAM SUBWATERSHED

The Ram Subwatershed is in the Foothills Natural Region. It encompasses 632,541 hectares including 2,040 hectares of water bodies which is 2% of the Subwatershed area. Less than 1% (4,405 ha) of the Subwatershed is found in Banff National Park (park) or the Siffleur Wilderness Area (provincial protected area). Almost this entire Subwatershed lies in an FMU (99%). The Ram Subwatershed is in the municipal boundaries of Clearwater and Brazeau Counties and includes the settlements of Rocky Mountain House and Nordegg, as well as Crimson Lake Provincial Park and the Bighorn 144A First Nations Reserve. The Ram Subwatershed contains many parks and campgrounds including the 3,217 hectare Crimson Lake Provincial Park located just west of Rocky Mountain House.

The topography is that of strong, rolling ridges of shale and sandstone. The Subwatershed receives about 550 mm in annual precipitation and has a mean annual temperature of 1°C.

The economic base of the region consists of oil and gas, forestry, agriculture, and tourism. This area may be at risk due to the large amount of the Subwatershed which is not protected (i.e. a park or protected area).

Many of the indicators described below are referenced from the “Ram Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.3.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 5.3.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Ram Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Ram Subwatershed.

#### 5.3.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Linear development takes up 1.6% (10,229 ha) of the land area in the Ram Subwatershed. The majority of this (51%) is cutlines. Roads of one form or another (24.1%) and pipeline rights of way (17.0%) are the majority of the remainder. About 2% of the linear disturbance is railway line right of way.



### 5.3.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health.

Thirty-one percent of the watershed has been classified based on the PFRA Land Classification System. Of this 162,838 hectares, 83% (162,838 ha) is classified as trees and 8% (15,731 ha) as forage. The remainder consists of grassland (6%, 11,880 ha) and shrubs, water bodies and other lands. Ninety-nine percent of the watershed is in provincial government forest management units.

In addition to the linear disturbances noted above, 2% (12,364 ha) of the Subwatershed area is classified as municipal or reserve area and 0.3% (2,104 ha) is taken up by well sites. A small percentage (0.03% or 214 ha) is used for various other facilities including an air strip, gas plants, and gravel pits.

### 5.3.1.4 Livestock Density

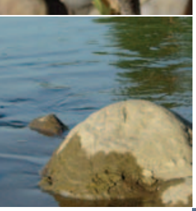
Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems.

Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production in the actual watershed. Based on the available information, livestock densities in the Ram Subwatershed are low. Manure production in the soil polygons that cover the Ram Subwatershed was estimated at between 0 and 726,300 tonnes.



### 5.3.1.5 Wetland Inventory



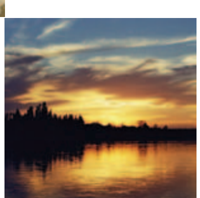
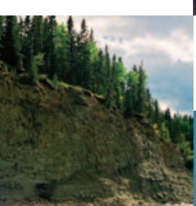


Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. There was no information available on wetland area in the Ram Subwatershed; however, the Alberta Sustainable Resource Development base features hydrology data indicated that only 0.3% (2,040 ha) of the Subwatershed was made up of water bodies.

### 5.3.2 Water Quality and Quantity

The Town of Rocky Mountain House takes its raw water supply from the North Saskatchewan River and discharges treated wastewater to the river.

Water bodies in the Subwatershed include the North Saskatchewan, Baptiste, Ram, Joyce, and Bighorn Rivers, and Jock, Gap, Dutch, Grace, Chambers, Shunda, Brewster, Deserters, Trout, Kiska, and Tershishner Creeks. Some of the larger lakes in this Subwatershed include Abraham, Cow, Crimson Radial, Shunda, Ernie, McGregor and Jackfish Lakes. Water quality for Crimson Lake can be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990). The largest glacier in the Subwatershed is the Ram River Glacier in the south of the Subwatershed.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, one station on the Ram River was sampled for fecal coliforms and TP from 1985-86. The six fecal coliform samples ranged from 1 to 7 counts/100 mL, and averaged 4 counts/100 mL. All fecal results were below the CCME Surface Water Quality Guidelines for Contact Recreation. The 8 TP samples ranged from 0.008 to 0.061 mg/L, and averaged 0.022 mg/L. No pesticide samples were taken.





Water quantity is measured at twelve HYDEX stations (05DC001-05DC009), two of which have real-time online data (05DC001 and 05DC006). Figure 10 shows the open water season hydrograph for the Ram River. This hydrograph is typical for a glacial meltwater dominated headwater stream, with flows only during the warm summer months, and flows falling to zero in the fall.

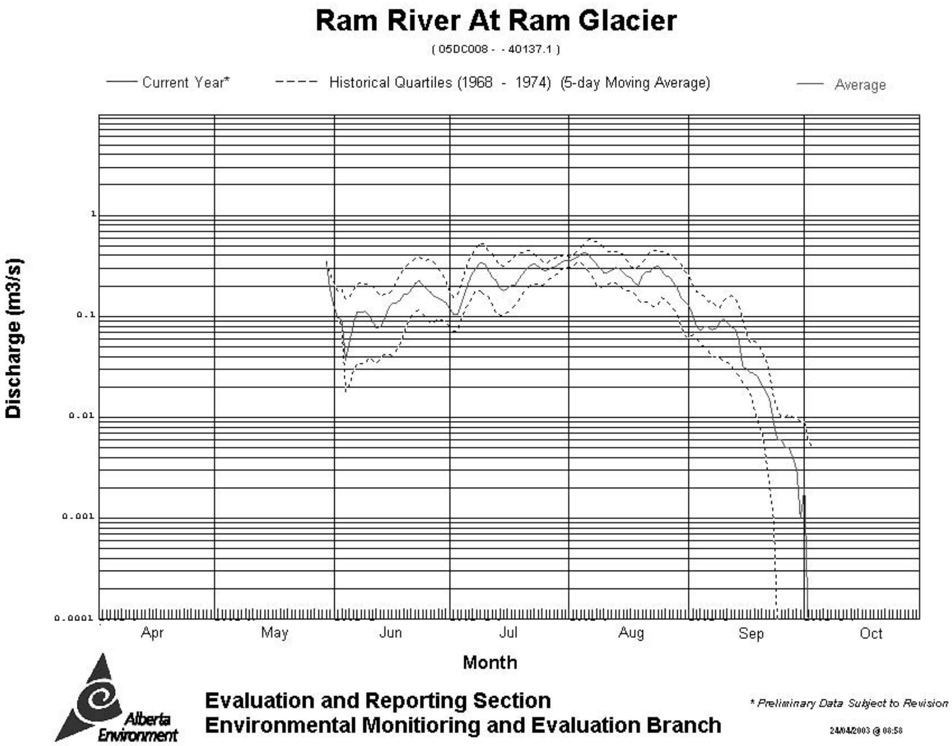



**Figure 10:** Ram River at Ram Glacier mean monthly discharge for the open water season (Station 05CD008).

### 5.3.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.3.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.





No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Brazeau Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Ram Subwatershed.

### 5.3.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity.

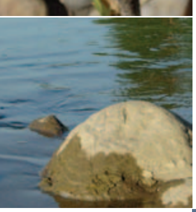
The North Saskatchewan River in this Subwatershed is frequently confined to a stream cut valley with islands, pool and riffle sequences with sand bars and a predominately gravel substrate. Many of the water bodies in the Subwatershed provide a high quality, cold water habitat for fish. Fish species include cutthroat trout, bull trout, mountain whitefish, brown trout, and lake trout. Cutthroat trout and brown trout are introduced species and are abundant in some streams. Bull trout probably are the most widely distributed trout in the Subwatershed, but mountain whitefish are the more abundant, especially in the larger rivers including the North Saskatchewan River. Other fish species include northern pike, walleye, brook trout, rainbow trout and goldeye. Mountain whitefish likely spawn and overwinter in this section of the North Saskatchewan River (Allan 1984).

The Baptiste River system contains about 500 kilometres of streams. Based on surveys in the early 1980's the system contains crucial areas of habitat for spawning, rearing and overwintering of salmonid species in the upper main stem and tributaries (Allan 1984).



### 5.3.3.3 Vegetation Types



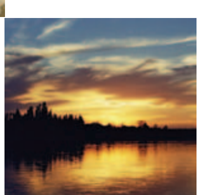
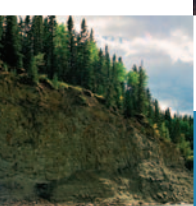


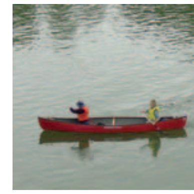
Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Ram Subwatershed is located in the Foothills Region of Alberta. The Foothills Region is split into the upper foothills and the lower foothills. The upper foothills includes species such as white spruce, black spruce, lodgepole pine and subalpine fir. The lower foothills are composed mainly of mixed forests, featuring white spruce, black spruce, lodgepole pine, balsam fir, aspen, balsam poplar and paper birch.  Fens are very common in the lower foothills area. Coniferous forests of white spruce and lodgepole pine dominate the vegetation in the higher elevations. At lower elevations, there is a co-dominance of trembling aspen, balsam poplar, lodgepole pine and white spruce.

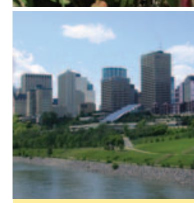
### 5.3.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes in the presence and abundance of species that may be related to changes in water quality.

Alberta Environment conducted surveys of benthic invertebrates in the North Saskatchewan River between 1973 and 1977. Data from the five-year period were summarized in a report published in 1978 (Reynoldson and Exner 1978). One of the sampling sites was at Rocky Mountain House. The authors concluded that upstream of the City of Edmonton, there was little change in the species diversity or total numbers of macrobenthic fauna from year to year and season to season. The site also showed less variability in both diversity and standing crop compared to sites downstream of Edmonton. The main invertebrate groups in five years of sampling the river upstream of Edmonton were Chironomidae (Midges), which made up 38.4% of the samples, Ephemeroptera (Mayflies), 31.7% and Plecoptera (Stoneflies), 20.0%. The remainder of the sample was Trichoptera (Caddisflies), 4.9% and Oligochaeta (Earthworms), 0.5%.



### 5.3.4 Ram Summary

Most of the Ram Subwatershed is forested and allocated to forest management and less than 1% lies in parks or protected areas. Because so much of the Subwatershed is allocated to forest management, this watershed is potentially at risk and sustainable practices must be followed to avoid negative impacts in this Subwatershed. The economic base consists of oil and gas, forestry, tourism and some agriculture. A relatively high percentage of the Subwatershed has been affected by liner development (1.6%). This development includes cutlines, roads, and pipelines rights of way. In addition, 2% of the developed area is municipal or reserve area and a small area is affected by well sites and other facilities.

No long-term river water quality information exists for this Subwatershed; however, it should be noted that the Town of Rocky Mountain House discharges treated wastewater to the North Saskatchewan River. The impact of this discharge on river water quality should be assessed.

Water quantity is measured at twelve stations, two of which have real-time online data.

Detailed assessments of fish populations in the Subwatershed have not been done. Studies suggest that the North Saskatchewan River and Baptiste River systems provide critical areas of habitat for spawning, rearing and overwintering of fish species.

A systematic examination of aquatic plants and assessment of riparian health have not been completed in the Ram Subwatershed. Surveys of benthic invertebrates in the North Saskatchewan River at Rocky Mountain House, between 1973 and 1977, concluded that there was little change in the species diversity or total numbers from year to year and season to season.

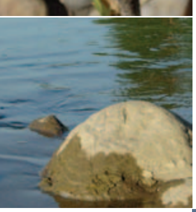
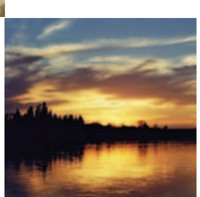
In summary, there has been little systematic assessment of the impact of development on the Ram Subwatershed and there are significant data gaps, which should be addressed. However, of the eight indicators assessed, six were good, two were fair, and none were poor, yielding an overall subjective rating of good. In particular, future studies should focus on the impacts of linear development and the potential conflicts between industrial activities – forest harvesting and oil and gas development – and recreational uses. These data gaps should be addressed given the importance of this area of recreational use and tourism, and the importance of habitat in the area for fish species.



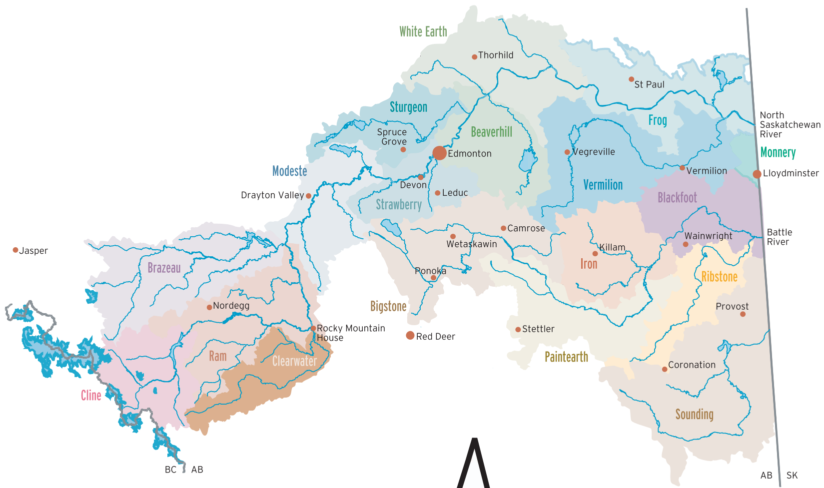


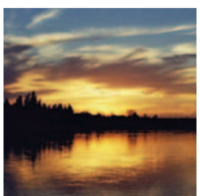


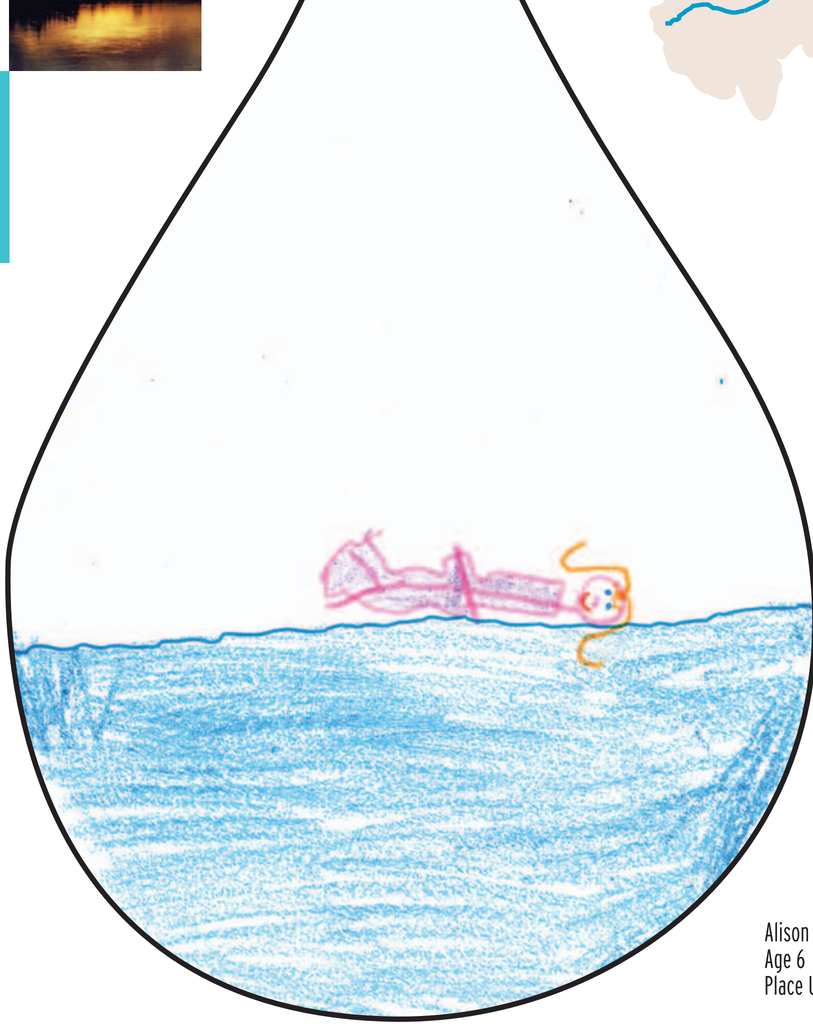



# Clearwater





Alison Schumacher
Age 6
Place Unknown




## 5.4 CLEARWATER SUBWATERSHED

The Clearwater Subwatershed lies within parts of the Rocky Mountain and Foothills natural regions and encompasses 322,787 hectares. A very small portion of the Subwatershed is within parks or protected areas (1.4%; 4,405 ha) and includes 66 hectares located within the boundary of Banff National Park. The Clearwater Subwatershed lies in the municipal boundaries of Clearwater County and includes a portion of the Town of Rocky Mountain House. The topography of the Subwatershed is that of strong, rolling ridges of shale and sandstone. The Subwatershed receives about 550 mm in annual precipitation and has a mean annual temperature of 1° C. Waterbodies cover about 1.6% (5225 ha) of the Subwatershed.

Like the Ram Subwatershed, the economic base of the Clearwater Subwatershed consists of oil and gas, forestry, agriculture, and tourism.

Many of the indicators described below are referenced from the "Clearwater Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.4.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 5.4.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices.

No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Clearwater Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Clearwater Subwatershed.

#### 5.4.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

Two percent (6,572 ha) of the land area in the Clearwater Subwatershed is taken up by various linear developments. The majority of the linear developments (59.4%; 3906 ha) is cutlines. Roads of one form or another (28.8%), pipeline rights of way (15.3%) and transmission line rights of way (5.5%) are the majority of the remainder. About 1% of the linear disturbance is railway line rights of way.

#### 5.4.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes





in water quality and quantity, fish and wildlife populations, and riparian health. Forest Management Units cover a large portion (86.7%) of the Subwatershed. Twenty-eight percent of the watershed has been classified based on the PFRA Land Classification System. Of the 90,567 hectares classified, 59.7% (54,084 ha) is classified as trees and 29.9% (27,075 ha) as forage. The remainder consists of grassland (10.2%, 9,191 ha), water bodies and crop lands.

In addition to the linear disturbances noted above, 3.4% (11,117 ha) of the Subwatershed area is classified as municipal or reserve area and 0.3% (976 ha) is occupied by well sites. A small percentage (0.09% or 280 ha) is used for various other facilities including an air strip, gas plants, and gravel pits.

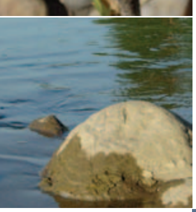
#### 5.4.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production in the actual watershed. Based on the available information, livestock densities in the Clearwater Subwatershed are low in most of the Subwatershed with manure production being between 0 and 726,300 tonnes. However, manure production is high in the soil polygons that cover the eastern-most corner of the Subwatershed near Rocky Mountain House. In this area, manure production is in the order of 2,449,000 to 5,422,000 tonnes.

#### 5.4.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. There was no information available on wetland area in the Clearwater Subwatershed; however, the PFRA Land Classification indicated that only 0.1% (114 ha) of the Subwatershed was any form of water bodies.

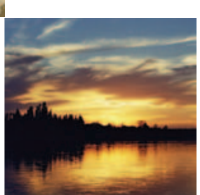




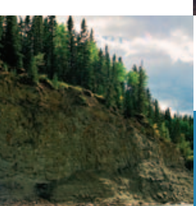
### 5.4.2 Water Quality and Quantity

Water bodies in the Subwatershed include the Clearwater and Tay Rivers, Elk, Rocky, Cut-off, Swan, Prairie, and Cow Creeks. Larger lakes include Swan, Martin, Devon, Strubel, Clearwater and Phyllis. The largest glacier in the Subwatershed is the Ram River Glacier, and there are several unnamed glaciers in the far western section of the reach. The Rocky Riparian Group is an active regional watershed group in this Subwatershed, and this group has an agricultural focus.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, the Clearwater River was sampled at two stations for fecal coliforms and TP between 1964-1986. Five fecal coliform samples ranged from 1 to 17 counts/100 mL, and averaged 9 counts/100 mL. These fecal results are well below the CCME Surface Water Quality Guidelines for Contact Recreation. Eleven TP samples ranged from 0 to 0.111 mg/L and averaged 0.012 mg/L.



Water quantity is measured at seven HYDEX stations (05DB001-05DB007) with one having real-time online data (05DB006). Figure 11 shows the Clearwater River hydrograph, which is typical of a glacial meltwater dominated stream, with peak flows during the warm summer months and some impact on flows from summer storms.





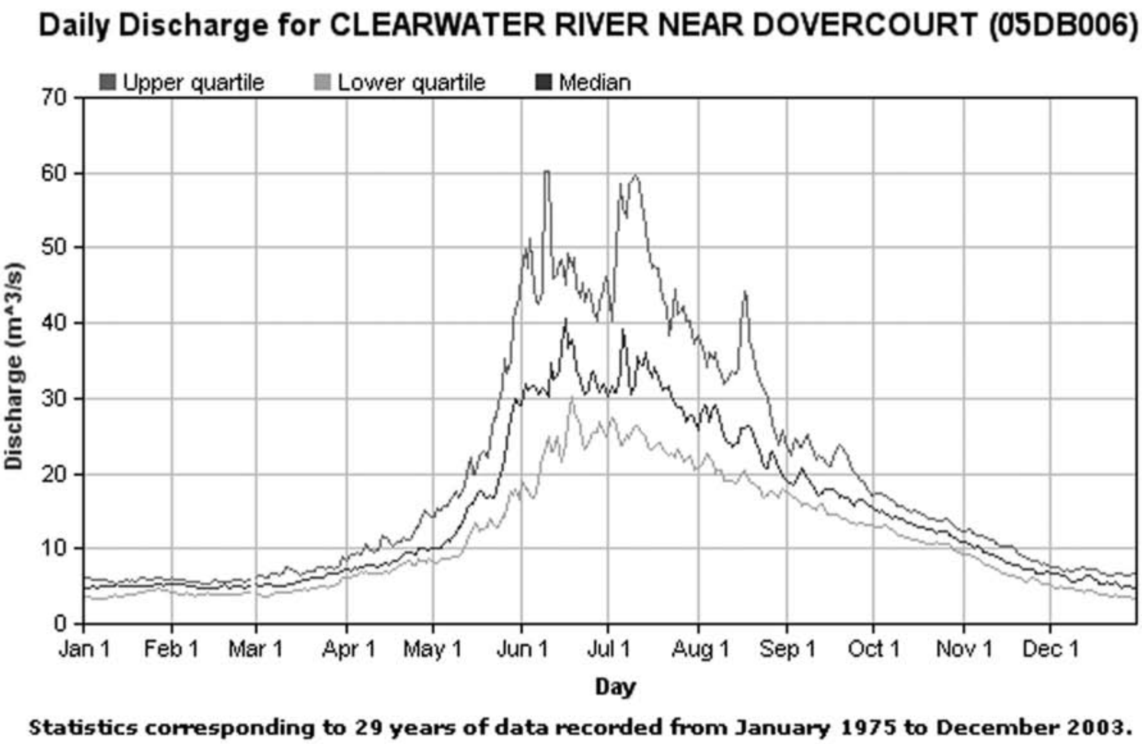




**Figure 11:** Clearwater River at Dovercourt mean monthly discharge for the year (Station 05DB006).



### 5.4.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.4.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Clearwater Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Clearwater Subwatershed.



#### 5.4.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. The Subwatershed contains about 700 kilometres of streams, 473 kilometres of which are rated as high quality, cold water salmonid streams. Bull trout and mountain whitefish are widely distributed in the Subwatershed. Brook trout and brown trout have been widely introduced by stocking and are abundant in some tributary streams. Walleye and northern pike occur occasionally in the lower main stem of the Clearwater River and Prairie Creek. The lower section of the Clearwater River has an irregular channel pattern with occasional island and mid channel bars, partly entrenched and confined in a stream cut valley and a predominately gravel substrate. The upper section has an irregular channel pattern with occasional islands, pool and riffle sequences, diagonal bars, and is partly entrenched and occasionally confined in a wide mountain valley and a gravel substrate (Allan 1984).

#### 5.4.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Clearwater Subwatershed is located in both the Rocky Mountain Natural Region and the Foothills Region of Alberta. The Rocky Mountain Natural Region is split into 4 subregions; the alpine subregion, the lower subalpine, the upper subalpine and the montane subregion. The alpine subregion is typically unvegetated and lacking soil. The lower subalpine is composed mainly of lodgepole pine, Engelmann spruce, and subalpine fir, while the upper subalpine has spruce and fir closed forests, and open forests featuring Engelmann spruce, subalpine fir and whitebark pine. Lodgepole forests can be found at lower elevations. The montane subregion is composed of Douglas fir, limber pine, white spruce and grasslands. Coniferous forests of white spruce and lodgepole pine dominate the vegetation in the higher elevations. At lower elevations, there is a co-dominance of trembling aspen, balsam poplar, lodgepole pine and white spruce.

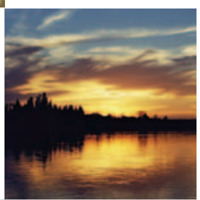
#### 5.4.3.4 Benthic Invertebrates

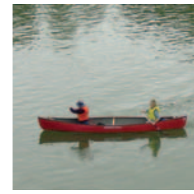
Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Clearwater Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Clearwater Subwatershed.

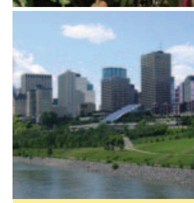
### 5.4.4 Clearwater Summary

The economic base of the Clearwater Subwatershed consists of oil and gas, forestry, agriculture, and tourism. About 2% of the Subwatershed is taken up by linear developments, including cutlines, roads, pipelines, transmission lines and railway rights of way. In addition, 3.4% is classified as municipal or reserve area and a small percentage is affected by well sites and other facilities.

Less than a third of the Subwatershed has been classified under the PFRA Land Classification System. The area that has been classified shows about 60% as trees and 40% as forage, grassland, water bodies and croplands. Livestock densities are low in most of the Subwatershed except in the soil polygons that cover the eastern-most corner of the Subwatershed near Rocky Mountain House where livestock densities are high.





There was no information available on wetland area. These data need further examination because peatlands are known to be abundant in some areas of the Subwatershed.

Water quantity is measured at seven stations with one having real-time online data. No long-term river water quality information exists for the Subwatershed, and no published assessment of riparian health was found. In addition, a systematic examination of water plants has not been completed and no published assessment of benthic invertebrates or fish populations was found for the Clearwater Subwatershed.

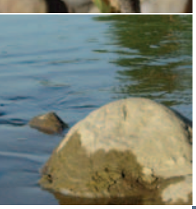
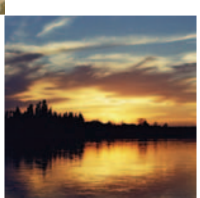
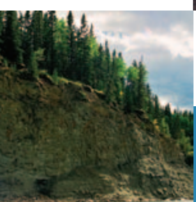
In summary, there has been little systematic assessment of this Subwatershed and there are significant gaps in the information. However, of the six indicators assessed, four were good, two were fair, and none were poor, yielding an overall subjective rating of good. These data gaps should be addressed given the importance of this area for recreational uses and tourism, the importance of habitat in the area for fish species, and potential for conflicts with forestry, oil and gas activities and agriculture in some areas.



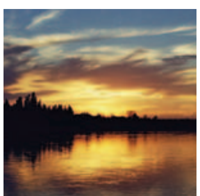


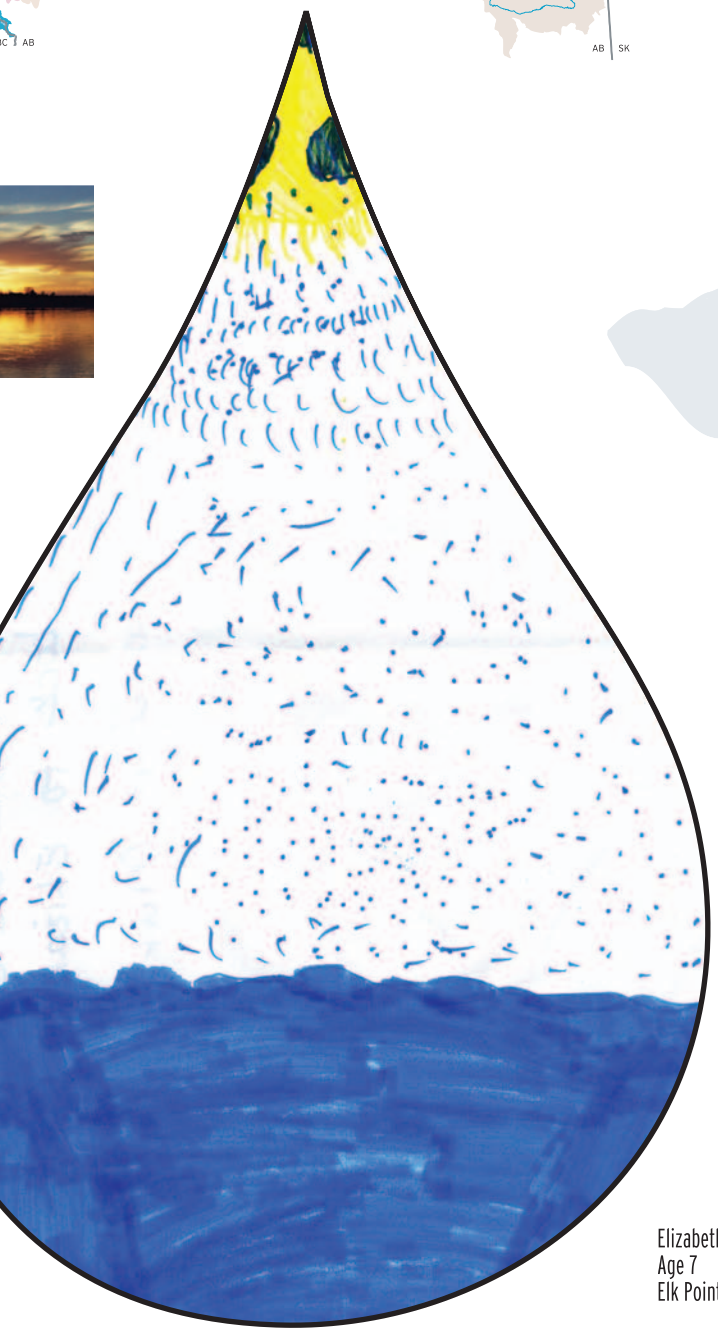




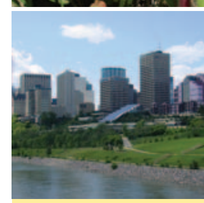
# Modeste



Elizabeth Orr
Age 7
Elk Point



## 5.5 MODESTE SUBWATERSHED

The Modeste Subwatershed lies in the Foothills and Boreal Forest natural regions of Alberta, and encompasses 482,746 hectares including 21,461 hectares of natural and artificial water bodies which include lakes, quarries, reservoirs, rivers, wetlands and canals. The Modeste Subwatershed includes the municipal boundaries of Brazeau, Clearwater, Leduc, Parkland and Wetaskiwin Counties, the settlements of Alder Flats, Betula Beach, Breton, Buck Creek, Carvel, Drayton Valley, Duffield, Fallis, Kapasiwin, Keephills, Lakeview, Lodgepole, Point Alison, Rocky Rapids, Seba Beach, Tomahawk, Wabamun, Winfield and the First Nation's Reserves Wabamun Lake 133A, O'Chiese 203 and Buck Lake 133C. The Jack Pine Provincial Grazing Reserve and the Buck Mountain Provincial Grazing Reserve are within the Subwatershed. The geology consists of fluvial and glaciofluvial deposits along major stream valleys.

The economic base of the region is primarily oil and gas, with agricultural and forestry activity. The Highvale Coal Mine near Wabamun Lake is the largest surface strip mine in Canada and supplies coal to the nearby TransAlta Utilities Corporation Wabamun, Keephills and Sundance power plants.

The larger lakes in the Subwatershed, Wabamun, Buck, Jackfish, Johnnys, Mayatan, Mink and Hasse, are popular for swimming, camping, boating, and fishing.

Many of the indicators described below are referenced from the "Modeste Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.5.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 5.5.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Modeste Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research in this area.

#### 5.5.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. More than 3.5% (17,255 ha) of the land in the Modeste Subwatershed is taken up by linear developments. The area of linear development includes roads of one form or another (31%; unimproved and gravel roads), pipeline rights of way, (33% of the area of linear development) and cutlines and trails (25%). There also is a small amount of transmission line rights of way (10.3%) and rail lines (0.7%).

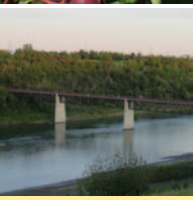


### 5.5.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, and including lakes, rivers, streams, wetlands, dugouts and reservoirs cover just over 4% of the Subwatershed. The majority of the Subwatershed is in various land uses related to agricultural production: forage, 43%; grassland, 23%; and cropland, 1%. About 19% of the Subwatershed is treed; however, 100% of the Modeste Subwatershed lies in a provincial FMU.

In addition to the area of linear disturbance, about 3% of the land area (14,486 ha) has been disturbed by various forms of development including oil and gas wells, sand and gravel pits, open pit mines, and power stations. Several small towns and villages in the Subwatershed cover 917 hectares and First Nations lands encompass 7642 hectares.

### 5.5.1.4 Livestock Density



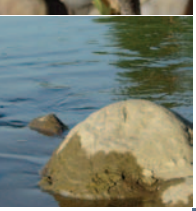
Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual watershed. Based on the available information, livestock densities in the Modeste Subwatershed are generally moderate. Manure production in the soil polygons that cover the Modeste Subwatershed was estimated at between 0 in the west to 3,246,000 tonnes in some of the soil polygons in the eastern part of the Subwatershed.



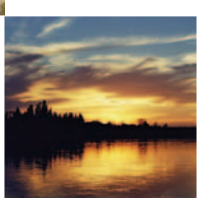
### 5.5.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. The PFRA Land Classification failed to identify wetlands in the Modeste Subwatershed, however, Alberta Sustainable Resource Development has collected hydrology data and identified wetlands over 4.7 ha of the land area in the Modeste Subwatershed (1% of land area). However, an inventory completed by Ducks Unlimited Canada for part of the Modeste Subwatershed found a total of 20,565 hectares of wetlands (4.3% of the Subwatershed area). The DUC inventory included both permanent and temporary wetlands.

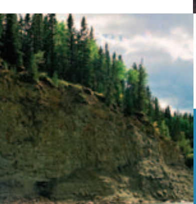
### 5.5.2 Water Quality and Quantity



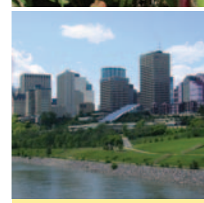
Water bodies in the Subwatershed include the North Saskatchewan River, and Modeste, Bucklake, Tomahawk, Mishow, Washout, and Rose Creeks. Larger lakes in this Subwatershed include Wabamun, Buck, Jackfish, Johnnys, Mayatan, Mink and Hasse. Lakewatch water quality data for Buck and Jackfish Lakes are available for 2001 from ALMS. Water quality for Buck, Jackfish, Hasse and Wabamun Lakes can be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990).



The Town of Drayton Valley has a primary wastewater treatment plant, which uses chlorination disinfection prior to discharge into North Creek. The towns of Alder Flats, Breton, Tomahawk, and Buck Creek all have wastewater treatment lagoons. Alder Flats discharges into Rose Creek, Breton into Modeste Creek, Tomahawk into Tomahawk Creek, and Buck Creek into an unnamed creek.





No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, Rose Creek was part of the CAESA stream network as a site in an area of low agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-1996 (Anderson *et al.* 1998).

AESA stream monitoring took place yearly on Tomahawk Creek from 1996-2001 (CAESA 1998, Anderson 1998, Anderson 2000, Carle 2001, Donahue 2001). This creek is in an area of “moderate” agricultural intensity (CAESA 1998), and has shown very high fecal coliform counts (1999), low flows (2000) and high particulate phosphorus concentrations (2001) resulting in marginal to fair Alberta Agriculture, Food and Rural Development Water Quality Index Scores (1999-2001) (Carle 2001, Donahue 2001).

Wabamun Lake is one of the most intensively studied lakes in Alberta. Recent water quality, fisheries, and sediment data were reported by Alberta Environment (2003). Results of a comprehensive study in 2002 and a 20-year history of water quality have shown that ion concentrations have increased due to inputs from the Wabamun Lake Wastewater Treatment Plant. A variety of disinfection by-products discharged by the wastewater treatment plant are found throughout the lake. When compared to other Alberta lakes, Wabamun sediments had higher metal and polycyclic aromatic hydrocarbon levels, due in part to the TransAlta Utilities Corporation power plants on the lake. An environmental risk assessment of the power plant on the lake is currently being undertaken by Alberta Environment.

Modeste Creek was sampled at one station for fecal coliforms and TP during the years 1985-86, 1988, and 1998-2000. The eight fecal coliform samples ranged from <10 to 4300 counts/100 mL, and averaged 1068 counts/100 mL. Most of these samples are above the CCME Surface Water Quality Guidelines for Contact Recreation. The 18 TP samples ranged from 0.006 to 1.58 mg/L, and averaged 0.192 mg/L. Pesticide detections in this Subwatershed included 2,4-D, Bromoxynil, MCPA, MCPP, Dicamba and Picloram, all of which were below the CCME Guidelines for the Protection of Aquatic Life.



The North Saskatchewan River channel in this Subwatershed averages about 120 metres wide and 1.2 metres deep. The channel is sinuous with islands and bars and a pool and riffle sequence. It is partly entrenched and frequently confined in a stream-cut valley. Peak summer flows have been reduced and minimum winter flows increased by water releases from the Brazeau and Bighorn dams (Allan 1984).

Water quantity is measured at seven HYDEX stations (05DE001; Figure 12, 05DE003, 05DE006-05DE009, 05DE911): two have real-time online data (05DE006 and 05DE007). Water is removed from the North Saskatchewan River for use in TransAlta’s cooling towers. Figure 12 shows the North Saskatchewan River hydrograph, which is typical of a glacial meltwater dominated stream, with peak flows during the warm summer months and some impact on flows from spring runoff and summer storms.



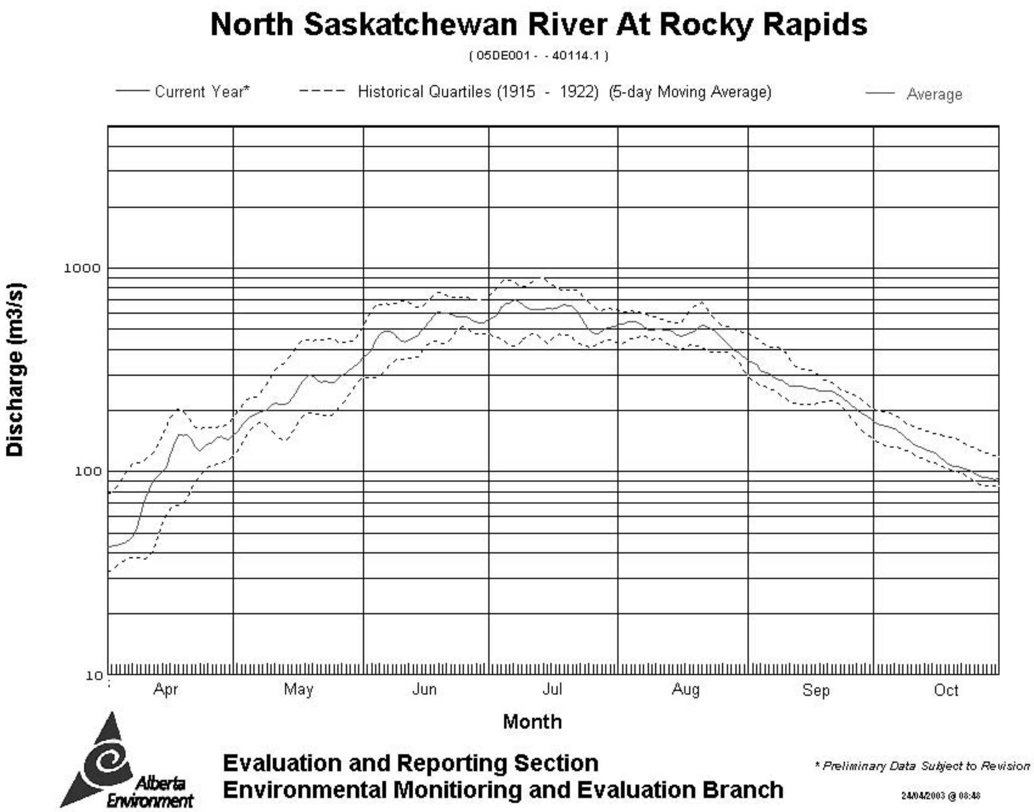


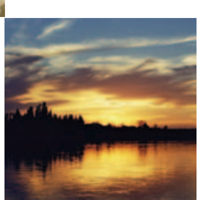

**Figure 12:** North Saskatchewan River near Rocky Rapids mean monthly discharge for the open water season (Station 05DE001).

### 5.5.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

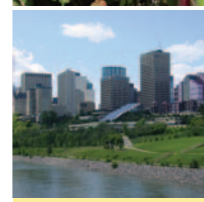
#### 5.5.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



A systematic examination has not been conducted of macrophytes in the Modeste Subwatershed; however, inventories were completed in several lakes as part of fisheries inventories completed by R.L. & L. in 1986. The inventory of Wabamun Lake (R.L. & L. 1987a) found aquatic macrophytes throughout the photic (shallow) zone of the lake. The main species of emergent vegetation were greater bulrush, common cattail, reed grass and sedge. The most abundant submerged macrophytes were northern watermilfoil, Richardson pondweed, stonewort, and large-sheath pondweed.




Similar emergent macrophytes were found in Mayatan Lake. In addition, arrowhead was reported. Among the submergent vegetation species in Mayatan Lake, the most abundant were stonewort, northern watermilfoil and large-sheath pondweed. In addition, sago pondweed was abundant (R.L. & L. 1987b).

Aquatic vegetation also was found throughout the photic (shallow) zone of Jackfish Lake. The most abundant emergent vegetation species were sedge, common cattail, greater bulrush, arrowhead and reed grass. The most common species of submergent macrophytes were stonewort, northern watermilfoil, sago pondweed and large-sheath pondweed (R.L. & L. 1987c).

### 5.5.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity.

The North Saskatchewan River in this Subwatershed is transitional from cold water to cool water fish habitat and contains a wide variety of fish species. Some streams in the Subwatershed also provide cool water fish habitat. Fish species in the North Saskatchewan River include pike, walleye, sauger, goldeye, mountain whitefish and bull trout as well as longnose, white, mountain and northern redhorse suckers and burbot. In lakes in the Subwatershed, walleye, pike, yellow perch, lake whitefish, longnose and white suckers and burbot are generally the most abundant species (Allan 1984, R.L. & L. 1987 a, 1987b, 1987c).

Buck Lake contains walleye, pike, yellow perch, lake whitefish, longnose and white suckers and burbot. Wabamun Lake supports a mix of cool water species with lake whitefish, pike, yellow perch, and white suckers being the most abundant (Allan 1984). R.L & L. (1987a) caught white sucker, burbot, yellow perch and northern pike and minnow species in beach seines. Brook stickleback were collected in seine hauls in Mayatan Lake. Yellow perch and northern pike have been reported from the lake but severe winter kills since may have eliminated these populations (R.L. & L. 1987b). Northern pike and yellow perch were caught in gill nets or seines and walleye have been reported from Jackfish Lake (R.L. & L. 1987c).

### 5.5.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Modeste Subwatershed lies in the Foothills Region and Boreal Forest Region of Alberta. The Foothills Region is split into the upper foothills and the lower foothills. The upper foothills region includes species such as white spruce, black spruce, lodgepole pine and subalpine fir. The lower foothills are composed mainly of mixed forests, featuring white spruce, black spruce, lodgepole pine, balsam fir, aspen, balsam poplar and paper birch. Fens are very common in the lower foothills as well. The Boreal Forest Region includes many areas of bogs, fens, swamps and marshes. The Dry Mixedwood Subregion, within the Boreal Forest Region, includes species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, along with many peatland areas.

### 5.5.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality.

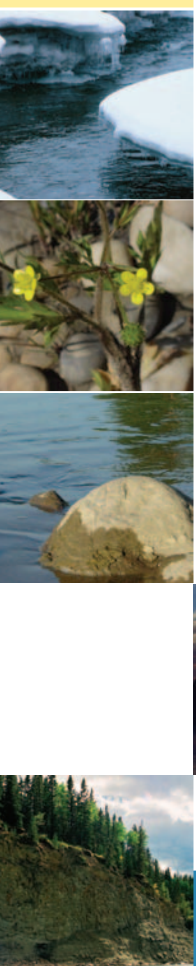


Alberta Environment conducted surveys of benthic invertebrates in the North Saskatchewan River between 1973 and 1977. Data were summarized in a report by Reynoldson and Exner (1978). One sampling site was at Drayton Valley. The authors concluded that upstream of the City of Edmonton there was little change in the species diversity or total numbers of macrobenthic fauna from year to year or season to season. The site at Drayton Valley also showed less variability in both diversity and standing crop compared to sites downstream of Edmonton. The main invertebrate groups at river stations upstream of Edmonton, over a five year sampling time frame, were Chironomidae (Midges), which made up 38.4% of the samples, Ephemeroptera (Mayflies), 31.7% and Plecoptera (Stoneflies), 20.0%. The remainder of the sample was Trichoptera (Caddisflies), 4.9% and Oligochaeta (Earthworms), 0.5%.

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

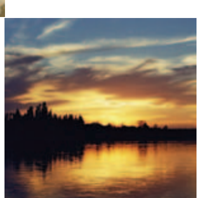
### 5.5.4 Modeste Summary

The majority of the lands in the Modeste Subwatershed are used for agricultural production and only about 19% of the area is treed. The Subwatershed includes several towns and First Nation's Reserves, which cover about 2% of the land area, and discharge treated wastewater to local creeks. The economic base is primarily oil and gas, with agriculture, forestry activity, and strip mines to supply coal to local power plants. Water bodies cover about 4% of the Subwatershed and lakes are popular for recreational uses. Data from different sources show wetlands accounting for less than 1% to 4.3% of the Subwatershed area. These data do not include peatlands, which are abundant in some parts of the Subwatershed.



More than 3.5% of the land area has been affected by linear developments including roads, pipeline rights of way, cutlines trails, transmission line rights of way and rail lines. In addition, oil and gas wellsites, sand and gravel pits, open pit mines, and power stations have disturbed about 3% of the land area.

Livestock densities generally are moderate and no long-term river water quality information exists for the Subwatershed. However, water quality monitoring on Tomahawk Creek in an area of "moderate" agricultural intensity showed very high fecal coliform counts, low flows, and high particulate phosphorus concentrations. These conditions resulted in marginal to fair Water Quality Index Score as determined by Alberta Agriculture, Food and Rural Development. In addition, studies on Lake Wabamun have shown changes in water and sediment quality due to industrial impacts when compared to other Alberta lakes.



Water quantity is measured at seven stations in the Subwatershed: two have real-time online data.

No published assessment of riparian health was found for the Subwatershed and a systematic examination of aquatic plants in the Subwatershed has not been done; although, inventories have been completed in several lakes. Inventories of fish species have been conducted on several lakes in the Subwatershed but no published summary of fish populations was found.




Surveys of benthic invertebrates in the North Saskatchewan River at Drayton Valley concluded that upstream of the City of Edmonton there was little change in the species diversity or total numbers from year to year or season to season. A benthic invertebrate survey in Wabamun Lake indicated some effects due to the Wabamun Power Plant and the Wabamun Lake Water Treatment Plant. The differences were slight and not indicative of a toxic effect; however, signs of mild nutrient enrichment were apparent.

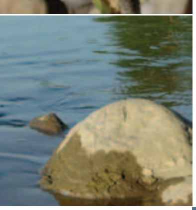
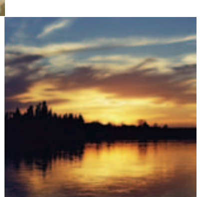
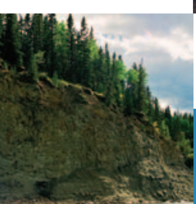
There has been little systematic assessment of the Subwatershed. However, of the 10 indicators assessed, none were good, six were fair, and four were poor, yielding an overall subjective rating of fair. The available information suggests that various human activities such as agriculture in the Subwatershed may be having an impact on water quality in local waterbodies. The Modeste Subwatershed has a moderate level of development of agricultural and industrial activities and a relatively high amount of disturbance. The data gaps should be addressed given the potential for impacts to the Subwatershed.



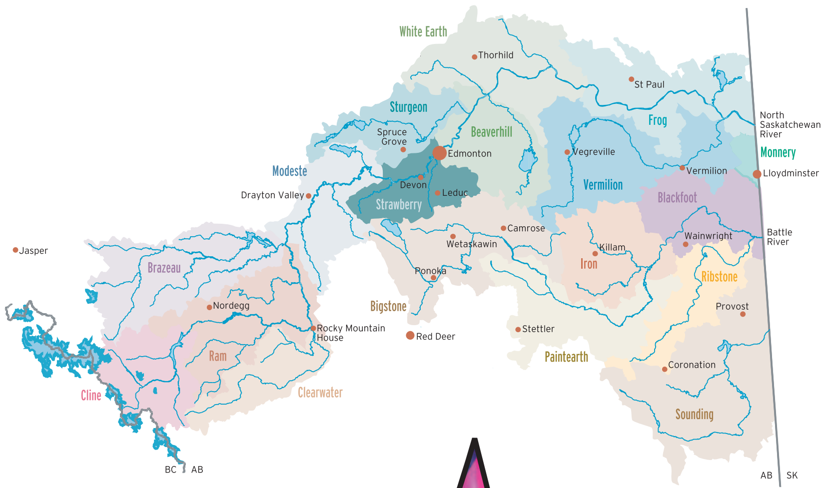


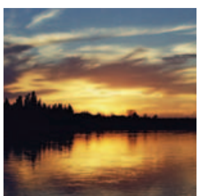


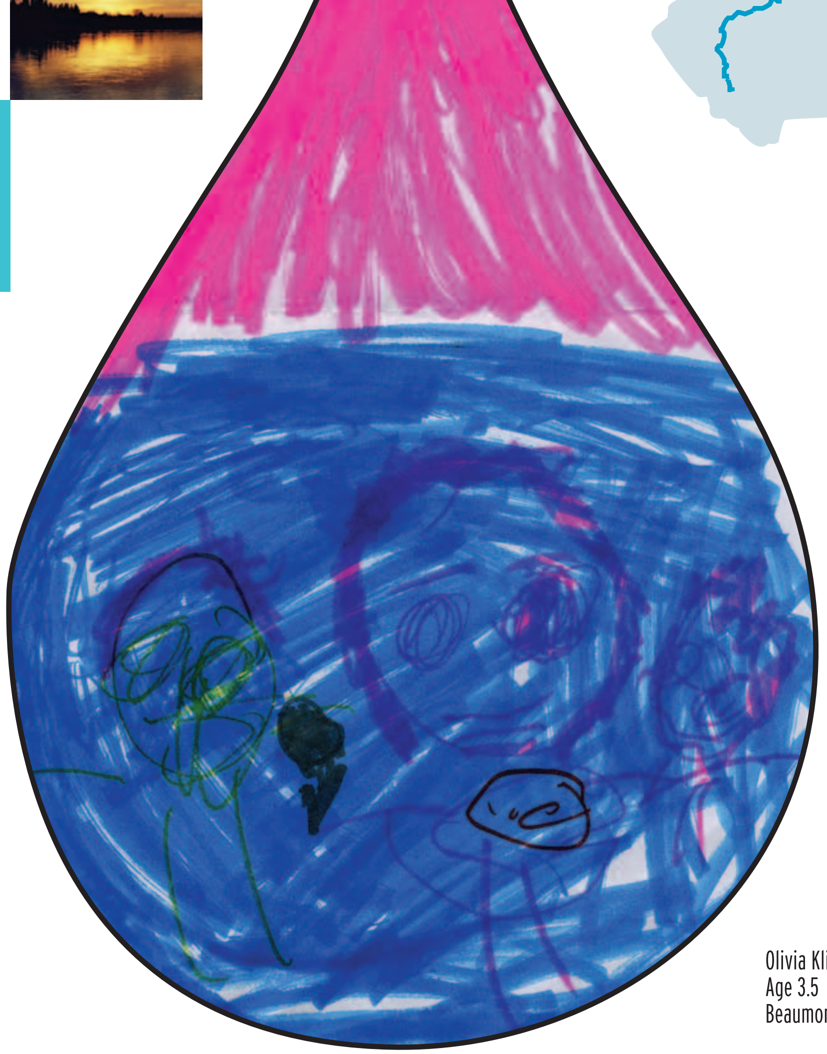


# Strawberry





Olivia Klimosko
Age 3.5
Beaumont




## 5.6 STRAWBERRY SUBWATERSHED

The Strawberry Subwatershed lies in both the Boreal Forest and Parkland Natural Regions and encompasses 299,662 hectares including 5,240 hectares of natural and artificial water bodies. The Strawberry Subwatershed includes the municipal boundaries of Leduc, Parkland, Strathcona and Wetaskiwin Counties and the settlements of Beaumont, Buford, Calmar, Devon, Edmonton, Kavanagh, Leduc, Looma, New Sarepta, Nisku, Rolly View, St. Albert, Sunnybrook, Telfordville, Thorsby, Warburg and the Stony Plain First Nations Reserve 135.

Most of the regional landmass is covered by forests or has been developed for agriculture, but there are also large oil and gas reserves in the area. As a result, the main economic base is oil and gas extraction and agriculture, including both beef and dairy cattle.

Many of the indicators described below are referenced from the “Strawberry Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.6.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.6.1.1 Riparian Health



The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. Several creeks have been assessed in the Strawberry Subwatershed by Leduc County and Cows and Fish.

Riparian assessment data were collected for Conjuring Creek in 2003 (ARHMP Cows and Fish, unpublished data). Of the 14 quadrats sampled, 72% were considered healthy, 7% were healthy with problems, and 21% scored in the unhealthy range. The only major problem noted was the presence of the noxious weeds Canada Thistle and Common Tansy. Other problems that were identified included narrow buffer strips, the over-utilization of trees and shrubs, poisonous plants, and the presence of old feeding sites with bare ground and introduced species.

Riparian assessment data were collected for Weed Creek in 2003 (ARHMP Cows and Fish, unpublished data). Of the 16 quadrats sampled, 63% were considered healthy, 31% were healthy with problems, and 6% scored in the unhealthy range. The only major problem noted was the presence of the noxious weeds Canada Thistle, Scentless Chamomile and Common Tansy. Bare ground at crossings and heavily grazed areas, and introduced species with insufficient root mass to protect banks were major concerns. Heavy utilization of poplar and willow, and grasshopper pressure on open areas were also problems.

Riparian assessment data were collected for Cache Creek in 2003 (ARHMP Cows and Fish, unpublished data). Of the 2 quadrats sampled, 50% were considered healthy, 50% were healthy with problems. The major problem noted was the presence of the noxious weeds Canada Thistle and Scentless Chamomile.



Riparian assessment data were collected for Willow Creek in 2003 (ARHMP Cows and Fish, unpublished data). Of the 3 quadrats sampled, 100% were considered healthy. The only major problem noted was the presence of the noxious weeds Canada Thistle, Scentless Chamomile and Common Tansy. ATV use had left trails with bare ground that was susceptible to erosion, and some litter was also present.

Riparian assessment data were collected for Strawberry Creek in 2002 (ARHMP Cows and Fish, unpublished data). Of the 19 quadrats sampled, 62% were considered healthy, 24% were healthy with problems, and 14% scored in the unhealthy range. The only major problem noted was the presence of the noxious weeds Canada Thistle and Scentless Chamomile.

Riparian assessment data were collected for Sunnybrook Creek in 2002 (ARHMP Cows and Fish, unpublished data). Of the 7 quadrats sampled, 86% were considered healthy, 14% were healthy with problems. The only major problem noted was the presence of the noxious weeds Canada Thistle and Perennial Sow Thistle.

#### 5.6.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

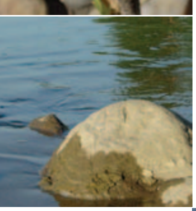
Almost 4% (11,395 ha) of land in the Strawberry Subwatershed is taken up by linear developments. The majority of this (55%) is in roads of one form or another, including gravel and unimproved roads (52%) and paved roads (48%). Other linear developments include pipeline rights of way, (25% of the area of linear developments), cutlines (6%), transmission line rights of way (11%), and active or abandoned rail lines (3%).

#### 5.6.1.3 Land Use Inventory

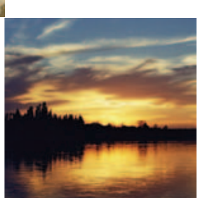
An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health.

About 19% of the land area in the Subwatershed has been disturbed by various forms of development; most of this disturbance (11% of the Subwatershed) is due to municipalities of various sizes; including Beaumont, Devon, Leduc, and Nisku. The remainder of the land disturbance is related to linear developments (4%), wellsites (2%), and industrial sites. The First Nation Reserve 135 covers an area of about 5,200 ha (less than 2% of the Subwatershed area).

Water bodies, both natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover less than 2% of the Subwatershed. The vast majority of the Subwatershed is classified into various land uses related to agricultural production: forage, 54%; cropland, 23%; and grassland, 10%. The treed area of the Subwatershed is about 3.5% (10,399 ha), while 69% of the Subwatershed lies in a Provincial FMU.

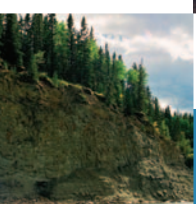


#### 5.6.1.4 Livestock Density



Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems.

Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the






Subwatershed boundaries and provide only a rough estimate of manure production within the actual watershed. Based on the available information, livestock densities in the Strawberry Subwatershed are moderate. Manure production in the soil polygons that cover the Strawberry Subwatershed was estimated at between 1,194,000 and 3,246,000 tonnes.

#### 5.6.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. In the Strawberry Subwatershed, wetlands were not identified from either the PFRA Land Classification data or the Alberta Sustainable Resources Development base features hydrology data. However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 70,454 hectares of wetlands (23.5% of the Subwatershed area). The inventory included both permanent and temporary wetlands.

As part of their policy, the City of Edmonton is working hard to conserve remaining natural wetlands and upland areas that exist within its boundaries. Where possible, natural wetlands are incorporated into drainage infrastructure for natural stormwater management benefits and water quality benefits that wetlands provide. Whether or not they are drawn into the City's drainage infrastructure, conservation of wetlands is a high priority. Constructed stormwater management facilities comprise an important part of modern drainage infrastructure for all new urban developments. It is also City policy that new stormwater management facilities are planned and implemented as constructed wetlands for their water quality benefits. Dry and wet ponds are no longer encouraged as part of new development.

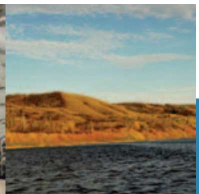


### 5.6.2 Water Quality and Quantity

Water bodies in the Strawberry Subwatershed include the North Saskatchewan River, and the Whitemud, Blackmud, Conjuring, and Strawberry Creeks. Larger lakes in the Subwatershed include Wizard, Looking Back, Saunders, Telford, Ord, Cawes, Frog, Kinokamau and Levering Lakes. ALMS Lakewatch data for Wizard Lake exists for 1996. Water quality for Wizard Lake can also be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990). The Devon Watershed Alliance is an active watershed stewardship group in this Subwatershed.

Water quality is monitored regularly on the main stem of the NSR by Alberta Environment at Devon under the long-term river network (LTRN) program. In 2001, the SWQI for metals, nutrients, bacteria and pesticides all rated good (Alberta Environment, 2004). In the prior five-year period, all parameters were excellent or good, except for nutrients in 1998-99 and 1999-2000, which had a fair rating (Table 3). Fair nutrient ratings resulted from instances of high nutrient concentrations during the spring runoff period. Concentrations of total phosphorus (TP) ranged from 0.64 to 0.0015 mg/L, total nitrogen (TN) ranged from 2.422 to 0.01 mg/L. The decreasing trend through time may suggest that water quality is deteriorating due to increased development and land practices upstream of this sampling location. However, this decrease may be within the natural variation seen in water quality as it related to lower flow events, as has been experienced with recent drought conditions.







Numerous samples for TP and fecal coliforms have been taken from the upstream portion of the North Saskatchewan River during the years 1997-2002 (upstream samples include those coming into the city from the west and up to the intake of the Rossdale water treatment plant). The 324 fecal coliform samples taken upstream from the water treatment plant ranged from 0 to 250 counts/100mL, and averaged 13 counts/100mL. Some of these samples are above the CCME Guidelines for Contact Recreation. The 120 samples taken for TP ranged from 0 to 0.64 mg/L, and averaged 0.028 mg/L. Pesticide detections in this Subwatershed included 2,4-D, Dicamba, MCPA, MCPP and Picloram, all of which were below the Guidelines for the Protection of Aquatic Life. Other compounds detected include monochloroacetic acid, as well as Triclopyr. Currently, there are no existing water quality guidelines for either of these chemicals.

Seven sites along Strawberry Creek were sampled for fecal coliforms and TP during the years 1994-2002. The 18 fecal coliform samples ranged from 0 to 44,000 counts/100 mL, and averaged 1109 counts/100 mL. Most of these results exceed the CCME Surface Water Quality Guidelines for Contact Recreation. The 18 TP samples ranged from 0.011 to 3.15 mg/L, and averaged 0.311 mg/L. Pesticide detections in this Subwatershed included 2,4-D, Bromoxynil, MCPA, MCPP, Dicamba and Picloram, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. Also detected were the pesticides Alpha-BHC, Imazamethabenz-methyl, Clopyralid, and Triclopyr, but there are currently no water quality guidelines for these compounds.

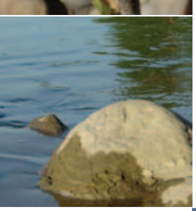


**Table 3:** ASWQI Devon, Alberta in the Strawberry Subwatershed

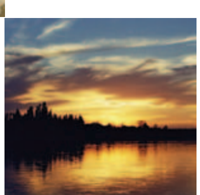
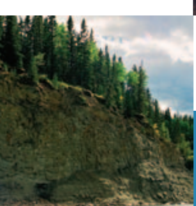
| Index Period | Metals | Nutrients | Bacteria | Pesticides |
|---|---|---|---|---|
| 1996 - 1997 | E | G | E | G |
| 1997 - 1998 | E | G | E | E |
| 1998 - 1999 | E | F | E | E |
| 1999 - 2000 | G | F | G | G |
| 2000 - 2001 | G | G | G | G |

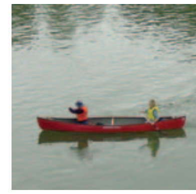
[1]Alberta Surface Water Quality Index (ASWQI) ratings: E = Excellent, G = Good, F = Fair, P = Poor





Water quality data is collected by EPCOR Water Services at both E.L. Smith and Rossdale water treatment plant intakes. E.L. Smith data shows pesticide concentrations below detection for all compounds analyzed (e.g. carbamates and glyphosate; Table 4), and low mean fecal coliform counts with episodic high counts (Table 5).



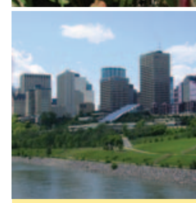



**Table 4:** Pesticide data collected by EPCOR Water Services 1999-2003 in the Strawberry Subwatershed[2]

| Year | Number of Samples Taken | Number of Compounds Analyzed | Number of Compounds Below MDL |
|---|---|---|---|
| 1999 | 2 | 1 | 1 |
| 2000 | 2 | 14 | 14 |
| 2001 | 3 | 30 | 30 |
| 2002 | 2 | 28 | 28 |
| 2003 | 4 | 51 | 51 |

[2] Data provided by EPCOR Water Services, August 2004. MDL=Minimum detection limit.

**Table 5:** Fecal coliform counts in raw water at EL Smith intake, 1998-2003[3]

| | 1999 | 2000 | 2001 | 2002 | 2003 | All years |
|---|---|---|---|---|---|---|
| Mean | 5 | 9 | 8 | 6 | 9 | 7 |
| Maximum | 160 | 2200 | 900 | 260 | 350 | 2200 |
| Minimum | 1 | 1 | 1 | 1 | 1 | 1 |

[3] Data provided by EPCOR Water Services, August 2004.



The City of Edmonton (population 850,000) and surrounding areas serviced by EPCOR Water Services has the largest attributable impact on the North Saskatchewan River's water quality due to return water flows of treated wastewater and urban stormwater runoff. Treated wastewater from the Gold Bar and Capital Region wastewater treatment plants are major sources of BOD (biological oxygen demand), fecal coliform bacteria and nutrients (nitrogen and phosphorus), while 238 stormwater outfalls from all areas of the City add suspended solids to the river (Figure 13) (See Map Pocket, or CD-ROM for Figure 13). Combined sewer overflows are a major source of fecal coliforms (River Water Quality Taskforce 1996). There are currently 19 combined sewer overflows that discharge to the North Saskatchewan River, and the City of Edmonton is working towards completing an impact reduction strategy by 2016.

Municipalities in the Subwatershed have wastewater treatment plants and detention lagoons from which treated effluents release into the North Saskatchewan River or its tributaries. The Devon wastewater treatment plant chlorinates its treated effluents before discharging to the North Saskatchewan River. Thorsby and Warburg have detention lagoons; Thorsby discharges into Weed Creek and Warburg into Strawberry Creek. The Genesee Power Plant, near Warburg, has a reservoir for cooling water, which is filled from the North Saskatchewan River.

Riverwatch (www.riverwatch.ab.ca) occasionally monitors water quality at four sites along the river within the town of Drayton Valley, at seven sites within the City of Edmonton on the "Aqualta run", and at nine sites on the "Gold Bar run". Riverwatch can be contacted directly for their data.

Strawberry Creek was part of the CAESA stream network as a site in an area of high agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-1996 (CAESA 1998).





The channel of the North Saskatchewan River in this Subwatershed has a mean width of approximately 135 metres and a mean depth of 1.4 metres. The channel is irregularly meandering with point and side bars and is entrenched in a stream cut valley. Upstream regulation from the Bighorn and Brazeau dams has modified flows.

Water quantity is measured at six HYDEX stations (05DF001-05DF004, 05DF006-05DF007), two of which have real-time online data (05DF001 and 05DF004). Station 05DF001 is located on the Low Level Bridge in Edmonton (Table 6). Figure 14 shows the Blackmud Creek hydrograph, which is typical of a non-glacial fed stream. Flow contributions are from spring runoff and summer storms only.

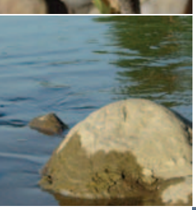
**Table 6:** Daily mean flow ($m^3/s$) for the North Saskatchewan River at Edmonton, Station 05DF001[4]

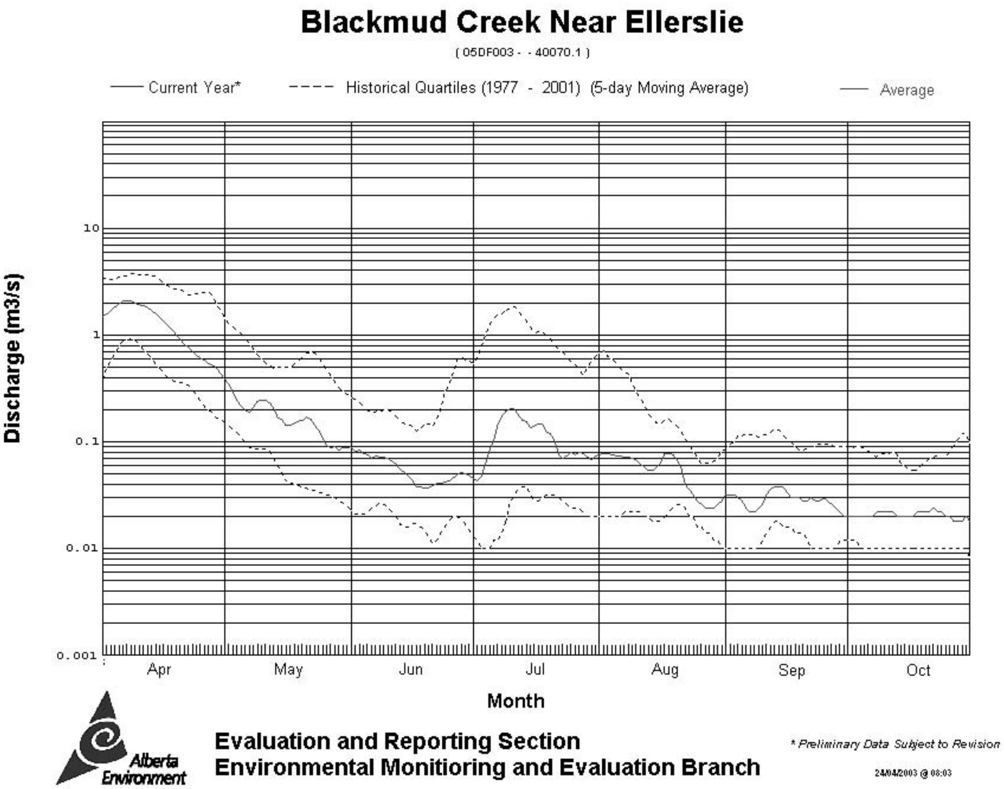
[4] Data provided by EPCOR Water Services, August 2004.

| | 1999 | 2000 | 2001 | 2002 | 2003 | All years |
|---|---|---|---|---|---|---|
| Mean | 237 | 165 | 145 | 147 | 201 | 178 |
| Maximum | 1500 | 778 | 846 | 360 | 774 | 1500 |
| Minimum | 65 | 64 | 43 | 71 | 81 | 43 |









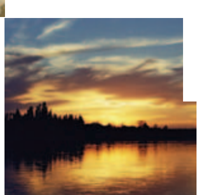
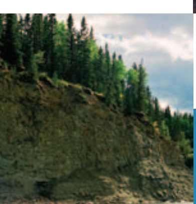



**Figure 14:** Blackmud Creek near Ellerslie mean monthly discharge for the open water season (Station 05DF003).








### 5.6.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.6.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices. No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Strawberry Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Strawberry Subwatershed.

#### 5.6.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Cool water fish species such as pike, walleye and goldeye are common or seasonally abundant. Other cool water species including sauger, mooneye, yellow perch, lake sturgeon, and cold water species such as mountain whitefish and bull trout are occasionally found in this reach of the North Saskatchewan River.

#### 5.6.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Strawberry Subwatershed is located in both the Boreal Forest Region and the Parkland Natural Region of Alberta. The Boreal Forest Region includes many areas of bogs, fens, swamps and marshes, as well as the Dry Mixedwood Subregion. The Dry Mixedwood Subregion includes species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and has many peatland areas. The Parkland Natural Region is the transition region between grasslands and coniferous forests. It includes one subregion, the Central Parkland, which is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Species include trembling aspen and balsam poplar.

#### 5.6.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes in the presence and abundance of species that may be related to changes in water quality.

Alberta Environment surveyed benthic invertebrates in the North Saskatchewan River between 1973 and 1977. Data were summarized in a report published in 1978 (Reynoldson and Exner 1978). One sampling site was located at Devon, Alberta. The authors concluded that upstream of the City of Edmonton there was little change in the species diversity or total numbers of macrobenthic fauna from year to year or season to season. The upstream site also showed less variability in both diversity and standing crop compared to sites downstream of Edmonton. The main invertebrate groups in five years of sampling at Devon were Chironomidae (38.4%),



Ephemeroptera (Mayflies - 31.7%) and Plecoptera (Stoneflies - 20.0%). The remainder of the sample was Trichoptera (Caddisflies - 4.9%) and Oligochaeta (Earthworms - 0.5%).



### 5.6.4 Strawberry Summary

The Strawberry Subwatershed includes several towns and municipalities, parts of the City of Edmonton, and a First Nations Reserve. The vast majority of the Subwatershed is under heavy agricultural production, and only 3.5% of the Subwatershed is treed. Based on the available information, livestock densities in the Strawberry Subwatershed are moderate to high in the southern portion of the Subwatershed. There are also large oil and gas reserves. As a result, the main economic base is oil and gas exploration and processing, and agriculture.

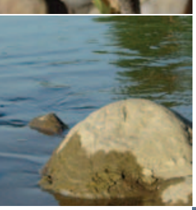
Almost 4% of land area is taken up by linear developments including roads, pipeline rights of way, cutlines, transmission line rights of way, and rail lines. An additional 19% of the Subwatershed has been disturbed by municipalities of various sizes, wellsites, and industrial sites. Water bodies cover less than 2% of the Subwatershed.

Data from both the Alberta Sustainable Resources Development base features hydrology and PFRA Land Classification showed no wetlands in the Subwatershed; however, a Ducks Unlimited Canada inventory found that wetlands covered 23.5% of the land area. These important discrepancies must be resolved during the development of a management plan.

Water quality is monitored regularly by Alberta Environment at Devon. In 2001, the Alberta Surface Water Quality Index for metals, nutrients, bacteria and pesticides all rated good. This was an improvement in nutrient levels over the rating for the two previous years, but generally a decrease in rating for metals, bacteria and pesticides. Further examination of the data is needed to determine if the changes in ratings are significant.

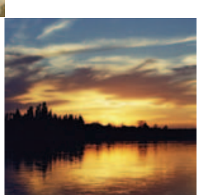
Treated wastewater from the Gold Bar and Capital Region wastewater treatment plants and stormwater runoff from the City of Edmonton are major sources of contaminants in the Subwatershed; although, the quality of these effluents has improved in recent years.



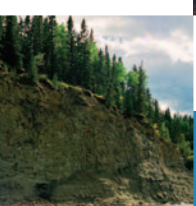


Water quantity is measured at six stations, two have real-time online data.

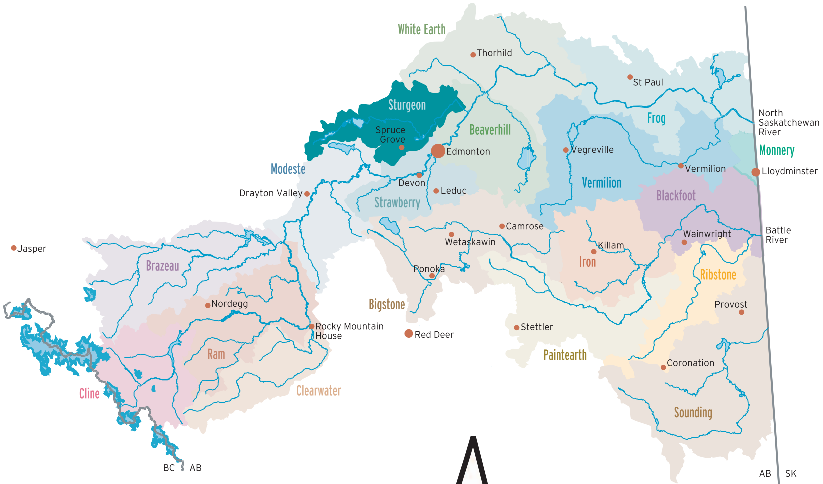
No detailed population assessments were found for fish species in the Subwatershed, nor was a systematic examination of riparian health, aquatic plants or benthic invertebrates found for the lakes, creeks, rivers and streams of the Strawberry Subwatershed. Surveys of benthic invertebrates in the North Saskatchewan River at Devon concluded that upstream of Edmonton there was little change in the species diversity or total numbers of macrobenthic fauna from year to year or season to season. However, of the eleven indicators assessed, three were good, three were fair, and five were poor, yielding an overall subjective rating of poor.  Given that the above are recognized as important indicators of ecological health, these data gaps should be addressed in future research in the Strawberry Subwatershed.

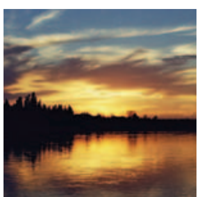


Given the high degree of linear development in the Subwatershed and the intensity of agriculture, there is a significant potential for additional development to have an impact on this Subwatershed. The available data indicate a possible decline in water quality upstream of Edmonton. The significance of potential changes in water quality should be assessed. The conflicting information on the area of wetlands in the Subwatershed must also be resolved.

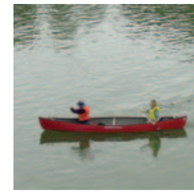


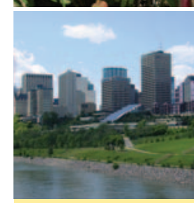
# Sturgeon



Bryan Smith
Age 7
Edmonton





## 5.7 STURGEON SUBWATERSHED

The Sturgeon Subwatershed lies in the Parkland and Boreal Forest Natural Regions and encompasses 331,764 hectares including 15,813 hectares of natural and artificial water bodies. The Sturgeon Subwatershed includes the municipal boundaries of Barrhead, Lac Ste. Anne, Parkland and Sturgeon Counties and the communities of Spruce Grove, Stony Plain, Onoway, Morinville, Bon Accord, Gibbons, Calahoo, Villeneuve, Spring Lake, the First Nations' reserves of Alexis 133 and Alexander 134 and parts of the City of Edmonton and St. Albert.

The Subwatershed contains Class 1 soils which makes this some of the most arable agricultural land in Alberta. However, this area is strongly impacted by urban development. Those areas in the Subwatershed that are not developed for municipal uses are mostly agricultural land with areas in boreal mixedwood forests and muskeg. As a result, the main economic base is agriculture along with oil and gas production, processing and aggregate extraction.

Several lakes in the Subwatershed provide a high amount of recreational activity including power boating, sailing, water skiing, and windsurfing. Camping and cross-country skiing are also common.

Many of the indicators described below are referenced from the "Sturgeon Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.7.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.7.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Sturgeon Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Sturgeon Subwatershed.

#### 5.7.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

More than 3% (10,901 ha) of the land in the Sturgeon Subwatershed is taken up by linear developments. The majority of this (56%) is in roads of one form or another, mostly paved undivided roads and gravel roads. Other linear developments include pipeline rights of way, (17% of the area of linear developments), cutlines and seismic lines (13%), utilities (non-pipeline) rights of way and used or abandoned rail lines (4%).



### 5.7.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies that are natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover just over 5% of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: cropland, 31%; forage, 25%; and grassland, 22%. Only 11% of the Subwatershed is treed.

Almost 71% of the land area has been disturbed by various forms of development; the vast majority (94%) of this disturbance is due to municipalities of various sizes; mainly the large urban centres of Spruce Grove, Stony Plain, St. Albert, Morinville and Edmonton. The remainder of the land disturbance is related to linear developments, wellsites, and industrial sites and gravel mining.

### 5.7.1.4 Livestock Density

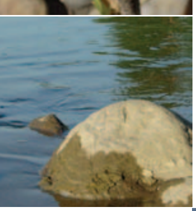
Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems.

Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual watershed. Based on the available information, livestock densities in the Sturgeon Subwatershed are moderate. Manure production in the soil polygons that cover the Sturgeon Subwatershed was estimated at between 1,194,000 and 3,246,000 tonnes.

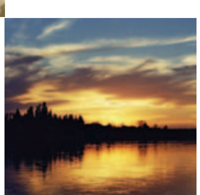
### 5.7.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Alberta Sustainable Resource Development base features hydrology data shows that wetlands account for a fraction of 1% (2,956 ha) of the land area in the Sturgeon Subwatershed. However, another inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 22,582 hectares of wetlands (6.8% of the Subwatershed area). The DUC inventory included both permanent and temporary wetlands. The Big Lake wetland near the city of St. Albert has been designated under Special Places 2000 as one of the top ten Alberta wetlands under Wetlands for Tomorrow. This wetland is also recognized as a Globally Significant Important Birding Area because of the number and diversity of avian species using the area for breeding, migration and staging.

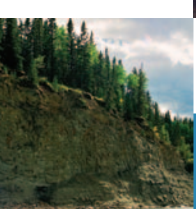
### 5.7.2 Water Quality and Quantity



Water bodies in the Sturgeon Subwatershed include the Sturgeon River, and Lac Ste. Anne, Isle, Sandy, Big, Manawan, Deadman, Birch, Big, Eden, Sauer, Hubbles, Spring, Muir, Round and Matchayaw (Devil) Lakes. The Lac Ste. Anne and Lac Isle Water Quality Society, the Onoway River Valley Conservation Association and the Sandy Lake Restoration Society are all active community watershed groups in this Subwatershed. Lakewatch data for Lac Ste. Anne (2002), Isle Lake (2000 and 2001) and for Sandy Lake (2000 and 2001) are available from ALMS. Water quality for Lac Ste. Anne, Sandy, Isle, Eden, Sauer, Hubbles and Spring Lakes can be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990). Big Lake Environmental Support Society (BLESS) is an active advocate for Big Lake.



No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality



data has been summarized. However, Atim Creek was part of the CAESA stream network as a site in an area of high agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-1996 (Anderson *et al.* 1998).

Thirty-one different stations along the Sturgeon River were sampled for fecal coliforms and TP over the years 1971-77, 1983-2000, and 2002-2004. The 41 fecal coliform samples ranged from 0 to 110 counts/100 mL, and averaged 19 counts/100 mL. These samples were below the CCME Surface Water Quality Guidelines for Contact Recreation. The 784 TP samples collected ranged from 0 to 3.5 mg/L, and averaged 0.195 mg/L. Pesticide detections in this Subwatershed included 2,4-D, Gamma-benzenehexachloride (Lindane), Atrazine, Bromoxynil, Dicamba, MCPA, MCPP, Picloram, Triallate, and Trifluralin, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. Imazamethabenz-methyl, Imazethapyr, Triclopyr, Clopyralid, Ethalfluralin, and Gamma-BHC were detected, but no guidelines have been set for these chemicals to date.

Water quantity is measured at seven HYDEX stations (05EA001-05EA005, 05EA009-05EA010) with one station having real-time online data (05DEA005). Figure 15 shows the Atim Creek hydrograph, which is typical of a non-glacial fed stream. Flow contributions are from spring runoff and summer storms only.

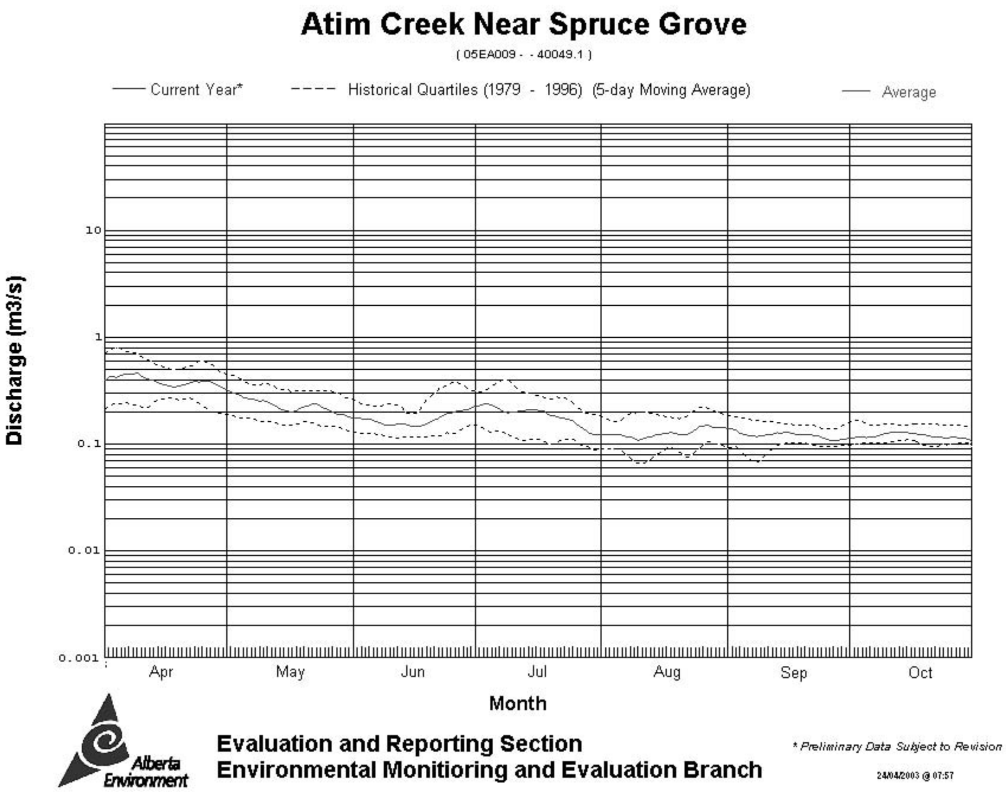



**Figure 15:** Atim Creek near Spruce Grove mean monthly discharge for the open water season (Station 05EA009).



## 5.7.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

### 5.7.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

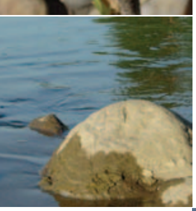
A systematic examination of macrophytes in the Sturgeon Subwatershed has not been conducted; although inventories have been completed on several lakes. For example, an inventory of macrophytes in Lake Isle was completed as part of a fisheries inventory by R.L. & L. (1987d). The inventory found that aquatic macrophytes occurred throughout the photic zone of the lake. Greater bulrush, common cattail, sedge and reed grass were the most abundant emergent species. Northern watermilfoil, Richardson pondweed, large-sheath pondweed and coontail were the most abundant submergent species.

### 5.7.3.2 Fish Population Estimates



Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity.

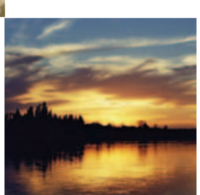




Fish species in the Subwatershed include lake whitefish, northern pike, walleye, burbot, white sucker, goldeye, and yellow perch. The lower 24 kilometres of the Sturgeon River are seasonally occupied by common North Saskatchewan River species such as northern pike, walleye, sauger, and goldeye. The remainder of the Sturgeon River is occupied primarily by pike, the occasional walleye, perch or lake whitefish that have entered the river from one of the larger lakes. Emigration from the North Saskatchewan River and the main stem lakes into the Sturgeon River, particularly by pike, is an important mechanism for repopulating the main river (Allan 1984).

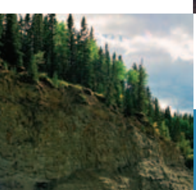
The Sturgeon River is subject to considerable fluctuations in discharge; zero flows have been frequently recorded, reducing its capability to support fish. Shallow lakes in the Subwatershed may be subject to winter kill and can be described as eutrophic. The rate of eutrophication may have been accelerated by adjacent land use practices that add nutrients into the water (Allan 1984).

Sport fish in Lake Isle include northern pike, yellow perch, walleye; although white suckers account for most of the fish biomass. Other lakes in the Subwatershed typically contain northern pike and yellow perch, but some lakes are subject to winter kill (Allan 1984).



### 5.7.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Sturgeon Subwatershed is located mainly in the Parkland and Boreal Forest Regions of Alberta. The Boreal Forest Region includes







many areas of bogs, fens, swamps and marshes, as well as the Dry Mixedwood Subregion. The Dry Mixedwood Subregion includes species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and has many peatlands. The Parkland Natural Region is the transition region between grasslands and coniferous forests. It includes one subregion, the Central Parkland, which is composed mainly of grassland with aspen, aspen parkland and closed aspen forest. Species include trembling aspen and balsam poplar.

#### 5.7.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality.

No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Sturgeon Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Sturgeon Subwatershed.

### 5.7.4 Sturgeon Summary

The Sturgeon Subwatershed includes several towns, Reserves as well as parts of the City of Edmonton. Almost 71% of the land area has been disturbed by various forms of development; the vast majority due to municipalities and the remainder related to linear developments, wellsites, and industrial sites.

The Subwatershed also contains some of the most arable agricultural land in Alberta and those areas not developed for municipal uses are mostly agricultural land with only about 11% of the Subwatershed treed. Livestock densities in the Sturgeon Subwatershed are moderate. The main economic base is agriculture along with oil and gas production and processing. Several lakes in the Subwatershed provide a high amount of recreational activity.

No long term river water quality information exists for this Subwatershed. Water quantity is measured at seven stations, with one station having real-time online data.

Water bodies cover just over 5% of the Subwatershed. The available data showed that wetlands accounted for between less than 1% and 6.8% of the Subwatershed area. The differences in the estimate of wetland area may be resolved with future research. Peatlands are also abundant in areas of the Subwatershed.

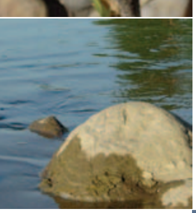
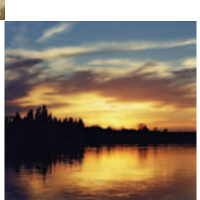
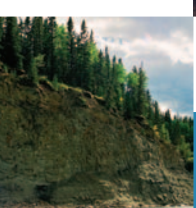
No published assessment of riparian health, benthic invertebrates or aquatic plants was found for the Sturgeon Subwatershed. While a systematic examination of aquatic plants has not been conducted, inventories have been completed on several lakes. Detailed assessments of fish populations have not been done. However, of the nine indicators assessed, two were good, five were fair, and two were poor, yielding an overall subjective rating of fair. As all of the above have been identified as important biological indicators, studies could be undertaken on the lakes, reservoirs, creeks, streams and rivers in the Subwatershed to gain a better understanding of Subwatershed health.

In summary, there has been little systematic assessment of the Sturgeon Subwatershed and there are some data gaps that should be addressed. Given the high percentage of the Subwatershed area that is affected by municipal and agricultural development, it is important to address these data gaps to assess the net impact of various land uses on the Subwatershed. Municipal development decisions should consider the value of prime agricultural lands to the agriculture industry and where possible, explore alternatives.

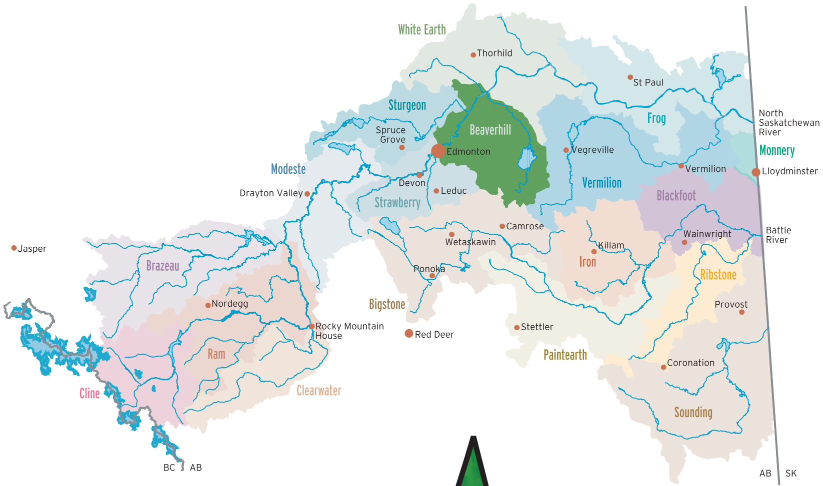


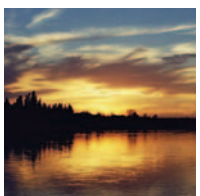




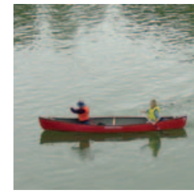




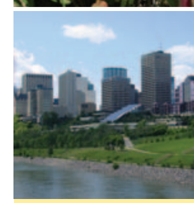
# Beaverhill



Elizabeth Orr
Age 7
Elk Point



## 5.8 BEAVERHILL SUBWATERSHED

The Beaverhill Subwatershed lies in the Boreal Forest and Parkland natural regions and encompasses 440,544 hectares including 39,532 hectares of natural and artificial water bodies. Much of this area is an extensively treed, upland area consisting of rolling to hummocky terrain with knob and kettle topography that supports a high diversity of vegetation, waterfowl, mammals and birds. The area is rich in natural wetlands and aspen dominated Boreal mixedwood habitat.

This Subwatershed contains a combination of ecologically significant natural areas and centers of high urban activity. The Beaverhill Subwatershed includes the municipal boundaries of Camrose, Leduc, Lamont, Strathcona and Sturgeon Counties and Elk Island National Park and Miquelon Provincial Park lie completely within the Subwatershed. Municipalities in the subwatershed include all or parts of the Cities of St. Albert, Edmonton and Fort Saskatchewan. Other towns and hamlets include Antler Lake, Ardrossan, Bruderheim, Chipman, Collingwood Cove, Half Moon Lake, Josephburg, Kingman, Lamont, North Cooking Lake, Round Hill, Ryley, Sherwood Park, South Cooking Lake and Tofield.

The Beaver Hills (also known as the Cooking Lake Moraine) span into five separate Counties and includes Elk Island National Park and the Cooking Lake-Blackfoot Recreation Area. The Beaverhill Subwatershed supports a diverse range of wildlife and is a premium bird watching location. Beaverhill Lake is the focal point of the Snow Goose Festival held for the past ten years at Tofield. In 1982, Beaverhill Lake was declared a National Nature Viewpoint by the Canadian Nature Federation, and designated a Wetland of International Importance in 1987 by the RAMSAR Convention. The RAMSAR convention identifies wetlands of international importance, and provides a framework for wetland conservation.



The Cooking Lake Moraine area is one of four important areas identified by the Nature Conservancy of Canada. The mosaic of grasslands, woodlands and wetland habitats found there is important for many characteristic parkland species including the endangered Piping Plover, the threatened Trumpeter Swan, and the two species of special concern: Loggerhead Shrike and Sprague's Pipit. With the exception of wetland depressions, very little of the surrounding Central Parkland landscapes retain native vegetation. The continued disappearance of native habitats and species underlines the need to protect and steward these critical sites.

Elk Island National Park and Miquelon Lake Provincial Park both provide critical habitat for wildlife as well as recreational activities including hiking, cross-country skiing, canoeing, horseback riding, and snowmobiling.

Economic activity in the Subwatershed includes agriculture, oil and gas-related industries, urban and rural subdivision development and manufacturing including fertilizer, chemical and petrochemical plants.

Many of the indicators described below are referenced from the "Beaverhill Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.8.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.





### 5.8.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. Riparian inventory data were collected for individual landowners in the Beaverhill Subwatershed at Mud Lake, Walter Lake, Astotin Lake, Bennett Lake and Campbell Slough in 2003 and at Beaverhill Lake, Hastings Lake and Amisk Creek in 2002 by Cows and Fish (Norine Ambrose *pers. comm.*). However, each report was based on one sample site only, and does not represent the entire area in the way that an overall community report would.

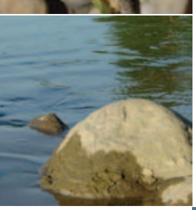
No other published assessment of riparian health was found for the Beaverhill Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed. For such an ecologically significant and important wildlife area, riparian health data is noticeably lacking. A thorough riparian health inventory should be undertaken for the Beaver Hills waterbodies. The City of Edmonton should also inventory the riparian areas within its jurisdiction.

### 5.8.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Just over 3% (13,846 ha) of land in the Beaverhill Subwatershed is taken up by linear developments. The majority of linear development (64%) is roads of one form or another, including paved roads (39%), and gravel and unimproved roads (26%). Other linear developments include pipeline rights of way, (18% of the area of linear developments), transmission line rights of way (8%), active or abandoned rail lines (8%) and cutlines (2%).

### 5.8.1.3 Land Use Inventory

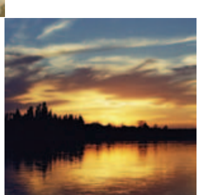




An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover about 9% of the Subwatershed. The vast majority of the Subwatershed is classified into various land uses related to agricultural production: grassland, 25%; cropland, 27%; and forage, 11%. About 20% of the Subwatershed is treed (87, 218 ha). The large percentage of treed land supports the high diversity of vegetation, mammals and birds found in this Subwatershed.

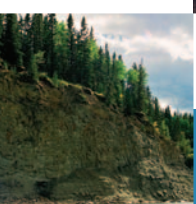
About 14% of the land area in the Subwatershed has been affected by various forms of development. Most of this disturbance (10% of the Subwatershed) is due to municipalities of various sizes including Sherwood Park, Fort Saskatchewan and parts of Edmonton. The remainder of the land disturbance is related to linear developments (3%), wellsites (0.6%), and industrial sites (0.1%). Only 7.3% of the Subwatershed is allocated to an FMU.

Water bodies including wetlands, rivers, lakes and dugouts cover about 42,895 hectares representing almost 10% of the area of the Subwatershed. Most of the waterbodies in this area are natural wetlands, which support a high diversity of vegetation, waterfowl, mammals and birds seen in this Subwatershed.

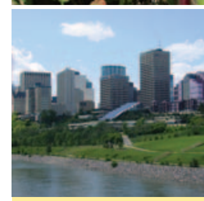


### 5.8.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production





information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Beaverhill Subwatershed are moderate with higher densities in areas to the east and southeast of Edmonton. Manure production in the soil polygons that cover the Beaverhill Subwatershed was estimated at between 1,194,000 and 5,422,000 tonnes. In the areas with higher agricultural intensity, there is an increased likelihood of impacts to surface water quality including increased nutrients, bacteria and pesticides. The waterbodies in these areas should be monitored regularly.

#### 5.8.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. The available hydrology data show few wetlands in the Beaverhill Subwatershed. However, small sloughs and marshes are found throughout the area, and are most abundant in and south of the moraine and on the lowland in the eastern third of the area. An inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 37,508 hectares of wetlands (8.5% of the Subwatershed area). The DUC inventory included both permanent and temporary wetlands. The natural wetlands in this Subwatershed support a high diversity of vegetation, waterfowl, mammals and birds.

The City of Edmonton is working hard to conserve the remaining natural wetlands that exist within its boundaries. This is part of City policy and includes natural upland areas as well as wetlands. Where possible the City has incorporated natural wetlands into the City's drainage infrastructure to benefit from the natural stormwater management and water quality benefits that a wetland can provide. Conservation of wetlands however is a high priority whether they can be drawn into the City's drainage infrastructure or not. Constructed stormwater management facilities comprise an important part of modern drainage infrastructure for all new urban developments. It is also City policy that new stormwater management facilities are planned and implemented as constructed wetlands for the obvious water quality benefits. Dry and wet ponds are no longer encouraged as part of new development.



### 5.8.2 Water Quality and Quantity

Larger waterbodies in this Subwatershed include the North Saskatchewan River and the Beaverhill and Norris Creeks. Lakes in the area include Beaverhill, Cooking, Hastings, Joseph, Ministik, Astotin, Tawayik, Oliver, Antler, and Wanisan. ALMS Lakewatch water quality data are available for Hastings Lake for 1999. Water quality data for Beaverhill, Cooking, Halfmoon and Hastings Lakes can be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990).

Most municipalities in the Subwatershed receive their drinking water from the North Saskatchewan River through two water treatment facilities provided by EPCOR Water Services under the Capital Region Water Services Commission (Figure 16). The City of Edmonton's Gold Bar Wastewater Treatment Plant and the Capital Region's Wastewater Treatment Plant provide wastewater treatment for much of the region. The Town of Redwater takes its water from the North Saskatchewan River (via EPCOR Water Services pipeline to Thorhild), but its wastewater treatment is provided by a wastewater treatment lagoon.



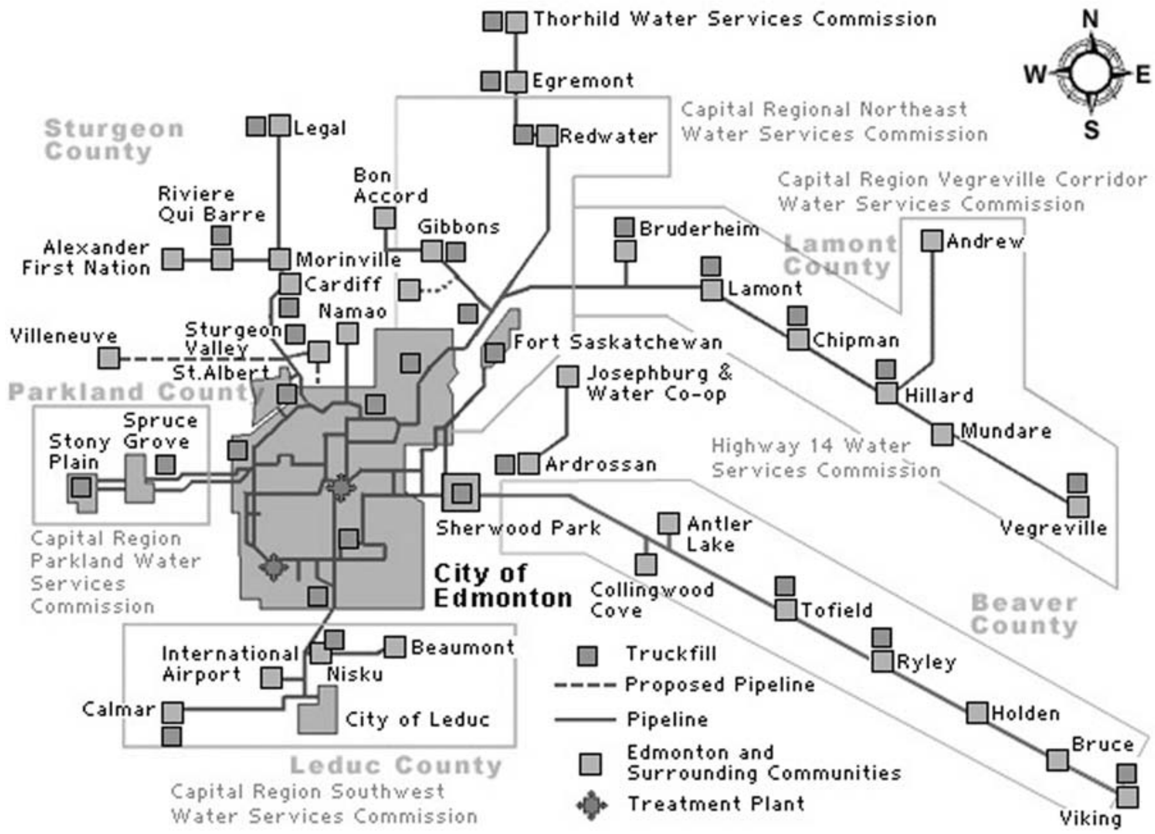



**Figure 16:** Capital Region Water Services Commission details. North Saskatchewan River water is withdrawn at the E.L. Smith treatment plant and treated by EPCOR Water Services. EPCOR-treated water flows to several outlying communities including Thorhild, Villeneuve, Vegreville and Viking. Figure courtesy of EPCOR Water Services.

Water quality is routinely monitored by Alberta Environment at Pakan under the LTRN program. In 2001, the ASWQI for metals, nutrients, bacteria and pesticides all rated 'good' or 'fair'. In the prior five-year period, nutrients were consistently rated 'fair', bacteria were rated 'good' or 'poor' and pesticides were rated as 'good' or 'fair' (Table 7). During the five-year index period, TP concentrations ranged from .012 to 1.15 mg/L while TN concentrations ranged from 0.06 to 4.5 mg/L. TP concentrations over 0.200 mg/L exceed the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life and can lead to eutrophic conditions of enhanced aquatic vegetation growth and low dissolved oxygen levels. The index shows the impact of inputs to the river from the City of Edmonton, industrial discharges in the Edmonton region and the Edmonton regional municipalities.

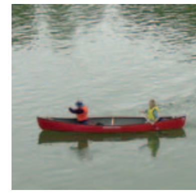



**Table 7:** ASWQI for Pakan, Alberta in the Beaverhill Subwatershed[1].

| Index Period | Metals | Nutrients | Bacteria | Pesticides |
|---|---|---|---|---|
| 1996 - 1997 | E | F | P | F |
| 1997 - 1998 | E | F | P | F |
| 1998 - 1999 | G | F | G | F |
| 1999 - 2000 | F | F | G | G |
| 2000 - 2001 | G | F | G | F |

[1]Alberta Surface Water Quality Index (ASWQI) ratings: E = Excellent, G = Good, F = Fair, P = Poor

Over 1,400 samples for TP and fecal coliforms have been taken from the downstream portion of the North Saskatchewan River during the years 1997-2002 (downstream samples are those collected east of the Rossdale water treatment plant). The 415 fecal coliform samples taken downstream from the water treatment plant ranged from 0 to 29,000 counts/100 mL, and averaged 412 counts/100 mL. Most of these samples greatly exceed the CCME Surface Water Quality Guidelines for Contact Recreation. The 1119 TP samples ranged from 0 to 2.03 mg/L, and averaged 0.117 mg/L. Pesticide detections in this Subwatershed included 2,4-D, MCPA, MCPP, Picloram, Triallate and Dicamba, all of which were below the Guidelines for the Protection of Aquatic Life. Other compounds detected include Gamma-BHC, Imazamethabenz-methyl, Diuron and Diazinon, but there are no existing water quality guidelines for these chemicals.



Amisk Creek was part of the CAESA stream network as a site in an area of high agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-1996 (Anderson *et al.* 1998).

Water quantity is measured at nine HYDEX stations (05EB001-05EB002, 05EB006, 05EB015-05EB016, 05EB902, and 05EB909-05EB911). None of these sites has real-time online data. Figure 17 shows the Pointe-Aux-Pins Creek hydrograph for the open water season. This hydrograph is typical of a non-glacial, non-groundwater fed stream, with flow contributions from spring runoff and summer storms only and drying in late summer.





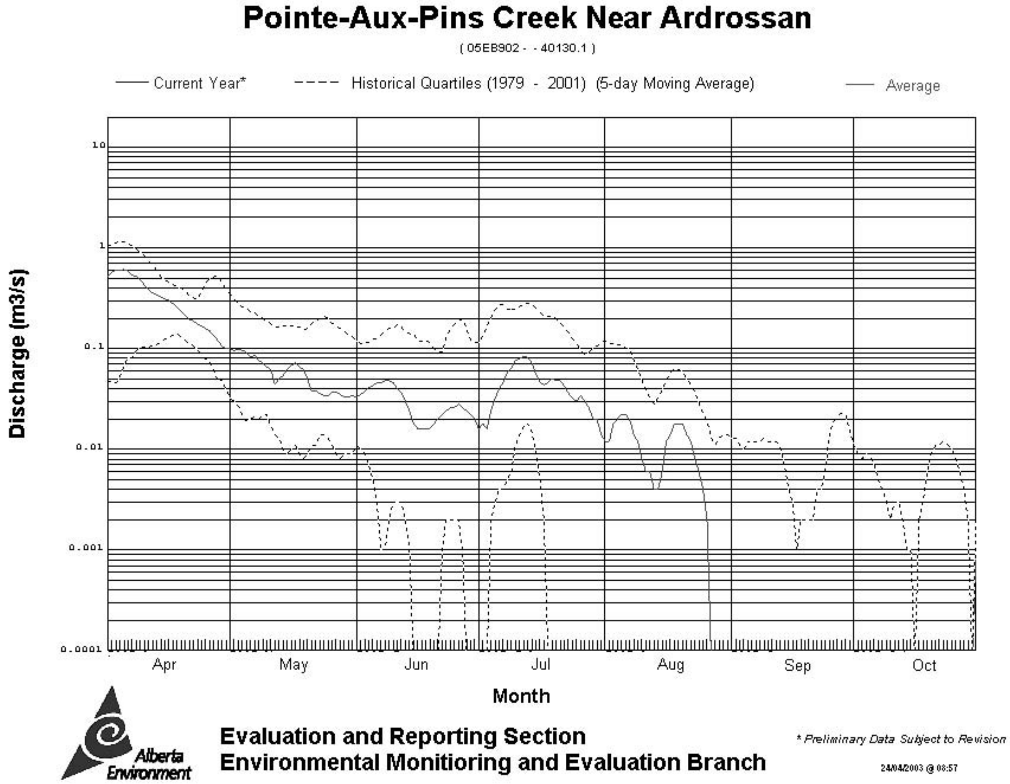




**Figure 17:** Pointe-Aux-Pins Creek near Ardrossan mean monthly discharge for the open water season (Station 05EB902).



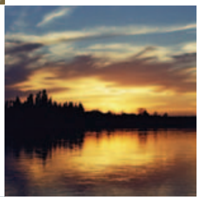


### 5.8.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.8.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Beaverhill Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research.

### 5.8.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Fish species in many of the lakes and creeks in the Subwatershed are limited by the shallow water depths in these systems. Shallow lakes can have low or no oxygen concentrations during winter ice cover, which can suffocate and "winter-kill" fish.

No systematic estimate of fish populations in the Beaverhill Subwatershed has been done. However, walleye, perch, and northern pike are found in some of the lakes. Lake trout and whitefish have little endurance in the warm, shallow prairie lakes, and the rivers are too turbid to support fish. The North Saskatchewan River supports northern pike, perch, walleye, and goldeye.

### 5.8.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Beaverhill Subwatershed is located in the Boreal Forest and Parkland Regions of Alberta. The Boreal Forest Region includes many areas of bogs, fens, swamps and marshes, as well as the Dry Mixedwood Subregion. The Dry Mixedwood Subregion includes species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and has many peatlands. The dominant forest cover types are trembling aspen, balsam poplar, white birch, and white spruce, with white spruce dominating in older stands. The Parkland Natural Region is the transition region between grasslands and coniferous forests. It includes one subregion, the Central Parkland, which is composed mainly of grassland with aspen, aspen parkland and closed aspen forest.



### 5.8.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes in the presence and abundance of species that may be related to changes in water quality. Between 1973 and 1977, Alberta Environment surveyed benthic invertebrates in the North Saskatchewan River. Data were summarized in a report published in 1978 (Reynoldson and Exner 1978). The study included sampling sites upstream of the major discharges from Edmonton (Big Island and Groat Bridge) as well as sites downstream of these discharges (Beverly Bridge, Fort Saskatchewan, Vinca Bridge, Duvernay and Elk Point). The authors concluded that there was little change in the species diversity or total numbers of macrobenthic fauna from year to year or season to season at the upstream sampling sites. These sites also showed less variability in both diversity and standing crop compared to the downstream sites. At the downstream Beverly Bridge site there was a major increase in numbers but a decline in species diversity. The Beverly Bridge site also had a much less stable community showing severe fluctuations in both numbers and diversity in contrast to the upstream sites. The nature of the change in the biological community suggested that the major impacts are due to organic rather than inorganic or toxic effluents.

The main invertebrate groups in five years of sampling the river upstream of Edmonton were Chironomidae, which made up 38.4% of the samples, Ephemeroptera (Mayflies), 31.7% and Plecoptera (Stoneflies), 20.0%. The remainder of the sample was Trichoptera (Caddisflies), 4.9% and Oligochaeta (Earthworms), 0.5%. At sites downstream of Edmonton, Oligochaeta made up 43.3% of the samples, Chironomidae, 40.8%, Ephemeroptera, 6.3%, Plecoptera, 4.8% and Trichoptera, 0.4%.

There have been major changes in the Edmonton area in the almost 26 years since these studies were done. In particular, stormwater management and wastewater treatment have been significantly improved. *Edmonton's Environment: A Snapshot 2002* (City of Edmonton, 2003) states that between 1996 and 2001, the City's impact on the North Saskatchewan River has steadily decreased from a ASWQI value of 26 in 1996 to 4 in 2001. This was due mainly to upgrades at the wastewater treatment plant including biological nutrient removal, enhanced primary treatment and ultra-violet disinfection prior to discharge of return flows to the NSR.

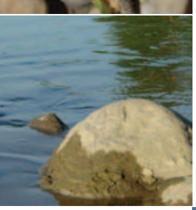
### 5.8.4 Beaverhill Summary

The Beaverhill Subwatershed contains a combination of ecologically significant natural areas, recreational opportunities, and centers of high urban activity. The majority of the Subwatershed is classified in land uses related to agriculture; however, about 20% is treed. Livestock densities are moderate with higher densities being indicated in areas to the east and southeast of Edmonton. Economic activity includes agriculture, oil and gas-related industries, urban development and manufacturing.

Riparian inventory data were collected for landowners at several locations in the Subwatershed; however, these data are not representative of the Subwatershed. For such an ecologically significant and important wildlife area, riparian health data is noticeably lacking. A thorough riparian health inventory should be undertaken for the Beaver Hills waterbodies. The City of Edmonton should undertake a project to have its riparian areas assessed.

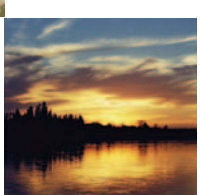


Just over 3% of the Subwatershed is taken up by linear developments including roads, pipeline rights of way, transmission line rights of way, rail lines and cutlines. In addition, about 11% of the land area has been affected by development including municipalities, well sites and industrial sites. Water bodies cover about 9% of the Subwatershed. The available hydrology data show few wetlands; however, Ducks Unlimited Canada data show wetlands on 8.5% of the Subwatershed. This variance should be resolved.

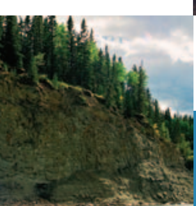


Water quality is routinely monitored by Alberta Environment at Pakan. The City of Edmonton has a pronounced negative impact on water quality for some distance downstream (as far down river as Pakan). Water quality downstream of wastewater discharges from the City of Edmonton, was much lower than water quality upstream of the City at Devon. Municipal discharges increase river nutrient and bacterial concentrations, while household, municipal and agricultural pest control efforts leach pesticides into the river. Total phosphorus concentrations exceed the Guidelines for the Protection of Aquatic Life, and for Recreational Use. In 2001, the Surface Water Quality Index for metals, nutrients, bacteria and pesticides all rated 'good' or 'fair'. This was similar to the rating in the prior five-years for nutrients and pesticides. It was an improvement in the rating for bacteria, but a slight decrease for metals. The improvements are likely due to improvements in stormwater management and wastewater treatment by the City of Edmonton. Further examination of the data are needed to determine if the changes are significant and the reasons for them. Water quantity is measured at nine stations. No site has real-time online data.

Fish species in many of the lakes and creeks in the Subwatershed are limited by the shallow waters, which can result in low oxygen concentrations and winterkill. No systematic estimate of fish populations in the Beaverhill Subwatershed has been done. Of the seven indicators assessed, none were good, four were fair, and three were poor, yielding an overall subjective rating of fair.



Surveys of benthic invertebrates in the North Saskatchewan River in this Subwatershed concluded that downstream sites showed more variability in both diversity and standing crop compared to the sites upstream of Edmonton. There is a major increase in numbers and a decline in species diver-






sity downstream of Edmonton. The benthic invertebrate community was also much less stable at the downstream sampling sites. The changes suggested impacts due to organic rather than inorganic or toxic effluents. No information was found on water plants in the Subwatershed.

In summary, water quality information and surveys of benthic invertebrates indicate some detrimental impacts of development in this Subwatershed. Land disturbance affects a relatively large percentage of the Subwatershed, which contains many ecologically significant areas and important recreational opportunities. The Beaver Hills Initiative is a sustainable community initiative that is active in this area. Further data collection and analysis are needed to understand the impacts of this development and to develop actions for management.

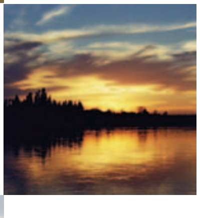




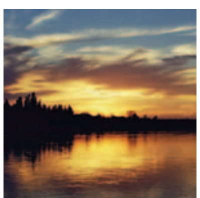









# White Earth

Joel Smith
Age 5
Edmonton





## 5.9 WHITE EARTH SUBWATERSHED

The White Earth Subwatershed lies entirely in the Boreal Forest Natural Region. It encompasses 649,481 hectares including 19,457 hectares of natural and artificial water bodies. The Smoky Lake and Thorhild Provincial Grazing Reserves lie in the Subwatershed. Many environmentally sensitive areas within the reserves have been left as natural habitat. White Earth Natural Area was created to protect the slopes of Long Lake and White Earth Creek.

The White Earth Subwatershed is sparsely populated and includes the municipal boundaries of Lamont, Improvement District 18, Smoky Lake, Sturgeon, Thorhild, Two Hills and Westlock Counties. Its main community is the Town of Thorhild with a population of 486 and also includes the settlements Abee, Andrew, Bellis, Busby, Clyde, Egremont, Legal, Mundare, Newbrook, Opal, Pickardville, Radway, Redwater, Smoky Lake, St. Michael, Star, Vimy, Warspite, Waskatenau, and Wostok.

Soils are excellent for agriculture and the primary economic activities are agriculture, including many mixed farming operations, and oil and gas exploration and development.

Long Lake Provincial Park provides recreational opportunities including hiking, camping, canoeing, cross-country skiing, bird watching and fishing in an artificial lake in the park.

Many of the indicators described below are referenced from the "White Earth Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.9.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.9.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices.

No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the White Earth Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the White Earth Subwatershed.

#### 5.9.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

About 3.5% (15,720 ha) of land in the White Earth Subwatershed is affected by linear developments. The majority of linear developments (44%) are roads of one form or another, including gravel and unimproved



roads (34% of linear development) and paved roads (9% of linear developments). Other linear developments include cutlines (27% of the area of linear development), pipeline rights of way, (21%), transmission line rights of way (4%) and active or abandoned rail lines (4%).

#### 5.9.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health.

Water bodies, both natural and constructed, and including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 3% of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: cropland, 38%; grassland, 28%; and forage, 11%. About 20% (126,844 ha) of the Subwatershed is treed.

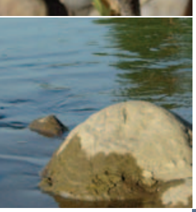
About 3.5% of the land area in the Subwatershed has been disturbed by the linear development. The greatest area of disturbance is due to well sites, which affect 0.7% of the Subwatershed (4,717 ha). Disturbance due to municipalities of various sizes including Legal, Redwater, Thorhild, and Smoky Lake affects about 0.3% of the Subwatershed (2,247 ha). The remainder of the land use is related to two First Nations' reserves (less than 1%) and a runway.

Water bodies including rivers, lakes and dugouts cover about 19,457 hectares, or 3% of the Subwatershed area.



#### 5.9.1.4 Livestock Density

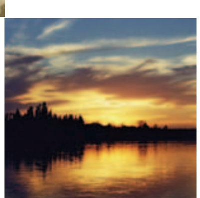
Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems.



Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production in the actual Subwatershed. Based on the available information, livestock densities in the White Earth Subwatershed are moderate with low densities in the northeast and somewhat higher densities in areas near St. Paul. Manure production in the soil polygons that cover the White Earth Subwatershed was estimated at between 0 and 5,422,000 tonnes.

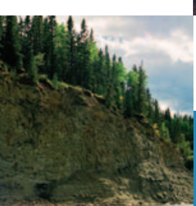
#### 5.9.1.5 Wetland Inventory

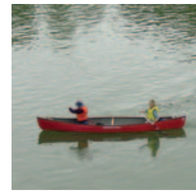
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Data from Alberta Sustainable Resource Development base features hydrology failed to identify wetlands in the White Earth Subwatershed. The PFRA Land Classification shows wetlands on 0.3% (1,952 ha) of the White Earth Subwatershed. However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 22,479 hectares of wetlands (3.5% of the Subwatershed area). The latter inventory included both permanent and temporary wetlands.

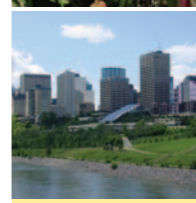


### 5.9.2 Water Quality and Quantity

Water bodies in the Subwatershed region include the North Saskatchewan River, Redwater River and White Earth, Egg, Kennedy, Weasel, Waskatenau, Peno, Whitford, and Namepi Creeks. Larger Lakes are Whitford, Smoky, Wakomao, Hanmore, Mons, Bridge, Hollow, Duggans, Cucumber,





Skaro and Gregory. Smoky Lake County is active with watershed initiatives in the Smoky Lake, Stony Creek, and White Earth Creek watersheds.

Towns in the Subwatershed have various types of wastewater treatment facilities. Mundare's drinking water supply is provided from Edmonton by EPCOR Water Services and the North Saskatchewan River. Retention lagoons provide wastewater treatment and effluent is released in the spring.

In this Subwatershed, the channel of the North Saskatchewan River is about 245 metres wide and 1.9 metres deep and is entrenched in a stream cut valley in a hummocky till plain. The channel is sinuous with occasional islands and mid-channel bars and a substrate dominated by sand and gravel.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. There are no fecal coliform results for White Earth Creek, but it was sampled for TP once in 1990 and the level was 0.076 mg/L. There have been no pesticide samples collected in this Subwatershed. These gaps should be addressed in future studies.

Water quantity is measured at six HYDEX stations (05EC002-05EC007). None of the sites has real-time online data. Figure 18 shows the Redwater River hydrograph, which is typical of a non-glacial fed stream. Flow contributions are from spring runoff and summer storms only.



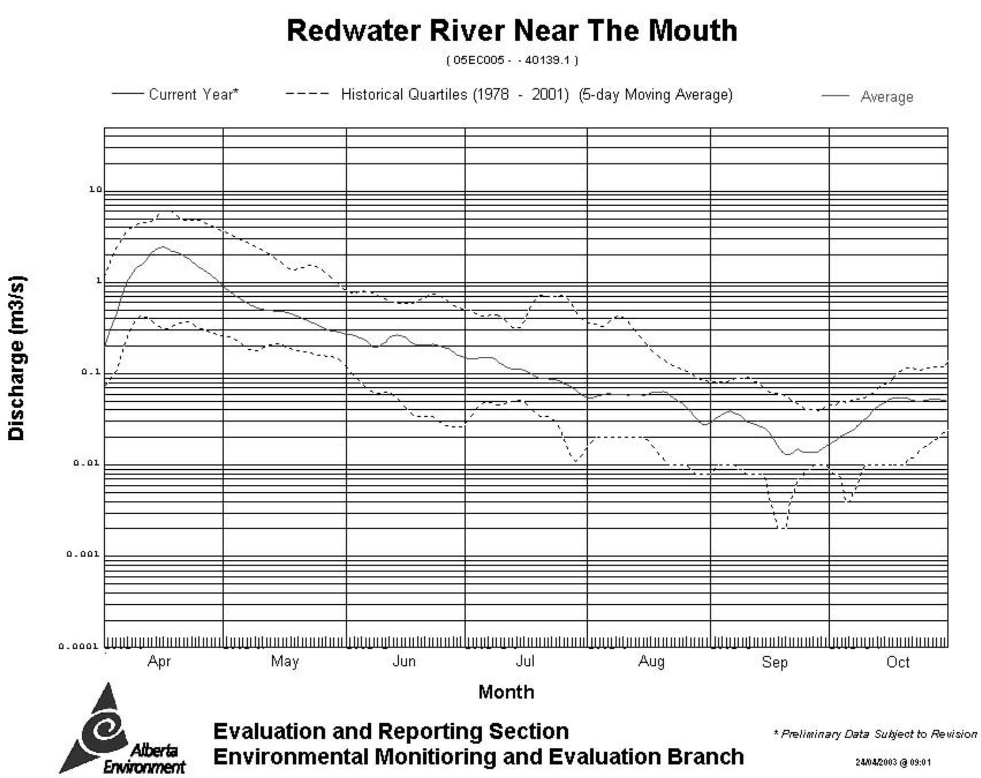
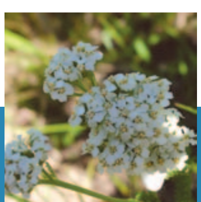
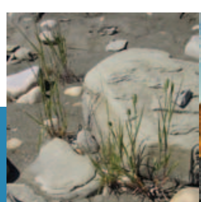



**Figure 18:** Redwater River near the Mouth mean monthly discharge for the open water season (Station 05EC005).




### 5.9.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.9.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the White Earth Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the White Earth Subwatershed.

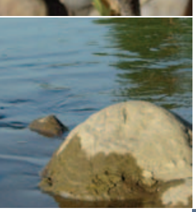
#### 5.9.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity.

A systematic estimate of fish populations in the White Earth Subwatershed has not been conducted. Because of turbulent flow patterns, warmer temperature, turbidity and substrate, the North Saskatchewan River in this Subwatershed provides good quality habitat for walleye, sauger, and goldeye and support a mix of other cool water fish species including northern pike, mooneye and yellow perch (Allan 1984).





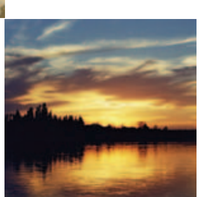


#### 5.9.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The White Earth Subwatershed is located in the Boreal Forest Region of Alberta. The Boreal Forest Region includes many areas of bogs, fens, swamps and marshes, and has the Dry Mixedwood Subregion. The Dry Mixedwood Subregion includes tree species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and has several peatlands.

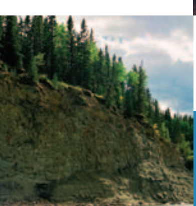
#### 5.9.3.4 Benthic Invertebrates

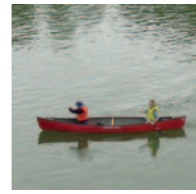
Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the White Earth Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the White Earth Subwatershed.

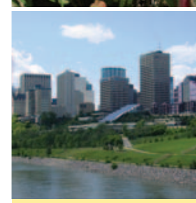


### 5.9.4 White Earth Summary

The White Earth Subwatershed is sparsely populated. The majority of the land use in this Subwatershed is related to agricultural production, and about 20% of the Subwatershed is treed.





Livestock densities are moderate with low densities in the northeast and somewhat higher densities in areas near St. Paul. Primary economic activities include agriculture and oil and gas exploration and development. Over 2% of the Subwatershed is affected by linear developments including roads, cutlines, pipeline rights of way, transmission line rights of way and rail lines. Another 1% is affected by well sites, municipalities, two First Nations' reserves, and a runway.

Water bodies cover 3% of the Subwatershed; however, no published assessment of riparian health was found. The available PFRA Land Classification shows wetlands on 0.3% of the Subwatershed; however, Ducks Unlimited Canada data show wetlands covering 3.5% of the land area. This variance should be resolved.

No long-term river water quality information exists for the Subwatershed. Water quantity is measured at six HYDEX stations, and none of these has real-time online data.

A systematic estimate of fish populations in the White Earth Subwatershed has not been conducted and no information was found on water plants or benthic invertebrates.

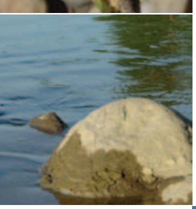
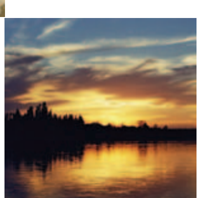
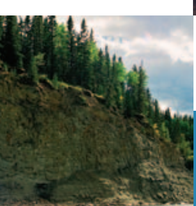
In summary, there has been little systematic assessment of this Subwatershed and there are significant gaps in the available information. However, of the six indicators assessed, two were good, three were fair, and two were poor, yielding an overall subjective rating of fair. These gaps should be addressed; however, the relatively low level of development and disturbance, and the moderate level of livestock development suggest that there may be fewer concerns in this Subwatershed as compared to other Subwatersheds.



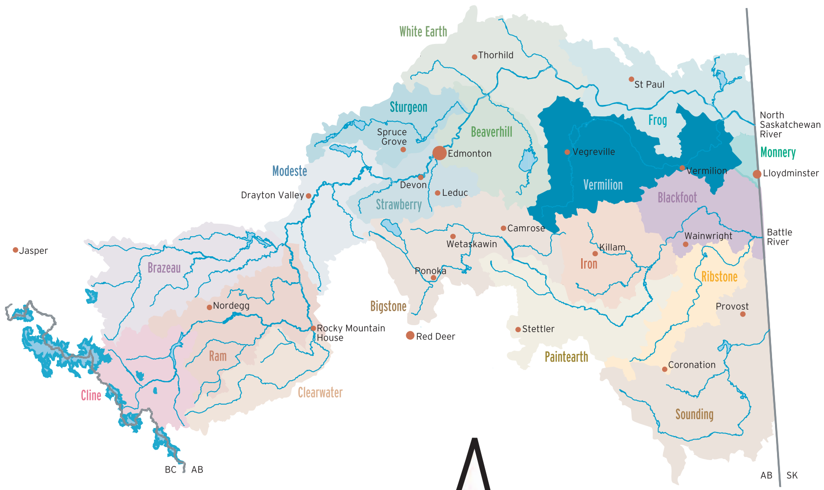


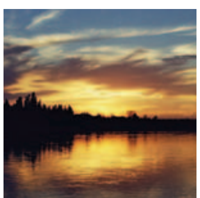


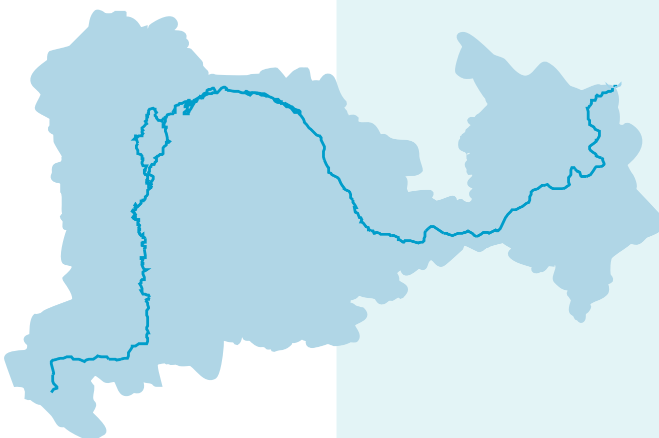


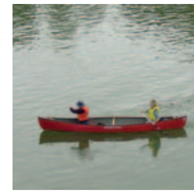
# Vermilion

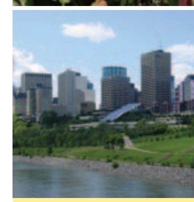




Bryan Smith
Age 7
Edmonton



## 5.10 VERMILION SUBWATERSHED

The Vermilion Subwatershed comprises about 11% of the entire North Saskatchewan Watershed in Alberta and drains 5,700 $km^2$ of land in the Parkland Natural Region. The Vermilion Subwatershed encompasses 782,642 hectares including 35,995 hectares of natural and artificial water bodies and includes the Minburn Provincial Grazing Reserve. The Vermilion Subwatershed includes the municipal boundaries of Beaver, Lamont, Minburn, Two Hills, St. Paul and Vermilion River Counties and the towns of Beauvallon, Clandonald, Dewberry, Hairy Hill, Holden, Innisfree, Islay, Kitscoty, Mannville, Marwayne, Minburn, Mundare, Musidora, Ranfurly, Two Hills, Vermilion, Vegreville and Willingdon. Vermilion Provincial Park occupies 728 hectares in the Subwatershed. Vermilion Provincial Park provides recreational opportunities including hiking, camping, canoeing, cross-country skiing, bird watching and fishing in an artificial lake in the park. Major structures are located at Watts/Bens Lakes, Morcambe and Vermilion.

Many of the indicators described below are referenced from the "Vermilion Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.10.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 5.10.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices.

Riparian health along the Vermilion River was assessed in the summer of 1999 by Westworth Associates Environmental Ltd. and the Land Stewardship Centre of Canada using Cows and Fish methodology (1999). Fifty-four percent of the sites were assessed as 'unhealthy', 30% as 'healthy, but with problems' and 16% as 'healthy'. Livestock grazing and cultivation were mostly associated with unhealthy sites. A riparian bird biodiversity inventory was also conducted in 2003 by Cows and Fish, and a report should be published sometime in 2004.

#### 5.10.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

Almost 3% (20,984 ha) of land in the Vermilion Subwatershed is affected by linear developments. The majority of this (62%) is in roads of one form or another, including gravel and unimproved roads (48% of the linear development) and paved roads (12% of linear developments). Other linear developments include pipeline rights of way (18% of the area of linear development), cutlines (9%), transmission line rights of way (8%), and active or abandoned rail lines (4%).



### 5.10.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health.

Water bodies, both natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 5% of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: cropland, 51%; grassland, 46%; and forage, 1%. About 0.2% (1,227 ha) of the Subwatershed is covered with trees.

About 4% of the land area in the Subwatershed has been affected by various forms of disturbance including the linear development described above. The greatest area of disturbance following linear development is due to well sites, which affect about 1% of the Subwatershed (7,065 ha). Disturbance due to municipalities of various sizes including Vermilion, Two Hills, Vegreville and Minburn affects about 0.5% of the Subwatershed (4,157 ha). The remainder of the land disturbance is related to linear developments (2.7%), and industrial facilities including oil and gas plants, runways, sand and gravel pits, and other industrial sites (311 ha).

Water bodies including rivers, lakes and dugouts cover about 35,995 hectares; about 5% of the Subwatershed.

### 5.10.1.4 Livestock Density

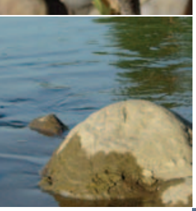
Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems.



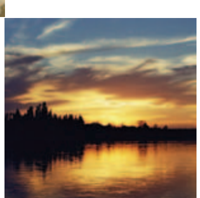
Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Vermilion Subwatershed are moderate with higher densities indicated in the north-central portion of the Subwatershed in a soil polygon that also extends into the Frog and White Earth Subwatersheds. Manure production in the soil polygons that cover the Vermilion Subwatershed was estimated at between 726,400 and 5,422,000 tonnes. Surface water bodies within the regions of high agricultural intensity may be adversely affected by elevated total phosphorus concentrations, fecal coliform counts and elevated pesticide concentrations.

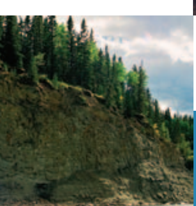
### 5.10.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats.



The available PFRA Land Classification shows 1,770 hectares of wetlands occurring in the Vermilion Subwatershed (0.2% of the land area). However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 43,783 hectares of wetlands (5.6% of the Subwatershed area). The inventory included both permanent and temporary wetlands. The Holden Drainage District, the oldest in Alberta, drains approximately 12,000 acres in the southwest portion of this and the southeast part of the Beaverhill Subwatershed into the Vermilion River.





### 5.10.2 Water Quality and Quantity

Water bodies in the Subwatershed include the Vermilion River, and Waskwei, Deer, Irish, and Birch Creeks. Larger Lakes include Birch, Kenilworth, Akasu, Plain, Watt, Bens, Campbell, Dusty, Vermilion Lakes and Raft.

Towns in the Subwatershed have various types of wastewater treatment facilities. Vermilion's wastewater is pumped into an extended aeration plant and then into a lagoon system from which it is discharged into the Vermilion River.

Water quality in the main stem of the North Saskatchewan River is monitored regularly by Environment Canada at Lea (Jubilee) Park and the river crossing at Highway 17. Monthly physical, nutrients, metals and flow data are available from 1970 to the present. CCME Water Quality Index (WQI) data are available for both sites from Environment Canada for 1983-2002 (*Glozier et al.* 2004). For the 1983-2002 period, river water quality at both sites was found to be marginal (calculated WQI = 53). A marginal value (calculated WQI 45 to 59) means that water quality is frequently threatened or impaired, and that conditions often depart from natural or desirable levels. The variables of non-compliance were not stated in the report (*Glozier et al.* 2004). As expected, the CCME WQIs decreased markedly from the other Environment Canada headwater site WQI at Whirlpool Point. Water quality typically decreases as one travels downstream due to inputs from both natural, anthropogenic, point and non-point sources.



Thirteen samples were taken for pesticides between 1997-2001. Pesticides detected in this Subwatershed included 2,4-D, Bromoxynil, MCPA, MCPP, and Picloram, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. 2,4-DP and Clopyralid were also detected, but there are currently no water quality guidelines for these compounds.

Water quantity is measured at eleven HYDEX stations (05EE001-05EE007, 05EE009, 05EE913, 05EE915 and 05EE930): three have real-time online data (05EE005, 05EE006, and 05EE009). The main stem of the Vermilion River is 380 kilometres long and has no major permanent tributaries. The flow regime is characterized by lengthy periods of low flow. The system depends on groundwater sources for base flows and zero discharge has been recorded on several occasions. Figure 19 shows the Vermilion River hydrograph, which is typical of a non-glacial fed stream. Flow contributions are largely from spring runoff and smaller contributions from summer storms.



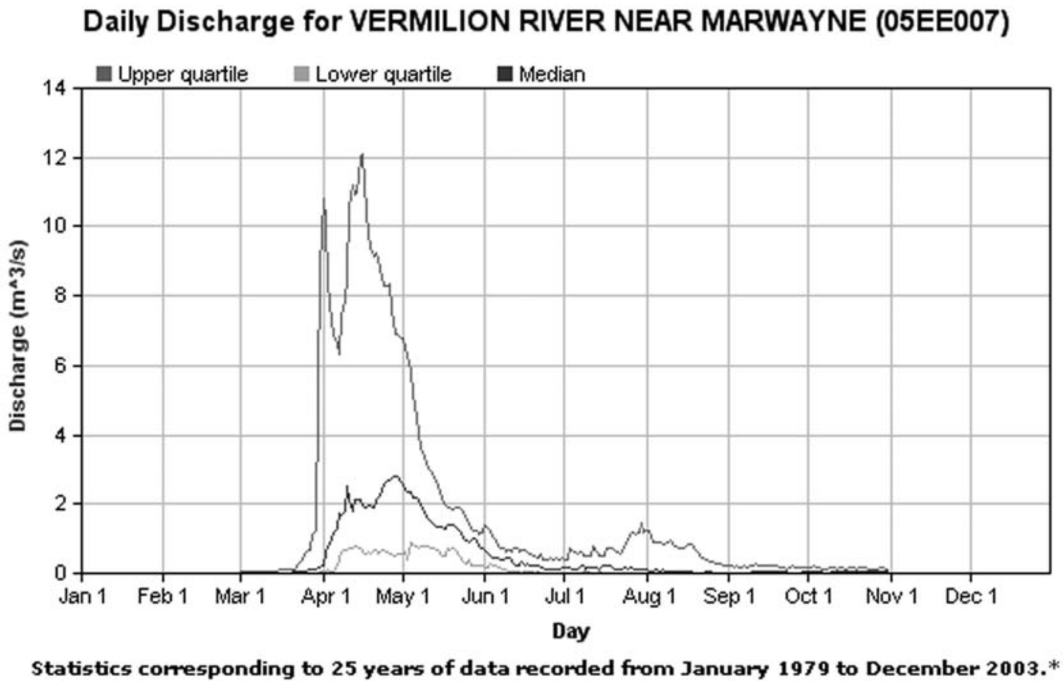



**Figure 19:** Vermilion River near Marwayne mean monthly discharge (Station 05EE007).



### 5.10.3 Biological Indicators

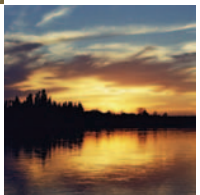


Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.10.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices. No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Vermilion Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Vermilion Subwatershed.

#### 5.10.3.2 Fish Population Estimates



Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. A systematic estimate of fish populations in the Vermilion Subwatershed has not been done. Northern pike is the only game fish occurring in the main stem of the North Saskatchewan River in this Subwatershed. It is sparsely and irregularly distributed and restricted to a few sites (Allan 1984). Future research on the Vermilion Subwatershed should address this gap.




#### 5.10.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Vermilion Subwatershed is located in the Parkland Natural Region of Alberta. The Parkland Natural Region is the transition region between grasslands and coniferous forests. It includes one subregion, the Central Parkland, which is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest.

#### 5.10.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality.

No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Vermilion Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Vermilion Subwatershed.

### 5.10.4 Vermilion Summary

The majority of the Vermilion Subwatershed land uses are related to agriculture. Only 0.2% is covered with trees. Livestock densities are moderate with higher densities indicated in the north-central portion of the Subwatershed. Almost 3% of the land is affected by linear developments including roads, pipeline rights of way, cutlines, transmission line rights of way, and rail lines. Another 4% is affected by well sites, disturbance due to municipalities, and industrial facilities. The available PFRA Land Classification shows wetlands on 0.2% on the land area; however, Ducks Unlimited Canada information indicates that wetlands cover 5.6% of the Subwatershed area. This variance should be resolved.



No published assessment of water plants, benthic invertebrates, or long-term river water quality information was found for the Subwatershed. The Vermilion River depends on groundwater sources for base flows and zero discharge has been recorded on several occasions. Water quantity is measured at eleven stations in the Subwatershed: three have real-time online data.

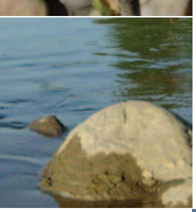
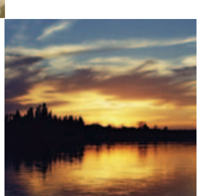
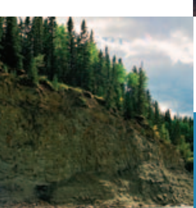
Riparian health along the Vermilion River was assessed in 1999. Fifty-four percent of sites were assessed as ‘unhealthy’, 30% as ‘healthy, but with problems’ and 16% as ‘healthy’. Livestock grazing and cultivation were mostly associated with unhealthy sites. A systematic estimate of fish populations in the Vermilion Subwatershed has not been done. No information was found on water plants or benthic invertebrates.

In summary, there has been little systematic assessment of this Subwatershed and there are significant gaps in the available information. However, of the seven indicators assessed, none were good, two were fair, and five were poor, yielding an overall subjective rating of poor. The overall size of this Subwatershed, the high level of agricultural land use and relatively high livestock densities, the results of riparian health assessments and the available water quality data would all suggest that it is important to address the data gaps and to further assess the impacts of various land uses on the Vermilion Subwatershed.

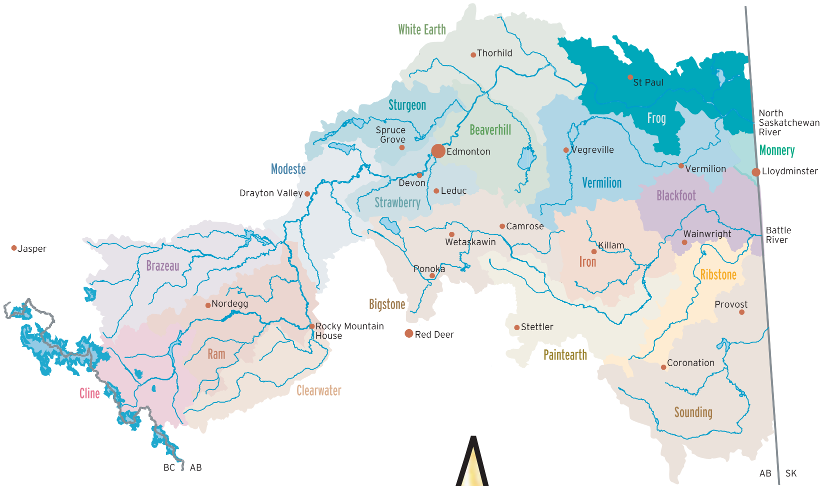


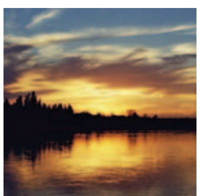


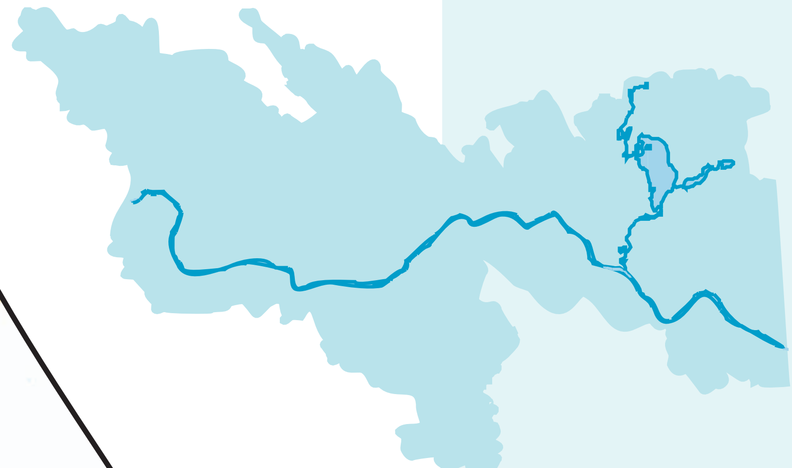


# Frog





Curtis Ward
Age 5
Edmonton




## 5.11 FROG SUBWATERSHED

The Frog Subwatershed is located in the Dry Mixedwood Natural Subregion with a small portion near the North Saskatchewan River overlapping in the Central Parkland Natural Subregion. The Frog Subwatershed encompasses 562,622 hectares including 41,229 hectares of natural and artificial water bodies. The Rannach and St. Paul Provincial Grazing Reserves lie in the Subwatershed. The Rannach Provincial Grazing Reserve lies along the south bank of the North Saskatchewan River. The St. Paul Provincial Grazing Reserve is located 19 kilometres southwest of St. Paul on the north side of the North Saskatchewan River. The geology and soil types of the Subwatershed are similar to the surrounding Subwatersheds and provide for a viable agricultural industry.

The Frog Subwatershed includes the municipal boundaries of Bonnyville, Improvement District 18, Smoky Lake, St. Paul, Two Hills, and Vermilion River Counties. The Subwatershed also includes the settlements of Ashmont, Derwent, Duvernay, Elk Point, Heinsberg, Horseshoe Bay, Lafond, Lindbergh, Myrnam, Riverview, Spedden, St. Edouard, St. Paul, St. Vincent, Vilna and the First Nation's Reserves of Puskiakiwenin 122, Saddle Lake 125, Unipouheous 121, Makaoo 120, and the Fishing Lake Métis Settlement. Total population in the Subwatershed is about 8,500.

Whitney Lakes Provincial Park provides an abundance of recreational activities including camping, canoeing, kayaking, cycling, fishing, hiking, swimming, water skiing, and bird watching. Camping is a popular summertime activity in the St. Paul Grazing Reserve, particularly around Lac Bellevue and Perch Lake.

Many of the indicators described below are referenced from the "Frog Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.11.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.11.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. Riparian inventory data were collected for 4.8 kilometres of Bonnie Lake shoreline in 2001 (ARHMP Cows and Fish, 2002c). Of the 13 quadrats sampled on Bonnie Lake, 46% were considered 'healthy' and another 46% were considered 'healthy but with problems'. The final 8% (one quadrat) was considered 'unhealthy' due to shoreline modifications for recreational purposes. The only major problem noted was the presence of invasive plants.

Riparian inventory data were also collected for Vincent Lake in 2000 and 2001 by Cows and Fish (Norine Ambrose, pers. comm.). These data were based on one sample site and do not represent the entire lake area. The Vincent Lake Working Model group, in partnership with the Alberta Conservation Association, has developed a new tool called Riparian Health Assessment using Aerial Videography. This tool can be used by groups to complete a quick overview of a lake's riparian health and determine if problems exist. This tool will be linked to a GIS database. The Vincent Lake Working Model group can be contacted directly for more information



(www.healthyshorelines.com). Their assessment found that the riparian area around Vincent Lake in 2001 was 20% healthy, 66% moderately impaired and 14% highly impaired.

#### 5.11.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Over 2% (12,599 hectares) of land in the Frog Subwatershed is affected by linear developments. The majority of this (43%) is in roads of one form or another, including gravel and unimproved roads (32% of the linear development) and paved roads (8% of linear developments). Other linear developments include cutlines (24% of the area of linear development), pipeline rights of way (22%), transmission line rights of way (8%), and active or abandoned rail lines (3%).

#### 5.11.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, and including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 7% of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: grassland, 41%; cropland, 28%; and forage, 1%. About 18% (103,316 ha) of the Subwatershed is covered with trees.

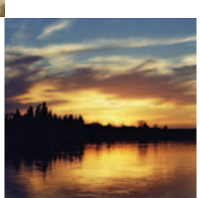


About 14.5% of the land area in the Subwatershed has been disturbed by various land uses including the linear development described above. The greatest area of disturbance following linear development is the area encompassed by First Nations' reserves representing almost 11% of the Subwatershed. Well sites affect about 1% of the Subwatershed (4,717 ha). Disturbance due to municipalities of various sizes including Ashmont, Elk Point, St. Paul and Vilna affects about 0.3% of the Subwatershed (1,888 ha). The remainder of the land disturbance is related to linear developments (2.2%), and industrial facilities including oil and gas plants, runways, and sand and gravel pits (169 ha).

Water bodies including rivers, lakes and dugouts cover about 41,229 hectares; about 7% of the area of the Subwatershed.

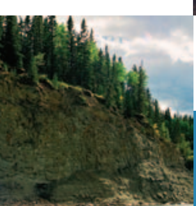
#### 5.11.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Frog Subwatershed are moderate to low in the northeast with higher densities near St. Paul in a soil polygon that extends into the White Earth and Vermilion Subwatersheds. Manure production in the soil polygons that cover the Frog Subwatershed was estimated at between 0 and 5,422,000 tonnes.



#### 5.11.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Both the Alberta Sustainable Resource Development base features hydrology data and the PFRA Land Classification data failed







to identify wetlands in the Frog Subwatershed. However, an inventory completed by Ducks Unlimited Canada found a total of 42,523 hectares of wetlands (7.6% of the Subwatershed area). Their inventory included both permanent and temporary wetlands.

### 5.11.2 Water Quality and Quantity

Water bodies in the Frog Subwatershed include the North Saskatchewan River, and Slawa and Atimoswe Creeks. Larger lakes include Lac Sante, as well as Frog, Upper and Lower Therien, Cache, Vincent, Fishing, Laurier, Saddle, Bonnie, Eliza, Two Hills, Prairie, Rock Island, Christopher, Tulabi and Lac St. Cyr. ALMS Lakewatch data are available for Vincent (2000, 2001), Laurier (2002) and Bonnie (2002) Lakes. Water quality for Bonnie Lake and Lac St. Cyr can be found in the Atlas of Alberta Lakes (Mitchell and Prepas 1990). The Bonnie Lake Sustainability Association is an active regional watershed group in this Subwatershed.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. This data gap should be addressed in future studies. The Town of St. Paul takes its water supply from Lac St. Cyr, supplemented from the North Saskatchewan River. Wastewater treatment for St. Paul is provided through aeration ponds. Water is pumped from the North Saskatchewan River to offset St.Paul's withdrawals from the lake. The Town of Elk Point's drinking water source is the North Saskatchewan River.

Water quantity is measured at three HYDEX stations (05ED001-05ED003): none has real-time online data. Figure 20 shows the Atimoswe Creek hydrograph for the open water season. This hydrograph is typical of a non-glacial, non-groundwater fed stream, with flow contributions from spring runoff and summer storms only and drying in late summer.

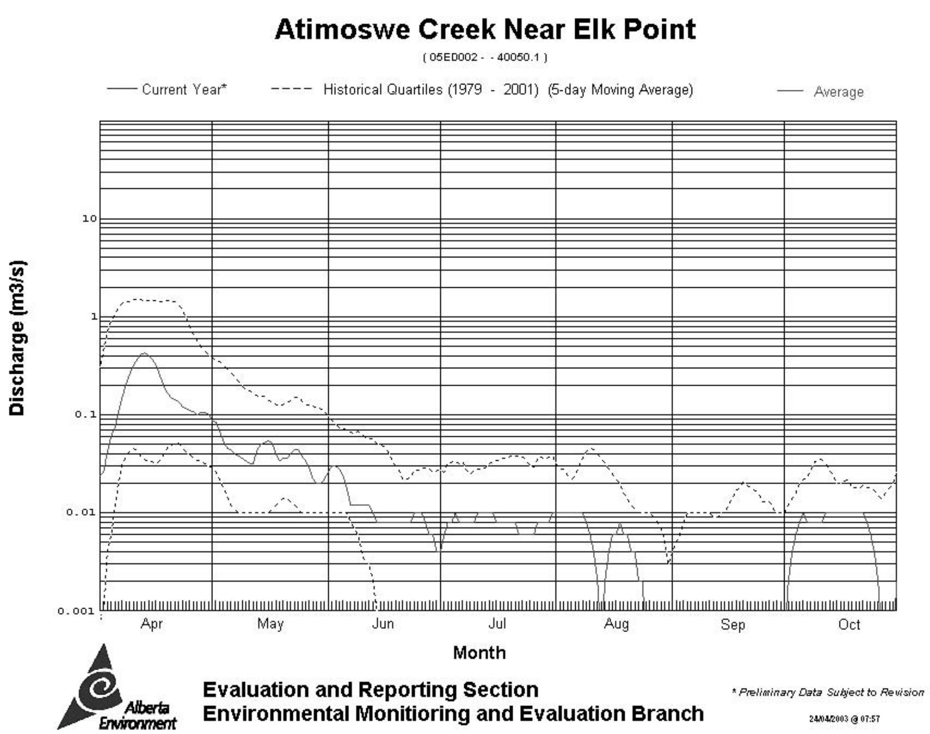
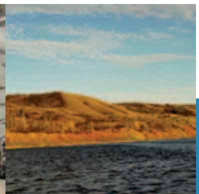
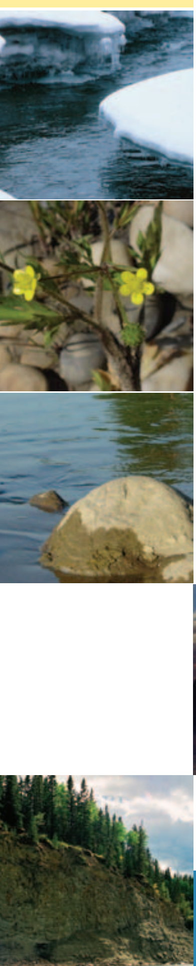


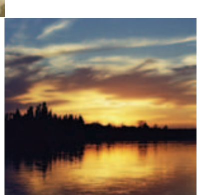

**Figure 20:** Atimoswe Creek near Elk Point mean monthly discharge for the open water season (Station 05ED002).











### 5.11.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.11.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices. No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Frog Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Frog Subwatershed.

#### 5.11.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Fish species found in the Subwatershed are the same as those in the White Earth and Vermilion Subwatersheds. Because of turbulent flow patterns, warmer temperatures, increased turbidity and substrate, the section of the North Saskatchewan River in this Subwatershed provides good quality habitat for walleye, sauger, and goldeye. Goldeye is the most abundant species and the main stem of the North Saskatchewan River is an important migratory corridor for this species between upstream spawning areas and downstream rearing areas. The river also supports other cool water fish species including northern pike, mooneye and yellow perch (Allan 1984).

#### 5.11.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Frog Subwatershed is located mainly in the Dry Mixedwood Natural Subregion, with some Central Parkland Natural Subregion. The Dry Mixedwood Subregion includes species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and has several peatlands. The Central Parkland is composed mainly of grassland with aspen, aspen parkland and closed aspen forest.

#### 5.11.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. Between 1973 and 1977, Alberta Environment surveyed of benthic invertebrates in the North Saskatchewan River. Data were summarized in a report published by Reynoldson and Exner (1978). The study included a sampling site at Elk Point. At sites downstream of Edmonton, including as far downstream as Elk Point, there was a major increase in numbers and a slight decline in species diversity. The nature of the change in the biological community suggested major impacts due to organic rather than inorganic or toxic effluents.

The main invertebrate groups in the river upstream of Edmonton were Chironomidae, which made up 38.4% of the samples, Ephemeroptera (Mayflies), 31.7% and Plecoptera (Stoneflies), 20.0%. The remainder of the sample was Trichoptera (Caddisflies), 4.9% and Oligochaeta (Earthworms), 0.5%.





At sites downstream of Edmonton, Oligochaeta made up 43.3% of the samples, Chironomidae, 40.8%, Ephemeroptera, 6.3%, Plecoptera, 4.8% and Trichoptera, 0.4%.

There have been major changes in Edmonton in the 30 years since these studies were undertaken. In particular, stormwater management and wastewater treatment have been significantly improved. *Edmonton's Environment: A Snapshot 2002* (City of Edmonton, 2003) states that between 1996 and 2001, the City's impact on the North Saskatchewan River was reduced by 84%. This was due mainly to upgrades at the Gold Bar Wastewater Treatment Plant including biological nutrient removal, enhanced primary treatment and ultra-violet disinfection.

**5.11.4 Frog Summary**

The geology and soil types of the Frog Subwatershed provide a viable agricultural industry. The majority of the Subwatershed is in land uses related to agricultural production: about 18% is treed. Water bodies cover about 7% of the land area. Livestock densities are moderate with low densities in the northeast and somewhat higher densities being indicated in areas near St. Paul.

Riparian inventory data were collected for 4.8 kilometres of Bonnie Lake shoreline in 2001. Of the 13 quadrats sampled, 46% were considered 'healthy', 46% were considered 'healthy but with problems' and 8% were considered 'unhealthy' due to shoreline modifications for recreational purposes. The only major problem noted was the presence of invasive plants.

Over 2% of land in the Subwatershed is affected by linear developments including roads, cutlines, pipeline rights of way, transmission line rights of way, and rail lines. Another 12% has been disturbed by land uses including First Nations' Reserves, well sites, municipalities, and industrial facilities.



The available PFRA Land Classification shows no areas classified as wetlands; however, Ducks Unlimited Canada data show wetlands on 7.6% of the Subwatershed area. This discrepancy should be resolved.

Water quantity is measured at three stations: none has real-time online data. No long-term river water quality information, information on water plants, fish population estimates or riparian habitat assessments was found for the Subwatershed.

Surveys of benthic invertebrates at Elk Point found an increase in numbers and a slight decline in species diversity as compared to sites upstream of Edmonton. The nature of the changes suggested impacts due to organic rather than inorganic or toxic effluents. There have been improvements in stormwater management and wastewater treatment in Edmonton since the surveys were conducted. Further studies of the benthic invertebrate populations are needed to determine the current level of impacts.

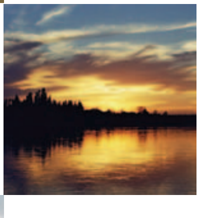
Goldeye is the most abundant fish species and the main stem of the North Saskatchewan River is an important migratory corridor for this species between upstream spawning areas and downstream rearing areas.

In summary, there has been little systematic assessment of the Frog Subwatershed and there are significant data gaps for the area. However, of the seven indicators assessed, one was good, six were fair, and none were poor, yielding an overall subjective rating of fair. These data gaps should be addressed; in particular the impacts of various land uses on riparian health, and the state of the aquatic ecosystem including water quality, water plants, and fish habitat and populations.

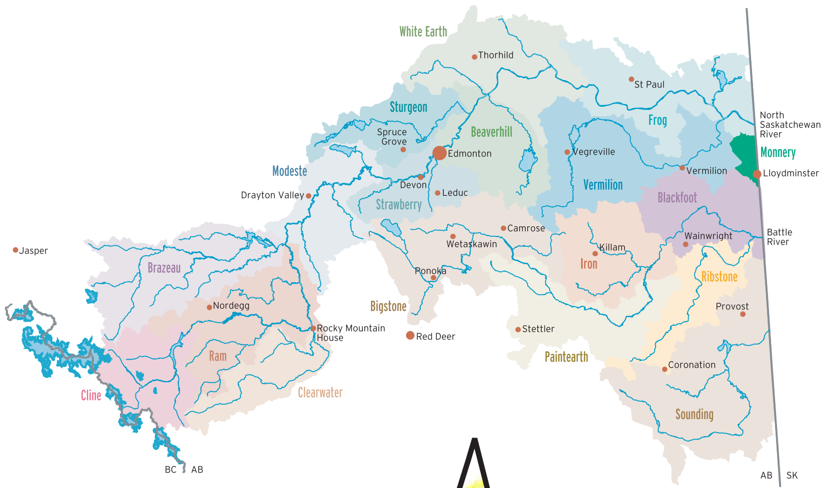


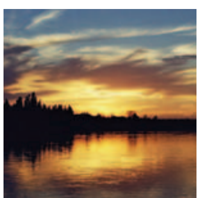




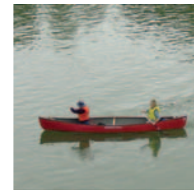

# Monnery

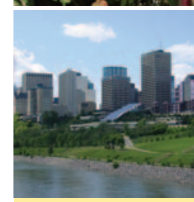





Corry
Age 6
Elk Point





## 5.12 MONNERY SUBWATERSHED

The Monnery Subwatershed lies in the Dry Mixedwood Natural Subregion and encompasses 125,537 hectares including 7,049 hectares of natural and artificial water bodies. The Monnery Subwatershed is bounded on the east by the Saskatchewan border and includes Improvement District 18 and Vermilion River County. Settlements in the Subwatershed include Blackfoot, Lloydminster, Streamstown, Tulliby Lake and the Makaoo 120 First Nations Reserve, with a total population of about approximately 12,000.

The geology and soil types of the Subwatershed provide for a viable agricultural industry. Agriculture is the primary industrial activity in the Subwatershed, although oil and gas operations are prevalent.

Many of the indicators described below are referenced from the "Monnery Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.12.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.12.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Monnery Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Monnery Subwatershed.

#### 5.12.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Almost 3% (3,419 ha) of land in the Monnery Subwatershed is affected by linear developments. The majority of this (51%) is in roads of one form or another, including gravel and unimproved roads (38% of the linear development) and paved roads (10% of linear development). Other linear developments include cutlines (20% of the area of linear development), pipeline rights of way (19%), transmission line rights of way (7%), and active or abandoned rail lines (3%).

#### 5.12.1.3 Land Use Inventory

An inventory of land quantifies natural landscape types and uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 6% of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: grassland, 43%; cropland, 36%; and forage, 0.3%. About 6.5% (8,150 ha) of the Subwatershed is covered with trees. Almost half (46%) of the Subwatershed area lies in a Provincial FMU, but none lies in Parks or Protected Areas.





About 9% of the land area has been disturbed by various disturbances including the linear development described above. Three percent of the Subwatershed is in a First Nations' reserve; 2% is area affected by well sites (2,779 ha). Municipalities of various sizes including Lloydminster affect about 2% of the Subwatershed (2,323 ha). The remainder of the land disturbance is related to linear developments (2.8%), and industrial facilities including oil and gas plants and a runway (28 ha).

Water bodies including rivers, lakes and dugouts cover about 7,049 hectares; about 6% of the area of the Subwatershed.

#### 5.12.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Monnery Subwatershed are moderate. Manure production in the soil polygons that cover the Monnery Subwatershed was estimated at between 1,194,000 and 2,448,000 tonnes.

#### 5.12.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Data from Alberta Sustainable Resource Development base features hydrology failed to identify wetlands in the Monnery Subwatershed. The available PFRA Land Classification includes 290 hectares of land classified as wetlands (0.2% of the Subwatershed area). However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 8,186 hectares of wetlands (6.8% of the Subwatershed area in Alberta). The inventory included both permanent and temporary wetlands.



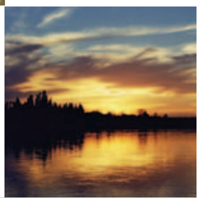


### 5.12.2 Water Quality and Quantity

Larger waterbodies in this Subwatershed include Pasatchaw, St. Ives, Rock Island, Two Hills, Christopher, John, Garson, Bennett, Onion and Meridian Lakes.

The City of Lloydminster obtains its water from the North Saskatchewan River. Wastewater treatment is provided by a secondary wastewater treatment plant and aeration lagoons.

Water quality in the main stem of the North Saskatchewan River is monitored regularly by Environment Canada at Lea (Jubilee) Park and the river crossing at Highway 17. Monthly physical, nutrients, metals and flow data are available from 1970 to the present. CCME Water Quality Index (WQI) data are available for both sites from Environment Canada for 1983-2002 (Glozier et al. 2004). For the 1983-2002 period, river water quality at both sites was found to be marginal (calculated WQI = 53). A marginal value (calculated WQI 45 to 59) means that water quality is frequently threatened or impaired, and that conditions often depart from natural or desirable levels. The variables of non-compliance were not stated in the report (Glozier et al. 2004). As expected, the CCME WQIs decreased markedly from the other Environment Canada headwater site WQI at Whirlpool Point. Water quality typically decreases as one travels downstream due to inputs from both natural, anthropogenic, point and non-point sources.







Water quantity is measured at one HYDEX station (05EF001) in the Alberta side of the Monnery Subwatershed on the main stem of the North Saskatchewan River at Deer Creek (Figure 21). This hydrograph is typical of a glacial meltwater dominated stream, with peak flows during the warm summer months and some impact on flows from spring and summer storms.

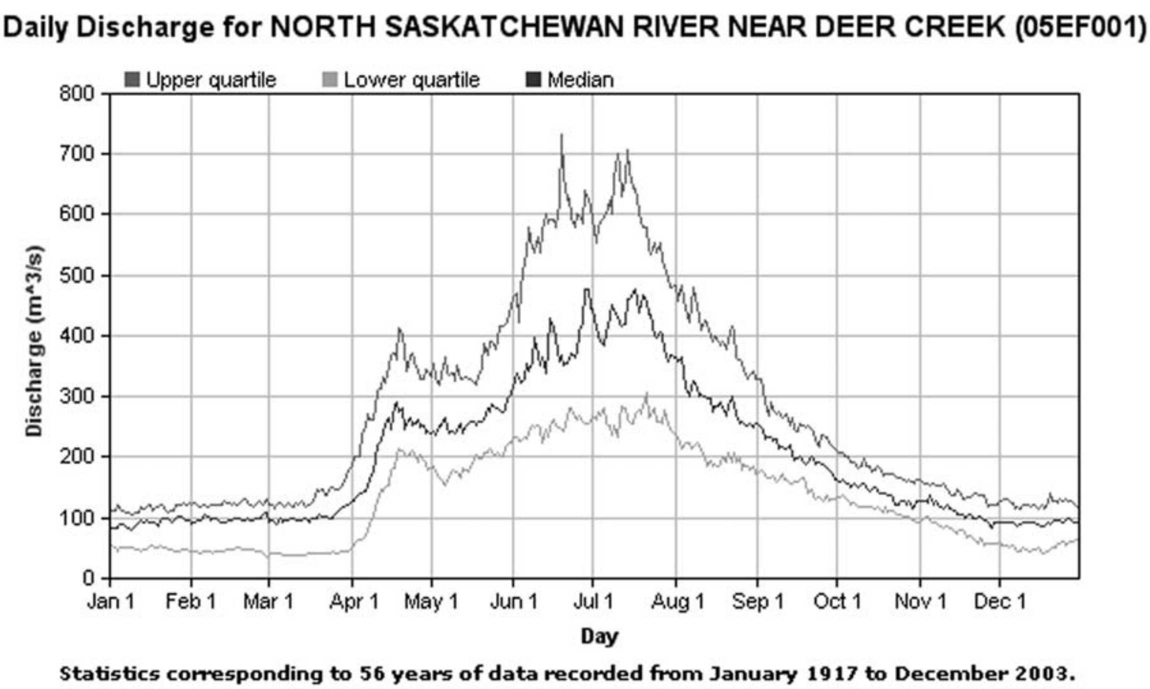



**Figure 21:** North Saskatchewan River at Deer Creek mean monthly discharge for the year (Station 05EF001).



### 5.12.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.12.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices. No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Monnery Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within this area.



### 5.12.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. The North Saskatchewan River supports a mix of cool water fish species including northern pike, walleye, sauger, goldeye, mooneye and yellow perch. Goldeye are the most abundant and the North Saskatchewan River is an important migratory corridor between upstream spawning areas and downstream rearing areas (Allan 1984).

### 5.12.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Monnery Subwatershed is located within the Dry Mixedwood Natural subregion. This subregion is dominated by tree types such as Trembling Aspen and Balsam Poplar, which are replaced over time by White Spruce and Balsam Fir. In dry areas Jackpine is more dominant, and peatlands are common in wetter regions. There are no dominant grasses.

### 5.12.3.4 Benthic Invertebrates

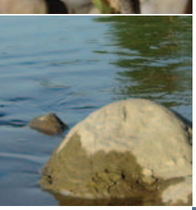
Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Monnery Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Monnery Subwatershed.

### 5.12.4 Monnery Summary

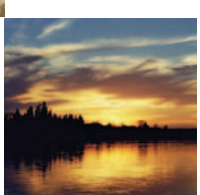
Agriculture is the primary industrial activity in the Monnery Subwatershed, although oil and gas operations are prevalent. The majority of the Subwatershed is classified in land uses related to agriculture and livestock densities are moderate. About 6.5% of the land area is treed.

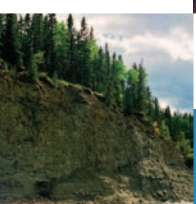
About 9% of the land area has been disturbed. Almost 3% of this is affected by linear developments including roads, cutlines, pipeline rights of way, transmission line rights of way, and rail lines. Other disturbances include a First Nations Reserve, well sites, municipalities, and industrial facilities.

Water bodies cover 6% of the Subwatershed. The PFRA Land Classification shows 0.2% of the Subwatershed as wetlands; however, Ducks Unlimited Canada information shows wetlands on 6.8% of the area. This variance should be resolved.



Water quality in the North Saskatchewan River is monitored regularly by Environment Canada. For the period 1983-2002, river water quality, based on the Canadian Council of Ministers of the Environment Water Quality Index, was marginal. This means that water quality is frequently threatened or impaired, and that conditions often depart from natural or desirable levels. The variables of non-compliance were not stated in the report by Glozier *et al.* (2004) and further analysis of the information is needed to determine whether water quality has improved in recent years as a result of improvements in water treatment by the City of Edmonton.





Water quantity is measured at one station in the Monnery Subwatershed. No long-term information on water plants, benthic invertebrates or riparian health was found for this Subwatershed. No assessment was found of fish populations; although it is reported that the North Saskatchewan River is an important migratory corridor between upstream spawning areas and downstream rearing areas.

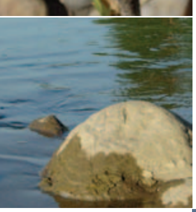
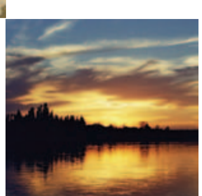
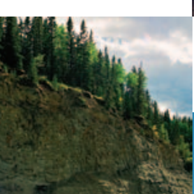
In summary, there has been little systematic assessment of the Monnery Subwatershed and there are significant data gaps for the area. However, of the six indicators assessed, none were good, five were fair, and one was poor, yielding an overall subjective rating of fair. These data gaps should be addressed; in particular, the impacts of various land uses on riparian health, and the state of the aquatic ecosystem including water quality, water plants, and fish populations.





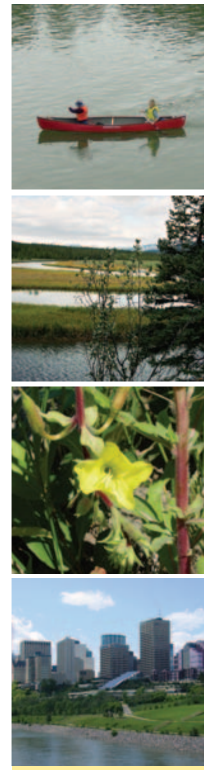




# Bigstone


Skye Irwin
Age 7
Rocky Mountain House



## 5.13 BIGSTONE SUBWATERSHED

The Bigstone Subwatershed is covered by the Dry Mixed Wood and Central Parkland natural subregions. The Bigstone Subwatershed is the headwaters of the Battle River watershed, which originates from Battle Lake. The Battle River watershed in Alberta includes the Subwatersheds of Bigstone, Paintearth, Iron, Ribstone and Blackfoot. The Battle River flows out of Alberta eastward to meet the North Saskatchewan River at North Battleford, Saskatchewan.

The Bigstone Subwatershed encompasses 727,714 hectares including 41,558 hectares (5.7%) of natural and artificial water bodies. The 16,471 acre Medicine Lake Provincial Grazing Reserve is in the Subwatershed. The Bigstone Subwatershed includes the Counties of Camrose, Flagstaff, Lacombe, Leduc, Ponoka and Wetaskiwin. Settlements in the Subwatershed include Argentia Beach, Armena, Bawlf, Bittern Lake, Blackfalds, Camrose, Crystal Springs, Daysland, Edberg, Falun, Golden Days, Grandview, Gwynne, Hay Lakes, Heisler, Hobbema, Itaska Beach, Kelsey, Lacombe, Ma-Me-O Beach, Millet, Morningside, Mulhurst Bay, New Norway, Norris Beach, Ohaton, Pipestone, Ponoka, Poplar Bay, Rosalind, Silver Beach, Westerose, Wetaskiwin, and the First Nations' reserves of Louis Bull 138B, Samson 137, Samson 137A, Ermineskin 138, Montana (Bobtail) 139, and Pigeon Lake 138A.

Soils types in the Subwatershed are among the most fertile in Alberta and the primary economic base is agriculture. In addition, oil and gas operations are common.

Recreational activities are common in the region and are concentrated in areas such as Pigeon Lake and Ma-Me-O Provincial Parks.



Many of the indicators described below are referenced from the "Bigstone Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.13.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.13.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. Riparian inventory data were collected for Pipestone Creek in 1999 (ARHMP Cows and Fish, unpublished data). Of the 33 quadrats sampled, 79% were considered healthy, 18% were healthy with problems, and 3% scored in the unhealthy range. Noxious weeds like Canada Thistle and Common Tansy were serious issues, as was the over-utilization of trees and shrubs. Insufficient rootmass and high percentages of bare ground were other major problems, as was the presence of pugging and hummocking in wet areas.

Riparian inventory data were collected for Bigstone Creek in 1999 (ARHMP Cows and Fish, unpublished data). Of the 24 quadrats sampled, 50% were considered healthy, 25% were healthy with problems, and 25%


scored in the unhealthy range. Noxious weeds like Canada Thistle and Common Tansy were serious issues, as was the over-utilization of trees and shrubs. Insufficient rootmass and high percentages of bare ground were other major problems, as was the presence of pugging and hummocking in wet areas.



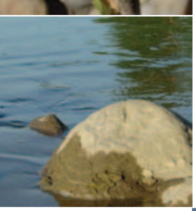
Riparian inventory data were collected for the Battle River in 2000 (ARHMP Cows and Fish, unpublished data). Of the 47 quadrats sampled, 72% were considered healthy, 26% were healthy with problems, and 2% scored in the unhealthy range. The presence of noxious weeds, especially Canada Thistle and Common Tansy was a major problem. The over-utilization of trees and shrubs, insufficient rootmass, and bare ground were other important issues.

Riparian inventory data were collected for Pigeon Lake Creek in 2000 (ARHMP Cows and Fish, unpublished data). Of the 9 quadrats sampled, 33% were considered healthy, 45% were healthy with problems, and 22% scored in the unhealthy range. Canada Thistle was a major problem, as was the over-utilization of trees and shrubs. Insufficient rootmass that contributes to bank slumping was another identified concern, as was the presence of bare ground.

Riparian assessment data were collected for Mink Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 6 quadrats sampled, 50% were considered healthy, 50% were healthy with problems. The major problems noted were the presence of the noxious weed Canada Thistle and the regeneration of trees and shrubs.

Riparian assessment data were collected for Poplar Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 22 quadrats sampled, 77% were considered healthy, 18% were healthy with problems, and 5% scored in the unhealthy range. The major problem noted was the presence of the noxious weeds Canada Thistle and Scentless Chamomile.



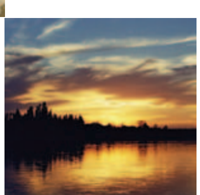


Riparian assessment data were collected for Sun Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 4 quadrats sampled, 25% were considered healthy and 75% were healthy with problems. Canada Thistle was identified as a major problem, as was over-utilization of trees and shrubs.

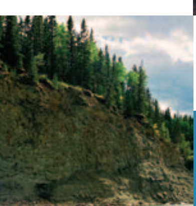
Riparian assessment data were collected for Modeste Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 6 quadrats sampled, 67% were considered healthy and 33% were healthy with problems. Noxious weeds like Canada Thistle were a major problem, along with the over-utilization of trees and shrubs.

Riparian assessment data were collected for Muskeg Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 10 quadrats sampled, 30% were considered healthy, 50% were healthy with problems and 20% scored in the unhealthy range. The over-utilization of trees and shrubs was found to be a major problem, as was the presence of pugging and hummocking in wet areas.

Riparian assessment data were collected for Lloyd Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 8 quadrats sampled, 100% were considered healthy. The over-utilization of trees and shrubs was found to be the major problem, along with the presence of Canada Thistle.



Riparian assessment data were collected for Rose Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 8 quadrats sampled, 88% were considered healthy and 12% were healthy with problems. The over-utilization of trees and shrubs was found to be a major problem, as was a high percentage of bare ground in some areas and presence of Canada Thistle and Tall Buttercup in the riparian area.



Riparian assessment data were collected for Elk Creek in 2001 (ARHMP Cows and Fish, unpublished data). Only 1 quadrat was sampled and that parcel was considered to be healthy. The over-utilization of trees and shrubs, and the presence of Canada Thistle were problems.

Riparian assessment data were collected for Horseshoe Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 8 quadrats sampled, 75% were considered healthy and 25% were healthy with problems. Canada Thistle and Common Tansy in the riparian area were found to be a major problem, as were the over-utilization of trees and shrubs, and high percentages of bare ground.

Riparian assessment data were collected for Washout Creek in 2001 (ARHMP Cows and Fish, unpublished data). Of the 17 quadrats sampled, 71% were considered healthy, 23% were healthy with problems, and 6% scored in the unhealthy range. The presence of Canada Thistle and the over-utilization of trees and shrubs were found to be major problems.

Riparian inventory data were collected for the County of Camrose on the Battle River and at Driedmeat Lake in 2001 (ARHMP Cows and Fish, 2002a). A total of 25.4 kilometres of shoreline along the Battle River and 1.8 kilometres of shoreline around Driedmeat Lake were assessed. Two-thirds of the quadrats sampled on both the Battle River and Driedmeat Lake were assessed as 'healthy, but with problems', with another 10% assessed as 'healthy'. The remaining 24% of the shorelines were considered 'unhealthy'. Major problems included the presence of invasive and disturbance-caused vegetation, utilization of preferred trees and shrubs and human alteration of shore vegetation, bank vegetation and shore structure.

#### 5.13.1.2 Linear Development



Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Linear development affects about 2.6% (18,655 ha) of the land in the Bigstone Subwatershed. The majority of linear developments (68%) are roads of one form or another. Approximately 76% of roads are gravel and unimproved. Paved roads account for about 21% of road development. Other linear developments include pipeline rights of way, (14% of the area of linear developments), cutlines (8%), power lines (6%) and used or abandoned rail lines (4%).

#### 5.13.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 6% of the Subwatershed. The vast majority of the Subwatershed overlaps various land uses related to agricultural production: forage, 37%; cropland, 32%; and grassland, 22%. Only about 3% of the Subwatershed is treed.

Including those areas affected by linear development, about 9% of the land area in the Subwatershed has been disturbed by various forms of development. Municipalities of various sizes, including the City of Camrose and Town of Lacombe, affect about 1.4% of the Subwatershed; six First Nations' reserves cover 4.4% of the Subwatershed. The remainder of the land disturbance is related to linear developments (2.5%), wellsites (1%), and industrial sites (0.1%).



#### 5.13.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual watershed. Based on the available information, livestock densities in the Bigstone Subwatershed are among the highest in the North Saskatchewan Watershed especially in the southern part of the Subwatershed along the Highway 2 corridor. In that area, manure production ranges from 1,768,000 to 10,570,000 tonnes. Based on findings from Alberta Agriculture, surface water in this Subwatershed is more susceptible to enrichment from phosphorus, and contamination from pesticides and fecal coliforms (CAESA 1998).

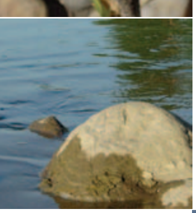
#### 5.13.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. The available hydrology data showed that wetlands accounted for less than one-tenth of a percent (514 ha) of the land area in the Bigstone Subwatershed. However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 54,111 hectares of wetlands (7.4% of the Subwatershed area). The inventory included both permanent and temporary wetlands.

### 5.13.2 Water Quality and Quantity

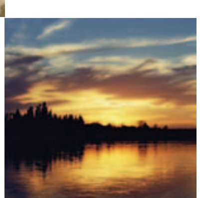
Water bodies in the Subwatershed include the Battle River, and the Maskwa, Bigstone, and Pipestone Creeks. Some of the larger lakes in this Subwatershed include Pigeon, Bittern, Red Deer, Driedmeat, Coal, Miquelon, Samson, and Battle. Many of the lakes and wetlands in the Subwatershed are somewhat saline. Lakewatch data for Driedmeat Lake (1999), Battle Lake (2001) and Pigeon Lake (2001) are available from ALMS. The Battle River Riparian Partnership in Camrose and the Community Riparian Program in Westaskiwin are active community watershed groups in the Bigstone Subwatershed. Check with Alberta Watersheds site.



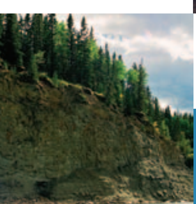


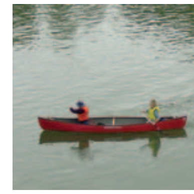
Most towns and cities in the Subwatershed have wastewater treatment lagoons that discharge directly into the Battle River or one of its tributaries. Camrose discharges into Camrose Creek, Wetaskiwin and Millet into Pipestone Creek, Lacombe into Wolf Creek, and Ponoka into the Battle River.

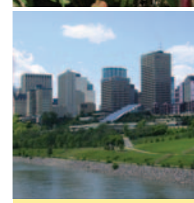
No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. Two stations on Bigstone Creek were sampled for fecal coliforms and TP during the years 2000-2002. The 20 fecal coliform samples ranged from <10 to 680 counts/100 mL, and averaged 115 counts/100 mL. Some of these samples were above the CCME Surface Water Quality Guidelines for Contact Recreation. The 20 TP samples ranged from 0.095 to 0.305 mg/L, and averaged 0.169 mg/L. Pesticide detections in this Subwatershed included 2,4-D, MCPA, MCPP, Dicamba and Picloram, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. Clopyralid and Triclopyr were detected but there currently are no water quality guidelines regarding these compounds.



Unlike most systems in Alberta, the Battle River system does not derive its base flow from mountain snowpack or glacial meltwater but depends on limited groundwater sources and runoff. Therefore, land use practices have a much higher capacity to impact surface water quality.






Water quantity is measured at seventeen HYDEX stations (05FA001-05FA002, 05FA007-05FA008, 05FA010-05FA012, 05FA014-05FA015, 05FA017-05FA019, 05FA021-05FA024, and 05FA912). One station has real-time online data (05FA001). Figure 22 shows the Pipestone Creek hydrograph, which is typical of a non-glacial fed stream. Flow contributions are from spring runoff and summer storms only.

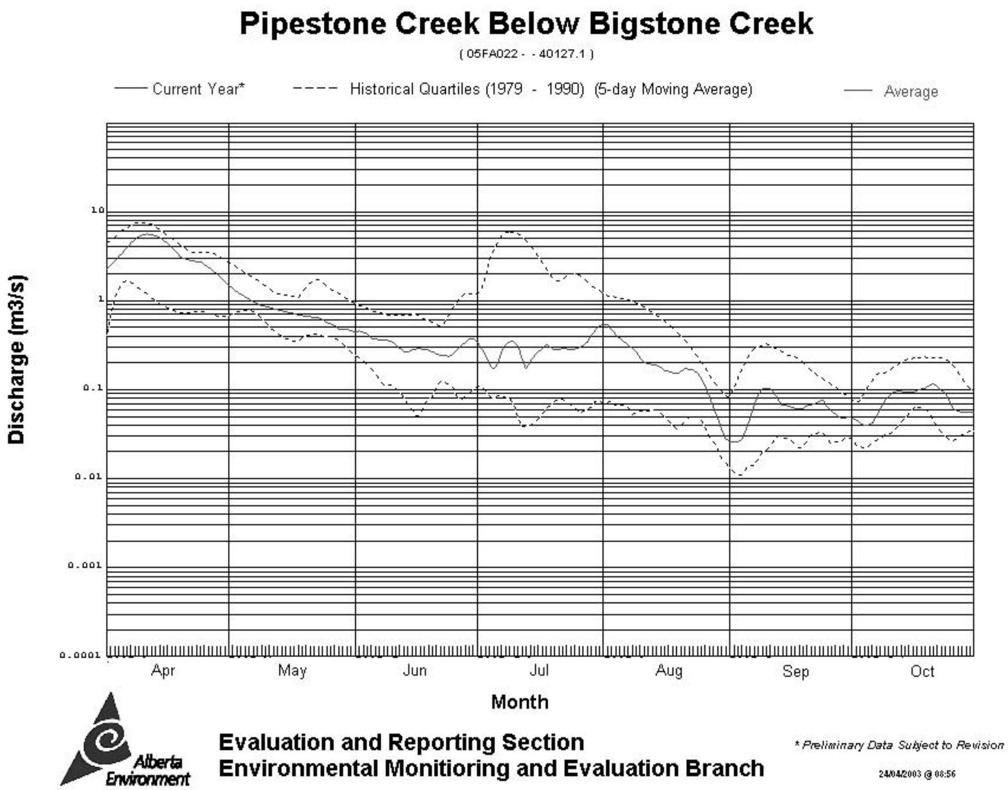



**Figure 22:** Pipestone Creek below Bigstone Creek mean monthly discharge for the open water season (Station 05FA022).

### 5.13.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.13.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Bigstone Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Bigstone Subwatershed.

#### 5.13.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Fish species in the Bigstone Subwatershed are similar to those in the Modeste Subwatershed. White suckers and pike are widely distributed and lake whitefish, burbot and yellow perch occur in Battle and Pigeon lakes. Walleye were indigenous to Pigeon Lake and have been reintroduced. The upper portion of the Battle River provides cool water fish habitat. Northern pike are the only sport fish and are limited in distribution and numbers because of low flows and barriers to movement (Allan 1984).

#### 5.13.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Bigstone Subwatershed is located in both the Dry Mixedwood and Central Parkland ecological subregions. The Dry Mixedwood Subregion includes tree species such as aspen, balsam poplar, white spruce, balsam fir and jack pine, and is host to many peatland areas. The Central Parkland is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Species include trembling aspen and balsam poplar.

#### 5.13.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Bigstone Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Bigstone Subwatershed.

### 5.13.4 Bigstone Summary

The Bigstone is a Subwatershed of the Battle River watershed. It includes several towns and First Nation's Reserves. Soils types are among the most fertile in Alberta and the vast majority of the Subwatershed is under high agricultural intensity. Only 3% of the Subwatershed is treed. Livestock densities in the Bigstone Subwatershed are among the highest in the North Saskatchewan Watershed especially along the Highway 2 corridor. Oil and gas operations are common. Water bodies cover 6% of the Subwatershed and larger lakes are used for recreation.

Riparian health has been assessed for 25.4 kilometres along the Battle River and 1.8 kilometres around Driedmeat Lake. These assessments indicate that most of the habitat is either "healthy but with problems" or "unhealthy". Major problems included the presence of invasive and disturbance-causing plants, preferred grazing, and human alteration of shore vegetation, bank vegetation and shore structure. It is not known if these assessments reflect general conditions in the Subwatershed or localized conditions. Further assessments should be conducted to determine the need for remedial action.

Linear developments affect about 2.6% of the Subwatershed. This is mostly roads, but also includes pipeline rights of way, cutlines, power lines, and rail lines. Another 7% of the land area is affected by development including municipalities, First Nations' reserves, well sites and industrial sites.

The hydrology data showed that wetlands accounted for less than 0.1% of the land area in the Subwatershed. In contrast, Ducks Unlimited Canada inventory data show wetlands as covering 7.4% of the area. This variance should be resolved prior to developing management plans for the Subwatershed.

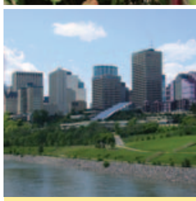
Most municipalities in the Subwatershed have wastewater treatment lagoons that discharge into the Battle River or one of its tributaries; however, no long-term river water quality information exists for this Subwatershed. A long-term river network station could be established on the Battle River downstream of Camrose.

Water quantity is measured at seventeen stations: one station has real-time online data. Unlike many systems in Alberta, the Battle River system depends on limited groundwater sources and rain and snowmelt runoff.

Except in the larger lakes, sport fish are limited in distribution and numbers because of low flows and barriers to movement in the Battle River. No assessment of fish populations was found. Nor has a systematic examination been conducted of water plants, or benthic invertebrates in the Bigstone Subwatershed. These data gaps should be addressed in future research of the Bigstone Subwatershed.

In summary, the Subwatershed supports extensive agriculture and high levels of livestock production. The impact of these activities on water resources needs to be examined further. Riparian habitat assessments suggest that improvement is needed in the management of these areas. Furthermore, there are limited flows in the Battle River and other streams in the Subwatershed, and these flows depend on groundwater sources and local snow melt. Thus water quality is more directly affected by local land use practices and activities. No long-term water quality data exists for the Subwatershed and no assessment has been made of aquatic plants or benthic invertebrates. However, of the nine indicators assessed, one was good, four were fair, and four were poor, yielding an overall subjective rating of poor. It is important to address these data gaps and assess the impact of various land uses on the water resources of the Subwatershed.

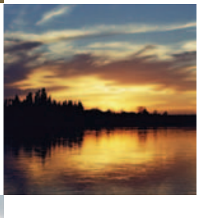


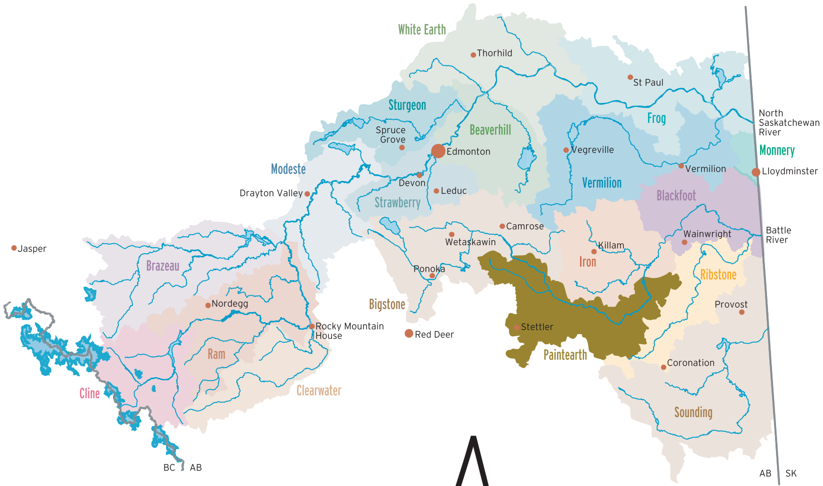


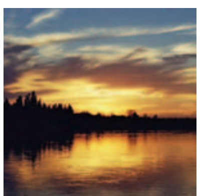





# Paintearth




Kalina
Age 5
Sputinow





## 5.14 PAINTEARTH SUBWATERSHED

The Paintearth Subwatershed lies in the Battle River watershed and is mostly in the Central Parkland Natural Subregion with some of the southern portion in the Northern Fescue Natural Subregion. The Paintearth Subwatershed encompasses 474,209 hectares including 13,105 hectares (2.7%) of natural and artificial water bodies. The Subwatershed includes Camrose, Flagstaff, Paintearth and Stettler Counties. Settlements in the Subwatershed include Amisk, Alliance, Botha, Brownfield, Castor, Donalda, Galahad, Ferintosh, Fleet, Gadsby, Halkirk, Meeting Creek, Red Willow and Stettler with a total population of about 3,000. Much of the area is extensively covered in badlands and underlain by coal deposits. The economic base of the region is oil, natural gas, agriculture, and mining for gravel and coal.

The Big Knife Provincial Park on the Battle River provides camping, hiking, swimming, canoeing/kayaking, fishing, and boating.

Many of the indicators described below are referenced from the “Paintearth Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.14.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



#### 5.14.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Paintearth Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research in the Paintearth Subwatershed.

#### 5.14.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Over 2% (10,159 ha) of the Paintearth Subwatershed lands are affected by linear developments. The majority of linear development (64%) is roads of one form or another, including gravel and unimproved roads (50% of the linear development) and paved roads (9% of linear developments). Other linear developments include pipeline rights of way (13% of the area of linear development), transmission line rights of way (10%), cutlines (9%) and active or abandoned rail lines (5%).

#### 5.14.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, and including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 3% of the



Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: grassland, 56%; cropland, 39%; and forage, 6%. About 1.5% (6,697 ha) of the Subwatershed is covered with trees or shrubs. Water bodies including rivers, lakes and dugouts cover about 13,105 hectares; 3% of the area of the Subwatershed.



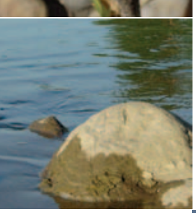
About 4% of the Subwatershed has been affected by various forms of disturbance including the linear development described above. The greatest area of disturbance following linear development is due to well sites and open pit mines, which affect 1% and 0.5% of the Subwatershed (5,102 ha and 2,154 ha, respectively). Disturbance due to municipalities of various sizes including Stettler and Castor affects about 0.3% of the Subwatershed (1,648 ha). The remainder of the land disturbance is related to linear developments (2.1%), and industrial facilities including oil and gas plants, runways, sand and gravel pits, and a power generating station (0.5%; 2,282 ha).

**5.14.1.4 Livestock Density**

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Paintearth Subwatershed are moderate. Manure production in the soil polygons that cover the Paintearth Subwatershed range between 256,000 and 2,448,000 tonnes.

**5.14.1.5 Wetland Inventory**

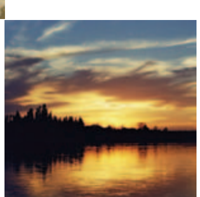




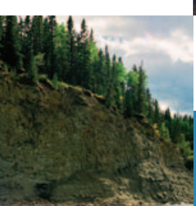
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Both the Alberta Sustainable Resource Development base features hydrology data and the PFRA Land Classification data failed to identify wetlands in the Paintearth Subwatershed. However, an inventory completed by Ducks Unlimited Canada found a total of 34,771 hectares of wetlands (7.3% of the Subwatershed area). The inventory included both permanent and temporary wetlands. The western part of the watershed includes the Buffalo Lake First Step Project for the North American Waterfowl Management Plan (NAWMP) in Alberta.

**5.14.2 Water Quality and Quantity**

Water bodies in the Subwatershed include the Battle River, and the Nelson, Paintearth, Castor, Young, Big Knife, Red Willow, Meeting and Frenchmans Creeks. Some of the larger waterbodies in this Subwatershed include Driedmeat, Lonepine, Lowden, Beltz, Hughender, Barnett, Lowden and Little Beaver Lakes. Many of the towns have wastewater detention ponds that discharge into tributaries of the Battle River. Stettler discharges into Red Willow Creek, and Castor into Castor Creek.



No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. This data gap should be addressed in future studies in this Subwatershed. However, three stations along Paintearth Creek were sampled for fecal coliforms and TP during 1987-1990. The 3 fecal coliform samples ranged from 8 to 72 counts/100 mL, and averaged 37 counts/100 mL. All of these samples were below the CCME Surface Water Quality Guidelines for Contact Recreation. The 7 TP samples ranged from 0.084 to 0.544 mg/L, and averaged 0.313 mg/L. There has been no sampling for pesticides in this Subwatershed.






Water quantity is measured at eight HYDEX stations (05FC001-05FC007 and 05FC904): one station has real-time online data (05FC001). Figure 23 shows the Paintearth Creek hydrograph for the open water season. This hydrograph is typical of a small prairie stream with only runoff contributions. Flows are highly sporadic, and only occur following spring runoff and summer storm events.

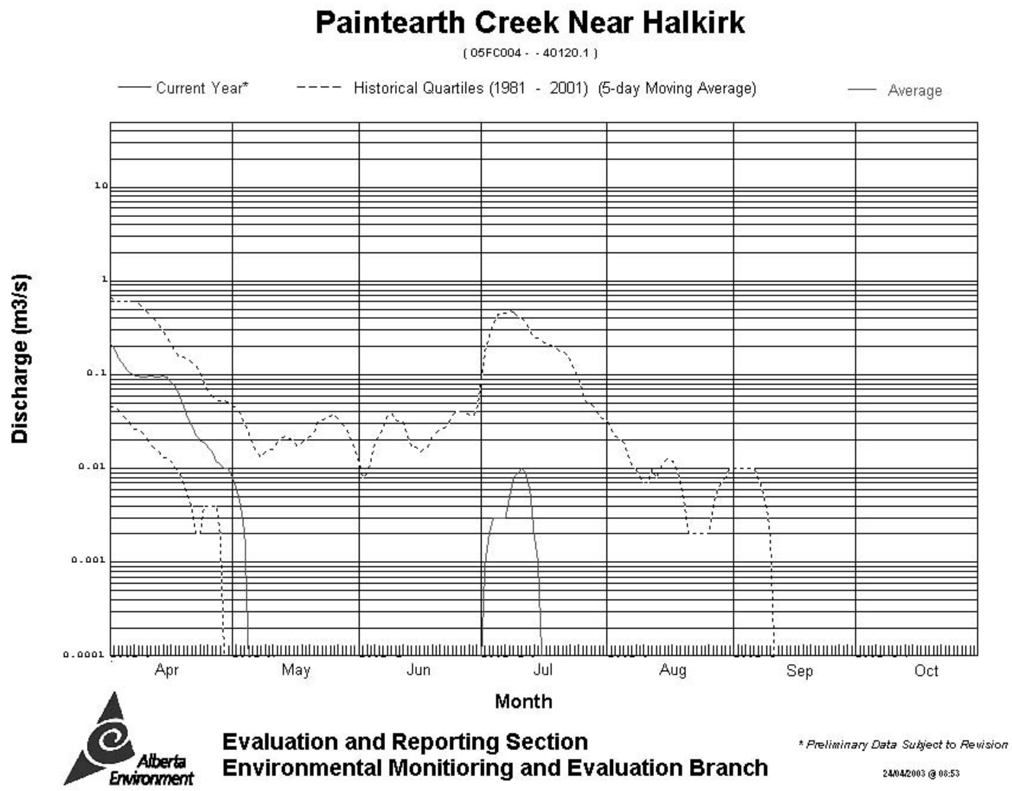



**Figure 23:** Paintearth Creek near Halkirk mean monthly discharge for the open water season (Station 05FC004).



### 5.14.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.14.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Paintearth Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Paintearth Subwatershed.

### 5.14.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. A systematic estimate of fish populations in the Paintearth Subwatershed has not been conducted. Walleye, goldeye, northern pike occur in the Battle River; however, their numbers are limited by low flows.

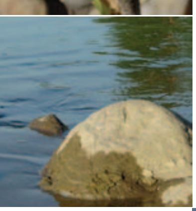
### 5.14.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Paintearth Subwatershed is located in the Central Parkland and Northern Fescue Natural Subregions. The Central Parkland Subregion is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Tree species include trembling aspen and balsam poplar. The Northern Fescue Subregion is characterized by gently rolling terrain, low-relief ground moraine and hummocky moraine. The dominant vegetation type in this subregion is Rough Fescue.

### 5.14.3.4 Benthic Invertebrates



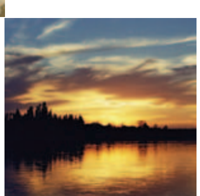
Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Paintearth Subwatershed, so we cannot make any conclusions about aquatic ecosystem health using this indicator. This data gap could be addressed in future research within the Paintearth Subwatershed.



### 5.14.4 Paintearth Summary

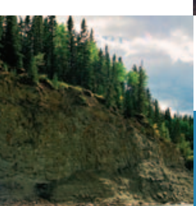
The Paintearth Subwatershed lies in the Battle River watershed. Much of the area is underlain by coal deposits. Livestock densities in the Paintearth Subwatershed are moderate. The economic base is oil, natural gas, agriculture, and mining for gravel and coal. Over 2% of the Subwatershed is affected by linear developments including roads, pipeline rights of way, transmission line rights of way, cutlines, and rail lines. Another 2% is affected by well sites, municipalities, and facilities including oil and gas plants, runways, sand and gravel pits, and a power station. Water bodies cover 3% of the Subwatershed. The majority of the Subwatershed is classified in land uses related to agriculture. About 1.5% of the Subwatershed is covered with trees or shrubs.

The available PFRA Land Classification shows no wetlands in the Subwatershed; however, Ducks Unlimited Canada data show wetlands on 7.3% of the Subwatershed area. This variance needs to be resolved.



No published assessment of riparian health, water plants, benthic invertebrates, or long-term river water quality information was found for the Subwatershed. Water quantity is measured at eight stations: one has real-time online data.

A systematic estimate of fish populations in the Paintearth Subwatershed has not been conducted. Fish species are limited by low flows in the Battle River and other streams.





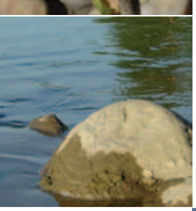
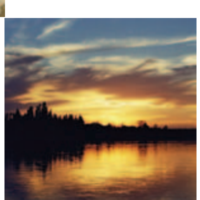
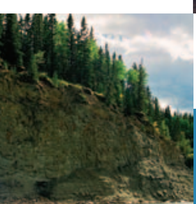

In summary, there has been little systematic assessment of the Paintearth Subwatershed and there are significant data gaps for the area. However, of the eight indicators assessed, two were good, four were fair, and two were poor, yielding an overall subjective rating of fair. These data gaps should be addressed; in particular, the impacts of various land uses on riparian health, and the state of the aquatic ecosystem including benthic invertebrates, water plants, and fish populations.



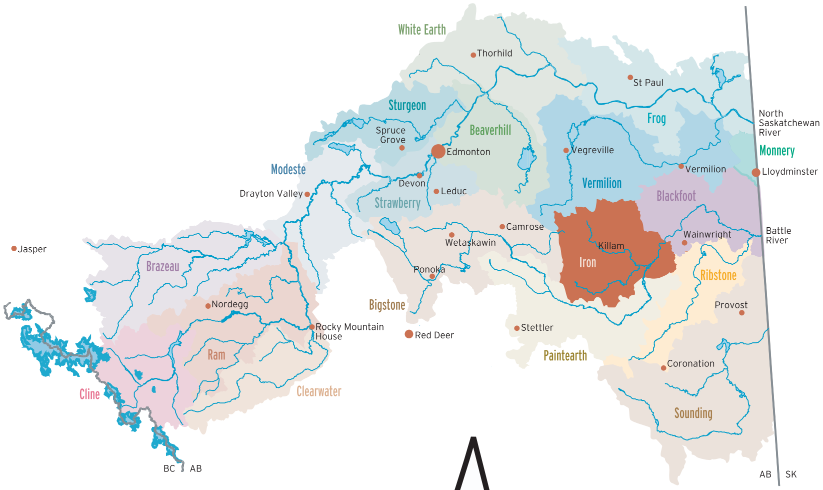


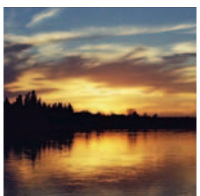




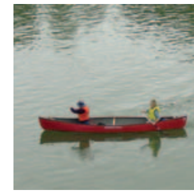





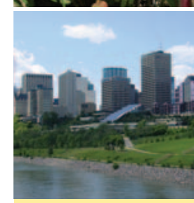
# Iron



Tara Carter
Age 9
Wes Hosford School



## 5.15 IRON SUBWATERSHED

The Iron Subwatershed lies in the Central Parkland Natural Subregion and encompasses 556,001 hectares including 20,566 hectares of natural and artificial water bodies. The Iron Subwatershed is part of the Battle River watershed and includes Beaver, Flagstaff, Provost and Wainwright Counties. The Subwatershed includes the settlements of Amisk, Forestburg, Galahad, Hardisty, Heisler, Irma, Killam, Kinsella, Lougheed, Sedgewick, Strome and Viking with a total population of about 11,500. In addition to oil and gas and mining activity, agriculture is the major economic activity in the Subwatershed.

Many of the indicators described below are referenced from the “Iron Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.15.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.15.1.1 Riparian Health



The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. Riparian inventory data were collected in 2001 for 31 kilometres of Iron Creek shoreline in Flagstaff County (ARHMP Cows and Fish 2002e). The majority (53%) of riparian areas along Iron Creek were rated as ‘healthy, but with problems’ while 37% were rated as ‘unhealthy’ and 10% as ‘healthy’. Major problems included invasive plants, preferential grazing, pugging and hummocking and alteration of streambanks (by livestock or humans).

Riparian inventory data were gathered in the County of Wainwright in 2001 for 14 kilometres of Grattan Creek shoreline (ARHMP Cows and Fish 2002d). The majority (54%) of the quadrats sampled were assessed as ‘healthy, but with problems’, with 38% being assessed as ‘unhealthy’. Two quadrats (8%) were assessed as ‘healthy’. Major problems were invasive plants, preferential grazing, human alteration of shore and bank structure, and pugging and hummocking.

#### 5.15.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Over 2% (13,192 ha) of land in the Iron Subwatershed is affected by linear developments. The majority of this (58%) is in roads of one form or another, including gravel and unimproved roads (48% of the linear development) and paved roads (7% of linear developments). Other linear developments include pipeline rights of way (16% of the area of linear development), cutlines (14%), transmission line rights of way (9%), and active or abandoned rail lines (3%).

#### 5.15.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes



in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, and including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 20,566 (4%) of the Subwatershed. The vast majority of the Subwatershed is classified in various land uses related to agricultural production: grassland, 50%; cropland, 44%; and forage, 4%. About 0.3% (1,744 ha) of the Subwatershed is covered with trees.

About 7.6% of the land area in the Subwatershed has been disturbed by various forms of disturbance including the linear development described above. The greatest area of disturbance following linear development is the area affected by C.F.B. Wainwright; 33,539 hectares - 6% of the Subwatershed. Well sites affect about 1% of the Subwatershed (5,858 ha). Disturbance due to municipalities of various sizes including Forestburg, Hardisty, Sedgewick and Viking affects about 0.4% of the Subwatershed (2,278 ha). The remainder of the land disturbance is related to linear developments (2.4%), and industrial facilities including oil and gas plants, runways, sand and gravel pits, and other industrial sites (577 ha).

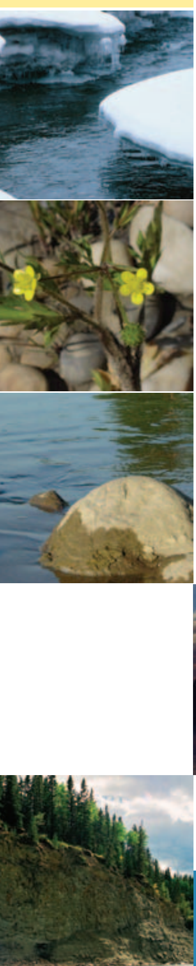
### 5.15.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Iron Subwatershed are moderate. Manure production in the soil polygons that cover the Iron Subwatershed was estimated at between 256,000 and 1,767,000 tonnes.



### 5.15.1.5 Wetland Inventory

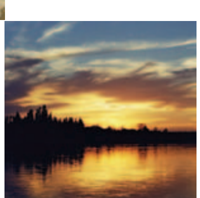
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats.



Data from both Alberta Sustainable Resource Development base features hydrology and PFRA Land Classification failed to identify wetlands in the Iron Subwatershed. However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 34,182 hectares of wetlands (6.1% of the Subwatershed area). The inventory included both permanent and temporary wetlands.

### 5.15.2 Water Quality and Quantity

Water bodies in the Iron Subwatershed include the Battle River and Iron and Grattan Creeks. Larger lakes in this Subwatershed include Wavy, Thomas, Vernon, Bellshill, Hattie, Peninsula, Wilkins, Jamieson, Betty, Byers, Schultz and Camp. The Iron Creek Watershed Improvement Society is an active community watershed group in this Subwatershed. Several towns in the Subwatershed have wastewater detention lagoons that discharge into tributaries of the Battle River. Viking discharges into Thomas Creek; Killam into an unnamed creek, and Wainwright into Bushy Head Lake.



No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. This data gap should be addressed in future research in this Subwatershed. However, four stations along Iron Creek were sampled for fecal coliforms and TP during the years 1972, 1986, 1989, 2000, and 2003-04. The 60 fecal coliform samples contained no evidence of fecal coliforms. The 11 TP samples ranged from 0.005 to 0.5 mg/L, and averaged 0.197 mg/L. No pesticide sampling has been completed in this watershed to date.





Water quantity is measured at two HYDEX stations (05FB002-05FB003): neither have real-time online data. Figure 24 shows the Iron Creek hydrograph for the open water season. This hydrograph is typical of a non-glacial, non-groundwater fed stream, with flow contributions from spring runoff and summer storms only and drying in late summer.

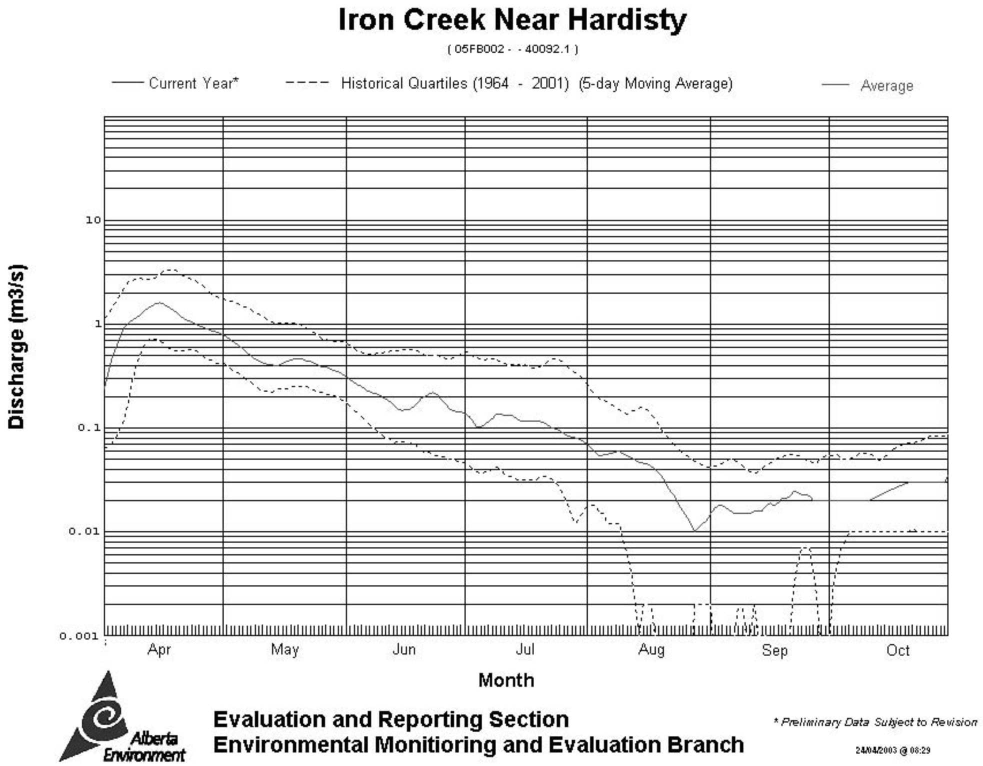



**Figure 24:** Iron Creek near Hardisty mean monthly discharge for the open water season (Station 05FB002).

### 5.15.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.15.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Iron Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Iron Subwatershed.

### 5.15.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. Fish species are those characteristic of the Central Parkland Natural Subregion; although there is a lack of permanent water bodies and high salt concentrations. In the main stem of the Battle River, walleye, goldeye and northern pike occur; however, their numbers are limited by low flows (Allan 1984).

### 5.15.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Iron Subwatershed is located in the Central Parkland Subregion. This subregion is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Tree species include trembling aspen and balsam poplar, while grasslands are dominated by Rough Fescue.

### 5.15.3.4 Benthic Invertebrates

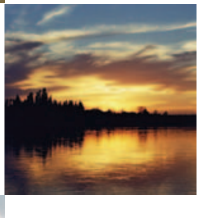
Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Iron Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Iron Subwatershed.

### 5.15.4 Iron Summary

The Iron Subwatershed is part of the Battle River watershed. In addition to oil and gas and mining activity, agriculture is the major economic activity. The majority of the Subwatershed is classified in land uses related to agriculture and livestock densities are moderate. About 0.3% is treed and water bodies cover 4% of the Subwatershed.

Riparian inventory data were collected for 31 kilometres of Iron Creek shoreline. Fifty-three percent of riparian areas were rated as 'healthy, but with problems' while 37% were rated as 'unhealthy' and 10% as 'healthy'. Riparian inventory data also were gathered for 14 kilometres of Grattan Creek shoreline. Fifty-four percent of the riparian area was assessed as 'healthy, but with problems', 38% as 'unhealthy' 8% were assessed as 'healthy'.

Over 2% of land is affected by linear developments including roads, pipeline rights of way, cutlines, transmission line rights of way, and rail lines. Another 5.6% of the land area is affected by C.F.B. Wainwright. Well sites, municipalities, and industrial facilities affect another 2%.



The PFRA Land Classification shows no wetlands in the Subwatershed; however, Ducks Unlimited Canada data show wetlands on 6.1% of the area. This discrepancy should be resolved.

Water quantity is measured at two stations: neither have real-time online data. No long term river water quality information or information on water plants, fish populations, or benthic invertebrates

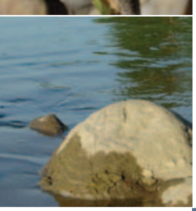
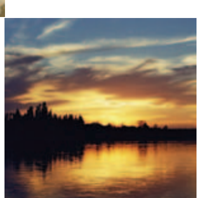
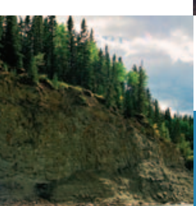
was found for Iron Subwatershed. In the main stem of the Battle River, walleye, goldeye and northern pike occur. Fish populations are limited by low flows, a lack of permanent water bodies and high salt concentrations.

In summary, there has been little systematic assessment of this Subwatershed and there are significant gaps in the available information. However, of the seven indicators assessed, none were good, four were fair, and three were poor, yielding an overall subjective rating of fair. The high level of agricultural land use, moderate livestock densities, and the results of riparian health assessments suggest that it is important to address the data gaps and to further assess the impacts of various land uses on the Subwatershed.

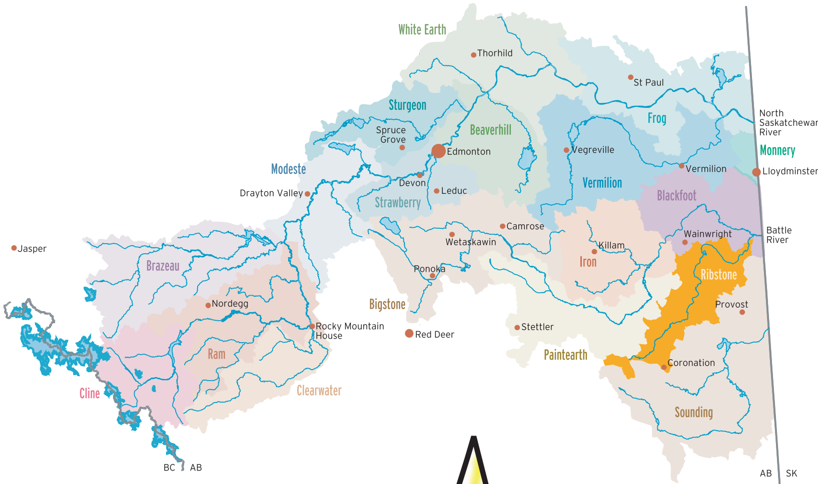


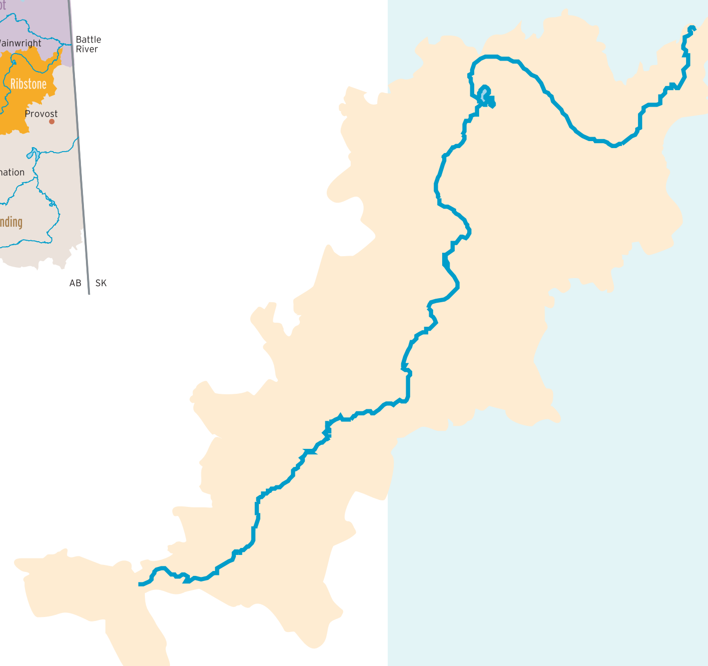


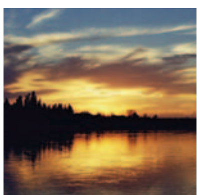


# Ribstone





Rebecca Maron
Age 8
Edmonton




## 5.16 RIBSTONE SUBWATERSHED

The Ribstone Subwatershed encompasses 374,155 hectares in the Battle River watershed, including 14,133 hectares of natural and artificial water bodies. Most of the Ribstone Subwatershed is in the Northern Fescue Natural Subregion, with some in the Central Parkland Natural Region. The Wainwright Dunes Ecological Reserve, situated just east of Ribstone Creek, encompasses 2,821 ha. The Subwatershed contains Paintearth, Provost, Special Areas # 4 and Wainwright Counties, the settlements of Chauvin, Coronation, Czar, Edgerton, Greenshields, Hughenden, Metiskow, Veteran, and the majority of the Canadian Forces Base at Wainwright. The CFB takes up 24,059 ha (6.43%) of the Subwatershed area. The total permanent population of the area is approximately 3,000. The main economic base of the region is agriculture and oil and gas activities.

Dillberry Lake Provincial Park is known for its shorebird migration and also provides recreational activities including canoeing and kayaking, sport fishing, power boating, water skiing, swimming, sailing, and windsurfing.

Many of the indicators described below are referenced from the "Ribstone Hydrological Overview" map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.16.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



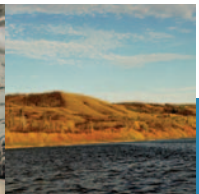
#### 5.16.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. The MD of Wainwright is active with riparian initiatives in the Ribstone Creek Subwatershed. Riparian health was assessed in 2001 for 9.5 kilometres of Black Creek in the MD of Wainwright (ARHMP Cows and Fish 2002b). Nearly three quarters (70%) of the quadrats were assessed as 'healthy, but with problems', with the remainder (30%) assessed as 'unhealthy'. None of the quadrats were deemed 'healthy'. Major problems included invasive and disturbance causing plants, preferential grazing, and pugging or hummocking. In 2001, riparian health was assessed along Ribstone Creek by Cows and Fish for the County of Paintearth. This information was not available for this watershed summary report. The County of Paintearth can be contacted directly for these results.

#### 5.16.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. Over 2% (8,548 ha) of land in the Ribstone Subwatershed is affected by linear developments. The majority of this (45%) is in roads of one form or another, including gravel and unimproved roads (34% of the linear development) and paved roads (7% of linear development). Other linear developments include cutlines (28% of the area of linear development), pipeline rights of way (11%), transmission line rights of way (9%), and active or abandoned rail lines (6%).





### 5.16.1.3 Land Use Inventory

An inventory of land quantifies natural landscape types and uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 14,133 (4%) of the Subwatershed. The vast majority of the Subwatershed is classified in agricultural land uses: grassland, 65%; cropland, 29%; and forage, 2%. About 2% (6,812 ha) of the Subwatershed is covered with shrubs or trees. Only 6,618 (1.9%) of the Subwatershed lie in Parks or Protected Areas (Ribstone Creek Heritage Rangeland).

About 10% of the Subwatershed has been affected by various forms of disturbance including the linear development described above. The greatest area of disturbance following linear development is the area within C.F.B Wainwright; 6.4% of the watershed – 24,059 hectares. Well sites affect about 1% of the Subwatershed (4,575 ha). Disturbance due to municipalities of various sizes including Coronation, Czar, Edgerton and Veteran affects about 0.2% of the Subwatershed (724 ha). The remainder of the land disturbance is related to linear developments (2.3%), and industrial facilities including oil and gas plants, runways, and sand and gravel pits (26 ha).

### 5.16.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Ribstone Subwatershed are generally moderate although there is a soil polygon with higher manure production indicated near Wainwright. Manure production in the soil polygons that cover the Ribstone Subwatershed was estimated at between 256,000 and 5,422,000 tonnes.

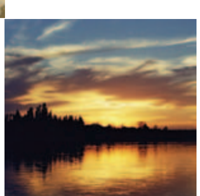


### 5.16.1.5 Wetland Inventory

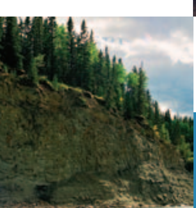
Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Data from both Alberta Sustainable Resource Development base features hydrology and PFRA Land Classification failed to identify wetlands in the Ribstone Subwatershed. However, an inventory completed by Ducks Unlimited Canada for the Subwatershed found a total of 48,151 hectares of wetlands (12.9% of the Subwatershed area). The inventory included both permanent and temporary wetlands.

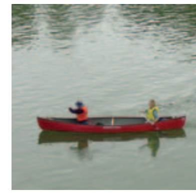
### 5.16.2 Water Quality and Quantity

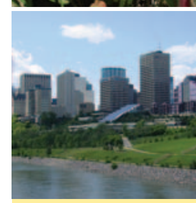
Water bodies in the Ribstone Subwatershed include the Battle River and Blackfoot, Ribstone, Black, Grizzly Bear, and Buffalo Creeks. Larger lakes include Ribstone, Shorncliffe, Dolcy, Houcher, Hughenden, David, Dixon, Border, Willow, Horseshoe, Bruce and Wallaby, Normandin, Clark, Albert, and McCafferty Lakes. ALMS Lakewatch data are available for 2000 for Shorncliffe Lake.



No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, Buffalo Creek was part of the CAESA stream network as a site in an area of high agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-present (CAESA 1998, Depoe and Westbrook 2003). The town of Coronation discharges its treated effluent into Ribstone Creek.





Three stations along Ribstone Creek were sampled for fecal coliforms and TP during the years 1971-73, 1977-78 and 1990. The 8 fecal coliform samples ranged from 0 to 4 counts/100 mL, and averaged 1 count/100 mL. These samples were well below the CCME Surface Water Quality Guidelines for Contact Recreation. The 16 TP samples ranged from 0.043 to 0.205 mg/L, and averaged 0.142 mg/L. Pesticide detections in this Subwatershed included 2,4-D, Bromoxynil, MCPA, and Picloram, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. 2,4 DP and Imazamethabenz-methyl were detected, but there are currently no guidelines for these compounds.

Water quantity is measured at four HYDEX stations (05FD001, 05FD003 and 05FD005-05FD006); none of these stations has real-time online data. Figure 25 shows a hydrograph for Ribstone Creek. This hydrograph is typical of a non-glacial fed stream, which has flows dominated by spring runoff and summer storms only.



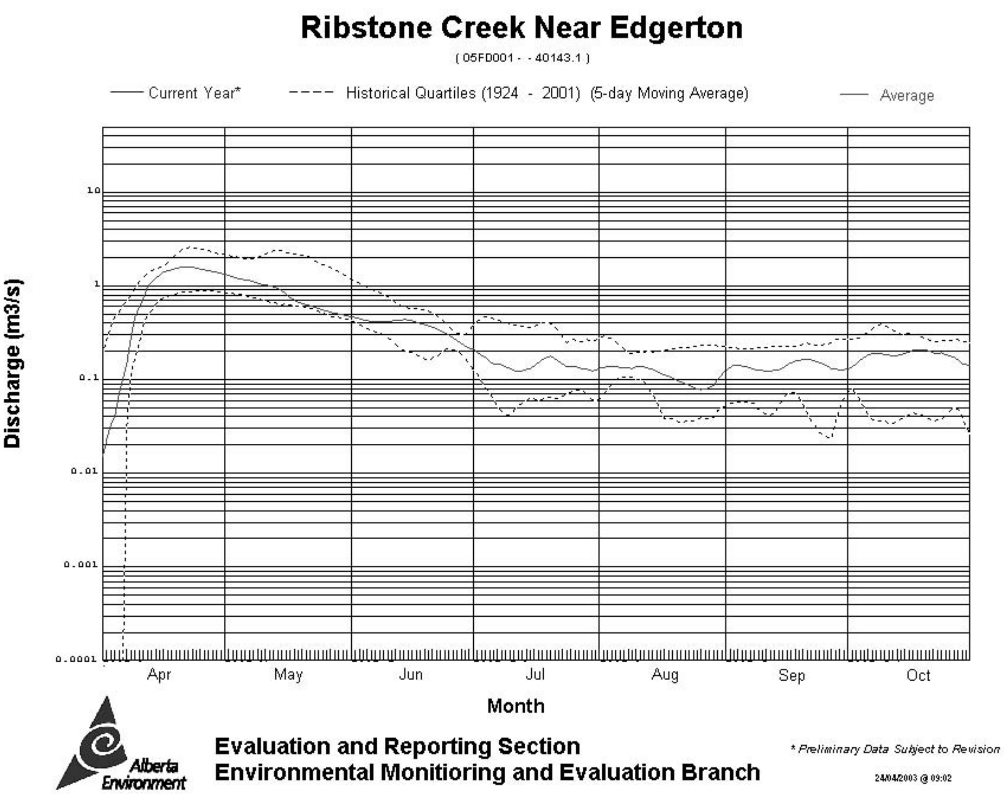



**Figure 25:** Ribstone Creek near Edgerton mean monthly discharge for the open water season (Station 05FD001).

### 5.16.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.



### 5.16.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Ribstone Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Ribstone Subwatershed.

### 5.16.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. A systematic estimate of fish populations in the Ribstone Subwatershed has not been conducted. Future research in the Ribstone Subwatershed should address this data gap.

### 5.16.3.3 Vegetation Types

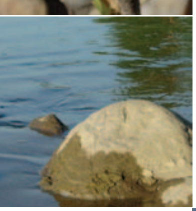
Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Ribstone Subwatershed is located in both the Northern Fescue and Central Parkland ecological regions. The Northern Fescue Subregion is characterized by gently rolling terrain, low-relief ground moraine and hummocky moraine. The dominant vegetation in this subregion Rough Fescue. The Central Parkland is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Tree species include trembling aspen and balsam poplar, while grasslands are dominated by Rough Fescue.



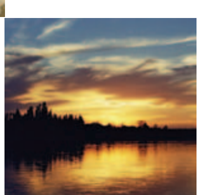
### 5.16.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Ribstone Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Ribstone Subwatershed.

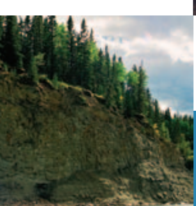
### 5.16.4 Ribstone Summary



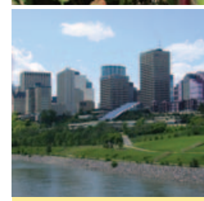
The main economic base of the region is agriculture and oil and gas activities. The majority of the Subwatershed is classified in agricultural land uses and livestock densities are generally moderate although there is a soil polygon with higher manure production indicated near Wainwright. About 2% of the Subwatershed is treed and water bodies cover 4% of the Subwatershed.



Riparian health has been assessed for 9.5 kilometres of Black Creek. Seventy percent of the area was assessed as ‘healthy, but with problems’; 30% was assessed as ‘unhealthy’. Riparian health was also assessed along Ribstone Creek; however, the results of that assessment were not available for this report.





About 10% of the Subwatershed has been disturbed. Over 2% of land is affected by linear developments including roads, cutlines, pipeline rights of way, transmission line rights of way, and rail lines. The remainder of the disturbance is due to C.F.B Wainwright; and well sites, municipalities, and industrial facilities.

The PFRA Land Classification shows no area classified as wetlands; however, Ducks Unlimited Canada information shows wetlands on 12.9% of the land area.

Water quantity is measured at four stations; none has real-time online data. No long-term river water quality information or information on water plants, fish populations, or benthic invertebrates was found for this Subwatershed.

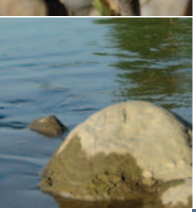
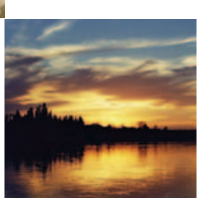
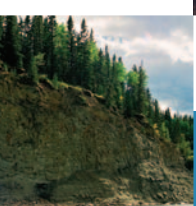
In summary, there has been little systematic assessment of the Ribstone Subwatershed and there are significant gaps in the available information. However, of the eight indicators assessed, two were good, three were fair, and three were poor, yielding an overall subjective rating of poor. The level of agricultural land use, moderate livestock densities, and the results of riparian health assessments suggest that it is important to address the data gaps and to further assess the impacts of various land uses on the Subwatershed.



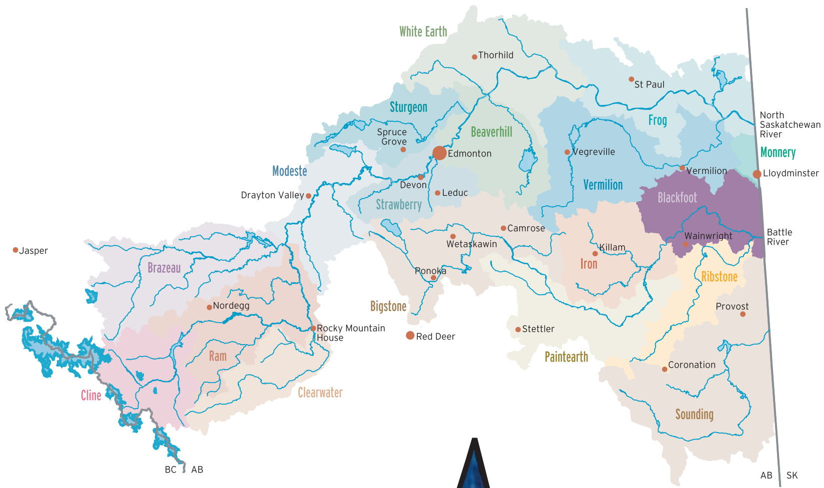


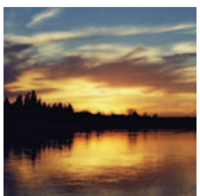


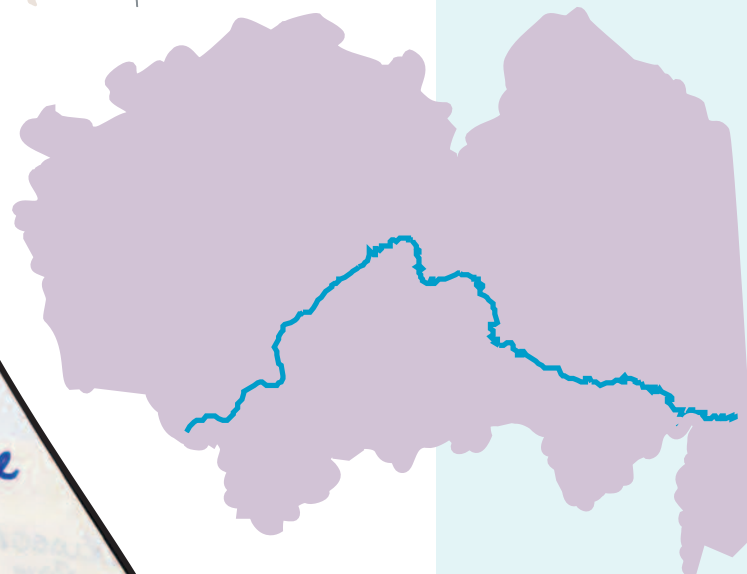


# Blackfoot

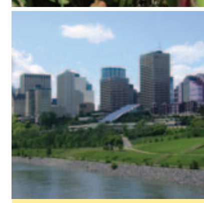


Zachary Walker
Age 8
Sherwood Park





## 5.17 BLACKFOOT SUBWATERSHED

The Blackfoot Subwatershed encompasses 434,466 hectares in the Battle River Subwatershed, including 15,595 hectares of natural and artificial water bodies and is bounded by the border with Saskatchewan on the east side. Most of the Blackfoot Subwatershed is in the Central Parkland Natural Region. The Subwatershed contains Minburn and Vermilion River Counties, the MD of Wainwright, and the towns of Fabyan, McLaughlin, Paradise Valley, Rivercourse, Vermilion and Wainwright. The eastern portion of the Canadian Forces Base at Wainwright takes up 3,860 ha (0.9%) of the Subwatershed area.

The main economic base of the region is agriculture and oil and gas activities.

Many of the indicators described below are referenced from the “Blackfoot Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.17.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.17.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Blackfoot Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research in this area.

#### 5.17.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health.

Almost 3% (11,217 ha) of land of linear developments in the Blackfoot Subwatershed is affected by linear developments. The majority (53%) are roads of one form or another, including gravel and unimproved roads (42% of the linear development) and paved roads (7% of linear development). Other linear developments include pipeline rights of way (17% of the area of linear development), cutlines (16%), transmission line rights of way (8%), and active or abandoned rail lines (2%).

#### 5.17.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Natural and constructed waterbodies including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 4% of the Subwatershed. The vast majority of the Subwatershed is classified in land uses related to agricultural production: cropland, 55%;



grassland, 41%; and forage, 2%. Less than 1% (2,340 ha) of the Subwatershed is covered with trees. There are no Parks and Protected Areas or Provincial FMUs in this Subwatershed.

About 5% of the Subwatershed has been disturbed by various forms of disturbance including the linear development described above. The greatest area of disturbance following linear development is the area affected by well sites, 1.5% of the Subwatershed (6,492 ha). C.F.B Wainwright covers 0.9% of the Subwatershed (3,860 ha) and municipalities of various sizes including Wainwright, Fabyan and part of Vermilion affect about 0.2% of the Subwatershed (981 ha). The remainder of the land disturbance is related to linear developments (2.3%), and industrial facilities including oil and gas plants, runways, sand and gravel pits, and other industrial sites (189 ha).

Water bodies including rivers, lakes and dugouts cover about 15,595 hectares; almost 4% of the area of the Subwatershed.

### 5.17.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Blackfoot Subwatershed are moderate throughout the Subwatershed. Manure production in the soil polygons that cover the Blackfoot Subwatershed was estimated at between 726,000 and 3,246,000 tonnes.



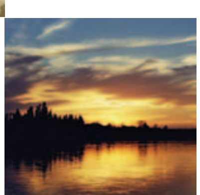
### 5.17.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Data from Alberta Sustainable Resource Development base features hydrology failed to identify wetlands in the Blackfoot Subwatershed. However, the PFRA Land Classification identified 504 hectares of land in the Subwatershed as wetlands (0.1% of the Subwatershed area).

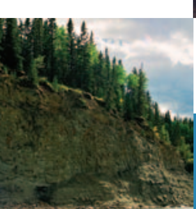
### 5.17.2 Water Quality and Quantity

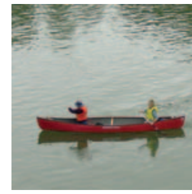
Larger waterbodies in this Subwatershed include Baxter, Clarke, Bushy Head, Albert, Earlie, Baxter, Bauer's, East, Briker and Arcand Lakes.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, Stretton Creek was part of the CAESA stream network as a site in an area of high agricultural activity. Water quality data (nutrients, organic and inorganic chemistry, suspended solids, color, pH, and bacteria) is available for this creek from 1995-1996 (Anderson *et al.* 1998) to the present (Depoe and Westbrook 2003).



Seventeen pesticide samples collected between 1997-2000 from Stretton Creek included 2,4-D, Bromoxynil, MCPA, MCPP, Triallate, Trifluralin and Picloram, all of which were below the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life.








Water quantity is measured in the Blackfoot Subwatershed at four HYDEX stations (05FE002-05FE005): one has real-time online data (05FE004). Figure 26 shows the hydrograph of Buffalo Creek. This hydrograph is typical of a non-glacial fed stream, which has flows dominated by spring runoff and summer storms only.

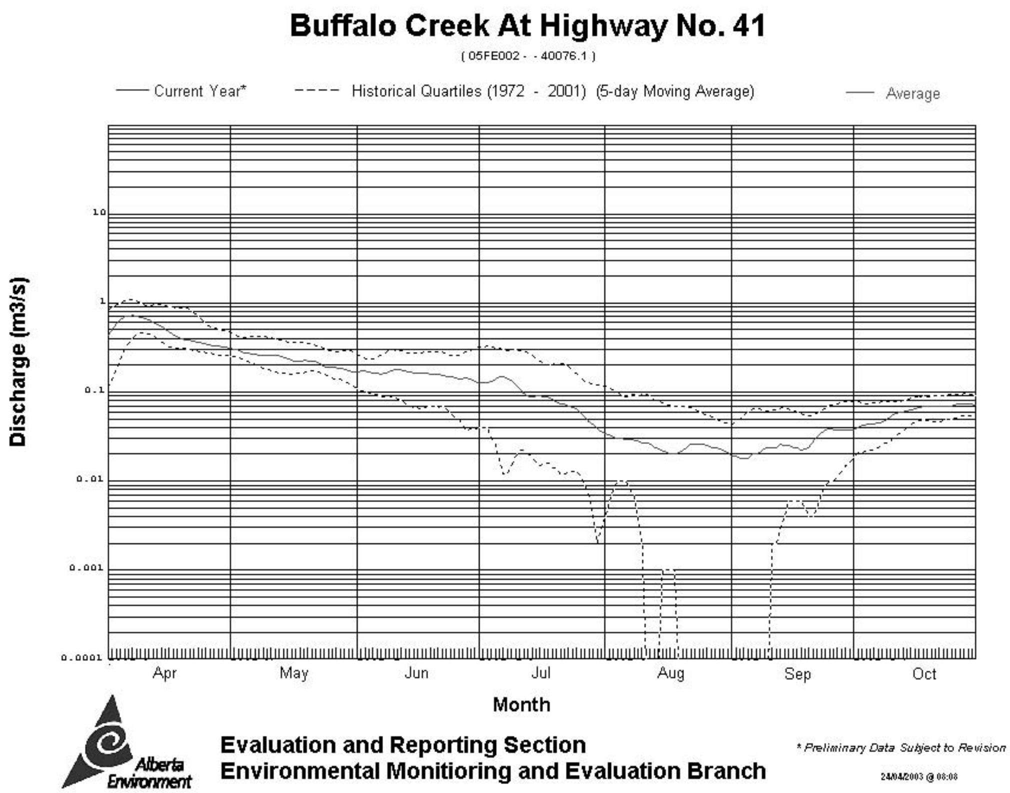



**Figure 26:** Buffalo Creek near Highway 41 mean monthly discharge for the open water season (Station 05FE002).

### 5.17.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

#### 5.17.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.



No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Blackfoot Subwatershed, so we cannot make any inferences about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Blackfoot Subwatershed.

**5.17.3.2 Fish Population Estimates**

Inventories of selected fish populations may show changes in the presence and abundance of species that may be related to environmental factors including changes in water quality or quantity. A systematic estimate of fish populations in the Blackfoot Subwatershed has not been conducted. This data gap should be addressed in future research in this area.

**5.17.3.3 Vegetation Types**

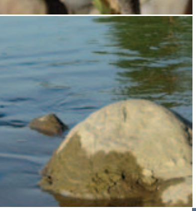
Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Blackfoot Subwatershed is located in the Central Parkland ecological subregion. This subregion is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Tree species include trembling aspen and balsam poplar, while grasslands are dominated by Rough Fescue.

**5.17.3.4 Benthic Invertebrates**

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality.



No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Blackfoot Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Blackfoot Subwatershed.

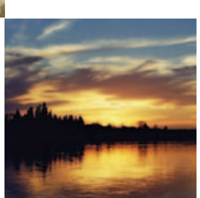


**5.17.4 Blackfoot Summary**

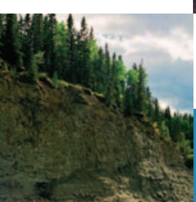
The majority of the land in the Subwatershed is classified in uses related to agricultural production and livestock densities are moderate. Less than 1% of the area is treed. Water bodies cover 4% of the Subwatershed and PFRA Land Classification shows wetlands on 0.1% of the land area.

About 5% of the Subwatershed has been disturbed. Almost 3% of this is linear developments including roads, pipeline rights of way, cutlines, transmission line rights of way, and rail lines. Other disturbances include well sites, a small part of C.F.B Wainwright, municipalities, and industrial facilities.

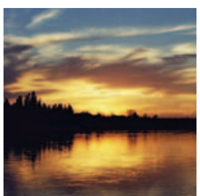
Water quantity is measured at four stations: one has real-time online data. No long-term river water quality information, riparian health assessments, or information on water plants, fish populations, benthic invertebrates, or riparian health exists for this Subwatershed.



In summary, there has been little systematic assessment of the Blackfoot Subwatershed and there are significant data gaps for the area. However, of the five indicators assessed, none were good, one was fair, and four were poor, yielding an overall subjective rating of poor. These data gaps should be addressed; in particular, the impacts of various land uses on riparian health, and the state of the aquatic ecosystem including water quality, water plants, and fish populations.



# Sounding

Jessica Maron
Age 4
Edmonton

## 5.18 SOUNDING SUBWATERSHED

The Subwatershed lies in the Central Parkland and Northern Fescue Natural Subregions and encompasses 1,097,697 hectares including 51,527 hectares of natural and artificial water bodies. This Subwatershed includes Acadian, Paintearth, Provost Counties, the MD of Wainwright and Special Areas # 2, 3 and 4. The Subwatershed includes the towns of Altario, Bodo, Cadogan, Cereal, Chauvin, Compeer, Consort, Coronation, Hayter, Kirriemuir, Monitor, New Brigden, Provost, Sedalia, Sibbald, Veteran and Youngstown. The predominant economic activities are agriculture and oil and gas operations. Recreational activities are provided at Gooseberry Lake Provincial Park.

Many of the indicators described below are referenced from the “Sounding Hydrological Overview” map located in the adjacent map pocket, or as a separate Adobe Acrobat file on the CD-ROM.

### 5.18.1 Land Use

Changes in land use patterns reflect major trends in development. Land use changes and subsequent changes in land use practices may impact both the quantity and quality of water in the Subwatershed and in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.

#### 5.18.1.1 Riparian Health

The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. No published assessment of riparian health was found for the lakes, wetlands, rivers or creeks in the Sounding Subwatershed, so we cannot make any conclusions about riparian health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Sounding Subwatershed.

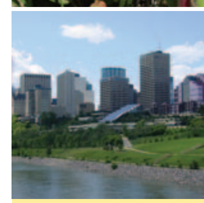
#### 5.18.1.2 Linear Development

Quantifying linear development in the Subwatershed helps us understand potential changes in water quality and quantity, fish and wildlife populations, and riparian health. About 1% (15,058 ha) of land in the Sounding Subwatershed is affected by linear developments. The majority (55%) is in roads of one form or another, including gravel and unimproved roads (42% of the linear development) and paved roads (7% of linear development). Other linear developments include cutlines (20% of the area of linear development), pipeline rights of way (13%), transmission line rights of way (6%), and active or abandoned rail lines (6%).

#### 5.18.1.3 Land Use Inventory

An inventory of land uses quantifies natural landscape types and land uses and may be used to explore changes in water quality and quantity, fish and wildlife populations, and riparian health. Water bodies, both natural and constructed, including lakes, rivers, streams, wetlands, dugouts and reservoirs cover 51,527 (5%) of the Subwatershed. The vast majority of the Subwatershed is classified as land uses related to agricultural production: grassland, 61%; cropland, 30%; and forage, 4%. Less than 1% (689 ha) of the Subwatershed is covered with shrubs or trees.





About 3% of the land area has been disturbed by activities including the linear development described above. The greatest area of disturbance following linear development is for active or abandoned well sites. In total, well sites affect 1.4% of the Subwatershed (15,861 ha). Disturbance due to municipalities of various sizes including Cereal, Chauvin, Coronation, and Veteran affects about 0.1% of the Subwatershed (1429 ha). The remainder of land disturbance is related to linear developments (1.4%), and industrial facilities including oil and gas plants, runways, and sand and gravel pits (209 ha).

#### 5.18.1.4 Livestock Density

Areas of higher livestock density may be expected to have greater impacts on downstream aquatic systems. Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons do not correspond to the Subwatershed boundaries and provide only a rough estimate of manure production within the actual Subwatershed. Based on the available information, livestock densities in the Sounding Subwatershed are moderate. Manure production in the soil polygons that cover the Sounding Subwatershed was estimated at between 256,000 and 1,767,000 tonnes.

#### 5.18.1.5 Wetland Inventory

Wetlands serve many functions in the natural landscape. The loss of wetlands to development can have impacts on water quantity and quality to downstream habitats. Data from Alberta Sustainable Resource Development base features hydrology failed to identify wetlands in the Sounding Subwatershed. However, the PFRA Land Classification identified wetlands on 6,608 hectares (0.6%) of land area in the Sounding Subwatershed. Another inventory completed by Ducks Unlimited Canada found a total of 93,561 hectares of wetlands (8.5% of the Subwatershed area). The DUC inventory included both permanent and temporary wetlands.

### 5.18.2 Water Quality and Quantity

Waterbodies in this Subwatershed include the Sounding Creek Reservoir and the Sounding, Eyehill, Loyalist, and Monitor Creeks. Larger lakes in this Subwatershed include Grassy Island, Killarney, Gooseberry, Reflex, Hansman, Gillespie, Leane, Fleeinghorse and St. Lawrence Lakes. No long term surface water quality information exists for this Subwatershed. This data gap should be addressed in future studies in the Sounding Subwatershed.

No LTRN water quality stations exist in this Subwatershed, therefore no long term water quality data has been summarized. However, eleven stations along Sounding Creek were sampled for fecal coliforms during the years 1971-74, 1983, and 1991-94. The 11 fecal coliform samples ranged from <1 to 150 counts/100 mL, and averaged 29 counts/100 mL. These samples were below the CCME Surface Water Quality Guidelines for Contact Recreation. No TP data was found for this Subwatershed.

Water quantity is measured at seven HYDEX stations (05GA003, and 05GA008-05GA013): three have real-time online data (05GA008, 05GA011, and 05GA012). Figure 27 shows the Monitor Creek hydrograph for the open water season. This hydrograph is typical of a small prairie stream with only runoff contributions. Flows are highly sporadic, and only occur following spring runoff and summer storm events. Figure 28 shows the Sounding Creek hydrograph for the open water season. This hydrograph is also typical of a small prairie stream with only runoff contributions, with sporadic flows that only occur following spring runoff and summer storm events.

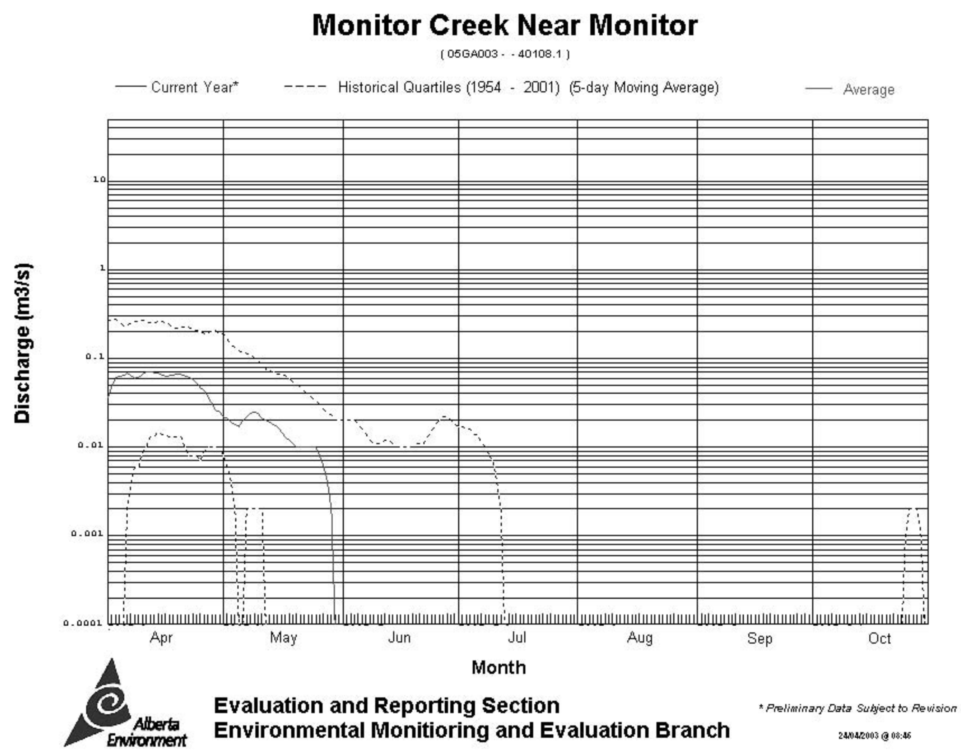



**Figure 27:** Monitor Creek near Monitor mean monthly discharge for the open water season (Station 05GA003).

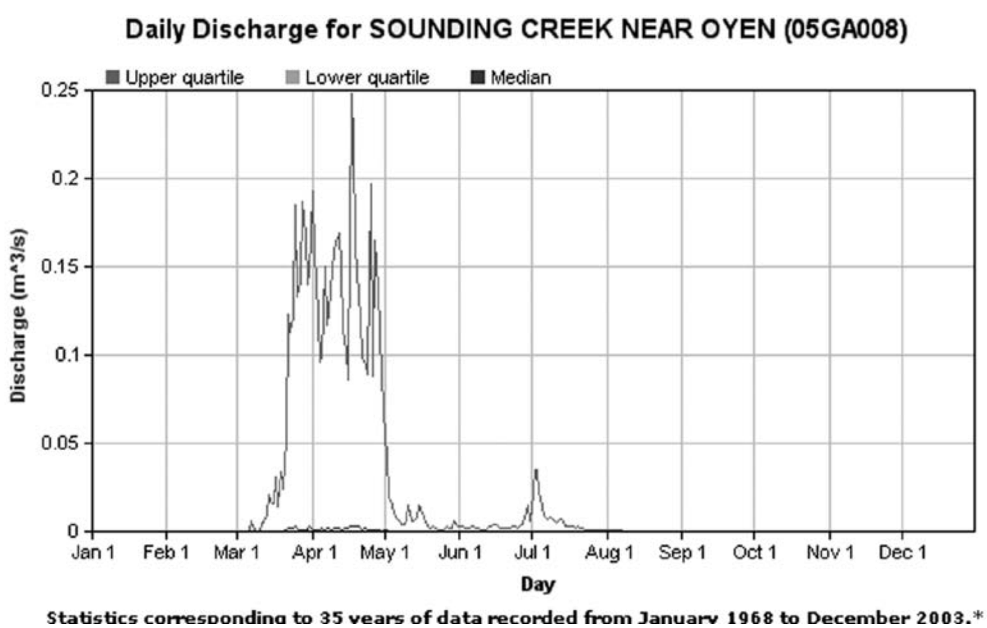



**Figure 28:** Sounding Creek near Oyen mean monthly discharge (Station 05GA009).







## 5.18.3 Biological Indicators

Biological indicators include information on plant and animal species from which various aspects of ecosystem health can be determined or inferred by linking this information to information on water quality and quantity, land use and management practices.

### 5.18.3.1 Aquatic Macrophytes

The growth of aquatic macrophytes is directly related to the availability of the nutrient phosphorus in the water in which they are growing. Excessive growth may indicate decreased water quality, which, in turn, may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

No published assessment of aquatic macrophytes was found for the lakes, wetlands, rivers or creeks in the Sounding Subwatershed, so we cannot make any conclusions about ecosystem health for this Subwatershed using this indicator. This data gap could be addressed in future research within the Sounding Subwatershed.

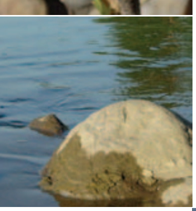
### 5.18.3.2 Fish Population Estimates

Inventories of selected fish populations may show changes in the presence and abundance of species that could be related to environmental factors including changes in water quality or quantity. A systematic estimate of fish populations in the Sounding Subwatershed has not been conducted. This data gap could be addressed in future research in the Sounding Subwatershed.



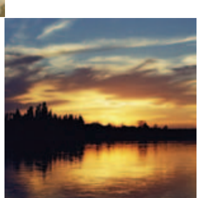
### 5.18.3.3 Vegetation Types

Inventories of flora populations may show changes in abundance that may be related to environmental factors including changes in land use practices. The Sounding Subwatershed is located in both the Central Parkland and Northern Fescue ecological subregions. The Central Parkland Subregion is composed mainly of grassland with aspen, to aspen parkland to closed aspen forest. Tree species include trembling aspen and balsam poplar, while grasslands are dominated by Rough Fescue. The Northern Fescue Subregion is characterized by gently rolling terrain, low-relief ground moraine and hummocky moraine. The dominant vegetation type in this subregion is Rough Fescue.



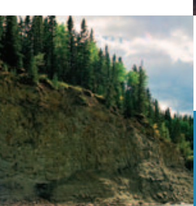
### 5.18.3.4 Benthic Invertebrates

Inventories of benthic invertebrate populations may show changes the presence and abundance of species that may be related to changes in water quality. No published assessment of benthic invertebrates was found for the lakes, wetlands, rivers or creeks in the Sounding Subwatershed, so we cannot make any conclusions about ecosystem health using this indicator. This data gap could be addressed in future research within the Sounding Subwatershed.



## 5.18.4 Sounding Summary

The predominant economic activities in the Sounding Subwatershed are agriculture and oil and gas operations. The majority of the land use in this Subwatershed is agriculture and livestock densities are moderate. Less than 1% of the Subwatershed is treed and water bodies cover about 5% of the area. About 3% of the land area has been disturbed by activities including roads, cutlines, pipeline rights of way, transmission line rights of way, and rail lines, well sites, municipalities, and industrial facilities.



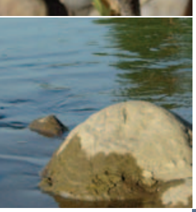
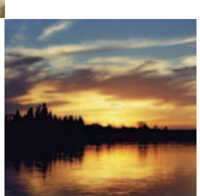
The PFRA Land Classification shows wetlands occurring on 0.6% of land area; however, Ducks Unlimited Canada information show wetlands on 8.5% of the land area. This variance needs to be resolved.

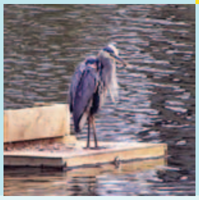
Water quantity is measured at seven stations: three have real-time online data. There is no long-term river water quality information for the Subwatershed or information on water plants, benthic invertebrates, fish populations or riparian health.

In summary, there has been little systematic assessment of the Sounding Subwatershed and there are significant data gaps for the area. However, of the five indicators assessed, two were good, two were fair, and one was poor, yielding an overall subjective rating of fair. These data gaps should be addressed; in particular the impacts of various land uses on riparian health, and the state of the aquatic ecosystem including water quality, water plants, and fish populations.





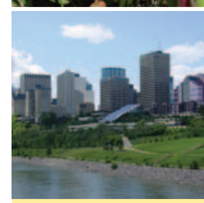



Chapter 6.0

# Data and Data Gaps Discussion



## 6.0 DATA AND DATA GAPS DISCUSSION

The Hydrological Overview Maps for each of the eighteen Subwatersheds includes a minimum of four inset maps (Linear Disturbance, Municipal, Commercial and Industrial Disturbance, PFRA/AAFC Land Classification, and Agriculture Census data of unimproved pasture, improved pasture, cropland and summer fallow). Other overviews include two other maps of Forest Management Units and Parks and Protected Areas. The data sources for each of these maps are described below. The latter two maps were compiled from data taken from the same source as the Linear Disturbance map and the Commercial and Industrial Disturbance map. Additional non-digital data sources are also described. Data used in these maps were from prior to 2003.

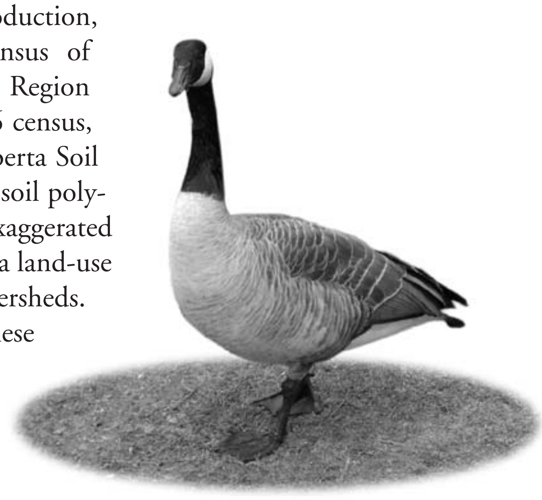
## 6.1 LAND USE DATA SOURCES

Riparian health data were provided by the Cows and Fish riparian health inventory community program. Cows and Fish are the only recognized agency providing technical riparian health assessments in Alberta. As this group is still very new in the Province, many sites still need to be assessed within the North Saskatchewan Watershed and throughout Alberta. Many of the sites that have been assessed in this report have too few data sites to allow for an overall conclusion of riparian health. This data gap will have to be addressed in future watershed studies.

The hydrological features (lakes, reservoirs, creeks, streams, rivers), linear disturbance, forest management units, parks and protected areas and municipal, commercial and industrial disturbance digital data is sourced from Alberta Sustainable Resource Development. The data is current as of 1990, and accurate to +/- 3 metres. The arc network is not clean, and there are numerous dangling arcs and the stream network is not contiguous. The datasets are complete for the entire watershed for all of these coverages.

The land use inventory is sourced from Agriculture and Agri-Food Canada's Prairie Farm Rehabilitation Association Western Grain Transportation Payment Program –- Landcover Generalization Process. This data is current as of 1993 – 1995, and accurate to 30 metres and should be used at a 1:1 million scale, as a generalized land cover for planning use. The dataset was created from 1:50,000 LANDSAT 7 imagery. Data gaps for this dataset exist for the western portion of the North Saskatchewan Watershed (i.e. no data exists for the Cline Subwatershed).

For the improved pasture, unimproved pasture, cropland, summer fallow, manure production, pesticides and herbicides maps, data was sourced from Statistics Canada's Census of Agriculture by Agriculture and Agri-Food Canada's defined landscapes in the Prairie Region (including the British Columbia Peace River region). The data is current as of 1996 census, and accurate to +/- 3 metres. A limitation of this dataset is that data are fitted to Alberta Soil polygon units. Several polygons have cropland area greater than the shape area of the soil polygon. This is due to the clipping of the data to fit the NSWA boundary and will be exaggerated again when that data is clipped to fit the Subwatershed polygons. For example, Ag-data land-use soil polygon #0883 falls inside the boundaries of the Brazeau, Ram and Cline Subwatersheds. Data for that land-use soil polygon will be equally attributed to all three of these Subwatersheds, which will inflate the overall value by a factor of three over the entire watershed area.







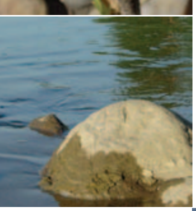
Wetland Inventory data were gathered from three sources—Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada and Ducks Unlimited Canada. All three sources were used to cover gaps that were apparent in each approach. Alberta Sustainable Resource Development data covered each Subwatershed, but the methodology used did not capture smaller waterbodies. The Ducks Unlimited Canada data collection method was the most sensitive to smaller waterbodies, but covered the smallest geographic area. A comprehensive wetland resource inventory, including drained wetlands, is a key component of a complete land use inventory. By identifying areas of wetland loss, land management planners can effectively implement watershed management plans which address this fundamental element of source water protection and restoration.

Wetland data was used from Alberta Sustainable Resource Development's hydrological features. This data is current as of 1990, and accurate to +/- 3 metres. The dataset is complete for the whole watershed for this coverage.

Wetland data from Agriculture and Agri-Food Canada was sourced from the Prairie Farm Rehabilitation Association Western Grain Transportation Payment Program Landcover Generalization Process. This data is current as of 1993 – 1995, and accurate to 30 metres and should be used at a 1:1 million scale. The data is limited to use at a 1 to 1 million scale with 30 meter resolution, as a generalized land cover for planning use. The dataset was created from 1:50,000 LANDSAT 7 imagery. Data gaps for this dataset exist for the western portion of the North Saskatchewan Watershed (i.e. no wetland data exist for the Cline Subwatershed).

Wetland data from Ducks Unlimited Canada was sourced from Ducks Unlimited Canada Habitat Inventory Data - Landsat Based Inventory (30m) from mid-1980's that includes permanent and temporary wetlands. Classes included open water, deep marsh, shallow marsh, wet meadow, mudflat, dry wetland, forested wetland and river acres. Data gaps exist for the western portion of the North Saskatchewan Watershed, as there is no data for the Brazeau, Ram, Cline, and Clearwater Subwatersheds.



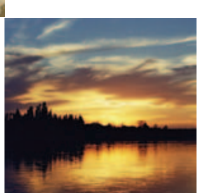
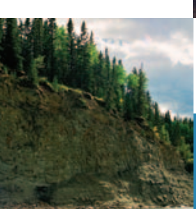


## 6.2 WATER QUALITY AND QUANTITY DATA SOURCES

Alberta Environment currently generates an Alberta Surface Quality Index for 2 river stations within the entire North Saskatchewan Watershed; upstream of Edmonton at Devon and downstream of Pakan. Environment Canada generates their own indices for 3 more stations—one at the headwaters at Whirlpool Point near Rocky Mountain House and two sites near the Saskatchewan border. Individual stakeholders (i.e. municipalities, industry) or small community watershed groups currently drive additional water quality monitoring programs.

To obtain a more 'holistic' snap-shot of the watershed, it is recommended that stakeholders interested in water quality collaborate and develop more comprehensive monitoring programs. This may serve to increase monitoring efficiencies, in terms of cost and time, while alleviating sample duplications.

Few data exists on groundwater sources and quality. However, Alberta Environment, Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada — PFRA, the Alberta Geological Survey or your local municipality should be contacted for any information on groundwater aquifers within the North Saskatchewan Watershed.

## 6.3 BIOLOGICAL INDICATOR DATA SOURCES

Aquatic macrophyte, fish population estimates, and benthic invertebrate data were gathered from a literature survey of work undertaken in the North Saskatchewan Watershed. Sources searched to complete the survey were Alberta Environment, Alberta Sustainable Development, the Alberta Lake Management Society, partner organizations, scientific abstract databases, and consultant reports.

Vegetation data was sourced from Agriculture and Agri-Food Canada's Prairie Farm Rehabilitation Association Western Grain Transportation Payment Program Landcover Generalization Process. This data is current as of 1993 – 1995, and accurate to 30 metres and should be used at a 1:1 million scale. The data is limited to use at a 1 to 1 million scale with 30 meter resolution, as a generalized land cover for planning use. The dataset was created from 1:50,000 LANDSAT 7 imagery. Data gaps for this dataset exist for the western portion of the North Saskatchewan Watershed (i.e. no wetland data exist for the Cline Subwatershed).





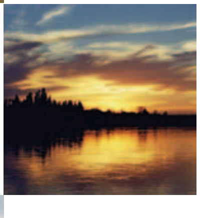


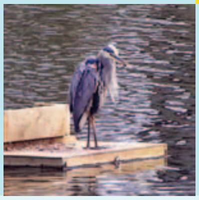








Chapter 7.0

# Conclusion




# 7.0 CONCLUSION

## 7.1 DISCUSSION OF INDICATORS

### 7.1.1 Land Use

#### 7.1.1.1 Riparian Health

There have been no comprehensive assessments undertaken for riparian habitat in any Subwatershed; although small-scale assessments have been completed along several lakes, streams and creeks. To gain a better understanding of the impact that linear developments, agriculture and municipal land uses may have on a Subwatershed, comprehensive assessments of riparian health are needed within all 18 Subwatersheds. Such a study was recently completed for the South Saskatchewan Basin (Red Deer, Bow and South Saskatchewan Rivers) by Cows & Fish (ARHMP Cows & Fish 2004). At a minimum, the City of Edmonton and other larger municipalities should undertake a comprehensive assessment and inventory of riparian areas within their jurisdictions.

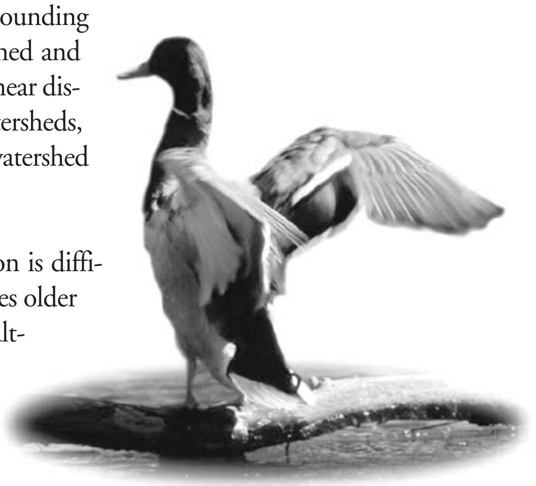
The assessments completed to date suggest that a significant portion of the riparian habitat has been damaged in Subwatersheds that have a higher proportion of agricultural development. However, this finding may be biased by a tendency to conduct assessments in agricultural areas (the “white zone” of Alberta) of most concern (i.e. those that are more likely to have been impacted). The riparian health assessments that have been completed by Cows & Fish may not be representative of other sites outside of the white zone within the North Saskatchewan Watershed. Sites completed also include those where specific requests have been made to undertake assessment work.



#### 7.1.1.2 Linear Development

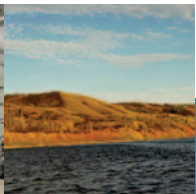
The least amount of linear development occurs in the headwaters of the Cline (0.1%), Brazeau (1.4%) and the Ram (1.6%) Subwatersheds. There is also relatively little linear disturbance in the Sounding Subwatershed (1.0%). The greatest amount of linear disturbance occurs in the Subwatersheds within the Foothills Natural region. Linear developments have affect 4% of the Strawberry Subwatershed area and 3.5% of the Modeste Subwatershed area.

The type of disturbance varies among the Subwatersheds. Among those with the least amount of linear disturbance are the Brazeau, Sounding and Cline Subwatersheds. In the Brazeau and Sounding Subwatersheds, 63% and 51% of the linear disturbance is due to cutlines, respectively. In the Cline and Sounding Subwatersheds, the majority of the disturbance is due to roads, 63% in the Cline Subwatershed and 55% in the Sounding Subwatershed. Among the Subwatersheds with the greatest amount of linear disturbance, pipelines account for most of the disturbance in the Modeste and Strawberry Subwatersheds, 33% and 25% respectively. Roads account for 31% of the disturbance in the Modeste Subwatershed and 55% in the Strawberry Subwatershed.



Seismic cutlines are particularly damaging because of their multitude of impacts. Regeneration is difficult due to soil and root disturbance, grass competition and access use. As many as 88% of lines older than 20 years have still not regenerated (AB Centre for Boreal Studies, November 2001), resulting in progressive loss of mature forest and alteration of forest structure. Forest fragmentation reduces habitat effectiveness, and can lead to avoidance of habitat by certain species. Damage to aquatic systems increases sedimentation, bank erosion, alteration of drainage patterns and destruction of aquatic habitat (AB Centre for Boreal Studies, Nov 2001). Groundwater sources (aquifers) can also be negatively impacted by seismic activities including blasting.





### 7.1.1.3 Land Use Inventory

The land use inventory information is based on the PFRA Land Classification as well as information related to forest management agreements and protected areas. As one travels from west to east, progressively more land is in grasslands and agricultural land uses and less in forests. Grasslands mainly cover several Subwatersheds but most notably in Paintearth, 55% of the land area; Blackfoot, 55%; Sounding, 61% and Ribstone, 65%. Cropland covers more than half of the land area of the following Subwatersheds: Vermilion, 51%; and almost half in the Iron, 44%, and Blackfoot, 41%. In the central part of the North Saskatchewan Watershed, forage is more dominant with 54% of Strawberry Subwatershed being in forage, 43% of the Modeste Subwatershed and 37% of the Bigstone Subwatershed. With an increase in lands converted to cropland comes a loss of biodiversity (Tilman et al. 2002). Ideally, agricultural practices need to encourage biodiversity, such as on marginal lands.

In addition to the linear disturbances noted above, the Subwatersheds with the most disturbance in the form of well sites and other facilities, urban development and reserve lands are the Sturgeon Subwatershed, 68%; which is affected mainly by urban development in and around Edmonton; the Strawberry Subwatershed, 15%, and the Frog Subwatershed, 12.3%. The Subwatersheds with the least amount of land disturbance are the Cline, no disturbance noted; Brazeau, 0.2%; and the Ram, 2.3%. Continued efforts should strive to maintain the low disturbance of these areas as headwaters source protection. In those areas that are already significantly impacted, best management practices (agriculture, oil and gas, stormwater, etc.) can be utilized to manage the impacts of these activities in the watershed.

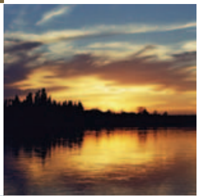
### 7.1.1.4 Livestock Density



Manure production was used as a surrogate for livestock density. Manure production information was available only on the basis of soil polygons. These polygons provide only a rough estimate of manure production in a Subwatershed area. Based on the available information, livestock densities were greatest in the Bigstone, Beaverhill and Sturgeon Subwatersheds and least in the Cline, Ram and Brazeau Subwatersheds. Because of the impacts that agriculture can have on surface water quality, it is recommended that intensive agriculture be minimized in the headwater Subwatersheds (Cline, Ram, Brazeau and Clearwater) as a source water protection measure. The high agricultural intensity in headwater Battle River Subwatersheds (such as the Bigstone) may be cause for some concern for surface waters in those Subwatersheds and for downstream users.

### 7.1.1.5 Wetland Inventory

The most detailed information on wetlands is provided by Ducks Unlimited Canada. Based on their information, the Subwatersheds with the largest percentage of the land area covered in wetlands are Strawberry, 23.5%; Ribstone, 12.9%; Sounding, 8.5%; and Beaverhill, 8.5%. Quite clearly, much more data is required for a detailed wetland inventory of the North Saskatchewan Watershed. This would help to more accurately assess watershed health. While the former will quantify existing wetlands, a drained wetland inventory would be useful to help assess how much wetland area has been lost. A comprehensive wetland resource inventory, including drained wetlands, is a key component of a complete land use inventory. By identifying areas of wetland loss, land management planners can effectively implement watershed management plans that develop and prioritize restoration goals which will address this fundamental element of source water protection and restoration. Establishing more active partnerships between agencies (Alberta Environment, Ducks Unlimited Canada, Alberta Agriculture, Agriculture and Agri-Food Canada and municipalities) will help provide necessary data to support the integrated watershed management planning.







### 7.1.2 Water Quality

#### 7.1.2.1 Alberta Surface Water Quality Index

Data on the Alberta Surface Water Quality Index (ASWQI) calculated at sites on the North Saskatchewan River, was available for two Subwatersheds, the Strawberry – calculated at Devon upstream of Edmonton – and the Beaverhill – calculated at the Pakan Bridge downstream of Edmonton. The index shows the impact of inputs to the river from the City of Edmonton, industrial discharges in the Edmonton region and the Edmonton regional municipalities. In general, water quality for metals was rated as “excellent” to “good” at Devon and “excellent” to “fair” at Pakan. For nutrients, the index was “good” to “fair” at Devon and “fair” at Pakan. For bacteria, the index was “excellent” to “good” at Devon and “good” to “poor” at Pakan. The index for pesticides was “excellent” to “good” at Devon and “good” to “fair” at Pakan. The impact of the capital region’s population, wastewater, stormwater, development and land use all contribute to decreased water quality seen immediately downstream of Edmonton.

#### 7.1.2.2 *Escherichia coli (E. coli)*

Little information was found for *E. coli* counts in the watershed. The Tomahawk Creek (in an area of moderate agricultural intensity) in the Modeste Subwatershed was found to have very high coliform counts (CAESA 1998). This result was typical of other moderate intensity agricultural sites. It is not known why moderate agricultural intensity streams have higher fecal coliform counts than high agricultural intensity streams. The North Saskatchewan River downstream of Edmonton (Strawberry Subwatershed) also has elevated fecal coliform counts, and with the source being treated wastewater and untreated stormwater runoff inputs (Alberta Environment 2004). Coliform counts have been reduced since the addition of UV treatment at the Gold Bar Wastewater Treatment Plant (City of Edmonton 2003).

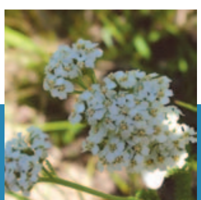
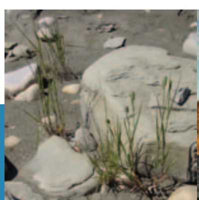
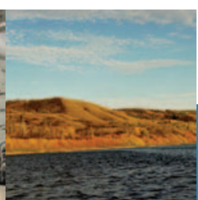


#### 7.1.2.3 Phosphorus

Data on phosphorus concentrations were found for relatively few lakes, rivers, streams and creeks in the North Saskatchewan Watershed. High phosphorus concentrations are a problem at several lakes within the North Saskatchewan Watershed (Alberta Lake Management Society 2004), due to the deep, phosphorus-rich soils found throughout the watershed. Lakes throughout the watershed report phosphorus related problems with algal blooms, fish kills, aesthetics, and impairment of recreational use.

Work by Alberta Agriculture, Food and Rural Development continues to demonstrate the strong positive correlation between intensity of agriculture and phosphorus concentrations in Alberta streams in agricultural watersheds (Anderson *et al.* 1998, Anderson 1998, Anderson 2000, Carle 2001, Donahue 2001, Depoe and Westbrook 2003). In addition, streams with greater agricultural intensity had increased peak, median and flow weighted mean phosphorus concentrations, and had higher frequencies and degree of non-compliance with phosphorus guidelines for the protection of aquatic life.

The Strawberry Subwatershed and the capital region are major sources of phosphorus and other nutrient loadings into the North Saskatchewan River. However, recent treatment improvements have been made at both Gold Bar and the Alberta Capital Region Wastewater Commission wastewater treatment plants. Biological nutrient removal was retrofitted at the Gold Bar wastewater treatment plant in 1997, and has reduced final effluent total phosphorus concentrations by 40% between 1996 and 2003 (Grace Nowak *pers. comm.*).

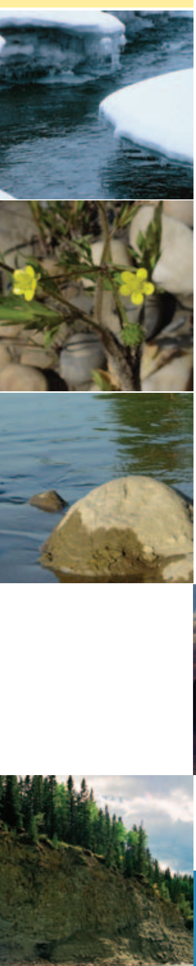
### 7.1.2.4 Pesticides

Summarized data on pesticides were available for two Subwatersheds; the Strawberry – measured in the North Saskatchewan River at Devon upstream of Edmonton – and the Beaverhill – measured at the Pakan Bridge on the North Saskatchewan River downstream of Edmonton. The Surface Water Quality Index for pesticides was “excellent” to “good” at Devon and “good” to “fair” at Pakan. More Alberta Environment sites in the Long Term River Network (LTRN) would give a better understanding of pesticide concentrations throughout the North Saskatchewan Watershed. Limited datasets from Alberta Agriculture, Food and Rural Development exist for their study streams within the North Saskatchewan Watershed. Streams draining high (Amisk Creek, Atim Creek, Buffalo Creek, Stretton Creek) and moderate (Lloyd Creek, Strawberry Creek) intensity agricultural areas all have detectable levels of several pesticides used in Alberta.

A recent study on pesticides in 32 semi-permanent wetlands of the Aspen Parkland eco-region in 2000 detected pesticides in 92% of the wetlands sampled (Anderson *et al.* 2002). Detections of 2,4-D and MCPA were most frequent, but glyphosate and picloram occurred at higher concentrations. Rainwater was also sampled during this survey, and 2,4-D, MCPA and glyphosate were encountered frequently in precipitation samples (65%, 53% and 57% of the samples, respectively). The authors recommended further research on the implications of chronic, low levels of multiple pesticide residues in air, precipitation, water and aquatic organisms (Anderson *et al.* 2002). Subwatersheds within the Aspen Parkland include the Beaverhill, Frog, Sounding and Battle Subwatersheds (Bigstone, Iron, Paintearth, Iron, Ribstone, and Blackfoot).

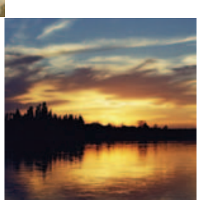
### 7.1.3 Water Quantity





Water quantity in Alberta, and therefore the North Saskatchewan Watershed, is directly affected by yearly and seasonal differences in weather. Total annual runoff from the high mountain regions varies little from year to year. The Bow River discharge at Banff shows a range from about 900 000 $dam^3$ in 1949 to 160 000 $dam^3$ in 1954. In contrast, total annual flow in the Battle River at Ponoka, a central plain stream, has ranged from 15 000 $dam^3$ in 1976 to 260 000 $dam^3$ in 1927. Seasonal variations also affect water supply. Spring melt and summer rains produce the greatest volumes of flow while drier fall weather and temporary storage of water in snow and ice during winter are reflected in low runoff patterns. This seasonal change in surface water flow varies across the province. Mountain-fed streams such as the North Saskatchewan River generally experience greatest flows in June or July during the mountain snow melting period, while streams located in the plains, such as the Battle, usually peak in April. Sounding Creek responds almost entirely to an early spring melt (Alberta Environment 2004).

Where surface water sources are not readily accessible, groundwater resources are of particular importance. It is estimated that the total volume of potable groundwater in Alberta may approach 5.5 billion $dam^3$ with a recoverable, sustainable volume of 16 million $dam^3$, an amount nearly equal to the total volume of Cold Lake. Groundwater is retrieved from permeable deposits such as sand, gravel or sandstone. Some groundwater can be found in practically every part of the province but aquifer depths, yields and water potability vary. Alberta's groundwater resource is not as well-defined as its surface water. Documentation of water quality, water volumes and depths of producing zones is a slow process because of the high cost of exploration. The locations of a number of major aquifers in the province are reasonably well known, and regional data are being accumulated and compiled into hydrogeologic maps and reports as the number of water wells and exploration programs expands (Alberta Environment 2004).








Groundwater is an integral part of the hydrological environment. It is a dynamic component subject to sub-surface flow and eventual discharge to surface water systems. Aquifer discharge is the base flow of many rivers and streams, sustaining them during winter and rainless periods. Over-development of groundwater resources could result in reduced flow from groundwater discharge areas. Such change could lead to the degradation of wetlands and alteration of surface runoff characteristics. Surface water developments such as reservoirs have the potential to add additional water to aquifer systems, thus contributing to higher water tables beyond their immediate vicinity (Alberta Environment 2004).

#### 7.1.3.1 Surface Water Allocation by Sector

The ten largest surface water allocations in the North Saskatchewan Watershed are given to TransAlta Utilities Corporation, ATCO Electric Ltd., EPCOR Generation Inc., the City of Edmonton and Alberta Environment (Table 8). With the exception of the City of Edmonton and Alberta Environment, the water is used for industrial cooling or hydropower generation. Edmonton's allocation is for municipal (household) use. A full listing of all licensed users appears on the report CD-ROM as additional information. Alberta Environment reports surface consumptive allocations by major Subwatershed (Figure 29).

**Table 8:** The ten largest active surface water allocations in the North Saskatchewan Watershed.

| Allocation (dam$^3$) | Applicant | Project | Source | Priority |
|---|---|---|---|---|
| 660,190 | TransAlta Utilities Corporation | Keephills/Industrial | Wabamun Lake | 1954 |
| 456, 388 | ATCO Electric Ltd. | Alta Power Ltd. | Battle River | 1955 |
| 234, 568 | TransAlta Utilities Corporation | Keephills/Industrial | Wabamun Lake | 1994 |
| 234, 373 | ATCO Electric Ltd. | Alta Power Ltd. | Battle River | 1976 |
| 234, 361 | EPCOR Generation Inc. | Edmonton Power Inc. | North Saskatchewan River | 1967 |
| 215, 859 | EPCOR Generation Inc. | Edmonton Power Inc. | North Saskatchewan River | 1971 |
| 149, 382 | EPCOR Generation Inc. | Edmonton Power Inc. | North Saskatchewan River | 1975 |
| 73, 023 | TransAlta Utilities Corporation | Keephills/Industrial | North Saskatchewan River | 1998 |
| 53, 017 | EPCOR Generation Inc. | Edmonton/Power | North Saskatchewan River | 1937 |
| 52, 546 | Alberta Environment | Environmental Protection WR | Wabamun Lake | 1997 |

The mean annual North Saskatchewan River discharge is 7,154,200 dam$^3$, of which approximately 32% of main stem natural flow is allocated. Of this, 70% (248,848 dam$^3$) is used for commercial/industrial use and 12% (41,771 dam$^3$) is used for municipal use.

The mean annual Battle River discharge is 310,800 dam$^3$, of which over 100% of main stem natural flow is allocated. Of this, 27% (15,546 dam$^3$) is used for commercial/industrial use and 19% (10,485 dam$^3$) is used for irrigation use.

The total annual surface water allocation for the Sounding Watershed is 25,416 dam$^3$. Of the allocated portion, 57% (14,560 dam$^3$) is for habitat enhancement use and 15% (3,912 dam$^3$) is for agricultural use.



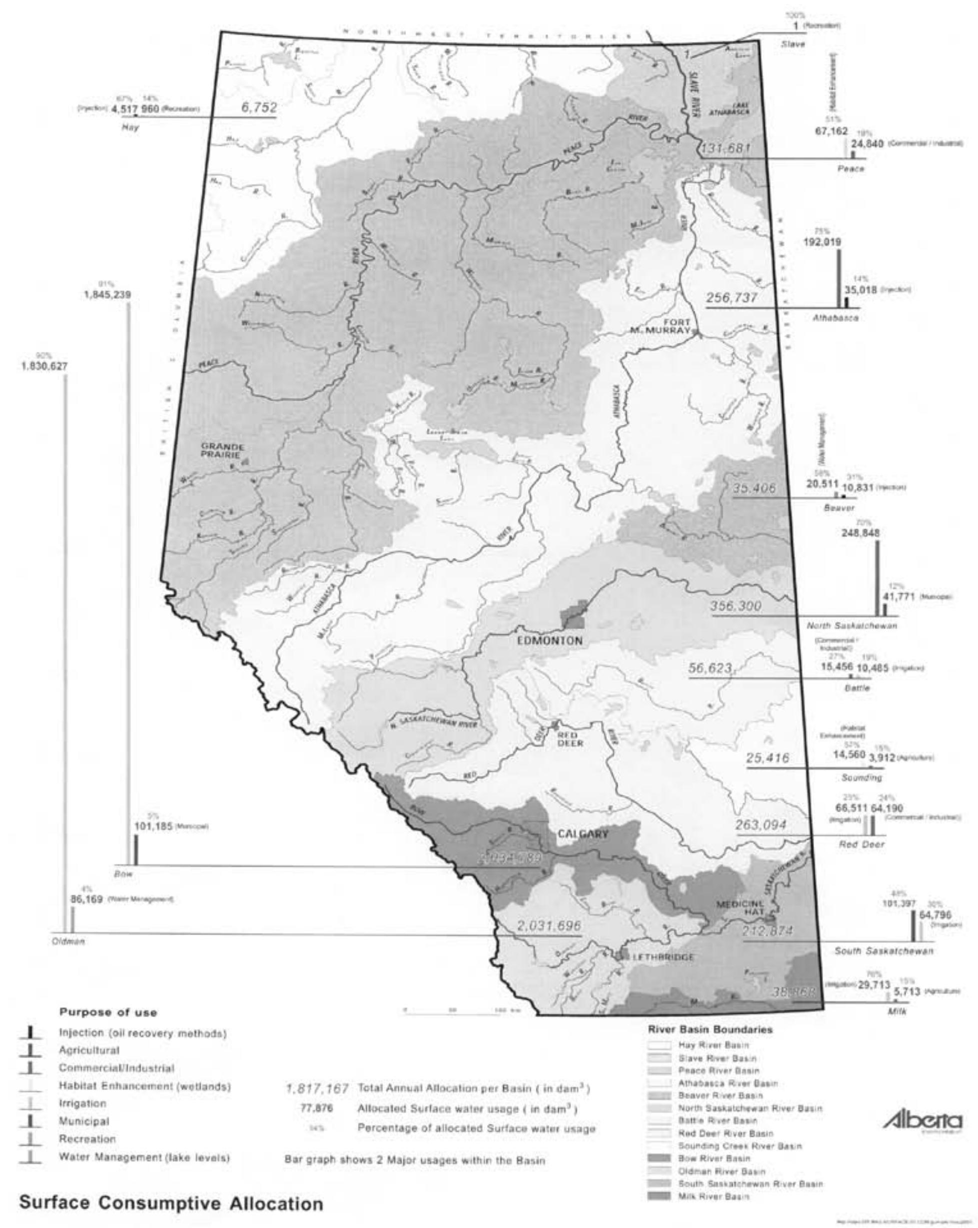
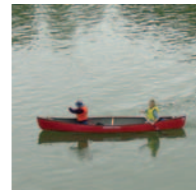
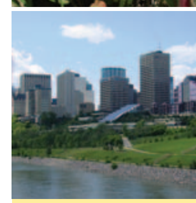



**Figure 29:** Surface water consumptive allocation in Alberta by major watershed.



### 7.1.3.2 Groundwater Extraction by Sector

The ten largest groundwater allocations in the North Saskatchewan Watershed are held by Lafarge Construction Materials, the Town of Stony Plain, Petro-Canada, the Town of Lacombe and the City of Edmonton (Table 9). The water is used primarily for drainage, well injection or municipal use (Town of Lacombe). A full listing of all licensed groundwater users appears on the CD-ROM.

**Table 9:** The ten largest active groundwater allocations in the North Saskatchewan Watershed as of January 8, 2004.

| Allocation ($dam^3$) | Applicant | Project | Use | Priority |
|---|---|---|---|---|
| 986,790 | Lafarge Construction Materials | Lafarge Construction Materials | DRAINAGE | 1988 |
| 954,720 | Town of Stony Plain | Town of Stony Plain | DRAINAGE | 1977 |
| 740,090 | Lafarge Construction Materials | Lafarge Construction Materials | DRAINAGE | 1984 |
| 595,770 | Town of Stony Plain | Town of Stony Plain | DRAINAGE | 1977 |
| 595,770 | Town of Stony Plain | Town of Stony Plain | DRAINAGE | 1977 |
| 534,050 | Town of Lacombe | Town of Lacombe | URBAN | 2001 |
| 534,050 | Town of Lacombe | Town of Lacombe | URBAN | 2001 |
| 431,720 | City of Edmonton | City of Edmonton | DRAINAGE | 1979 |
| 339,210 | Town of Vermilion | Town of Vermilion | URBAN | 1979 |
| 336,740 | Town of Ponoka | Town of Ponoka | URBAN | 1980 |



Alberta Environment reports groundwater consumptive allocations by major Subwatershed (Figure 30).

The total annual groundwater consumptive allocation for the North Saskatchewan Watershed is 11,714 $dam^3$. Of this, 56% (6,604 $dam^3$) is for commercial/industrial use and 29% (3,343 $dam^3$) is for agricultural use.

The total annual groundwater consumptive allocation for the Battle River Watershed is 10,022 $dam^3$. Of this, 50% (4,986 $dam^3$) is for agricultural use and 26% (2,600 $dam^3$) is for commercial/industrial use.

The total annual groundwater consumptive allocation for the Sounding Watershed is 1,810 $dam^3$. Of this, 50% (908 $dam^3$) is for habitat enhancement use and 37% (677 $dam^3$) is for municipal use.



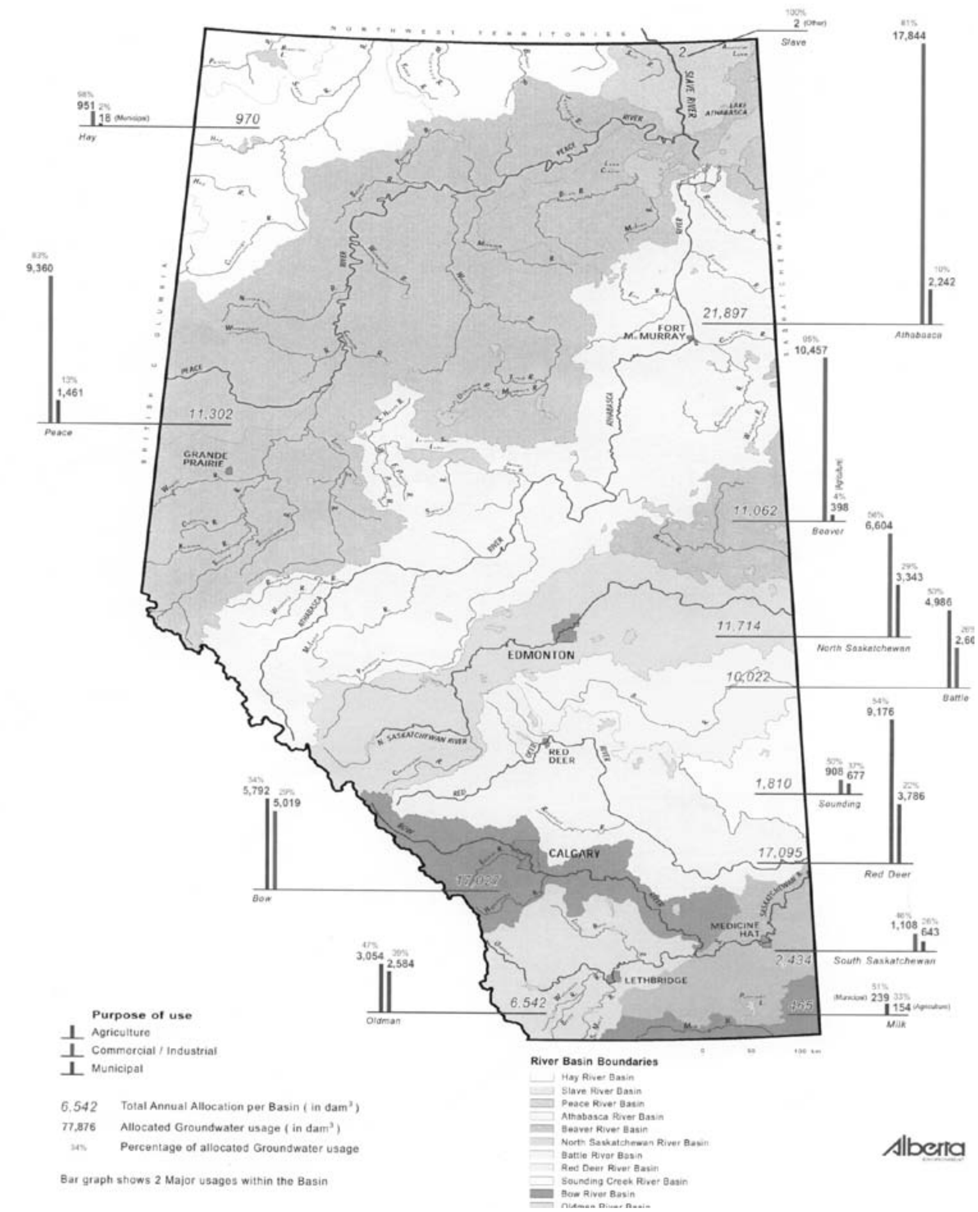
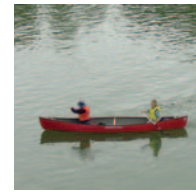
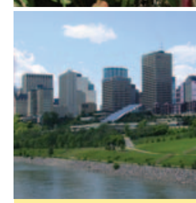



**Figure 30:** Groundwater consumptive allocation in Alberta by major watershed.





### 7.1.4 Biological Indicators

#### 7.1.4.1 Aquatic Macrophytes

A systematic examination of aquatic macrophytes and changes in their populations and distribution has not been completed in any Subwatershed, so an indication of watershed health cannot be predicted using this indicator. This data gap should be addressed in future research in the watershed.

Inventories in lakes in the Modeste Subwatershed found that the main species of emergent vegetation were greater bulrush, common cattail, reed grass, sedge, and arrowhead. The most abundant submerged macrophytes were northern watermilfoil, Richardson pondweed, stonewort, large-sheath pondweed, and sago pondweed.

Inventories in lakes in the Sturgeon Subwatershed found similar species. Greater bulrush, common cattail, reed grass, sedge, and arrowhead were the most abundant emergent species. Northern watermilfoil, Richardson pondweed, stonewort, large-sheath pondweed, sago pondweed, and coontail were the most abundant submergent species.

#### 7.1.4.2 Fish Population Estimates

A systematic estimate of fish populations has not been undertaken in any Subwatershed, so an indication of watershed health cannot be predicted using this indicator. This data gap should be addressed in future research in the watershed. However, in general, the most abundant fish species change from cold water and cool water species in the more western, higher elevation Subwatersheds to cool water and warm water species as one proceeds to Subwatersheds downstream where the water is warmer and, in the case of flowing water, generally slower moving.

Fish species occurring in the watershed include mountain whitefish, bull trout, cutthroat trout, rainbow trout, brook trout, lake trout, brown trout, lake whitefish, northern pike, yellow perch, walleye, sauger, goldeye, mooneye, lake sturgeon, longnose sucker, white sucker, Northern redhorse sucker and burbot (Nelson and Paetz 1992).

#### 7.1.4.3 Vegetation Types

In general terms, coniferous forests of white spruce and lodgepole pine dominate the vegetation in the higher elevations. Lodgepole pine is especially dominant where fire occurs and white spruce is dominant where there has been no recent fire. As one moves to lower elevations, the forest cover is lodgepole pine, Douglas fir, and Engelmann spruce. At still lower elevations, there is a co-dominance of trembling aspen, balsam poplar, lodgepole pine and white spruce. In the Boreal Forest Region, species such as trembling aspen and balsam poplar dominate.

#### 7.1.4.4 Benthic Invertebrates

There has been no systematic assessment of benthic invertebrates in the watershed, so an indication of watershed health cannot be predicted using this indicator. This data gap should be addressed in future research in the watershed. However, benthic invertebrates have been studied in specific locations. For example, Alberta Environment surveyed benthic invertebrates in the North Saskatchewan River between 1973 and 1977 (Reynoldson and Exner 1978). The study found changes in the main invertebrate groups between sites sampled upstream of



Edmonton and those sampled downstream. The main invertebrate groups upstream of Edmonton were Chironomidae, Ephemeroptera and Plecoptera. Downstream of Edmonton, there was a major increase in numbers and a decline of species diversity. At sites downstream of Edmonton, Oligochaeta and Chironomidae were the most abundant groups of benthic invertebrates. The nature of the change in the benthic invertebrate communities suggested the major impact was due to organic rather than inorganic or toxic effluents. Stormwater management and wastewater treatment in the City of Edmonton have been improved significantly since the study was conducted. Follow-up sampling should be undertaken at these sites to see how the benthic invertebrate communities have responded to these changes.

A benthic invertebrate survey was conducted in Wabamun Lake in November 2002. The results indicated some effects in the areas of the wastewater and power plant discharges when compared to background areas in the lake. Overall the differences were slight; however, signs of mild enrichment were apparent.

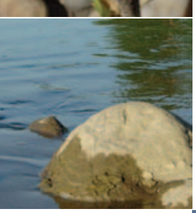
## 7.2 CONCLUSION SUMMARY

Fifteen indicators of watershed health were selected and ranked by a panel of experts and members of the NSWA for each of the 18 subwatersheds. These indicators were summarized and have yielded a subjective health rating. The overall health of the entire North Saskatchewan Watershed is generally fair, and includes some subwatersheds where ecosystem function is significantly impaired by human activity. Through an adaptive process, the NSWA should re-evaluate these indicators based on the current report for relevance, and focus future data collection efforts and state of the watershed reporting where data gaps have been identified and indicators refined. This report did not evaluate other industries such as forestry and oil and gas in any great detail – so it is unknown as to the degree of impairment caused by these and other industries.

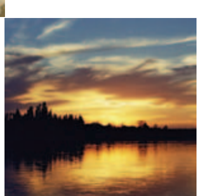
On a watershed scale, for the indicators where data were available, watershed health tends to decrease as you move towards the Modeste, Sturgeon and Strawberry subwatersheds, where livestock density, human activity and populations are greatest. Linear development, intensive land uses, and livestock densities are highest in these watersheds, while riparian health scores and wetland cover based on the maps generated, are lowest.

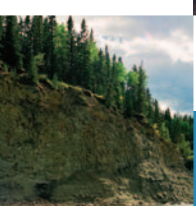
Disturbances of note include the Capital Region's impacts on the river main stem from treated wastewater and stormwater outfalls. For example, the Surface Water Quality Index drops downstream of Edmonton due to increases in both *E. coli* counts and phosphorus concentrations. However, the impact of the City has been lessened considerably by the recent improvements in wastewater treatment technology (tertiary treatment including biological nutrient removal) and should continue to improve as the City of Edmonton moves forward with proposed stormwater treatment strategies.

The impacts of high agricultural intensity in the Bigstone, Iron, Ribstone, Blackfoot, and Paintearth subwatersheds may be reflected in higher phosphorus and lowered riparian health scores and wetland densities. In these Battle River subwatersheds, water quantity will continue to be an issue, as will water quality.



Pesticides did not appear to be a major concern anywhere within the watershed. Pesticides were detected in several subwatersheds, but concentrations never exceeded the CCME Surface Water Quality Guidelines for the Protection of Aquatic Life. "Based on the research and monitoring work conducted, the risk of water quality degradation appears to be significant for areas of the province where intensive agriculture is practised, as measured by fertilizer or herbicide inputs or by animal unit density" (CAESA, 1998). However, several types of pesticides identified do not have guidelines established.








Biological indicators and water quantity were most poorly represented in this study, and available data were not adequate to properly address these indicators. For example, none of the biological indicators (aquatic macrophytes, fish population estimates, vegetation types and benthic invertebrates) were comprehensive enough to allow for a prediction of watershed health. Pharmaceuticals (animal and human) were found to be of concern to watershed residents. Effects on humans and aquatic life are not well known or documented in the watershed and this presents a data gap of interest to the public.

The NSWA, as Watershed Planning and Advisory Council for the North Saskatchewan River Watershed in Alberta, will continue to lead State of the Watershed reporting in this watershed. It will also undertake integrated watershed planning by involving its members and stakeholders in an ongoing, adaptive assessment and planning process. This State of the Watershed Report is a foundational document to be used by the NSWA to initially characterize and evaluate the overall health and issues of concern in this watershed.

As all major watersheds in this province are unique, this new approach to planning and growth while considering the limitations of watersheds creates an opportunity. The North Saskatchewan Watershed, with a relative abundance of water quantity, can consider the needs of the aquatic, riparian and other hydrological systems as part of its future. The Watershed Planning and Advisory Council for the North Saskatchewan (the NSWA) can choose to restore and plan to incorporate not just society's needs, but the needs of the natural systems which support social, environmental and economic health. It is hoped that this document and future reports of this kind will provide an assessment of just how well planning, implementation and actions improve the 'state of the watershed'.

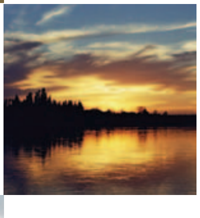




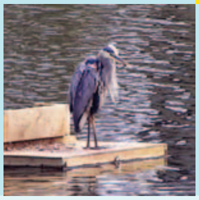








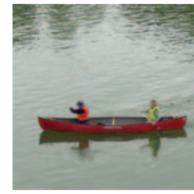


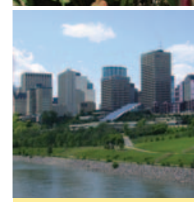



Chapter 8.0

# Recommendations







## 8.0 RECOMMENDATIONS

The following recommendations are a result of report data analysis, NSWA member and public comments, examining the needs of future State of the Watershed Reports and information required for wise use and management of the North Saskatchewan Watershed. These recommendations are for the review and consideration by NSWA members, NSWA partners and watershed stakeholders. The recommendations are:

**i.** To support municipal government initiatives that promote wise use and management of their portion of the watershed such as urban sustainability initiatives (Smart Growth), conservation planning, riparian area protection zones, wetland restoration and upgrades to wastewater and stormwater treatment.

**ii.** To encourage municipal governments to incorporate watershed function in planning and development policy reviews. Riparian areas, native and perennial tame vegetation, and wetlands are key elements in watershed protection. The NSWA should work with and encourage municipalities to develop and implement land use policies that protect these features.

**iii.** To discuss with the federal, provincial and municipal governments the provision to the public of digital data collected and created with public dollars. A major constraint of this project was obtaining digital data from government and the lengthy process that this required.

**iv.** To encourage the federal, provincial, municipal governments and Non-government Organizations (NGO's), industry and others, to undertake a review of their respective non-digital data sources and translate these to geo-referenced digital data for the purpose of GIS layer completeness (i.e. water quality and fisheries data).

**v.** To create a water quality working group to identify all agencies and volunteer organizations currently collecting water quality information in the watershed to ensure that monitoring efforts are adequate to address watershed health. This could be accomplished through a series of workshops or forums. This group could also share water quality data and ensure a consistent approach to data collection, and create a water quality report using existing data from throughout the basin. This would have value in further understanding the watershed's water quality not based solely on the Alberta Surface Water Quality Index (ASWQI).

**vi.** To encourage the provincial government and research organizations to systematically assess a suite of biological indicators in order to properly evaluate this aspect of watershed health. Alternatively, the NSWA should consider an initiative to collect biological indicator data that were absent from this report.

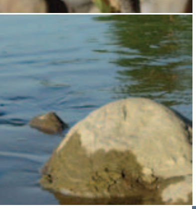
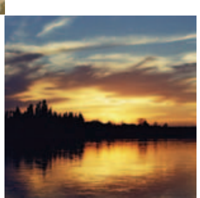
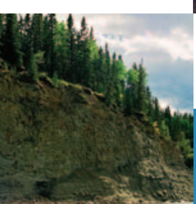
**vii.** To work with the Cows and Fish Program, and other riparian assessment experts, to develop a collective GIS-based riparian assessment process that is objective, universal, unconstrained by sharing issues and more accessible to the public. As a component of this, the NSWA should consider undertaking a thorough review of acceptable riparian buffer widths for all land uses, and determine best practices to be consistently incorporated into government land management practices and policies.

**viii.** To gain a better understanding of the cumulative impact of land disturbance, comprehensive assessments of provincial river basins should be a component of the province's 'state of the environment' reporting.







**ix.** To work with other Watershed Planning and Advisory Councils on adopting a consistent wetland classification system and scale (e.g. Stewart and Kantrud or Cowardin) to be used throughout the province. The NSWA should then encourage and support conservation groups and agencies to collect wetland digital data using this consistent classification system.

**x.** To undertake with other agencies and partners a comprehensive wetland resource inventory, including drained wetlands, as a key component of a complete land use inventory for the North Saskatchewan Watershed. This is an essential tool that would enable planners to effectively address source water protection, water storage and restoration needs in the watershed. A priority for the inventory would be areas of medium to high agricultural intensity and land drainage.

**xi.** That the provincial government develop and implement a Wetland Policy through the Alberta Water Council that effectively addresses both wetland loss and restoration.

**xii.** To encourage the province and research organizations to undertake research in the area of glacier recession and snow pack change in the North Saskatchewan Watershed. This research should then be linked to climate change models for predictive scenarios.

**xiii.** To encourage and support the province to fund groundwater quantity and quality assessments for major groundwater sources in the watershed. This should include an assessment of groundwater quantity to ensure adequacy and scale of existing data.

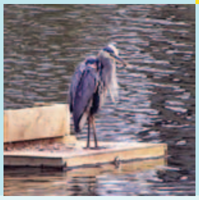
**xiv.** To support and encourage federal and provincial governments to continue to invest in research of emerging issues such as waterborne human and livestock pharmaceuticals. Research should focus on beneficial management practices to decrease their concentrations at the source (such as livestock waste and municipal wastewater treatment facilities) and increase proper disposal.

**xv.** To encourage all levels of government to support and promote management practices that result in increased biodiversity in the watershed.

**xvi.** To develop a system to record and track improvements to watershed protection and continue to evaluate the effects of these improvements through regular state of the watershed reporting.

**xvii.** The indicators of watershed health used in this study were selected and ranked by the NSWA. NSWA should re-evaluate these indicators based on the current report for relevance, and encourage the focus of future data collection efforts by all partners in the watershed, where data gaps have been identified.

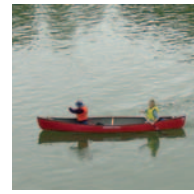
**xviii.** In future 'State of Watershed' reporting, the impact of resource extraction practices needs to be assessed relative to watershed health.


Chapter 9.0

# Glossary






## 9.0 GLOSSARY

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

**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).

**Dissolved Oxygen (DO):** 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, in their natural environment are treated together as a functional unit.



**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.

**Eutrophic:** Refers to aquatic environments that have abundant nutrients and high rates of productivity. In water bodies 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).

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

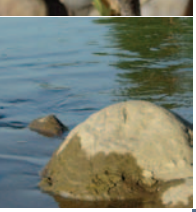
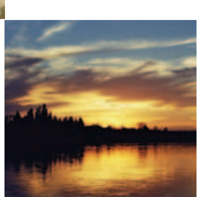
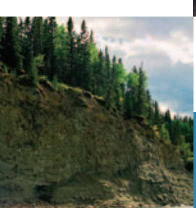
**Fecal Coliform:** Refers to the group of bacteria associated with the feces of warm-blooded animals. They constitute one of three bacteria commonly used to measure possible contamination of water by human or animal wastes. The others are *Escherichia coli (E. coli)* and *Enterococcus spp*.









**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.

**Forest Management Area (FMA):** 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 (FMU):** 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*).

**Glacial Flour:** Finely ground rock particles produced by glacial abrasion.

**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.

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

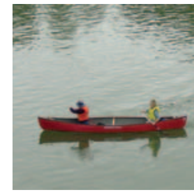
**Mass Loads:** The mathematical weight of a pollutant in a waterbody. The load is the calculated product of the concentration of a pollutant in water multiplied by the water volume.

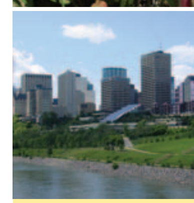
**Mesotrophic:** Refers to aquatic environments with adequate nutrients and sufficient rates of productivity to sustain aquatic life. (Meso = "middle").

**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.

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



**Pathogen:** An agent that causes disease, especially a living microorganism such as a bacterium or fungus (Webster's dictionary).

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

**pH:** A logarithmic scale used to measure the acidity of water.

**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 at several levels: total phosphorus (TP), total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP).

**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 milliequivalents per litre (Wetzel 1975).

**Secchi Disk:** An 8-inch (20 cm) disk with 2 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.

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





**Total Phosphorus:** A measure of both organic (particulate) and inorganic (dissolved) forms of phosphorus in a solution.

**Total Dissolved Solids (TDS):** Portion of dissolved solids that passes through a 2.0 µm filter (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 total 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 (TKN):** A measure of the sum of organic nitrogen and ammonia nitrogen (Standard Methods 1998).

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

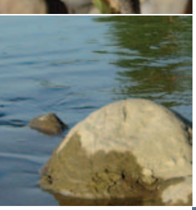
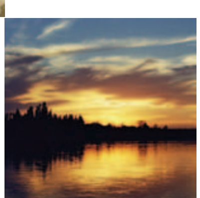
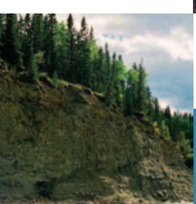
**Trophic:** Refers to the nutrient availability and productivity status of a waterbody.

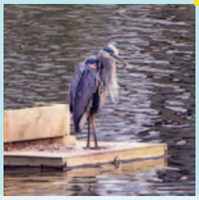
**Total Suspended Solids (TSS):** The portion of dissolved solids that are retained by a 2.0 µm filter (Standard Methods 1998).

**Watershed:** The area of land draining into a stream, lake, wetland or other waterbody. Wherever you are on the earth, you are in a watershed.



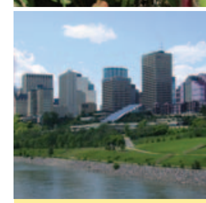




# Chapter 10.0
# References





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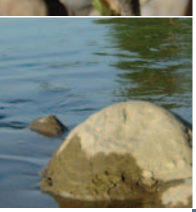
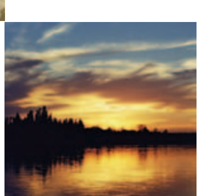
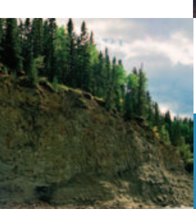







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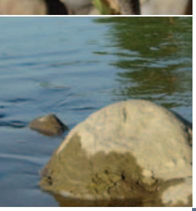
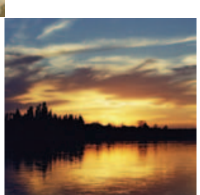
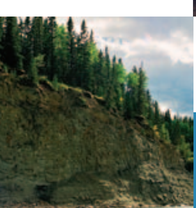
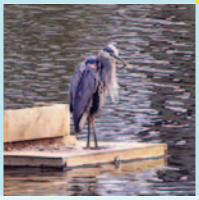






Chapter 11.0

# Appendix A: Member Involvement Process and Issues






## 11.0 APPENDIX A: MEMBER INVOLVEMENT PROCESS AND ISSUES

As part of the State of the North Saskatchewan Watershed project, activities were designed to gather feedback on the project and raise awareness of the NSWA and its initiatives. Public consultation activities for the State of the North Saskatchewan Watershed project included:

- NSWA membership input at the AGM
- NSWA membership feedback
- An Indicator workshop;
- Static displays at public locations; and
- Three watershed open houses.

### 11.1.1 Static Displays

Static displays were placed in public venues throughout the watershed to provide information about the NSWA, the open houses and watershed resources. Displays were placed in the Stanley Milner Library in Edmonton, Strathcona County Hall, Vilna, Elk Point, and Rocky Mountain House in July and August 2003.

### 11.1.2 Open Houses

In 2003, open houses were held in Rocky Mountain House, Elk Point and Sherwood Park on September 9th, 11th, and October 2nd respectively. The purpose of these open houses was to raise awareness regarding the importance of watershed integrity, promote the activities of community-based watershed initiatives, collect public input related to water management in the watershed, and present preliminary work for the 'State of the North Saskatchewan Watershed Report'.

Open houses lasted seven hours (from 2:00 p.m. until 9:00 p.m.) and were held in local community venues. Advertisements for each open house were done by radio and in local newspapers, brochures were left at public static displays, and notices were sent to NSWA members. Attendance at each open house was: Rocky Mountain House: 30; Elk Point: 30, plus 56 grade three and 50 senior high students; and Sherwood Park: 120.

### 11.1.3 Public Issues and Feedback

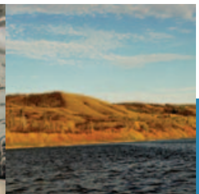
The following issues and comments were obtained from verbal and written comments recorded during the open houses. Water quality, quantity and the industrial use of water were the most frequently mentioned concerns. The comments have been summarized into eight categories, listed below alphabetically. These categories represent overlapping/interconnected issues and concerns. The comments and suggestions do not necessarily reflect the views of the NSWA or the authors of this report.

#### 11.1.3.1 Future Trends

Several comments were made that the State of the Watershed should look at future trends and be proactive regarding possible droughts and climate change. The following specific suggestions were made:

- The Brazeau Dam should have data for inflow and outflow; and
- Historical data should be used to identify trends for future drought and climate change.





### 11.1.3.2 Impact of North Saskatchewan Watershed Plan on Industry

Concerns were raised at the Elk Point open house that the watershed plan might be too restrictive on industrial activities.

### 11.1.3.3 Land Use

#### Municipal

Concerns about the impacts on the North Saskatchewan Watershed from the City of Edmonton, commercial and residential development in the Cooking Lake / Moraine area of Strathcona County were recorded at both the Elk Point and Sherwood Park open houses.

#### Riparian Areas and Vegetation

The following specific concerns were raised throughout the three watershed regions:

- Scentless chamomile and other noxious weeds coming from the cities to the rural areas;
- The need to keep trees in their natural state beside creeks, lakes and the river;
- The proximity of landfills and other dump sites to the river;
- The lack of a re-planting program in the County of St. Paul No. 19 for areas susceptible to soil erosion, cleared roads and power lines;
- Change of watershed vegetation due to 'flush out' (water being dumped at high temperatures) and dams; and
- Holding water too long in the Ribstone Creek causes flooding, which drowns the farmer's hay. (The creek is dammed and Alberta Environment holds water too long causing flooding.)

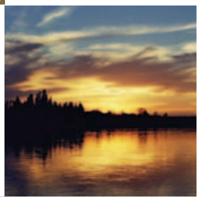
#### Forestry

At the Sherwood Park open house, the following concerns with forestry land use were raised:

- The decline of forested areas affects the flow of water;
- The ability of private landowners to remove forest cover on their land without restriction is a concern; and
- Uncertainty regarding whether or not the *Forestry Act* includes a section on sustainability for the upper watershed for water conservation.

#### Recreation Use

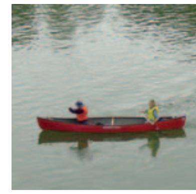
At both the Elk Point and the Rocky Mountain House open houses, issues were raised about how boating restrictions should be considered for airboats used by outfitters, as they are disruptive to waterfowl. There was also concern that more information needs to be gathered and communicated about the effects of motorized recreation on shallow water bodies. Additionally, the protection of flood plains from recreational use impacts was brought forward at the Rocky Mountain open house.

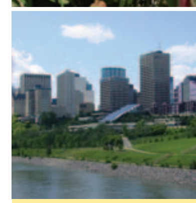


#### Land Management

Open house attendees expressed the following land management comments and issues:

- Fire bans should not be lifted in response to political pressure, if the conditions are too dry;





- The water and land management plan should take an integrated watershed management approach; and
- The management plan for the Athabasca watershed provides a good example of how industries can work together.

**Agriculture**

The impacts on water quality from intensive livestock operations and pesticides were concerns expressed at the Rocky Mountain House open house.

**Historic Resources and Cultural Values**

In Rocky Mountain House, it was mentioned that there are sensitive and cultural areas near/around water bodies that should be recognized. In addition, the identification of Aboriginal cultural and historical resources should be included in the management plan.

**11.1.3.4 Quality of Life**

The considerable improvement in water quality over the last 20 years was mentioned as a positive issue, however there was concern that these improvements can only continue with a strong economy. Additionally, it was suggested that the Alberta government look at the Norwegian oil and gas sector as an example for water management that may enhance the economic standard of living for all Albertans and Canadians.

**11.1.3.5 Quality of Water**

Water quality was one of the most commonly reported issues at both the Elk Point and Rocky Mountain House open houses. The specific concerns about water quality are given below.

- The 'capacity' of smaller villages and hamlets to ensure water quality (including delivered water supplies);
- Future availability and quality of water both in terms of domestic and agricultural uses;
- Roads that are not properly maintained by counties, leading to the erosion of ditches and polluted run-off;
- Damaging impacts from the road oil run-off from oil and gas activity; and
- Water quality related to wastewater treatment, including pharmaceuticals.

Additionally, it was mentioned that it is important to raise awareness of individual impacts on water quality.

**11.1.3.6 Quantity of Water**

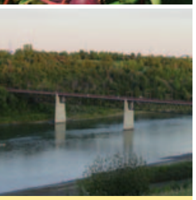
Water quantity was an issue identified at all open houses.  Specific comments and concerns are summarized below.

- The future availability of water;
- Lack of water for cattle;
- The amount of fresh water being lost due to oil recovery methods;
- Fluctuating water levels that ruin the littoral zone in the river and reservoir;
- The lack of water in the Battle River;
- Uncertainty about the impact of using data from the last 1000 years, which has been the wettest on record;
- Reduced flows and sediment infilling of the Sturgeon River within the City of St. Albert;
- Declining water levels in Sandy Lake;



• The effects of mining and aggregate extraction on aquifers;
• Wetland drainage reducing the amount of water storage in the watershed and reducing recharge of groundwater; and
• The 'cons' for aquatic life of stabilizing lake levels.





#### 11.1.3.7 Public Understanding

Concern was expressed that the general public does not understand how integrated the natural water systems are and the importance of protecting them. The importance of raising awareness of how individuals impact water quality was also reported. Additionally, it was suggested that the impact of natural drought cycles, such as the Pacific Decadal Oscillations, on hydrology and historical data for inflow and outflow demands should be included in watershed planning.

#### 11.1.3.8 Use and Management of Water

At NSWA open houses, the public discussed issues of water management that included municipal wastewater, the exporting of water, industrial use and diversion. Specific comments and concerns are summarized below.

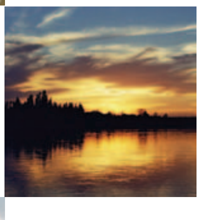
**Municipal Waste**
• Municipal wastewater being dumped into the river; and
• Impacts from the City of Edmonton on the North Saskatchewan River.

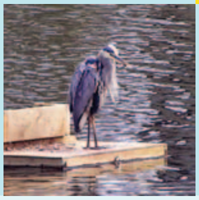
**Exporting of Water**
• The idea of selling water was both supported and refuted; and
• Government should retain control over water exports, not large corporations.

**Industrial Use of Water**
• Industry is using too much water and it needs to be monitored more closely;
• Chemical plants on the North Saskatchewan River are negatively impacting water;
• Industrial discharge to the North Saskatchewan River should be regulated more stringently; and
• Methane emissions from coal at Battle Lake.

**Water Diversion**
• The diversion of the Mackenzie and Peace River towards Elk Point; and
• Impacts from damming of the Colorado River could be used as comparison for the management plan.

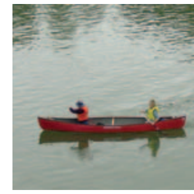


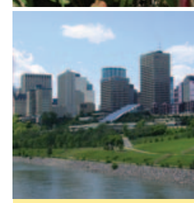



Chapter 12.0

# Appendix B: List of NSWA Members





**APPENDIX B: NSWA Membership (February 2005)**

**NON GOVERNMENT ORGANIZATIONS**

1. Alberta Conservation Association
2. Alberta Ecotrust
3. Alberta Lake Management Society
4. Alberta League for Environmentally Responsible Tourism (ALERT)
5. Bow River Basin Council
6. Bow River Project
7. Butte Action Committee for the Environment
8. Capital Health Authority
9. Cows & Fish Program
10. Ducks Unlimited Canada
11. East Central Regional Health Authority
12. Energy Efficiency Association
13. Environmental Law Centre
14. Environmental Resource Centre
15. Federation of Alberta Naturalists
16. Lakeland Regional Health Authority
17. Land Stewardship Centre of Canada
18. Legacy Lands Conservation Society
19. Northeast Alberta Water Management Coalition
20. Northwest Alliance Conservation Initiative
21. Parkland Residents Association
22. Partners FOR the Saskatchewan River Basin
23. Pembina Institute for Appropriate Development
24. Rocky & Nordegg Cooperative Fisheries Inventory Program
25. Rocky Riparian Group
26. Rossdale Community League
27. Saskatchewan Watershed Authority
28. Sierra Club, Prairie Chapter
29. The Living by Water Project
30. TOPSOIL
31. Toxics Watch Society of Alberta
32. Tri-town Environmental Society
33. Trout Unlimited Canada
34. Vermilion River Naturalist Club
35. Wonder of WaterRESEARCH/EDUCATION
36. Alberta Research Council
37. Edmonton Catholic Schools
38. Edmonton Science Outreach Network
39. Foothills Model Forest
40. Inside Education
41. Riverwatch
42. The King's University College


43. University of Alberta, Kinsella Research Station
44. University of Alberta, Renewable Resources Department
45. Water Institute for Semi-arid Ecosystems
46. YoWoChAs

**CULTURE/RECREATION/TOURISM**

47. Alberta Fish & Game Association
48. Alberta Recreation Canoe Association
49. Alberta Sport, Recreation, Parks and Wildlife Foundation
50. Alberta Trailnet Society
51. Banff National Park
52. Dickson Fish & Game Association
53. Edmonton & District Historical Society
54. Elk Island National Park
55. Kalyna Country
56. Midwest Tourism
57. Northeast Edmonton Heritage Conservation Initiative
58. Northwest Voyageurs Canoe and Kayak Club
59. River Valley Alliance
60. Riverland Recreational Trail Society
61. The Iron Horse Trail
62. Thorsby Fish & Game Association
63. Voyageur Ventures

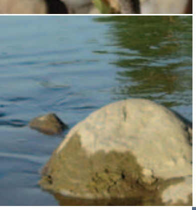


**AGRICULTURE**

64. Alberta Beef Producers
65. Canadian National Committee for Irrigation Drainage
66. Grey Wooded Forage Association
67. Intensive Livestock Working Group
68. Restorative Ecological Agriculture Projects Society
69. St. Mary's Irrigation District
70. St. Paul Grazing Reserve

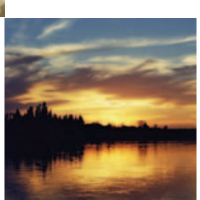
**ABORIGINAL COMMUNITIES**

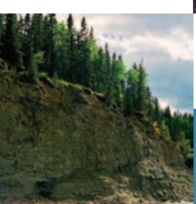
71. Enoch First Nation
72. First Nations Alberta Technical Services Advisory Group
73. Métis Nation of Alberta
74. Paul First Nation
75. Saddle Lake Tribal Administration

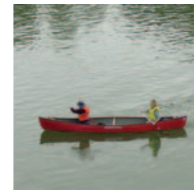


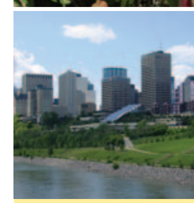
**INDUSTRY**

76. Alberta Capital Region Wastewater Commission
77. Alberta's Industrial Heartland
78. AMEC Earth & Environmental Ltd.
79. Aquality Environmental Consulting
80. Aquascience
81. Dillon Consulting Ltd.







82. EBA Engineering Consultants Ltd.
83. ECL Environmental Services Limited
84. EduTransfer Design Association Inc.
85. Elk Point Chamber of Commerce
86. EnviroMak
87. EPCOR Water Services
88. Golder and Associates
89. Komex International
90. Noble Resource Management Ltd.
91. Northeast Capital Industrial Association
92. Nova Chemicals Corporation
93. Parkland Stone Landscaping
94. Petro-Canada
95. Shell Canada Ltd.
96. Strathcona Industrial Association
97. Sunpine Forest Products
98. The Canadian Salt Company Limited
99. Top Draw
100. TransAlta Utilities
101. Weyerhaeuser

**GOVERNMENT**

**Federal**

102. Agriculture & Agri-Food Canada; Prairie Farm Rehabilitation Administration
103. Canadian Heritage Parks Canada
104. Fisheries and Oceans Canada
105. Department of Indian & Northern Affairs

**Provincial**

106. Alberta Agriculture, Food & Rural Development
107. Alberta Community Development
108. Alberta Energy and Utilities Board
109. Alberta Environment
110. Alberta Environmentally Sustainable Agriculture
111. Alberta Health and Wellness
112. Alberta Sustainable Resource Development
113. Special Areas

**Municipal**

114. Alberta Urban Municipalities Association
115. City of Camrose
116. City of Edmonton, Community Services
117. City of Edmonton, Drainage Services
118. City of Edmonton, Planning & Development
119. City of Leduc, Environmental Advisory Board
120. City of Lloydminster
121. City of Spruce Grove
122. City of St. Albert



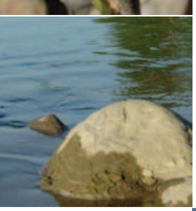



123. North West Alliance Conservation Initiative
124. Town of Bruderheim
125. Town of Devon
126. Town of Drayton Valley
127. Town of Elk Point
128. Town of Gibbons
129. Town of Rocky Mountain House
130. Town of Smoky Lake
131. Town of Tofield
132. Village of Marwayne

**Counties & MD's**

133. Beaver
134. Camrose
135. Clearwater
136. Flagstaff
137. Lac Ste Anne
138. Lacombe
139. Lamont
140. Leduc
141. Minburn #27
142. Paintearth #18
143. Parkland
144. Red Deer
145. Smoky Lake
146. St. Paul #19
147. Strathcona
148. Engineering & Environmental Planning
149. Environmental Operations
150. Sturgeon
151. Two Hills #21
152. Vermilion River #24
153. Wetaskiwin #10
154. M.D. Brazeau
155. M.D. of Wainwright No. 61





**CITIZEN MEMBERS**

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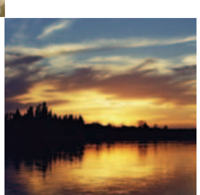
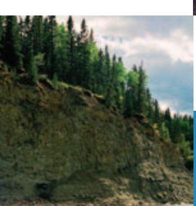
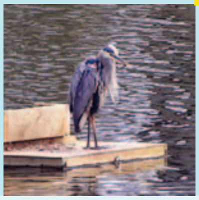
**WATERSHED STEWARDSHIP GROUPS**

174. Battle Lake Watershed Enhancement Association
175. Beaverhill Watershed Initiative
176. Big Lake Environment Support Society
177. Bonnie Lake Sustainability Association
178. Devon Watershed Alliance
179. Friends of Lily Lake
180. Iron Creek Watershed Improvement Society
181. Rocky Riparian Group
182. Vermilion Watershed Initiative






## Chapter 13.0

# Appendix C: Indicator Metrics Ranking Categories and Subwatershed Health Scores








# 13.0 APPENDIX C: INDICATOR METRICS RANKING CATEGORIES AND SUBWATERSHED HEALTH SCORES

## Indicator Rankings:

Linear disturbance

Subjectively, linear disturbance below 2% was considered good, between 2 and 3 percent was fair and above 3% was deemed poor.

Total phosphorous

Subjectively, total phosphorus less than 100 ug/L was good, between 100 ug/L and 199 ug/L was fair and 200 ug/L was deemed poor.

Livestock density

Subjectively, livestock density (surrogate of manure production used) that was low was deemed good, medium low and medium were deemed fair, medium high and high were deemed poor.

Land disturbance - other

Subjectively, subwatersheds that were less than 50% disturbed were deemed good, between 50% and 89% fair, and greater than 90% poor.

Riparian health – Cows and Fish rankings

Subjectively, the ranking that rated highest by percentage was used to rank the subwatershed. For example, in the Frog Subwatershed there were more healthy riparian areas (46%) than any other ranking, therefore the watershed was deemed to have 'healthy' riparian areas.

*E.coli*

Subjectively, *E.coli* counts between 0 and 50 were deemed good, counts between 51 and 100 were deemed fair, and counts greater than 100 were deemed poor.

Wetlands

Subjectively, subwatersheds with greater than 10% wetlands were deemed good, between 9% and 5% fair, and below 5% were deemed poor.

Alberta Surface Water Quality Index

Subjectively, the ASWQI subwatersheds with a rating of good were deemed healthy, good-fair, and marginal as fair, and poor were deemed poor.

Aquatic macrophytes

No systematic studies were done in any watershed. However, if studies found aquatic macrophytes, the overall health in the watershed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.





Benthic invertebrates

No systematic studies were done in any reach of the watershed.  However, if studies found benthic invertebrates, the overall health in the watershed was assumed to be ‘fair’. This knowledge gap must be addressed before a more accurate assessment can be made.

Fish populations

No systematic studies were done in any reach of the watershed.  However, if studies found fish populations existed, the overall health in the watershed was assumed to be ‘fair’. This knowledge gap must be addressed before a more accurate assessment can be made.

**Subwatershed Health Scores:**

**Cline**
Of the 4 indicators assessed, 3 were good, 1 was fair, and 1 was poor, yielding an overall subjective rating of **good**.

**Brazeau**
Of the 7 indicators assessed, 5 were good, 1 was fair, and 1 was poor, yielding an overall subjective rating of **good**.

**Ram**
Of the 8 indicators assessed, 6 were good, 2 were fair, and 0 were poor, yielding an overall subjective rating of **good**.

**Clearwater**
Of the 6 indicators assessed, 4 were good, 2 were fair, and 0 were poor, yielding an overall subjective rating of **good**.

**Modeste**
Of the 10 indicators assessed, 0 were good, 6 were fair, and 4 were poor, yielding an overall subjective rating of **fair**.

**Strawberry**
Of the 11 indicators assessed, 3 were good, 3 were fair, and 5 were poor, yielding an overall subjective rating of **poor**.

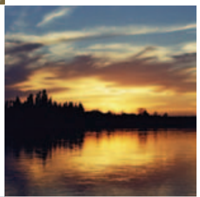
**Sturgeon**
Of the 9 indicators assessed, 2 were good, 5 were fair, and 2 were poor, yielding an overall subjective rating of **fair**.

**Beaverhill**
Of the 7 indicators assessed, 0 were good, 4 were fair, and 3 were poor, yielding an overall subjective rating of **fair**.

**White Earth**
Of the 6 indicators assessed, 2 were good, 3 were fair, and 2 were poor, yielding an overall subjective rating of **fair**.

**Vermilion**
Of the 7 indicators assessed, 0 were good, 2 were fair, and 5 were poor, yielding an overall subjective rating of **poor**.



**Frog**
Of the 7 indicators assessed, 1 was good, 6 were fair, and 0 were poor, yielding an overall subjective rating of **fair**.

**Monnery**
Of the 6 indicators assessed, 0 were good, 5 were fair, and 1 was poor, yielding an overall subjective rating of **fair**.




**Bigstone**
Of the 9 indicators assessed, 1 was good, 4 were fair, and 4 were poor, yielding an overall subjective rating of **poor**.

**Paintearth**
Of the 8 indicators assessed, 2 were good, 4 were fair, and 2 were poor, yielding an overall subjective rating of **fair**.

**Iron**
Of the 7 indicators assessed, 0 was good, 4 were fair, and 3 were poor, yielding an overall subjective rating of **fair**.

**Ribstone**
Of the 8 indicators assessed, 2 were good, 3 were fair, and 3 were poor, yielding an overall subjective rating of **poor**.

**Blackfoot**
Of the 5 indicators assessed, 0 were good, 1 was fair, and 4 were poor, yielding an overall subjective rating of **poor**.

**Sounding**
Of the 5 indicators assessed, 2 were good, 2 were fair, and 1 was poor, yielding an overall subjective rating of **fair**.



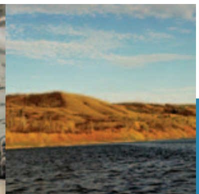
**Ranking of Subwatersheds:**

**"Good":** Cline
Brazeau
Ram
Clearwater

**"Fair":** Modeste
Sturgeon
Beaverhill
Whitearth
Frog
Monnery
Paintearth
Iron
Sounding

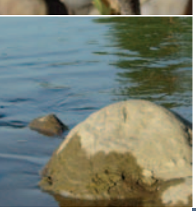
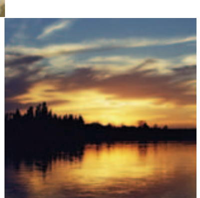
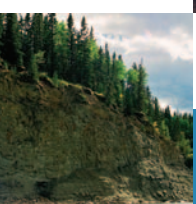
**"Poor":** Strawberry
Vermilion
Bigstone
Ribstone
Blackfoot









**Acknowledgments**

Due to the length and magnitude of this project, both in development and completion, there have been many NSWA members involved with the project direction. The NSWA has tracked membership of this Steering Committee over time. Current management apologizes for any omissions in this list.

The report would not have been possible without the efforts of many individuals and organizations. This project was conceived at a meeting in Edmonton on November 15, 2001. The following individuals met to discuss the current project: Christine Della Costa (FEESA; now Inside Education); Bruce McCulloch (Fisheries and Oceans Canada); Dave Trew, Anne Marie Anderson, Ed Bulger, Hamid Namsechi, Sal Figliuzzi, Jason Boisvert, Douglas Thrussell (Alberta Environment); Cherie Westbrook, Jamie Wuite (Alberta Agriculture, Food and Rural Development); Ron Bjorge, Kevin Tripp (Alberta Sustainable Resource Development); Adele Mandryk (then NSWA Manager); and Cindy Shepel (EPCOR Water Services). Through the efforts of NSWA Manager Adele Mandryk, terms of reference were created and funds were raised to start the project.

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Finally, the NSWA Membership is to be thanked for their ongoing support. NSWA members determine project work. This report is to be recognized as a foundational document for the Integrated Watershed Management Plan.