Athabasca
WATERSHED COUNCIL

State of the Athabasca Watershed:

Summary Report

2018

PREFACE: THE ATHABASCA WATERSHED COUNCIL

In 2003, the Government of Alberta (GOA) released Water for Life, a forward-looking strategy which looks at how to better manage water on a watershed basis. The strategy includes three goals including:

- Safe, secure drinking water,
- Healthy aquatic ecosystems, and
- Reliable, quality supplies for a sustainable economy.

In the Athabasca watershed, the Athabasca Watershed Council-Watershed Planning and Advisory Council (AWC-WPAC) was formed to work towards achieving the Water for Life goals. This multi-stakeholder, not-for-profit organization, formed in 2009, is one of 11 WPACs created in the province to give sectors and people living, working and playing in each watershed an opportunity to 'meet in the reeds' and participate in watershed management planning.[1] The work of the AWC-WPAC is also guided by its vision, mission and goals:

> Some say the word "Athabasca" traditionally refers to *"a meeting in the reeds".*

> ***Vision**: The Athabasca watershed is ecologically healthy, diverse and dynamic.*

> ***Mission**: The Athabasca Watershed Council promotes, fosters respect, and plans for an ecologically healthy watershed by demonstrating leadership and facilitating informed decision-making to ensure environmental, economic and social sustainability.*

Goals:

1. Ensure the Athabasca Watershed Council is an effective, efficient and sustainable Watershed Planning and Advisory Council.
2. Improve watershed knowledge and understanding within the Athabasca Watershed Council.
3. Champion increased awareness by providing information and education to all.
4. Encourage and work towards protection, conservation, and enhancement of the ecological integrity of the watershed.
5. Facilitate development and implementation of integrated management planning for the watershed.
6. Promote best practices to help achieve healthy aquatic ecosystems, safe and secure drinking water supplies and reliable quality water supplies for a sustainable economy.

Although it may look slightly different in each watershed, and it may evolve over time, all of Alberta's 11 WPACs work with the Provincial Government and other partners to implement a framework for watershed management, as seen in Figure 1.[2] For the AWC-WPAC, this includes:

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[1] For more information about the Athabasca Watershed Council, see their webpage.

[2] For more information about the role of WPACs, see the GOA WPAC webpage.

- assessing and reporting on the health, or state of, the Athabasca River watershed;
- developing and implementing a plan with actions to address watershed issues identified in the state of report; and
- through education and outreach activities, encouraging all who live, work and play in the watershed to be good stewards of the water resource.

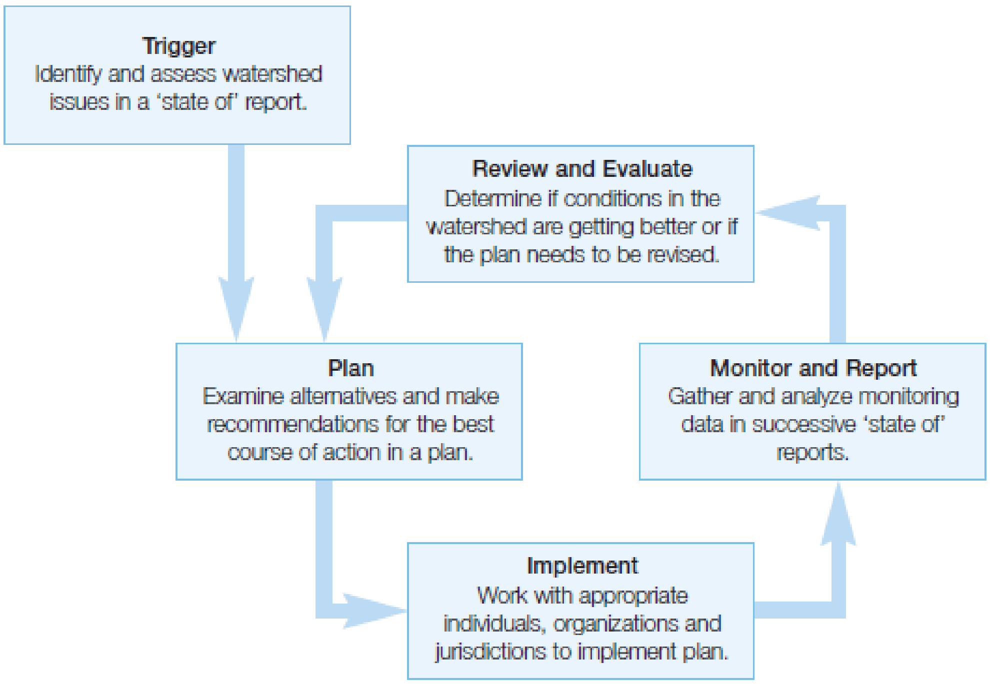

Figure 1. Steps in a framework for watershed management.

Since it was formed, the AWC-WPAC has carried out a number of activities to fulfill its mandate to understand and report on the state of health of the Athabasca watershed. This includes 1) improving understanding of how water is currently managed in the watershed; 2) meeting with individuals and organizations in order to understand local and regional water issues; and 3) commissioning reports to look at specific aspects of water resource management and watershed health.

The next major task for the AWC-WPAC is scoping out the development of an integrated watershed management plan (IWMP). An IWMP is a planning tool used to identify watershed goals, priority issues, and management actions to address the issues and achieve the goals. Information from the state of the watershed reports, as well as stakeholder feedback, will help set the direction of the IWMP. However, before the AWC-WPAC proceeds with this next step, we would like to share our learning's to date with watershed residents and stakeholders. Hence, this report provides a summary of past work, and will inform the future direction of AWC-WPAC IWMP activities.

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ACRONYMS AND ABBREVIATIONS

AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
AHS	Alberta Health Services
AWC	Alberta Water Council
AWC-WPAC	Athabasca Watershed Council - Watershed Planning and Advisory Council
CABIN	Canadian Aquatic Biomonitoring Network
m^3	cubic metre
dam^3	cubic dam (1 cubic dam = 1000 cubic metres)
EEM	Environmental Effects Monitoring
GOA	Government of Alberta
IWMP	Integrated Watershed Management Plan
km	kilometers
LTRN	Long Term River Network
m	metre
MTRN	Medium Term River Network
RAMP	Regional Aquatics Monitoring Program
RMWB	Regional Municipality of Wood Buffalo
SOW	State of the Watershed
TOR	Terms of Reference
WPAC	Watershed Planning and Advisory Council

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INTRODUCTION

THE ATHABASCA WATERSHED

The Athabasca River is the second largest river in Alberta, after the Peace River, and is about 1400 kilometres (km) long (Figure 2). It starts with the melting snow and ice of the Columbia Icefields in Jasper National Park in the Rocky Mountains of western Alberta (elevation 1,062 m). It then continues to flow downstream (northeast) through the Foothills and Boreal Forest.

As it moves northeastward, the Athabasca River is joined by several major tributaries (i.e., Berland, McLeod, Pembina, Lesser Slave and La Biche rivers).[3] Further along, it meets the Clearwater River and smaller Steepbank, Muskeg, Firebag, MacKay and Ells rivers before draining into Lake Athabasca in northeastern Alberta's Canadian Shield (elevation 205 m). In turn, Lake Athabasca flows into the Peace/Slave River system.[4]

> *"The Athabasca Watershed is comprised of 94 rivers and a minimum of 150 named creeks and 153 lakes. Near Lake Athabasca, the Athabasca, St. Claire, and Peace River systems form the largest fresh water delta in North America."* Science Outreach, Athabasca University

The Athabasca River is the only major river in Alberta that does not have a dam to regulate and control flow. The natural movement of water into and out of Lake Athabasca depends on water levels in the lake and the Peace and Athabasca Rivers. For most of the year, water flows into Lake Athabasca through the Athabasca River delta and other tributaries, and northward out of the lake into the Peace/Slave River, which flows northward to Great Slave Lake, the Mackenzie River, and, ultimately, the Arctic Ocean.[5] During spring or summer flooding, however, water levels in the Peace River can exceed the water level of Lake Athabasca, reversing flows back into Lake Athabasca.

> A ***Watershed*** (also known as a *catchment* or *basin*) is an area of land that catches precipitation (rain, hail, snow) and drains into a common body of water, such as a river, tributary, lake or wetland. For more general water information, see Facts about Water in Alberta.

The watershed associated with the Athabasca River and its tributaries drains an area of approximately 150,000 km^2, of which 90% is in Alberta. The Alberta portion of the Athabasca watershed makes up about 24% of the provincial landmass. The remaining 10% makes up that portion of the Lake Athabasca sub-watershed that lies in Saskatchewan.

The Athabasca watershed can be further divided into 10 sub-watersheds. These are smaller watersheds that drain either into smaller rivers, or lakes, that eventually flow into the Athabasca River (McLeod, Pembina, La Biche, Lesser Slave and Clearwater rivers) or riverside land corridors that drain into specific points along the Athabasca River mainstem itself (Upper Athabasca, Central Athabasca-Upper, Central Athabasca-Lower, Lower Athabasca, and Lake Athabasca).

[3] For a complete list of tributaries of the Athabasca River, see https://en.wikipedia.org/wiki/Athabasca River.
[4] For more information about the Peace/Slave watershed, see the Mighty Peace Watershed Alliance.
[5] For more information about the Mackenzie River watershed, see the Mackenzie River Basin Board.

Each of these 10 sub-watersheds has different characteristics such as human population, land uses and stewardship initiatives.[6] They can be further broken down into 31 tertiary watersheds based on Water Survey of Canada delineations. Note that a small portion of the Lake Athabasca sub-watershed lies within Alberta and is included here. In addition, Lesser Slave Lake is a part of the Athabasca watershed and was included in several AWC-WPAC technical reports. However, it is managed by its own WPAC, the Lesser Slave Watershed Council, which has already completed a state of report for this sub-watershed.

The AWC-WPAC website describes the Athabasca River and its watershed in more detail (see The Athabasca Watershed).

[6] Each sub-watershed also contributes different yield to the larger basin as mapped by Stefan Kienzle, University of Lethbridge.

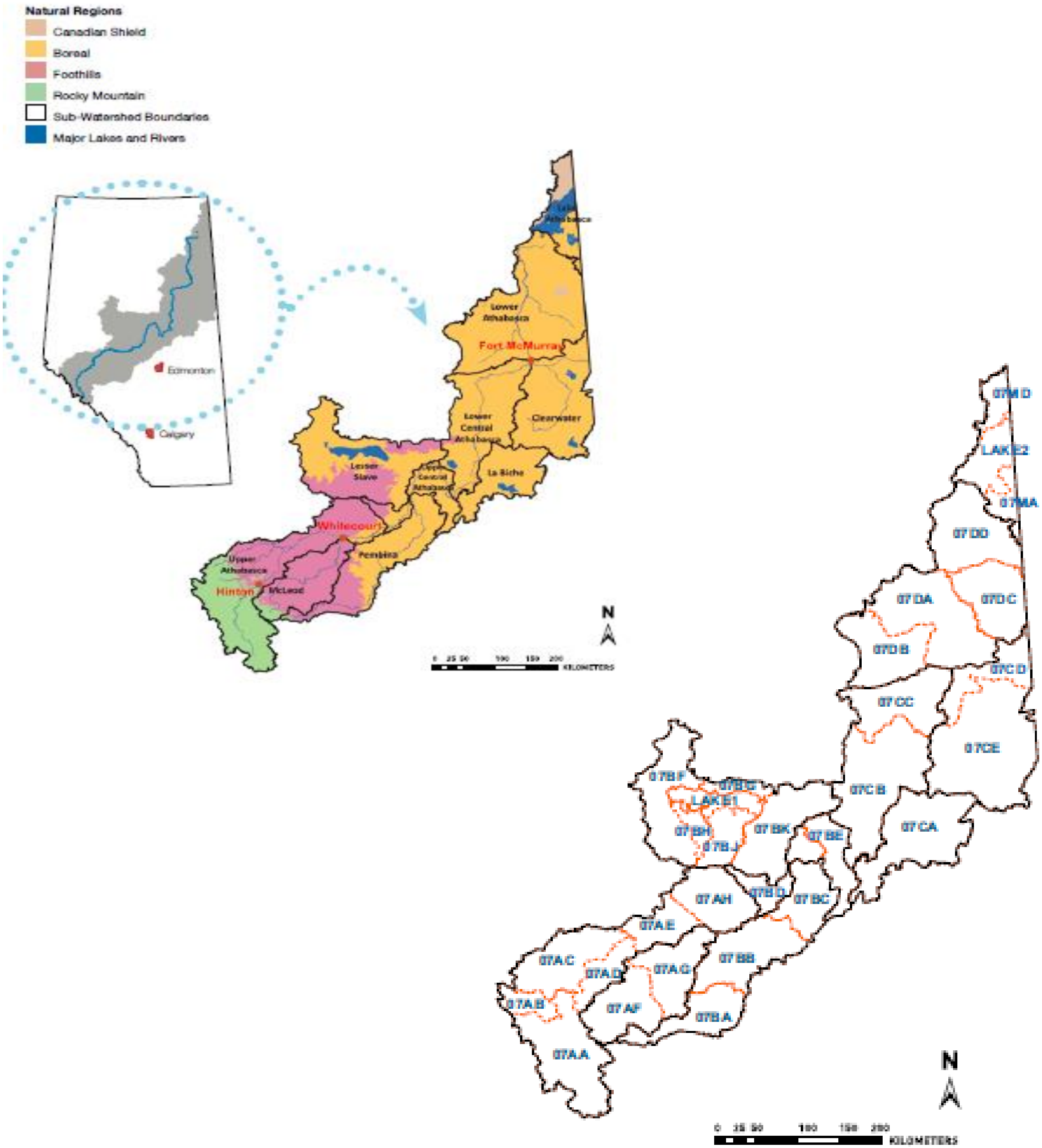

Figure 2. Maps of the Athabasca Watershed showing its 10 sub-watersheds and 31 tertiary watersheds[7].

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[7] A map of the Athabasca watershed is available online. Maps are also found in the AWC Interactive Atlas.

ASSESSING THE STATE OF THE WATERSHED

Water is fundamental for life. It is essential for ecosystem integrity, a vibrant economy, and human and community health. Increasing growth and intensification of urban development, recreation, agriculture, forestry, conventional and *in situ* oil and gas, and mining (oilsands, coal, and gravel) can negatively affect the health of the watershed. Given the importance of freshwater and its potential for degradation, many studies have been carried out in the Athabasca River Basin over the years to understand how healthy the ecosystem is, and what role human activities play in compromising the integrity of the ecosystem.

Since the first oilsands mining attempt in the 1950s and the damming of the Peace River in the late 1960s, there have been a large number of studies, such as the Northern River Basins Study and Northern Rivers Ecosystem Initiative , completed and today there is a substantive body of information about the Athabasca River.[8] A major effort to assess the state of the aquatic ecosystem of the entire Mackenzie River Basin, including the Athabasca watershed, was carried out by the Mackenzie River Basin Board in 2003. The Keepers of the Athabasca produced the State of the Athabasca watershed in 2008, based on existing information available at that time.[9] Additionally, there are several research initiatives and monitoring programs that add to our knowledge about the Athabasca River.

The AWC-WPAC, since forming in 2009, has focused its efforts on improving its understanding of, and reporting on, the health of the Athabasca watershed. Using a phased approach, a number of steps were carried out and a number of technical reports produced, as summarized in Table 1. Together with other research, these reports provide a broad pictures of the state of the Athabasca watershed.

[8] More than 30,000 references from government, scientific and other publications are located in the *Repository of the Athabasca River Basin Research Institute*, maintained by the Athabasca River Basin Research Institute.

[9] Note that the Saskatchewan Watershed Authority has also produced a state of the watershed report for the province including the Lake Athabasca sub-watershed, which was rated as 'healthy' in the 2010 report.

Table 1. Timeline of major steps and products for state of the watershed assessment reporting.

Period	Product or Step	Description
2008	WPAC Initiator's Group	Interested parties worked together to develop WPAC foundational documents such as organizational bylaws, process guidelines and a Board of Directors terms of reference (TOR).
2009 - 10	Formation of the AWC-WPAC	Under a newly elected Board, various committees were formed including a Technical Committee that initiated state of the watershed reporting to be completed in phases.
2010-11	AWC State of the Watershed Report: Phase 1	This report identified available basin information, providing an annotated bibliography and geospatial data for a series of maps. The report also included initial lists of issues, potential indicators, information gaps and a TOR for Phase 2 work.
	Stewardship and Municipal Forums	These forums and other sector presentations were important for starting to identify the water issues (real and perceived) of basin residents and stakeholders.
	Traditional Knowledge Overview for the Athabasca River Watershed	This report was commissioned to describe what Traditional Knowledge in the Athabasca Watershed is.
2011-12	Continued Sector Outreach	The AWC-WPAC continued to reach out to other sectors and experts through presentations, formation of a Science Advisory Team, etc.
	Athabasca State of the Watershed Report: Phase 2 and Online Interactive Atlas	This written report and online atlas provided an overview of water quality, bio-physical properties and potential stressors that may affect the ecological condition of the watershed (or sub-watersheds) using five criteria and several indicators for the period 2007-2011.
2012-13	4 Public Participation Events	Public events were held at Hinton, Westlock, Anzac and Fort McKay to discuss the Phase 2 report and indicators with stakeholders. Topics identified as important to stakeholders included groundwater, wetlands, riparian areas and fish.
2013-14	State of the Watershed Report Phase 3: Water Quantity and Basic Water Quality in the Athabasca Watershed	This report looked at water quantity (historically and under future hydrological and climatic conditions) and quality (looking at physical and chemical properties, inorganic compounds including trace metals, and community composition and abundance of benthic invertebrates) in the Athabasca watershed.
	Athabasca SOW Assessment Phase 4: Organic Compounds in Surface Water and Sediments, and Trace Metals in Sediments	This report provided a more detailed look at water and sediment quality in the Athabasca watershed.

UNDERSTANDING THE NATURAL LANDSCAPE

The landscape within the Athabasca River is diverse. Changes in water quality can be caused by natural changes in the landscape, such as geography, vegetation cover, and soil types. When evaluating if changes in water quality are a result of natural transitions or human activity, it is important to understand the local geography. Phase 1 of the state of the watershed assessment provided a number of geo-spatial data layers and generated a series of maps for the Athabasca watershed showing geology, soils, topography, land cover, meteorology, hydrology, water quality, fisheries and wildlife, surface water use, groundwater, point source effluents, and other land use indices. Several of these maps can be viewed in the report and on the AWC Interactive Atlas. This report provided the foundation for future assessment work.

As the Athabasca River travels across Alberta, it crosses over different natural regions (the Rocky Mountains, Foothills, and Boreal Forest; Figure **3**). These natural regions have different geology, soil types, slopes, and landscape cover that can influence the water quality and ecology of the Athabasca River. For example, the Rocky Mountains are steep and water flows fast over gravel and large cobbles. The water here is cold and low in nutrients and organic content. As the river travels northeast through the Foothills and Boreal Forest, the river slope decreases and water flows slower over a sandy and silty river bed. Water quality along the length of the river naturally increases in temperature, color, organic matter, and nutrients.

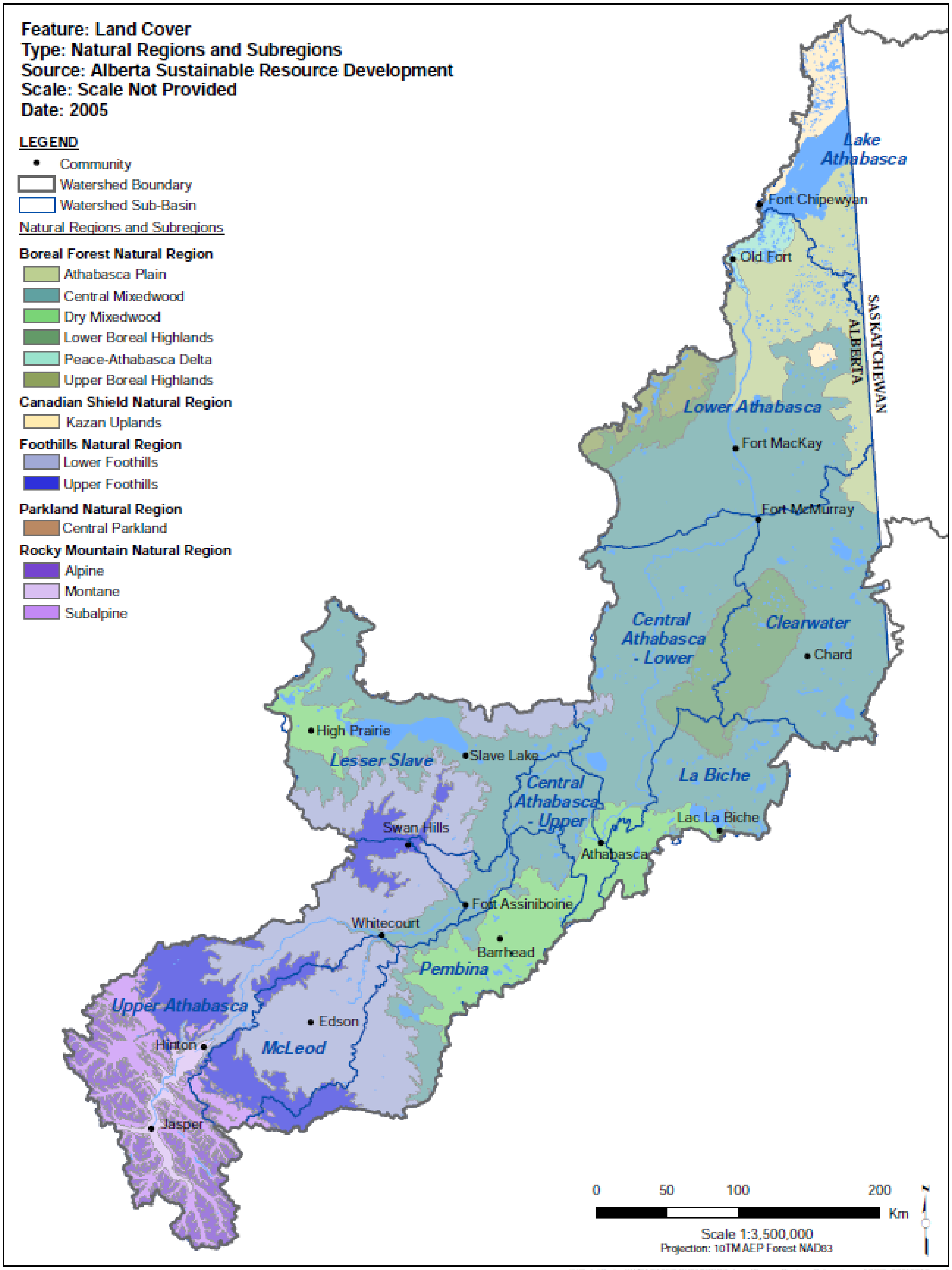

Figure 3. Natural regions and subregions in the Athabasca Watershed.

UNDERSTANDING LANDUSE PRESSURES

Land activities that occur in the watershed can impact the health of rivers and the quality of water. This is because all land within a watershed collects, stores, and slowly releases water from the soil. Therefore, understanding activities and pressures on the landscape are important for state of the watershed assessments. Some studies have indicated that for every 10% loss in natural watershed vegetation cover, there is an average 6% loss of the native freshwater fish and macro-invertebrate communities.

Phase 2 used Landsat satellite imagery to look at landscape activities within the watershed. The study used five 'health' criteria: the conservation of biological diversity; maintenance of surface water quality; maintenance of ecologically significant water levels and flows; maintenance of groundwater quality and quantity; and maintenance of watershed integrity. To assess the state or condition of each of these five criteria, several indicators were selected to measure the overall pressure on the watershed. Pressure and condition indicators for each criterion are listed in Table 2, below.

For example, to measure the health of watershed integrity, the study looked at the pressures on the watershed from human population growth, the percentages of impervious surfaces (built up cover), agricultural land use, and land conversion. Each one of these indicators was given a high, moderate, or low pressure based on pre-defined criteria that are outlined in detail in the Phase 2 report. All of the pressure ratings were summarized to give an overall indication of the landscape pressure on watershed integrity (Figure 4). The map in Figure **4** shows that the watershed integrity in most of the Athabasca watershed is under moderate pressure, while the Pembina and Lower Athabasca sub-watersheds are under high pressure.

Similarly, all of the pressure ratings of each indicator for the other four health criteria were summarized to provide an overall assessment of the state of the watershed. Figure 5 below shows a summary map of pressures for each criteria. The conservation of biological diversity is under high pressure in most areas of the upper and central Athabasca River watershed, and moderate to low pressure in the lower Athabasca. The maintenance of surface water quality was largely data deficient in the lower Athabasca and within Jasper National Park (note that this is in reference to the landscape indicators analyzed and not surface water quality data, which exist for these areas). Tertiary sub-watersheds within the Upper Athabasca, Pembina and Lesser Slave sub-watershed had high pressure. The maintenance of groundwater quality and quantity was under high pressure in tertiary sub-watersheds in the Lower Athabasca, McLeod, and Pembina sub-watersheds. The maintenance of ecologically significant water levels and flow was under high pressure in a tertiary sub-watershed near Fort McMurray and areas of the Pembina, La Biche, and Lesser Slave Lake sub-watersheds were under moderate pressure.

Table 2. Pressures and condition indicators selected to assess the state of the Athabasca watershed.

Criteria	Indicators	
Maintenance of Watershed Integrity	• Population growth • Built up cover (impervious surfaces)	• Agriculture land conversion • Point-source contamination
Conservation of Biological Diversity	• Road density • Stream connectivity	• Large patches of native vegetation • Seismic lines, pipeline density
Maintenance of Surface Water Quality	• Stream crossing density • Surface water quality • Chemicals	• Point source contamination • Application of fertilizer and manure • Livestock density
Maintenance of Groundwater Quality and Quantity	• Unlicensed well density	• Potential groundwater use • maximum withdrawals
Maintenance of Ecological Significant Water Levels and Flows	• River flow	• Potential surface water use

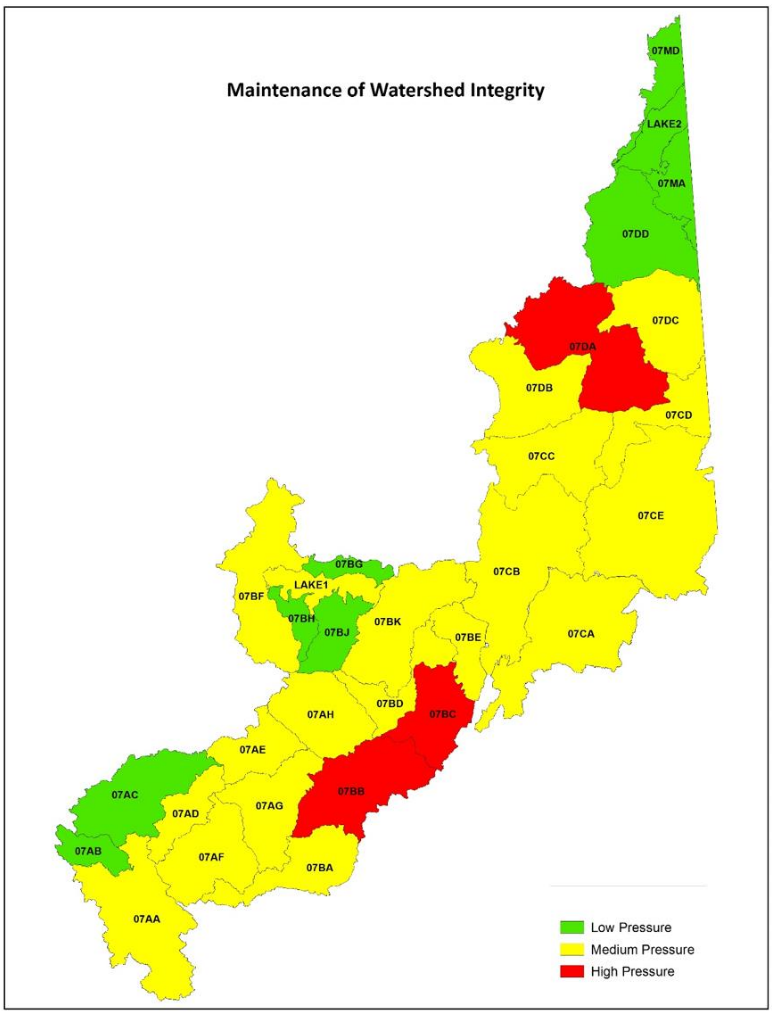

Figure 4. Summary map of all indicator pressures for the maintenance of watershed integrity

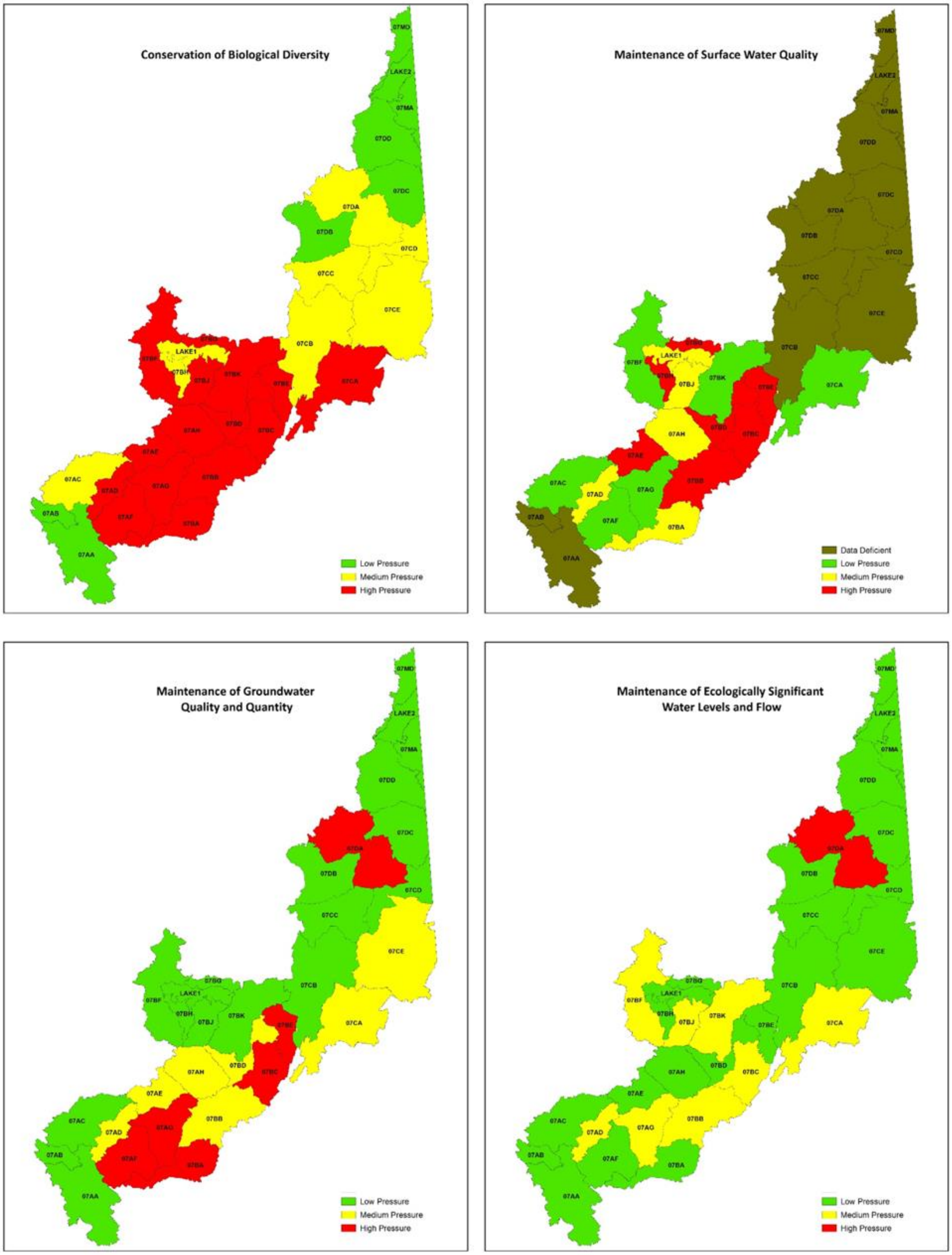

Figure 5. Summary map of indicator pressures for different criteria in the Athabasca watershed.

UNDERSTANDING WATER QUANTITY AND QUALITY

After gaining a good understanding of natural landscape features (Phase 1) and pressures on the landscape (Phase 2), Phase 3 looked at water quantity and quality data available in the watershed.

WATER QUANTITY

There are two main pressures on the availability of water (water quantity) in the Athabasca watershed: water use and climate. Current allocations (withdrawals from municipal, industrial, agricultural, and other uses) in the Athabasca watershed are largely from surface water sources versus groundwater, although groundwater use is increasing. Total water allocation in 2005 was 849,639 cubic dams or dam^3 (a dam = 1000 cubic meters or m^3). The Oil and Gas sector accounts for about half of this amount (Figure 6). Pulp mills account for another quarter. The remainder is largely for municipalities, industries and agriculture.[10] Note however, that not all water allocations are withdrawn or utilized fully. Also, water is sometimes returned to its source after use, as is the case for municipalities and pulp mills, whose treated wastewater return flow can be about 80% of the water they withdraw. All water license holders report their actual use and return flows, via Alberta's online Water Use Reporting System

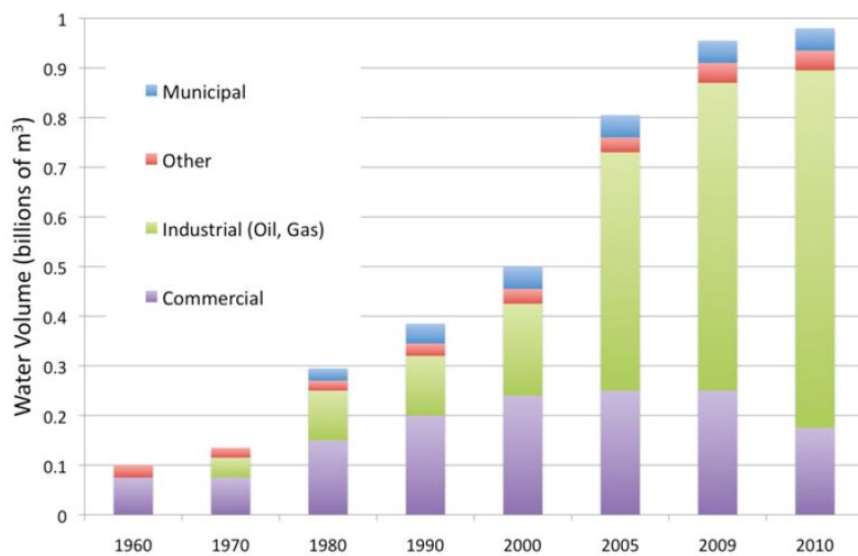

Figure 6. Sector water allocations for the Athabasca River.

Climate is the master control variable on hydrology. To evaluate the influence of climate on water quantity throughout the Athabasca watershed, several components of surface water were examined in the Phase 3 report for each tertiary watershed including precipitation (P), potential evapotranspiration (PET), discharge (Q), and change in surface water storage (S) over a 200-year time-frame (1901 – 2100). As anticipated, the hydro-climatic conditions of the Athabasca River watershed are changing with ongoing climate

[10] See Alberta Water Portal on Sector Water Allocations – Athabasca Basin or the 2011 Surface Water Quantity Management Framework.

change. The study showed that temperatures in the Athabasca watershed have increased by 2°C since 1901, potentially explaining the significantly increasing trends in precipitation and potential evapotranspiration. Precipitation in the Athabasca watershed is largely driven by summer convection – evaporation of water from the landscape that forms clouds and rainstorms – which is enhanced under warmer temperatures. Sub-watersheds in the Lower Athabasca and Lesser Slave Lake watershed show the strongest increasing trends in precipitation (Figure 7).

Increases in potential evapotranspiration (moisture lost from the land and plants) are also driven by warmer temperatures. All the sub-watersheds in the Athabasca River basin show increases in potential evapotranspiration Potential evapotranspiration is greater in the central and lower Athabasca portions of the watershed (Figure7). The overall impact to water balance in the Athabasca River basin depends on the balance between water inputs (precipitation) and water loss (evapotranspiration). For example, if evapotranspiration rates increase faster and greater than precipitation, lower water availability may result. The report looked at the difference between precipitation and evapotranspiration (P-PET) and found that only a few tertiary watersheds in the lower Athabasca and Lesser Slave sub-watershed showed significant increasing trends (Figure 7). Forecasting models predict that evapotranspiration will increase at a faster rate than precipitation, which will be an important consideration for future monitoring and Integrated Watershed Management Planning.

The overall hydrologic response to increasing temperatures in the Athabasca River in the last 40 years (1971 – 2010) has been a gradual decrease in flow in several of the central and northern sub-watersheds (Figure 7). In the last 50 years, discharge from the Athabasca glacier has increased, reflecting increases in glacial and snow melt due to warming temperatures. Yet further down in the watershed, near the Town of Athabasca and Fort McMurray, flows have decreased over the past 80 years perhaps reflecting increases in temperature and potential evapotranspiration and decreases in water contained in lakes and open water wetlands in the downstream areas of the watershed.

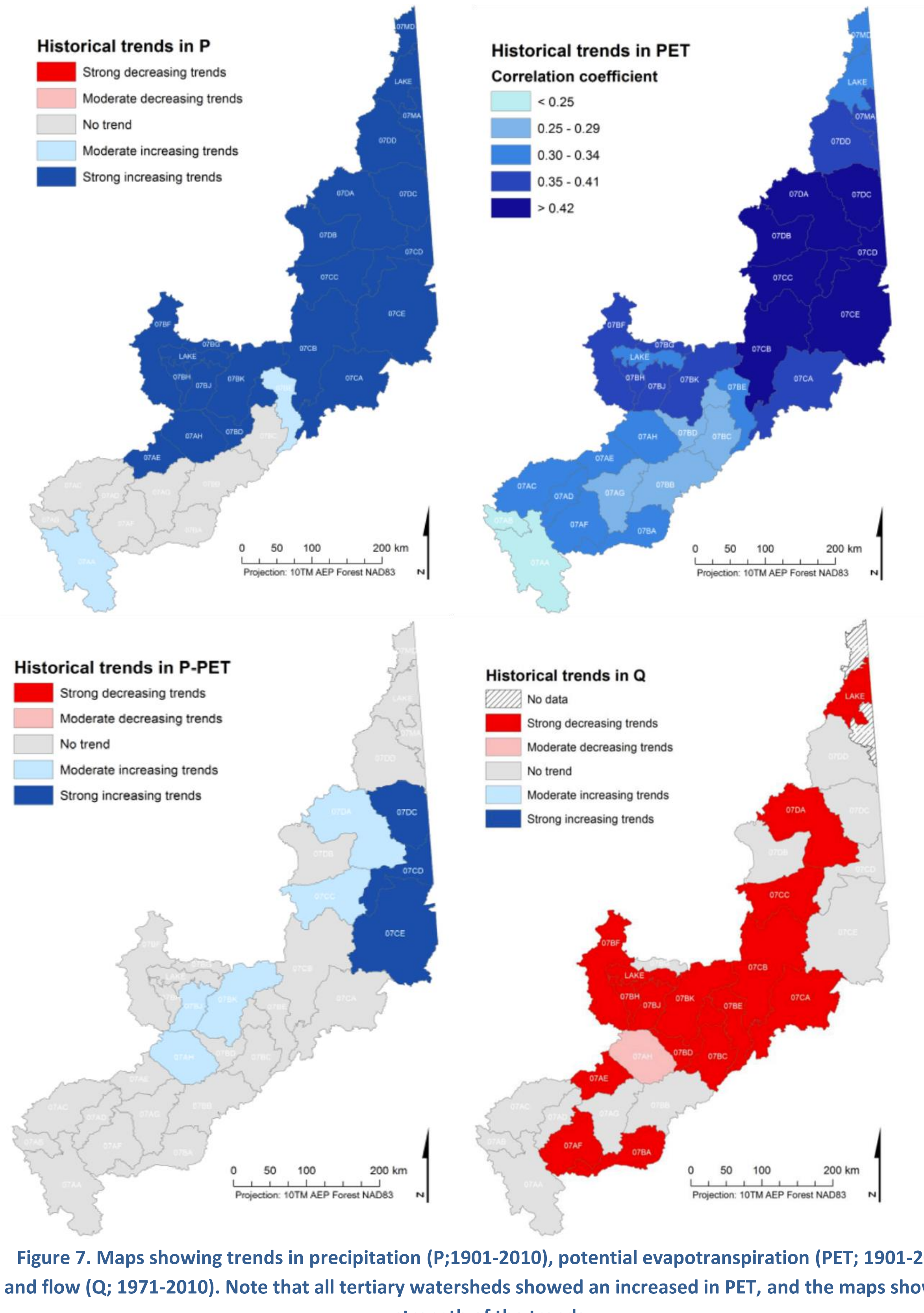

Figure 7. Maps showing trends in precipitation (P;1901-2010), potential evapotranspiration (PET; 1901-2010), and flow (Q; 1971-2010). Note that all tertiary watersheds showed an increased in PET, and the maps shows the strength of the trends.

WATER QUALITY

Water quality along the length of a long river such as the Athabasca will naturally vary owing to changes in the physical environment (landscape, prevalence of forest and wetlands, geology, gradient, substrate, flow). Like most river systems, the Athabasca River also experiences large changes in water quality between seasons (intra annually) and years (inter annually). These changes are a result of climate, flow rates, changes in landscape activities, and a complex mix of natural and human inputs. For example, during periods of high flow, the Athabasca River can transport large amounts of suspended sediments and associated parameters such as bacteria, nutrients and metals. Whereas in the summer total dissolved solids are low.

To assess water quality throughout the Athabasca watershed, the Phase 3 report looked at data on 47 physical, chemical, and inorganic variables measured at 22 locations across the watershed between 2007 and 2011.[11] Values were compared against federal and provincial water quality guidelines, where available.

The study found that dissolved oxygen levels in the Athabasca River were above short-term and long-term water quality guidelines for the protection of aquatic life set by the Canadian Council of Ministers for the Environment (CCME) (Figure **8**). The figure below shows the seasonality of dissolved oxygen at the Town of Athabasca. In some instances, dissolved oxygen was below the early life stage guideline (9.5 mg/L) during the summer months. The guideline for the protection of early life stages (9.5 mg/L) is only applicable to areas and times where salmonid spawning is occurring. During the anticipated times of salmonid spawning (spring and fall), these guidelines were met. In the Muskeg River (Figure **8**), dissolved oxygen levels were below long-term guideline for the protection of other life stages (6.5 mg/L).

Interestingly, the study found that pH dropped during spring snowmelt, potentially reflecting the inherently lower pH values of the snowpack and the large influence snowmelt runoff has on spring flows (Figure **8**). The report noted a declining pattern in pH between the years 2007-2011 in the Athabasca River and between 2007 - 2009 in the Muskeg River (Figure **8**). Although this does not represent a long-term trend, because surface water pH influences the abundance, speciation, availability, and toxicity of many dissolved parameters, such as metals and nutrients, a detailed trend analysis of surface water pH and chemical constituents is advised to gain a better understanding of pH in the Athabasca River. Episodic increases in aluminum, copper, cadmium, selenium, and mercury concentrations were also reported in some areas of the watershed; further investigation is required to evaluate the risk and impact of these metals in the Athabasca River.

Localized areas of nutrient enrichment are a concern in the Athabasca River, particularly downstream of major municipalities (Hinton, Whitecourt, Athabasca, and Fort McMurray). For example, relatively low increases in phosphorus from inputs of municipal wastewater effluent was observed to result in a 4- to 30-fold increase in the abundance of benthic algae and macroinvertebrates downstream of Jasper.

[11] Water quality data came from six AEP Long-term River Network (LTRN) stations, four Medium-term River Network (MTRN) stations, and 12 Regional Aquatics Monitoring Program (RAMP) stations.

Similarly, nutrient enrichment has been observed downstream of all pulp mill and municipal discharges in the Athabasca River.

Phase 3 identified some potential risks to the health of the Athabasca River that need to be further assessed by a detailed trend analysis that considers seasonality and flow This will allow users of the basin to better understand how water quality has changed over time. The study also highlighted that there is a need for more study on the behavior of metals in the Athabasca River.

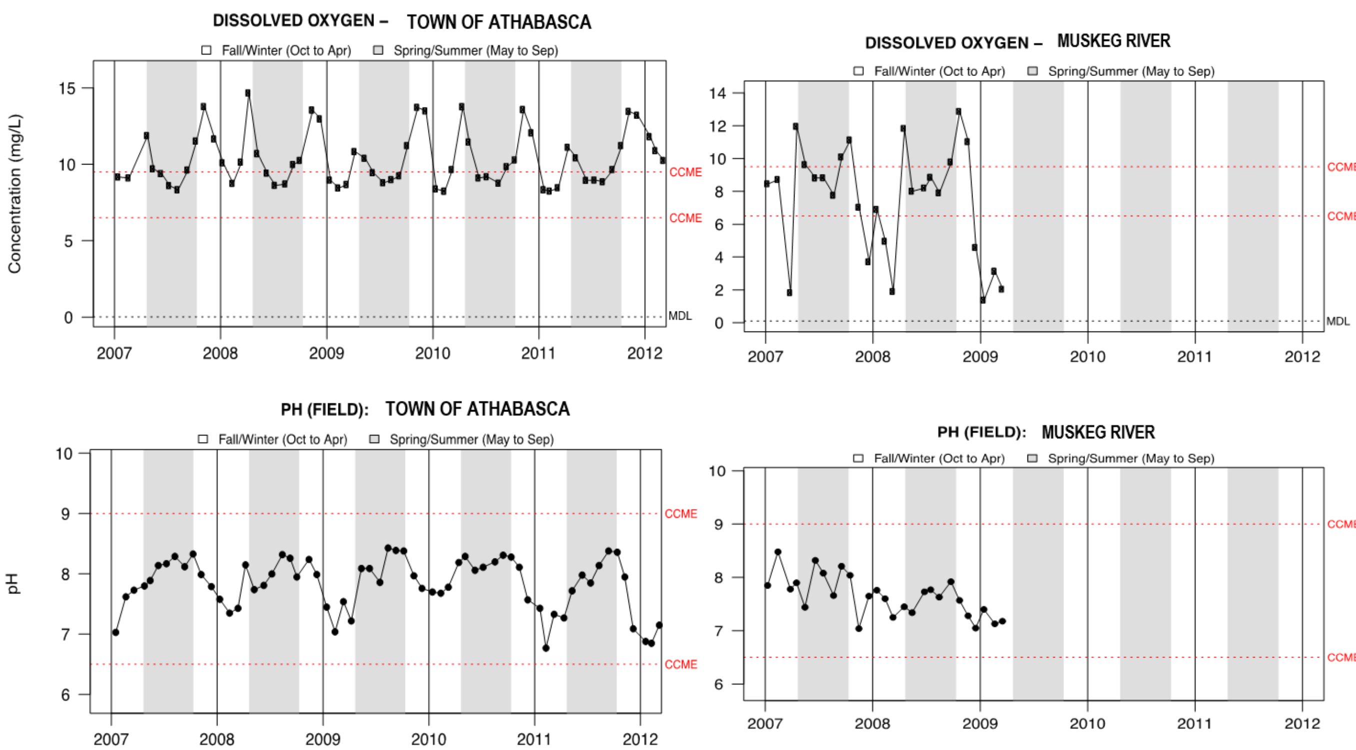

Figure 8. Dissolved oxygen and pH in the Athabasca River at the Town of Athabasca and the Muskeg River.

BENTHIC INVERTEBRATES

Information about benthic invertebrate (organisms that live in or on the bottom sediments of rivers, streams, and lakes) communities was also examined in the Phase 3 report and mapped for the AWC Interactive Atlas.[12] As expected, the report found differences in benthic invertebrate communities from upstream to downstream owing to natural changes in river characteristics. The benthic invertebrate community near Hinton was higher in abundance and diversity compared to downstream reaches, and the community was dominated by mayflies and stoneflies. The benthic invertebrate community near the Town of Athabasca was dominated by caddisflies and mayflies and the overall abundance was lower than upstream reaches. Overall benthic invertebrate abundance and species diversity was low near the end of the river and was mostly made up of chironomids.

[12] Data pertaining to algae and fish communities is insufficient.

Since some species of invertebrates are more sensitive to pollution than others, invertebrate community abundance and composition can be assessed by a pollution sensitivity index. Pollution sensitivity values indicated that water quality was very good near Hinton and the Town of Athabasca, good upstream of Fort McMurray, and fair near the end of the river. The patterns seen in the benthic invertebrate communities in the Athabasca River reflect those indicative of nutrient enrichment effects. This could be a result of the natural increase in nutrients along the length of the river as well as human nutrient sources from industrial and municipal inputs and land use activities (e.g. agriculture). Additionally, this could also be due to decreased scouring of riverbeds in recent years from declining water inputs from snowmelt and summer runoff in the central reaches of the watershed.

The study did not find evidence of cumulative negative effects of human impacts on benthic invertebrate communities. However, it is important to note that the data examined was limited, and that other environmental effects monitoring programs in the Athabasca River have detected localized changes in benthic invertebrate communities owing to industrial inputs. The report also noted the need for an improved broad-scale, integrated, and routine monitoring program for benthic invertebrates throughout the Athabasca watershed that follows standardized methods for site selection, sampling, analysis, and interpretation.[13]

UNDERSTANDING COMPLEX ORGANIC COMPOUNDS IN WATER AND SEDIMENT

The Phase 4 report looked at organic compounds and trace metals in surface water and sediment samples for the period 2007 to 2012. Organic compounds included total hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), aromatic hydrocarbons, pesticides, naphthenic acids, resin and fatty acids, and priority pollutants. The study looked at 137 water quality and 35 sediment sampling sites located throughout the watershed. In general, data for complex organic compounds in water and sediments was sparse, and even more scarce in the upper and central part of the watershed.

In general, organic compounds in the Athabasca River were either below the detection limit or detected at very low levels. Results are summarized in the table below.

[13] For an example of a monitoring program, see the Living Lakes Canada Upper Athabasca Citizen Science Monitoring Program.

Table 3. List of organic compounds examined in the Phase 4 report.

Compound	Surface Water	Sediment
Total Hydrocarbons	The majority of samples were below detection except for toluene which exceeded guidelines once, at several stations.	Below guidelines.
Polycyclic Aromatic Hydrocarbons (PAHs)	The majority of samples were below detection limits except for Benzo(a)pyrene, which was exceeded once at one RAMP station, and naphthalene which exceeded guidelines at two RAMP stations in the Lower Athabasca sub-watershed.	Six PAH species exceeded guidelines at RAMP stations (Lower Athabasca).
Aromatic Hydrocarbons	All samples below detection except for 1,2,4-trimethylbenzene, which was detected in one sample.	All samples below detection.
Pesticides	The majority of herbicides and all fungicides and insecticides were below detection for all stations, except at Wabash Creek (AESRD station: AB07BC0540) where nine herbicides were measurable but below guidelines.	All fungicides, herbicides, and insecticides were below detection with the exception of one insecticide at one station.
Naphthenic Acids	Detected at all stations but below guidelines.	Only measured for in 1 sample in 2010 where it was detected but below guidelines.
Resin and Fatty Acids	Below detection at all stations.	No data available.
Non-chlorinated Phenols and Total Phenols	Non-chlorinate phenols were below detection at all stations. Total phenols were measurable in almost all samples at all stations and generally showed an increase over time at RAMP stations in the Lower Athabasca, including stations upstream and downstream of oilsands development.	Non-chlorinate phenols were below detection at all stations. No data for Total phenols.
Organochlorines and Adsorbable Organic Halides (AOX)	All organochlorines were below detection at all stations. AOX were detected in at least one sample at six of seven stations with data and were seen to increase over time downstream of Fort McMurray and Fort McKay while generally decreasing upstream of Fort McMurray.	All organochlorines below detection at all stations. No data available for AOX.
Polychlorinated Biphenyls (PCBs)	No data available for the 2007-2012 study period.	All samples below detection limits.
Trace Metals	Not reviewed in this report.	Majority of metals were measurable in at least one sample at all stations in the Lower Athabasca and Clearwater sub-watersheds. Arsenic exceeded guidelines at 6 stations in the Lower Athabasca sub-watershed; mercury and copper exceeded guidelines at one station each.
Phthalates	Majority of concentrations below detection at all stations.	All below detection for all stations.
Aliphatic Hydrocarbons	All below detection at all stations.	All below detection at all stations.
Flame Retardants	No data available.	All below detection at all stations.
Nonylphenols	No data available.	All below detection at all stations.

GATHERING STAKEHOLDER FEEDBACK

Analyzing data in a scientific and technical format is fundamental to understanding the current state of the watershed and informing future decision-making. Yet, communities also possess an incredible wealth of local knowledge about the places in which they live, work, and play. To collect this vital information, the AWC-WPAC has made numerous public presentations to audiences, and hosted forums and open houses throughout the watershed. Attendees of various engagement sessions are able to provide key feedback and knowledge to the AWC-WPAC to increase broad understanding of problems, pressures, and perceptions throughout the watershed. For example, participating stewardships groups identified a number of local water issues such as riparian degradation on the Tawatinaw River (tributary of the Athabasca River), winter fish kills in lakes (e.g. Thunder Lake, Lac La Nonne), lake water level declines (e.g. Skeleton Lake, Lac La Nonne, Lac Ste. Anne), and invasive species (e.g. Isle Lake). Exit surveys given at public sessions indicated that climate change mitigation, groundwater, wetlands, riparian areas, and fish should be considered priority areas for future focus.

UNDERSTANDING TRADITIONAL KNOWLEDGE

The Athabasca watershed includes portions of Treaty #8 and Treaty #6 Indigenous peoples, and several regions of the Metis Nation of Alberta. Ecosystem health based on a Traditional Knowledge perspective is fundamentally connected to the capacity of Aboriginal peoples to sustain a "traditional" way of life. Many Indigenous peoples have developed valuable knowledge about the state of aquatic ecosystem health that can contribute to our understanding of historic and current issues and efforts to plan, monitor, and manage watersheds. Recognizing Traditional Knowledge as important and valuable to understanding the state of the watershed and Integrated Watershed Management Planning, the AWC-WPAC also commissioned a *Traditional Knowledge Overview for the Athabasca River Watershed* report. The report presents broad Traditional Knowledge on ecological information related to water quantity and flow, water quality, fisheries, waterfowl, and aquatic wildlife and related habitat.

One of the most comprehensive Traditional Knowledge studies in the Athabasca watershed was the Northern River Basin Study. In general, documented sources of Traditional Knowledge about water quantity and quality in the upper and central ranges of the watershed are limited. Some communities in the lower Athabasca have been more active in documenting Traditional Knowledge due to the availability of resources and need to do so for planning, assessment, and monitoring of oil sands mining.

WATER QUANTITY

Much Traditional Knowledge has been documented in relation to the impacts of hydro electric development on water levels and water flow dynamics, including the W.A.C. Bennett Dam (Northern River Basin Study). Key Traditional Knowledge indicators for water quantity include: water levels, flood patterns, incidence of flood events, ease of river travel, ice thickness and colour, timing of spring breakup and winter freeze up, dried up waterbodies, and shifts in creek beds.

Indigenous communities have observed major changes in water flows within the lower range of the Athabasca River as well as smaller tributaries. Observations include drying up of wetlands and creek beds, while at the same time experiences of major flood events. Changes related to water quantity impacts the ability of people to use the river, and land users are finding that lower water levels are making the Athabasca River more difficult to navigate.

WATER QUALITY

Many Indigenous communities have observed a decline in water quality in the Athabasca River over the last 50 years. Some of the key parameters include colour, amount of silt and mud, smell, algal growth, tea scum, and proximity to development projects (perceived contamination). Algal growth has been more commonly observed in the Athabasca River. As well, narratives around changes in the taste and colour of water has been documented. Land users have stated that surface water on the landscape no longer tastes good and that people no longer perceive untreated surface water safe to drink owing to contamination.

FISHERIES

Traditional Knowledge related to fish is well developed and indicators can include abundance (number of fish harvested), length-weight ratios (skinny fish), thickness of fat around organs, texture and colour of fish flesh, presence of parasites, and taste/smell. The Northern River Basin Study documented observations of fewer fish, smaller fish, poor quality of taste and texture of fish, increased incidence of deformities (white gel in gills, sores on gills, and worms), and contamination of fish (high mercury content) in the Athabasca watershed.

Many changes in fisheries have also been documented in relation to oil sands development in the lower Athabasca. Observations include a decrease in the abundance of many fish, and that fish are skinnier and unhealthy. Fish flesh/texture is softer and the taste of fish (Whitefish) has deteriorated. Winter fish kills in lakes have been observed in Lake Claire and occur in lakes throughout watershed. Most notable, are documented observations of deformed fish downstream of oil sands development, including bulging eyes, humped backs, crooked tails, abnormal growths, and changes in skin colour. There are high perceptions that fish are contaminated and that eating them will cause sickness. Real or perceived, this has a major impact on traditional foods and the overall livelihood of Indigenous peoples in this region.

AQUATIC WILDLIFE AND ASSOCIATED HABITAT

Due to the significance of the Peace-Athabasca Delta (PAD) as one of the most valuable habitats for aquatic waterfowl in North America, Indigenous peoples of the PAD have a strong, and even spiritual, relationship to aquatic birds. Other highly valued species that are well represented in Traditional Knowledge are muskrat and beaver. Thus, the population and health of waterfowl, muskrat, and beaver are key traditional health indicators of the Athabasca watershed.

Observations of declining waterfowl flock numbers and fewer muskrats were documented in 1996 during the Northern River Basin Study. In 2008, muskrat die-offs and continued declines in populations were noted. It was also noted that after a muskrat die-off occurs, the population is unable to re-establish and stabilize, and high rates of mortality are seen year after year. Similar to fish, there are concerns regarding the consumption of traditional foods, including waterfowl, muskrat, and moose, owing to the bioaccumulation of toxins.

IMPACTS OF POINT-SOURCE INPUTS ON WINTER WATER QUALITY

In addition to AWC-WPAC work, there are several other water management initiatives being carried out by different organizations working in the Athabasca watershed that can help inform the state of watershed assessment process. The Government of Alberta maintains a number of water-related databases and websites that provide valuable information such as the Alberta River Basins, Groundwater Observation Well Network, Surface Water Quality Data, etc.[14] The AWC-WPAC tries to be aware of, and where of benefit partner with, these initiatives.

In 2015 (after the four phases were complete), Alberta Environment and Parks completed an extensive synoptic study on the Athabasca River.[15] The goals of this study were to: a) evaluate winter spatial patterns in water quality; b) assess the cumulative effects of industrial and municipal wastewater discharges on the Athabasca River, while considering major tributaries; and c) compare current water quality conditions in the Athabasca River to data collected during the Northern River Basin Study (1990-1993).

Beginning in Jasper National Park, water samples were collected from 80 sites and included the mainstem (Athabasca River), major tributaries, and municipal and industrial (pulp mill) wastewater along the entire length of the Athabasca River. Sampling was done in the winter to capture critical low flow periods where dilution is at its lowest (the point in time when a river has a low capacity to receive wastewater without affecting ecosystem integrity). Water samples were measured for a broad suite of water quality parameters including physical measurements, inorganics, nutrients, metals, and organic compounds (resin and fatty acids, phenolic material, chlorinated phenolics, priority pollutants, total recoverable hydrocarbons, alkylated polycyclic hydrocarbons (PAHs), naphthenic acids, and pesticides).

[14] Note that as of April 1, 2014, this also includes the Regional Aquatic Monitoring Program.
[15] The synoptic report is available here https://open.alberta.ca/publications/9781460134221

What is a Synoptic Survey?
A 'synoptic survey' is a comprehensive survey that aims to sample the same parcel of water as if flows downstream in a river basin. The goal is to provide an understanding of the impact that individual and multiple sources of pollution and tributary inputs have on water quality. They require many people and many hours to complete.

Data gathered were extensive and showed that water quality in the Athabasca River is influenced by the natural landscape, tributaries, and inputs from treated wastewater. The transition from the Rocky Mountains to the Boreal Forest resulted in a natural increase in many parameters such as colour, organic carbon, some ions (potassium and sodium), nutrients, and some metals. For example, Figure 9 shows the increase of total nitrogen along the length of the Athabasca River. This increasing pattern along the length of the river is largely due to natural landscape changes, but is also influence by inputs from treated industrial and municipal wastewater.

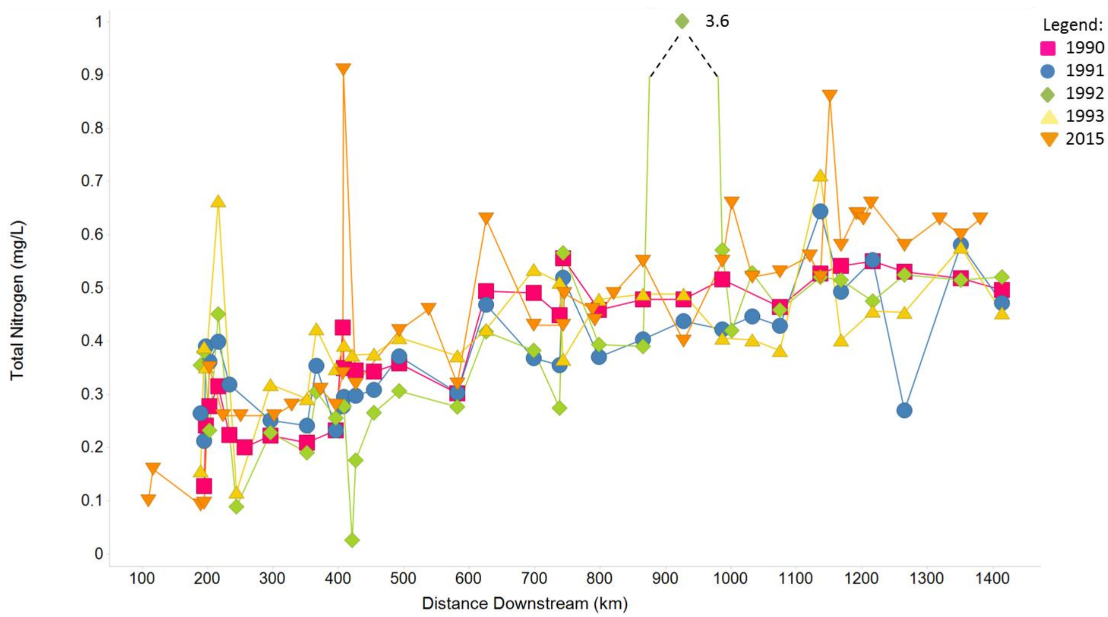

Figure 9. Spatial patterns in total nitrogen in the Athabasca River.

Conversely, some parameters were higher within the headwaters and decreased along the length of the Athabasca River. As shown in Figure 10, dissolved oxygen in the Athabasca River declined from headwaters to Grand Rapids. This is known as the "dissolved oxygen sag" and has been a long recognized water quality issue in the Athabasca River. Grand Rapids infuses the Athabasca River with more oxygen, as observable around the 1000 km mark in Figure 10, which then declines again to Lake Athabasca. The decrease in dissolved oxygen is due to inputs of oxygen depleted groundwater and degradation of both natural and human organic materials.

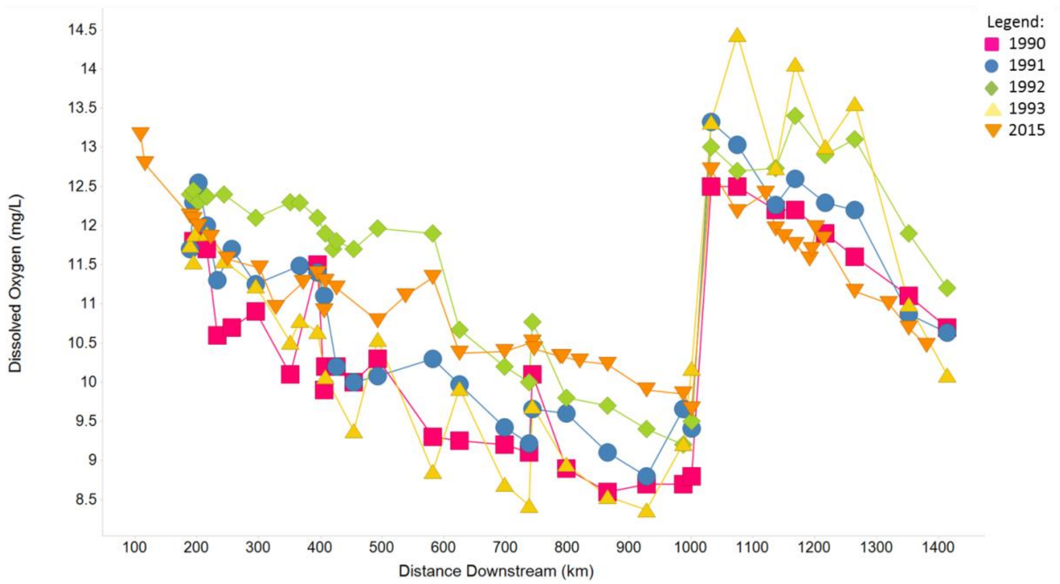

Figure 10. Spatial patterns of dissolved oxygen in the Athabasca River. Dissolved oxygen levels decline along the length of the Athabasca River until re-aeration occurs at Grand Rapids (~1000 km downstream).

Treated wastewater from pulp mills and municipalities resulted in increases in bacteria, major ions, nutrients, color, temperature, and some metals at one or more locations in the Athabasca River. These results were similar to observations made during the 1990-1993 surveys, indicating that the impacts of wastewater discharge on these water quality parameters has not changed significantly over the past 25 years. Previous work during the Northern River Basin Study found that pulp mill wastewater had large effects on phenols, chlorinated phenols, resin acids, and trace organics. These impacts were not observed during the 2015 survey, indicating an improvement in water quality conditions owing to advancements in technology and wastewater treatment processes within the pulp and paper industry.

In addition to the influence of natural changes in the landscape and treated wastewater, tributaries that flow into the Athabasca River can also impact water quality. For example, the Clearwater River has a large influence on water quality in the Athabasca River, and can have both an increasing and diluting effect on certain parameters.

Similar to the Phase 4 report, the synoptic survey found that most organic compounds in the Athabasca River and its tributaries were below detection limits. However, there were detections of some priority pollutants in pulp mill and municipal wastewater, in particular total hydrocarbons in municipal wastewater.

It is important to note that the results of this study only reflect winter conditions and the influence of point-source contributions (wastewater and tributaries) to the Athabasca River. Additional surveys during the open-water season would be required to determine the cumulative effects of both point-and non-point source pollution.

BRINGING IT ALL TOGETHER

With several technical reports in hand, we now have a better understanding of the state of the Athabasca watershed. Additionally, with input from several open houses and other outreach activities, we also have a better understanding of some of the water issues, both local and basin-wide, that residents, communities and industry are experiencing.

The Athabasca watershed is very large and diverse. When assessing the state of, it is important to keep in mind the big picture of the entire watershed, as well as be sensitive to some issues and concerns that are better understood at the regional, sub-watershed or even tertiary watershed level. The assessment provides a large-scale overview of factors that may impact the watershed and identifies priority areas of concern for future management and research. It is not a definitive statement on condition. For all WPACs, state of reporting is an iterative process that improves with each successive reporting period.

CUMULATIVE WATERSHED PRESSURES IN THE ATHABASCA RIVER BASIN

The State of the Watershed reports provided an overall view of the natural landscape, pressures from land use activities, and the impact of human activity on water quantity and quality. As described above, Phase 2 identified various landscape pressures within the Athabasca River watershed that have the potential to impact the ecological condition of the watershed. All of the indicators were summarized to provide a large overview of the cumulative pressures within the watershed and identify areas that might have a higher risk of watershed health degradation. The map in Figure 11 shows the cumulative pressure ratings (as described in Phase 2), and does not reflect the actual condition of the watershed. Understanding areas that may be of high risk to watershed health deterioration are fundamentally important for the development and implementation of an Integrated Watershed Management Plan.

Overall, there is a high or moderate cumulative watershed pressure within most of the Athabasca River basin that could result in impacts to the ecologic condition of the watershed. Areas of high cumulative pressure include most of the central area (Upper Athabasca, Central Athabasca, McLeod, and Pembina sub-watersheds) and the tertiary watershed near Fort McMurray. A majority of the Athabasca watershed has a moderate landscape pressure rating. Sub-watersheds within Jasper National Park and the northern portion of the watershed have low cumulative pressure ratings. Areas within the Athabasca watershed that have high and moderate cumulative landscape pressures should be targeted as priority areas for Integrated Watershed Management Planning.

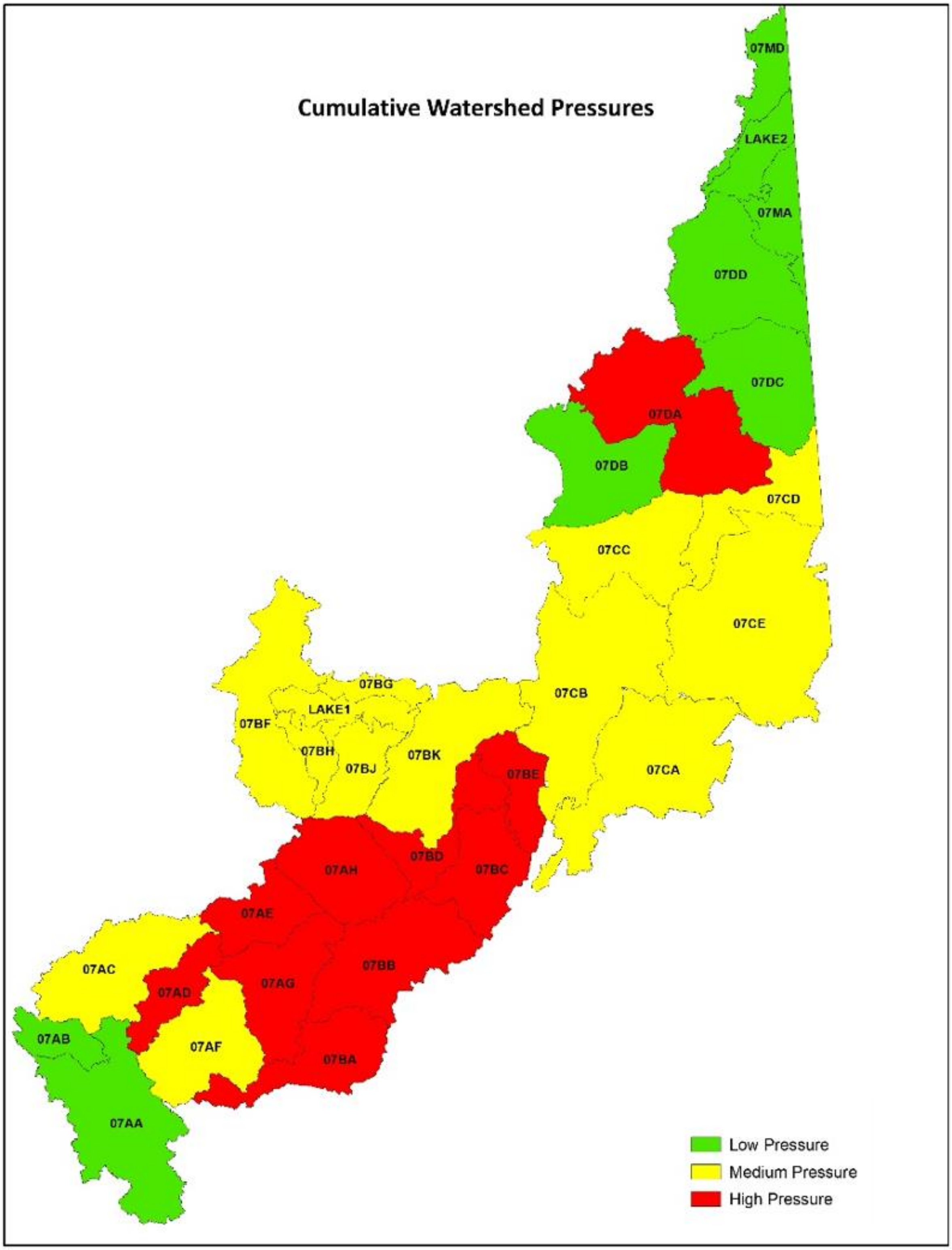

Figure 11. Cumulative watershed pressures, summarized from Phase 2, in the Athabasca River watershed.

KEY PRESSURES IN THE UPPER ATHABASCA (JASPER TO WHITECOURT)

- Road Density
- Seismic lines, pipelines
- Point-source pollution
- Loss of vegetation
- Loss of stream connectivity
- Groundwater well density/withdrawals

The Upper Athabasca is the western most extent of the Athabasca River watershed and includes the Upper Athabasca and McLeod sub-watersheds. As such, it is the headwaters for the entire basin. These headwaters occur within the confines of Jasper National Park in the Rocky Mountains and are managed by Parks Canada. As the river leaves the Park, the mountains give way to foothills that are covered with dense forest and underlain with rich coal deposits. Land use activities include forestry, conventional oil and gas[16], coal and aggregate mining, and recreation and tourism.

Overall, cumulative pressure ratings within Jasper National Park are low, but as the river moves into the foothills, cumulative pressure ratings increase to moderate and/or high. These landscape pressures are mostly in the form of linear disturbances such as roads and seismic lines but can occur in larger areal disturbances such as clear cut forestry operations. The loss of stream connectivity and loss of large patches of native vegetation are also important stressors resulting from human activities. These landscape activities can affect the conservation of biodiversity and impact fish populations, through overall habitat loss and fragmentation.

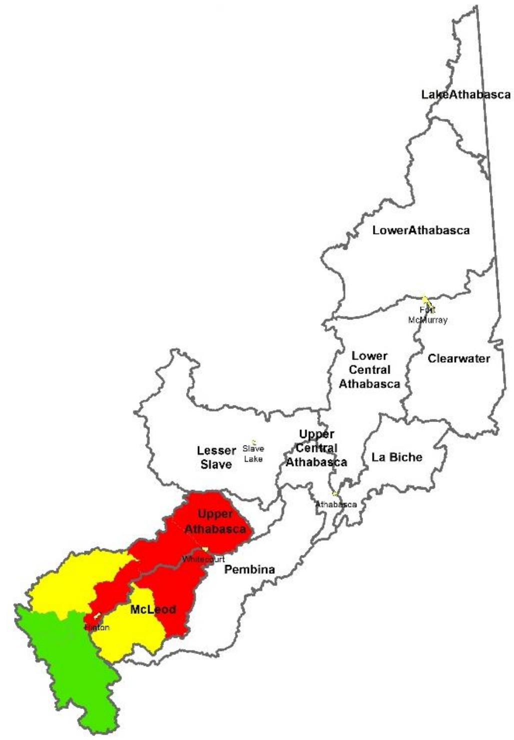

Figure 12. Cumulative Watershed Pressures in the Upper Athabasca.

In the Upper Athabasca sub-watershed, the towns of Jasper, Hinton, and Whitecourt discharge municipal wastewater and three pulp and paper mills located at Hinton and Whitecourt discharge treated industrial wastewater into the Athabasca River. Previous work on the Athabasca River has identified localized issues such as nutrient enrichment below these discharge locations. The winter synoptic survey completed by AEP observed greater impacts from treated wastewater downstream of Hinton and Whitecourt than municipalities in the middle and lower Athabasca, likely due to lower concentrations of nutrients, ions, and metals in the Upper Athabasca. Large inputs of these parameters can have a greater impact because it introduces a sudden contrast to background conditions rather than a small or gradual change. Thus, this area of the Athabasca watershed can be more sensitive to treated municipal and industrial wastewater discharge.

[16] See Water Allocation and Usage Report (surface water): Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays in West-Central Alberta.

The upper Athabasca area has active and inactive coal mines that produce metallurgical coal (for steel) and thermal coal (for power). Metallurgical coal mining the Upper McLeod sub-watershed has resulted in selenium loading to surface water. Selenium is a natural component of the geology of the Athabasca watershed, and through mining is transported through runoff into creeks in the area of activity. Selenium bio-accumulates in the food web and can affects fish ovaries (and, hence, eggs), causing deformities in fish that reduce survival rates, thereby impacting their populations. Selenium has been found to exceed water quality guidelines in the Upper McLeod River and its tributaries (e.g. Luscar and Gregg rivers). Coal companies are working with researchers and the province to address this issue.[17] In addition, mining incidents such as tailings pond failures can have a high impact to water quality. For example, the Obed Coal Mine spill in 2013 impacted the Upper Apetowun Creek, Plante Creek, and the Athabasca River.

Additionally, there are moderate pressures on groundwater quantity and quality in the upper Athabasca owing to moderately-high unlicensed well densities. Groundwater quality and quantity in the McLeod sub-watershed also has moderate to high pressure from unlicensed well densities and relatively large groundwater withdrawals.

KEY PRESSURES IN THE CENTRAL ATHABASCA (WHITECOURT TO GRAND RAPIDS)

- Road density
- Low summer flows
- Seismic lines, pipelines
- Point-source contamination
- Agriculture – livestock/fertilizer/manure
- Loss of vegetation
- Loss of stream connectivity
- Groundwater well density/withdrawals
- Land conversation – agriculture and built-up

Continuing to move north-east, the landscape of central Athabasca transitions to the Boreal Forest natural region. Agriculture is a predominant land use activity, with forestry, conventional and in situ oil and gas, recreation and tourism, and aggregate mining also present. This region includes four sub-watersheds: the Pembina, Lesser Slave, Upper Central and Lower Central. Most of the central Athabasca is under high pressure from cumulative landscape activities, while the Lesser Slave and Lower Central sub-watersheds are under moderate pressure. To address the issues within the Lesser Slave watershed, the Lesser Slave Watershed Council is developing an Integrated Watershed Management Plan to guide management actions.

[17] For an example, see how Teck is managing selenium issues at its Cardinal River operations.

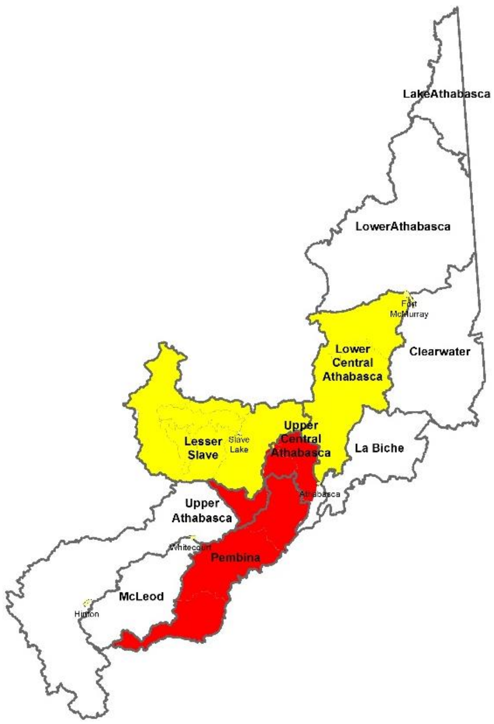

Figure 13. Cumulative Watershed Pressures in the Central Athabasca.

Similar to the upper Athabasca area, these sub-watersheds (especially the Pembina and Upper Central sub-watersheds) have high to moderate pressure ratings from linear disturbances such as such as roads and seismic lines, areal disturbances such as clear cuts, as well as loss of stream connectivity and loss of large patches of native vegetation. As a result, habitat fragmentation and loss in this area is high.

Agricultural activities in this area add to the cumulative pressure on the landscape. The Pembina and Upper Central sub-watersheds have the highest potential pressure from agriculture of any of the Athabasca Watershed sub-basins, where high acreages of land conversion from forest to agricultural land have occurred. The Lesser Slave watershed also experiences pressure from agriculture and cattle grazing that affects water quality of Lesser Slave Lake and its major tributaries. Agriculture can impact surface water quality through the distributed application of fertilizers, manure, and other chemicals, as well as high livestock density across the landscape.

The release of municipal and industrial treated (e.g. pulp mill) wastewater to the Athabasca River and its tributaries also add pressure to the aquatic ecosystem. For example, both the Town of Slave Lake (via Sawridge Creek) and Slave Lake Pulp release treated wastewater into the Lesser Slave River. Municipal and pulp mill treated wastewater releases also occur downstream of the Town of Athabasca. Many other communities in the central Athabasca area also discharge municipal wastewater of varying quality into tributaries of the Athabasca River.

There are also moderate to high pressures on both surface water and groundwater quantity in the Pembina, Upper Central, and Lesser Slave sub-watersheds. The Pembina and Upper Central watersheds have high to moderate unlicensed well densities and the upper Pembina experiences high groundwater withdrawals. All three sub-watersheds can experience low summer flows, which can exacerbate water quality issues and reduce available aquatic habitat.

KEY PRESSURES IN THE LOWER ATHABASCA (GRAND RAPIDS TO LAKE ATHABASCA)

- Population growth
- Point-source contamination
- Low summer flows and water usage
- Loss of vegetation
- Groundwater withdrawals
- Land conversion – built-up cover

The lower Athabasca is largely in the Boreal Forest natural region, with a small area of Canadian Shield around Lake Athabasca. Although some agriculture is still present in the La Biche area, this land use activity largely gives way to the more predominant oil and gas extraction land uses (including conventional, *in situ* and mineable oil sands). Forestry, recreation and tourism, and Aboriginal traditional use are also significant land uses in this region.

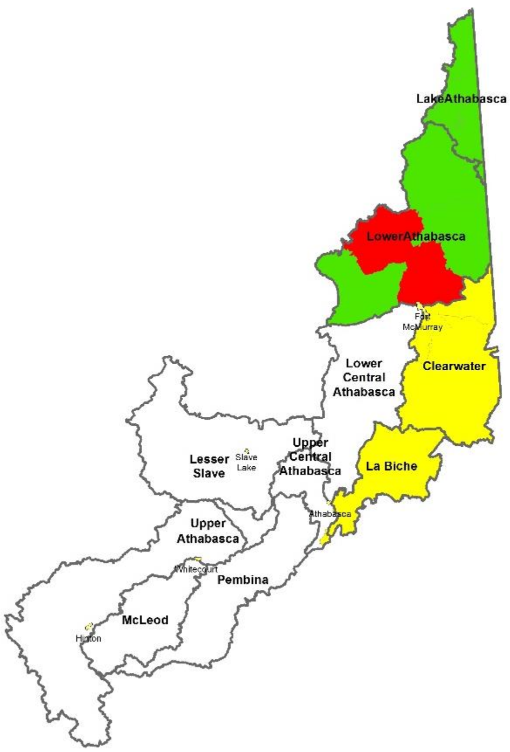

Figure 14. Cumulative Watershed Pressures in the Lower Athabasca.

The lower Athabasca area has a mix of low, moderate, and high cumulative watershed pressures. The sub-watershed around Fort McMurray has a high-pressure rating, mostly owing to development of oil and gas (*in situ* and mineable oil sands) within this area. Development of oil and gas in this region has led to increases in population growth, high levels of land conversion, and development of impervious surfaces (like roads and parking lots) that add pressure to the landscape and can impact watershed integrity. The lower Athabasca can also experience low summer flows, which are projected to become lower with ongoing climate change. Withdrawals from, and discharges to surface water and groundwater can add stress to the maintenance of water levels, flows, and water quality in this area.

The La Biche and Clearwater sub-watersheds have a moderate pressure rating, mostly associated with population growth and moderate to high impacts from linear disturbances such as such as roads and seismic lines, areal disturbances such as clear cuts, as well as loss of stream connectivity and loss of large patches of native vegetation.

Lac La Biche, a popular recreational and fishing lake, has ongoing water quality issues such a nutrient enrichment. Lac La Biche County has developed a lake watershed management plan to address water quality, shoreline development, sedimentation, and groundwater.

STATE OF THE ATHABASCA WATERSHED: KEY CONCERNS

While the work to date identifies data gaps and has limitations, the Phase 1-4 reports enhance our understanding of how natural features and human activities influence watershed conditions in different areas of the Athabasca River Basin. A summary of the key concerns are outlined below:

MAINTENANCE OF SURFACE WATER QUALITY

While surface water quality is generally good throughout the Athabasca watershed, the cumulative impact of multiple point and non-point sources of pollution can create localized issues. Key surface water quality issues in the Athabasca watershed include:

- **Nutrient Enrichment** – Nutrients (phosphorus and nitrogen) can be added to the river from a variety of natural (e.g. soil erosion) and human-made point (municipal and industrial effluent) and non-point (fertilizers, manure, other diffuse run-off, etc.) sources. Phase 3, the AEP synoptic survey, and historic work identified localized areas of nutrient enrichment in the Athabasca River downstream of major municipalities (Hinton, Whitecourt, Athabasca, Fort McMurray) as a result of municipal and pulp mill wastewater discharge. Additionally, nutrient enrichment is evident in areas of the Lesser Slave Watershed, Pembina River, and La Biche River. High levels of nutrients can cause excessive algal growth, which can impact benthic invertebrate and fish communities, and the overall health of the aquatic ecosystem.

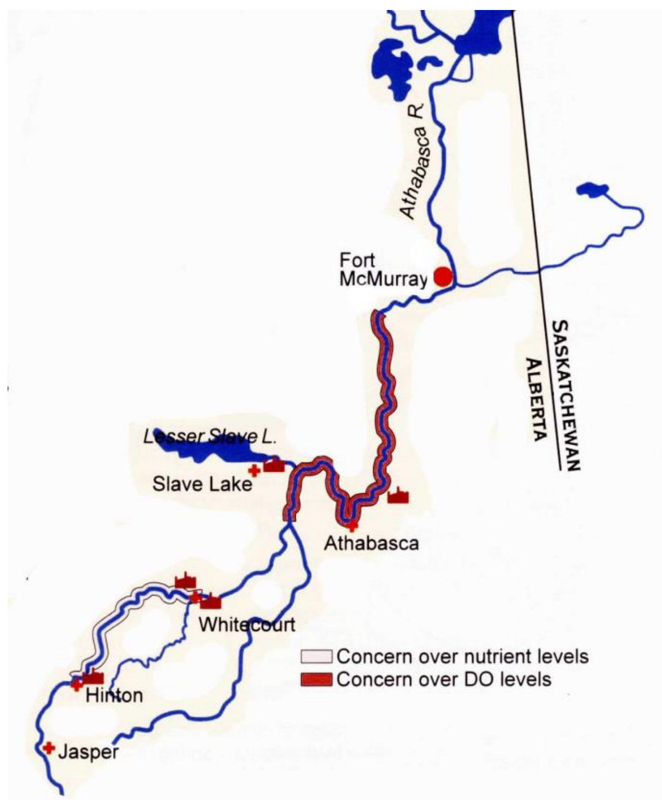

Figure 15. Nutrient and oxygen concerns in the Athabasca River, from NRBS, 1996.

- **Dissolved Oxygen Sag** – The Athabasca river shows a decline in dissolved oxygen from headwaters to Grand Rapids. During low flow periods in the winter dissolved oxygen levels can drop below water quality guidelines (e.g. 2003). The decline in dissolved oxygen is due to a cumulative influence of natural changes and wastewater inputs that are high in organic matter. Dissolved oxygen is critical for the maintenance of aquatic life and therefore is an important indicator of healthy aquatic ecosystems
- **Selenium Contamination** – Selenium levels are elevated above water quality guideline levels in the upper McLeod River and its tributaries (e.g. Luscar Creek and Gregg River) owing to coal

mining activities in the area. Selenium bioaccumulates through the food chain and is toxic to fish, birds, and other wildlife.

- **Trace Metals** – The Phase 3 report identified several trace metals that exceeded water quality guidelines. While these were episodic, the seasonal depression in pH may have implications for the bioavailability and toxicity of metals in the Athabasca watershed. Furthermore, the AEP synoptic study found that inputs of treated wastewater resulted in the increase of some dissolved metals (e.g. dissolved aluminum, boron, cadmium, cobalt, manganese, tin, vanadium, and zinc) directly downstream of wastewater discharges. In addition to wastewater discharges, elevated mercury concentrations were observed in Lower Athabasca. Phase 3 identified that reliable measures of trace metal concentrations in the Athabasca watershed are important for understanding their ecological significance in the basin.
- **Organic Contamination** – The addition of organic pollution, such as polycyclic aromatic hydrocarbons (PAHs), from oil sands mining and upgrading are a concern to water quality of the lower Athabasca River and its tributaries. Phase 3 identified several PAH species that exceeded water quality guidelines in the lower Athabasca sub-watershed. An understanding of the naturally occurring versus anthropogenic nature of PAHs is important in the region.
- **Report & Data Limitations**- The conclusions made here and within Phase 3 and 4 are based on a narrow timeframe and do not include all of the spatially available data for the basin. Both reports focuses on data from 2007-2011; however, there are historical data available at long-term monitoring stations (1987 to present). The Phase 3 and 4 reports focused mostly on data collected from the Athabasca River and tributaries in the lower Athabasca that are sampled as part of the oil sands monitoring program. There are other spatial water quality data available. For example, AEP has done extensive water quality monitoring in the McLeod sub-watershed. Historic data are also available for some major tributaries in the upper and central Athabasca. Additionally, the pulp and paper industry collect benthic invertebrate data as part of ongoing environmental effects monitoring programs. These data were not included in the Phase 3 report.
- **General Data Gaps -** There are several water-monitoring programs maintained by industries and governments, yet, these programs are not always integrated and data are not always comparable across the entire watershed. Water quality monitoring in the upper and central areas of the Athabasca watershed lack adequate spatial coverage. Overall, water quality data in these areas is deficient and existing monitoring programs need to be expanded to include major tributaries. Monitoring for organic pollution in water and sediments is low throughout the watershed, but particularly absent in the upper and central areas.
- **General Data Limitations** – The Phase 3 report identified several limitations within current datasets including: multiple and changing detection limits over time, low analytical precision for some metals, and a lack of quality assurance and quality control data to determine the accuracy of measured values.
- **General Reporting Gaps** – while there are gaps in data, surface water quality monitoring does occur throughout the Athabasca basin, and these data are not regularly assessed, interpreted, and reported on. Major efforts have been taken to assess and report on data collected in the

lower Athabasca as part of oil sand monitoring however, reporting for the upper and central part of the basin is scarce.

MAINTENANCE OF SURFACE WATER QUANTITY

Although it is Alberta's second largest river, the Athabasca River still experiences periods of low flows in the fall and over winter, particularly during dry years. The Athabasca River is the only major river in Alberta that does not have a dam to regulate water flows. There are growing pressures for water demand in the Athabasca watershed, especially in the lower Athabasca area. The Phase 3 report identified that water flow and storage are already declining and are anticipated to decline even more with ongoing climate change. Water withdrawals during these sensitive periods need to be managed carefully to ensure aquatic ecosystems are not impaired.

MAINTENANCE OF WATERSHED INTEGRITY (LAND USE PRESSURES)

Land cover and land use can affect the integrity of the watershed and the aquatic ecosystems found within it. Extensive modification of the landscape for human use that increases the extent of impervious surfaces can have profound impacts on watershed health. Cumulative impacts from linear disturbances, agriculture, municipal development, mining activities, and the overall conversion of land are of concern for the overall conservation of biological diversity and watershed integrity within the basin.

NEXT STEPS?

IDENTIFY PRIORITY AREAS FOR FUTURE WORK

The information provided here and in the state of the watershed reports have identified several key issues and concerns within the Athabasca watershed. An important next step towards IWMP development is to identify potential priority areas of work that need to be addressed and develop a set of recommendations and solutions to ensure that water quality and ecosystem integrity in the Athabasca watershed is protected.

Potential priorities for future work can include improving the current understanding about surface and groundwater quality and quantity throughout the basin, researching and promoting the use of beneficial management practices in agriculture and industry, encouraging the use of innovation and conservation, developing and delivering relevant educational programs, and developing and promoting partnerships and collaborations throughout the basin.

AN IWMP ROADMAP

With the completion of this report, we can now move forward with developing an IWMP for the Athabasca watershed. While every WPAC is unique in how it approaches this task, some key steps we will be taking in the near future include:

Step 1 – Draft Terms of Reference to Guide IWMP Development:
The draft Terms of Reference (TOR) will describe the IWMP project, desired objectives, key tasks, what is in scope and what is out of scope, who should be involved, how work will be done, how the project team will report and to whom, how decisions will be made, timelines and a budget.

Step 2 - Re-visit Our Vision and Goals for the IWMP:
Guided by our vision of the Athabasca watershed, as well as the goals of *Water for Life*, we will make sure that: a) our vision is still valid and shared by residents; b) the *Water for Life* goals reflect the Athabasca context; and c) we identify any additional goals associated with resolving issues identified in state of the watershed reports and other work that are not addressed in b).

Step 3 - Engage Watershed Residents and Stakeholders to:

a) Share the findings of the state of summary and technical reports,
b) Confirm priority issues to be addressed in the IWMP,
c) Ask how they want to be involved in future development and implementation of the IWMP,
d) Test the draft IWMP TOR before finalizing it, and
e) Confirm the draft IWMP vision and goals.

Step 4 – Flesh out the Details
Once we are certain we have strong support for the IWMP TOR, vision and goals, we can assign the work of fleshing out plan details to an IWMP or Technical Committee. Sometimes several working groups are struck to tackle different goals or topics. Whichever way the work is done, each goal will have strategies and actions that, when completed, will lead to its successful achievement. A lead agency, other partners, timelines and budgets, will also be attached to actions.

Step 5 – Trial and Approve the Draft IWMP
The Draft IWMP will be shared, reviewed and revised through a sector and community engagement process before it is approved by the AWC Board of Directors and the Government of Alberta. This will be long, careful, and committed work, and the AWC welcomes the participation, interest and support of the greater watershed community to realize the goals of an integrated watershed management plan that helps secure a healthy future for the Athabasca River and watershed.

IN CONCLUSION

Knowledge presented here and in state of the watershed reports have identified key issues and concerns in the Athabasca watershed. This is an important first step in the adaptive management approach utilized by Alberta's Watershed Planning and Advisory Councils. With this information in hand, the AWC-WPAC is well position to begin developing an integrated watershed management plan for the Athabasca watershed. Readers who are interested and want to stay informed about the future work of the AWC-WPAC should ensure they are signed up for the AWC-WPAC newsletter, follow the AWC on social media, become a member of the AWC, and direct any questions to staff at the office.

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GLOSSARY

Aquatic Ecosystem	**A body of water where living and non-living elements of the environment interact. This includes the physical, chemical, and biological processes and characteristics of rivers, lakes, wetlands and aquifers and the plants and animals associated with them.**
Aquifer	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand or silt) from which groundwater can be extracted.
Benthic Invertebrates	Organisms that live in or on the bottom sediments of rivers, streams, and lakes.
Best or Beneficial Management Practices	Any management practice that reduces or eliminates an environmental risk.
Biological Diversity / Biodiversity	The variety and variability of life on Earth.
Cumulative Effects	Effects on the environment which are caused by the combined results of past, current and future activities.
Ecology	The scientific analysis and study of interactions among organisms and their environment.
Ecosystem	A community of living organisms and their interaction with nonliving components of their environment (e.g., air, water, land, interacting as a system.
Evapotranspiration	The process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration from plants.
Eutrophication	The process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plants which in turn use up the dissolved oxygen available for fish and other species. For more information about eutrophication, see the AWC Info Sheet 5: Eutrophication.
Natural Region	A major ecosystem defined by distinctive geography and receiving uniform climatic conditions. The Athabasca watershed has four natural regions including Rocky Mountain, Foothills, Boreal Forest and Canadian Shield.
Point and Non-Point Source Pollution	Point pollution arises from a single source such as the end of a pipe at a municipal wastewater treatment plant. In contrast, non-point pollution arises from many diffuse sources (land runoff, precipitation, atmospheric deposition, etc.) and tracing it back to a single source is difficult.
Riparian Lands	Riparian lands are transitional areas between uplands and aquatic ecosystems. They have variable width and extent above and below ground and perform various functions. These lands are influenced by and exert an influence on associated water bodies, including alluvial aquifers and floodplains. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and hydrological processes. See AWC **Riparian Land Conservation and Management Report and Recommendations**.

Sector	An area of the economy that includes certain kinds of jobs like forestry, oil and gas, agriculture, etc.
Source Water Protection Plan	A planning tool used to control or minimize the potential for introduction of chemicals or contaminants in source waters, including water used as a source of drinking water, whether it is groundwater or surface water.
Species at Risk	Species that are at risk of disappearing (i.e. extinct or extirpated) in Alberta.
Stakeholder	A person, group or organization that has an interest or a concern in, or is affected by, an organization, an issue or a course of action.
Traditional Knowledge	In Aboriginal cultures, the body of accumulated knowledge that has developed over many generations about the environment.
Tributary	A stream or river that flows into a larger river or lake.
Watershed	An area of land that catches precipitation (rain, hail, snow) and drains into a common body of water, such as a river, tributary, lake or wetland (also known as a *catchment* or *basin*).
Wetland	Land saturated with water long enough to promote formation of water altered soils, growth of water tolerant vegetation, and various kinds of biological activity that are adapted to the wet environment.

Athabasca
WATERSHED COUNCIL