Upper Athabasca Region

Surface Water Quality Management Framework for the Upper Athabasca River

Upper Athabasca Region Surface Water Quality Management Framework for the Upper Athabasca River | Environment and Protected Areas
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Overview

The Surface Water Quality Management Framework for the Upper Athabasca River (the Framework) is divided into three parts:

Part One: Background and Context describes the fundamental principles and context for the development of the Framework and provides an overview of the upper Athabasca River watershed and water management therein.

Part Two: Key Components of the Framework describes components of the cumulative effects management system established under the Framework. These include the regional objective, selection of monitoring stations, a tailored list of surface water quality indicators, site-specific triggers and ambient limits.

Part Three: Framework Implementation describes the implementation cycle for the Framework, including monitoring, evaluation, reporting and response. Each step of the management response process is explained in detail and related roles and responsibilities are described.

Part One: Background and Context

1. Introduction

The Government of Alberta is committed to the management of cumulative effects, defined as the combined effects of past, present, and reasonably foreseeable land-use activities, over time, on the environment. The management of cumulative effects also considers the social and economic values of a particular place. This commitment is articulated in the Land-use Framework (LUF) and is supported by regional and sub-regional planning and other related initiatives of Alberta's Integrated Resource Management System. Environmental management frameworks are a key component of Alberta's approach to assessing and managing cumulative effects. They are developed for air quality, groundwater, surface water quality, surface water quantity, biodiversity and tailings management.

Environmental management frameworks are policy documents that provide context for development and related planning and decision making processes. They are implemented and given legal authority as specified in a regional plan, and/or through Alberta Environment and Protected Areas' (EPA) mandate and legislation. They are intended to add to and complement, not replace, existing policies, legislation, regulations, and management tools in place for air, water, and land-use management.

Surface water quality management frameworks are in place for the Lower Athabasca and South Saskatchewan regions since 2012 and 2014, under their respective regional plans. To complement these frameworks, the Government of Alberta introduced surface water quality management frameworks for both the North Saskatchewan and Upper Athabasca regions in 2022. The intent is for surface water quality frameworks to be in place for all major river systems in the province.

The Surface Water Quality Management Framework for the Upper Athabasca River applies to the mainstem of the Athabasca River, as encompassed by the boundary of the Upper Athabasca Region (Figure 1). The Framework is issued pursuant to Section 14 of the *Environmental Protection and Enhancement Act* (EPEA) until subsequent incorporation under a regional plan and the *Alberta Land Stewardship Act* (ALSA).

Cumulative effects

The combined effects of past, present, and reasonably foreseeable land-use activities, over time, on the environment.

Government of Alberta, 2008

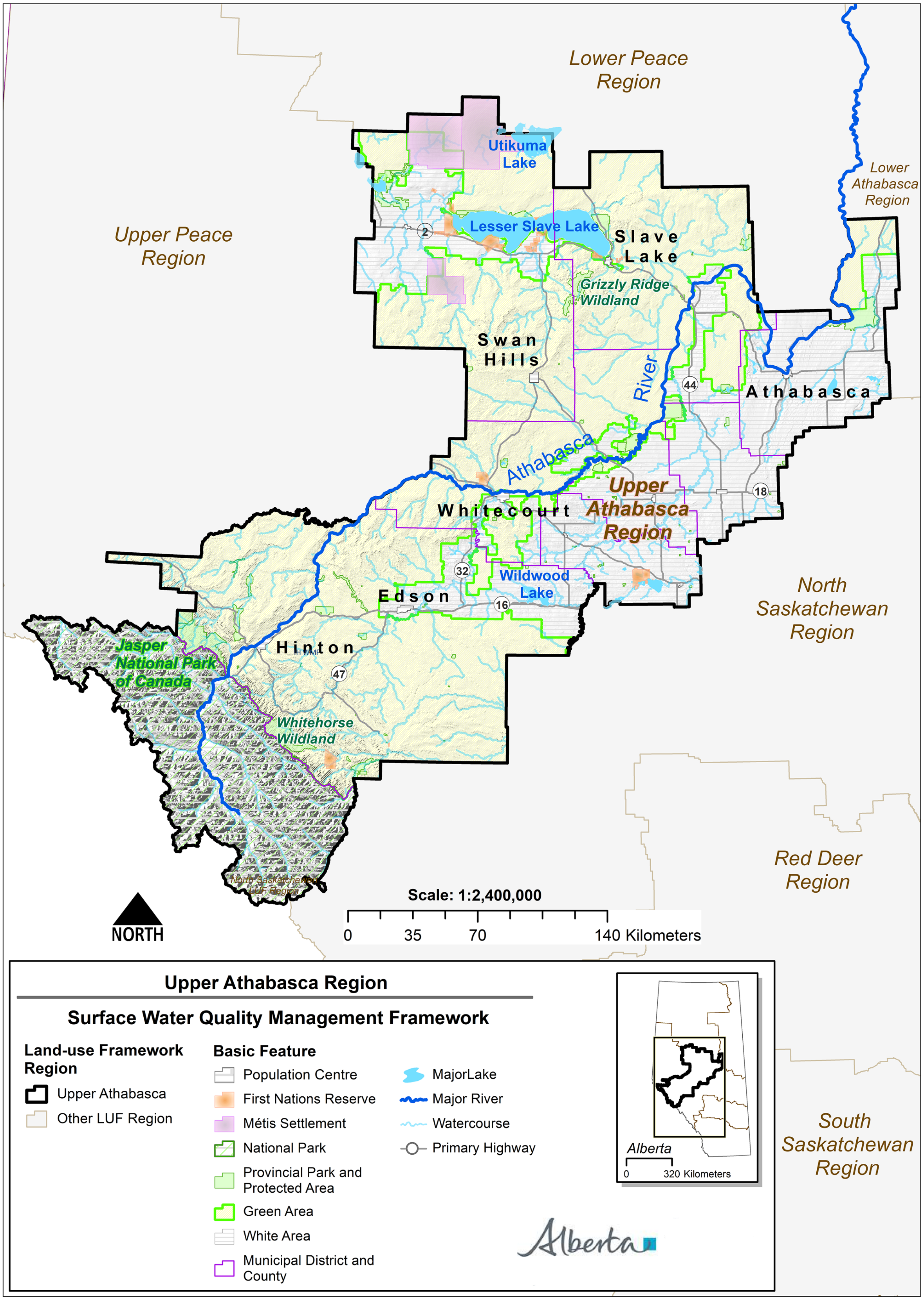

Figure 1: Map showing administrative boundaries of the Upper Athabasca Region and adjacent Land-use Framework regions. The Upper Athabasca Region also covers portions of Treaty 6 and Treaty 8.

1.1. Purpose of the Framework

The purpose of the Framework is to clearly define a regional approach to managing the cumulative effects of development on the surface water quality of the upper reaches of the Athabasca River (i.e., in the Upper Athabasca Region).

The Framework achieves this purpose by:

- establishing a regional objective for surface water quality;
- identifying key indicators of water quality;
- setting surface water quality thresholds for the suite of indicators (i.e., triggers, limits, and if appropriate in the future, targets);
- identifying a management response process that will be initiated, if an indicator exceeds a threshold;
- creating an integrated and robust management approach that is consistent amongst the province's land use planning regions; and
- describing roles and responsibilities for relevant groups.

Environmental management frameworks manage for the **long-term, cumulative impacts of human activities** on the environment on a regional or sub-regional scale, while individual activities in a specific location and time are managed through other regulatory and non-regulatory means.

Water is of cultural and spiritual importance to many Indigenous peoples and is seen as the interconnection among all living beings, supporting the well-being of Indigenous communities. The significance of water for Indigenous peoples and its importance in the continued practice of traditional activities is acknowledged, pointing to the need for better inclusion of Indigenous perspectives, values and knowledge expressed by those First Nations and Métis peoples living in this planning region.

The Athabasca River is important for all those who live, work, and play within this watershed, offering ecological, aesthetic, recreational, and economic value to the region. Management of the Athabasca River under this Framework aims to support the desire to broaden understanding of a changing environment by braiding Indigenous, local and scientific knowledge (Government of Alberta, 2019).

1.2. Development of the Framework

The Framework builds on the existing Lower Athabasca Region Surface Water Quality Management Framework for the Lower Athabasca River. It establishes a basin-wide approach for managing cumulative effects on the Athabasca River from its headwaters in the Rocky Mountains, to its ultimate discharge in the Peace-Athabasca Delta. Work on the Framework was initiated in 2017. In 2021, a formal engagement process on the development of the Framework, with stakeholders, Indigenous communities and organizations, and the public, was completed through a webinar, one-on-one meetings, and a public survey.

2. Key Concepts and Principles

2.1. Key Concepts

Several key concepts and principles underpin the Framework and guide its development and implementation in support of cumulative effects management.

2.1.1. Adaptive Management

The Government of Alberta is committed to cumulative effects management, which focuses on the achievement of outcomes and understanding the effects of multiple development pressures (existing and new). This management approach follows an adaptive management model where decision-makers are able to adapt to new information about social, economic, and environmental conditions. Regular monitoring, evaluation, and reporting are essential for providing information to Albertans on environmental conditions and identifying the need for adjustments to our management approaches on an ongoing basis.

2.1.2. Addressing Point and Non-point Source Contributions

The Framework identifies key water quality parameters of concern that, at certain concentrations, may have adverse effects on aquatic life or human activities. These parameters can arise from point sources or non-point sources and proposed management approaches must consider contributions from both. Point sources are discharges from a single source that can be easily identified and regulated (e.g., effluent from a municipal wastewater treatment plant). Non-point source pollution enters a water body from diffuse sources and has no single point of origin. Surface runoff during rainfall or snowmelt events can carry contaminants into surface waterbodies and is a major source of non-point source pollution. Monitoring and management of non-point sources is complex; it is an intergovernmental and cross-jurisdictional issue involving numerous stakeholders and Indigenous communities and organizations. Understanding the contributions from both sources is essential for informing relevant and effective management responses.

2.2. Key Principles

The following key principles form the foundation of the Framework. The Framework:

2.2.1. Identifies Surface Water Quality Management Risks and Adverse Trends

- The Framework identifies potential adverse effects on surface water quality from human activities along the river, through regular monitoring, evaluation, and reporting.
- Pollution prevention and continuous improvement, as outlined in policies of the *Environmental Protection and Enhancement Act*, will remain key management principles.

2.2.2. Applies a Regional Perspective

- The Framework leverages the provincial surface water quality monitoring program for the mainstem upper Athabasca River and key tributaries, considering the regional context for water quality.

2.2.3. Complements Existing Legislation, Regulations and Policies

- The Framework is intended to complement, not replace, existing national and provincial policies, legislation, regulations, and programs.

2.2.4. Incorporates Adaptability

- The Framework recognizes that development plans, technology, and scientific understanding may change over time. Flexibility and adaptability are needed to ensure that the desired environmental outcomes continue to be achieved.
- A range of potential actions and tools are expected to be used to manage surface water quality.
- EPA will review and update the Framework to reflect improvements in information, knowledge, and understanding of water quality indicators and their condition, reflecting scientific, local, and Indigenous knowledge systems.

2.2.5. Communicates Clearly

- There is a commitment to regular public reporting of environmental condition and management responses initiated under the Framework.

2.2.6. Involves Collaboration

- Individuals, communities, industry, agencies, and governments share the responsibility for managing surface water quality.
- EPA will continue to collaborate with Indigenous communities and organizations, local governments, and stakeholders, including Watershed Planning and Advisory Councils (WPACs), as the Framework is implemented.

2.2.7. Is Knowledge-Based/Science-Based

- The selection of indicators, triggers, and limits used in the Framework is based on current understanding of surface water quality and scientifically defensible methods.
- The Framework enables the identification and implementation of management actions, based on best available knowledge and investigations.

2.2.8. Is Outcome Focused

- The Framework supports planning and action that lead to achieving demonstrable results and achievement of the Framework objective.
- If surface water quality conditions approach or exceed limits, more stringent management actions are to be implemented.

3. Overview of the Current Management System

The Framework is one component of a larger system in Alberta that supports surface water quality management in the Upper Athabasca Region. The existing management system includes: policy, legislation, and regulation; compliance and enforcement; monitoring, evaluation, and reporting; and initiatives and activities undertaken through non-profit groups, including WPACs and watershed stewardship groups (WSGs) and Indigenous communities and organizations. The Framework adds the regional-scale cumulative effects perspective to the current system.

3.1. Regulatory and Policy Context

Alberta's surface water quality management system is supported by legislation, policies, and strategies. These inter-connected approaches exist at different scales, ranging from provincial to local scales, as shown in Figure 2.

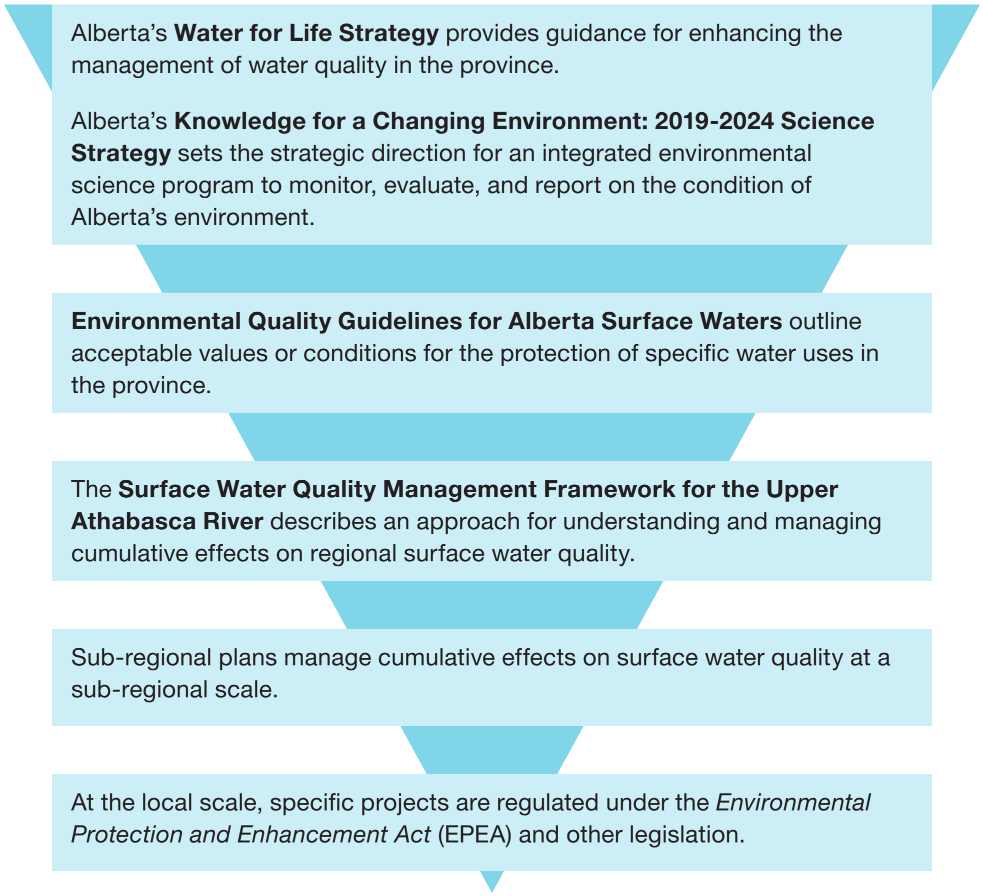

Figure 2: Key components of the provincial water management system in the Upper Athabasca Region from the provincial scale down to the facility scale.

Understanding the regulatory and policy context that supports surface water quality management (Table 1) is important to build a more comprehensive understanding of the system in place to manage water quality in Alberta and sustain healthy aquatic ecosystems.

TABLE 1: KEY GUIDANCE FOR MANAGING SURFACE WATER QUALITY IN THE UPPER ATHABASCA REGION

Governance

Legislation*	Jurisdiction
Canadian Environmental Protection Act	Canada
Fisheries Act	Canada
Alberta Land Stewardship Act (ALSA)	Alberta
Water Act	Alberta
Environmental Protection and Enhancement Act (EPEA)	Alberta
Municipal Government Act	Alberta
Public Lands Act	Alberta
Agricultural Operations Practices Act (AOPA)	Alberta
Policies, Strategies and Plans	
Water for Life	Alberta
Land-use Framework	Alberta
Knowledge for a Changing Environment: 2019-2024 Science Strategy	Alberta
Framework for Water Management Planning	Alberta
Industrial Release Limits Policy	Alberta
Municipal Policies and Procedures Manual	Alberta
Strategy for the Protection of the Aquatic Environment	Alberta
Standards and Guidelines	
Canadian Council of Ministers for the Canadian Environmental Quality Guidelines	Canada
Environmental Quality Guidelines for Alberta Surface Waters	Alberta
Water Quality Based Effluent Limits Procedures Manual	Alberta
Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems	Alberta
Agreements	
Mackenzie River Basin Transboundary Waters Master Agreement and Alberta – Northwest Territories Bilateral Water Management Agreement	Federal-Provincial-Territorial

* Includes associated regulations, codes of practice and authorizations.

4. Initiatives in the Region

4.1. Regional Planning

The Upper Athabasca Regional Plan (UARP) is one of seven regional plans being advanced under the LUF and its enabling legislation, the *Alberta Land Stewardship Act*. Planning work for the UARP has yet to be initiated; however, EPA is releasing the Framework in advance of the regional plan to proactively expand and strengthen the management of cumulative effects in the Athabasca River basin as a whole, including the Eastern Slopes.

4.2. Water Management Planning

There are several water management planning documents and processes in the region that support surface water quality management. The Framework is intended to align with and complement this ongoing work.

WPACs and WSGs are established under *Alberta's Water for Life* strategy. The work of WPACs can include reporting on the state of watersheds, leading collaborative watershed planning, and facilitating education and stewardship activities. WSGs may undertake initiatives such as lake watershed plans, technical studies, and educational activities. WPACs are actively engaged in many facets of watershed planning, including development of documents relevant to surface water quality engagement. The Athabasca Watershed Council (AWC) and the Lesser Slave Watershed Council (LSWC) are the WPACs in the Upper Athabasca Region.

Water planning initiatives undertaken by the AWC include four State of the Watershed reports (2011-2014) and the Athabasca River Integrated Watershed Management Plan: Draft (2021). Other initiatives by the AWC include substantial educational outreach programming and resources about water and watershed resources, promoting Beneficial Management Practices (BMPs), biomonitoring in the Eastern Slopes under the CABIN program, carrying out riparian assessments in the Pembina River subwatershed, publication of technical documents, and engagement with municipalities and other stakeholder groups.

Planning initiatives undertaken by the LSWC include the State of the Lesser Slave Watershed report (2009) and the Lesser Slave Integrated Watershed Management Plan (2018). The LSWC continues to provide educational outreach and resources about water and watershed resources, carry out stakeholder engagement, and support stewardship initiatives.

4.3. Surface Water Quality Monitoring

EPA's Long-term River Network (LTRN) is the primary source of surface water quality data used to develop and implement the Framework.

The LTRN is a core monitoring program that produces year-round, monthly river water quality monitoring data at 36 stations across 13 major rivers in Alberta (Kerr and Cooke, 2019). These stations are strategically located across diverse landscapes within major river basins and serve as a screening-level tool to assess water quality in Alberta's major rivers. Most LTRN stations have accumulated multiple decades of river water quality data, which enables our understanding of long-term trends of key water quality variables and supports the assessment of cumulative effects of human activities on water quality.

There are three LTRN stations on the mainstem upper Athabasca River (Figure 3):

- Old Entrance, upstream of Hinton (Station No: AB07AD0100)
- Vega Ferry crossing (Station No: AB07BD0010)
- Athabasca River at Town of Athabasca (Station No: AB07BE0010)

Over 100 chemical and physical parameters are monitored at all provincial LTRN stations, including nutrients, bacteria, metals, and pesticides. The LTRN stations are also used to monitor aquatic ecosystem parameters like bacteria and planktonic and epilithic algae.

In addition to the provincial LTRN monitoring program, the water quality in tributaries to major rivers across Alberta is monitored under the Tributary Monitoring Network (TMN). Currently, there are TMNs in the South Saskatchewan, Milk, North Saskatchewan, and Upper Athabasca river basins. Tributaries in the Lower Athabasca River are monitored under the Oil Sands Monitoring Program. For the TMN program, the suite of monitoring parameters and sampling frequency is similar to the LTRN program, but focuses on smaller streams and rivers to better understand potential environmental changes occurring in the sub-catchments of the major river systems.

There are seven TMN stations in the Upper Athabasca Region (Figure 3). Monitoring of these stations began in 2016, was paused in 2019, and resumed in 2021.

- Lesser Slave River 9.5 km upstream of Athabasca River Confluence (Station No: AB07BK0125)
- Pembina River near Jarvie (Station No: AB07BC0025)
- Sakwatamau River near Whitecourt (Station No: AB07AH0005)
- Mcleod River upstream Whitecourt (Station No: AB07AG0345)
- Berland River near Mouth (Station No: AB07AC0015)
- Miette River near Jasper (Station No: AB07AA0007)
- Sunwapta River at Athabasca Glacier (Station No: AB07AA0005)

Monitoring data from all LTRN and TMN stations are available on Alberta's Water Quality Data Portal (https://www.alberta.ca/surface-water-quality-data.aspx).

To understand more targeted impacts on water quality, EPA also conducts focused studies that are shorter-term projects designed to investigate a specific monitoring result, address data gaps, or answer regionally-specific questions about water quality that cannot be answered by core monitoring programs. For example, in 2015, a synoptic survey (a study that follows a parcel of water as it flows downstream), was carried out in the Athabasca River basin (Tondu, 2017). It involved sampling the entire Athabasca River from upstream to downstream (beginning in Jasper National Park and ending at Lake Athabasca), as well as major tributaries, and wastewater discharges. The purpose of this study was to assess the cumulative impacts of wastewater and tributary inputs to winter water quality. In addition, a study was undertaken in 2017 to investigate the impacts of surface coal mining on the water quality of streams and rivers of the upper McLeod River watershed (Redmond, 2021).

Apart from these provincial and federal monitoring programs, additional monitoring is conducted throughout the upper Athabasca River basin by WPACs, WSGs, academics, industry, and communities. The provincial Science Strategy (Government of Alberta, 2019) supports a multiple evidence-based approach, which includes Indigenous, local, and scientific knowledge. The Science Strategy recognizes community-based monitoring and citizen science as a way to advance the shared production of knowledge.

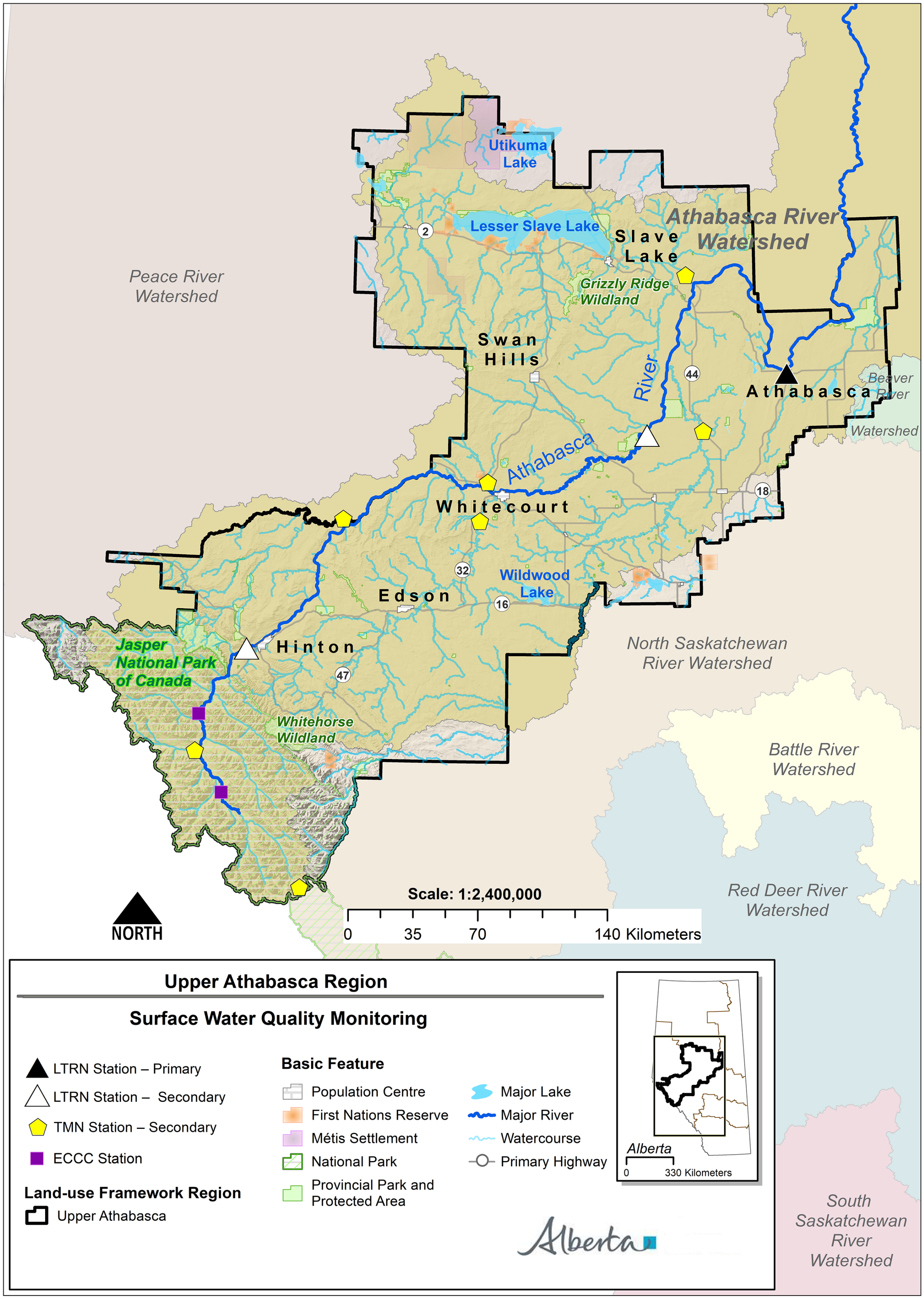

Figure 3: Map showing surface water quality monitoring stations in the Upper Athabasca Region.

5. Overview of the Upper Athabasca River Basin

Flowing through three natural regions, the Rocky Mountains, Foothills and Boreal Forest, the Athabasca River is the second largest river in Alberta, after the Peace River, and is about 1,400 kilometres (km) long (Athabasca Watershed Council, 2018). Originating from melting snow and ice of the Columbia Icefield (Athabasca Glacier) in Jasper National Park, the Athabasca River travels approximately 1,500 km in a north-easterly direction and drains into the Athabasca Delta and Lake Athabasca (Athabasca Watershed Council, 2012, 2013; Alberta WaterSMART Solutions Ltd., 2018). Along the way, the Athabasca River collects water from hundreds of tributaries with major contributions from the McLeod, Berland, Pembina, Lesser Slave, La Biche, Clearwater, and Muskeg rivers (Athabasca Watershed Council, 2018).

Originating in the Rocky Mountains, precipitation, snowmelt, and glaciers supply the largest proportion of the river's volume. Typical of many rivers in Alberta, snowmelt and spring rains throughout the basin increase flows in the Athabasca River in the spring and early summer and flows decline in late summer to fall (Alberta WaterSMART Solutions Ltd., 2018). Large increases in flow occur due to summer storms and vary depending on the magnitude and extent of the precipitation in the basin. Flow in the Athabasca River is unaltered by dams or other water control structures. The mean annual flow is 174 cubic metres per second (m^3/s) at Hinton and 439 m^3/s at the Town of Athabasca (Alberta WaterSMART Solution Ltd., 2018). Numerous communities occur along the Athabasca River within the Upper Athabasca Region, and rely on the river for drinking water, including the municipality of Jasper and the towns of Hinton, Whitecourt, and Athabasca (Athabasca Watershed Council, 2011).

Surface water quality of the Athabasca River varies with seasonal and annual changes in hydrology (Alberta WaterSMART Solutions Ltd., 2018). Surface runoff during spring melt and heavy rainstorms causes total suspended solids and turbidity to increase in the river, along with other parameters such as nutrients and metals attached to sediment particles (Alberta WaterSMART Solutions Ltd., 2018). Variations in water quality and ecology of the Athabasca River also occur due to landscape changes from Jasper National Park to the Athabasca Delta. Headwaters passing through the steep slopes of the Rocky Mountains are fast flowing, cold, and low in organic content and nutrients (Athabasca Watershed Council, 2018). Flows within the Athabasca River slow as the river slope decreases and the river widens and meanders through the Foothills and Boreal Forest, where increases in colour, ions, and nutrients occur (Athabasca Watershed Council, 2013).

There are a range of human pressures and sources of contaminants in the basin that may influence water quality in the river. These include municipal and industrial wastewaters, stormwater, and runoff (Alberta WaterSMART Solution Ltd., 2018). Economically diverse, the Athabasca River basin supports forestry, oil and gas development (conventional and hydraulic fracturing), surface mining (coal, sand and gravel, peat), agriculture, recreation, and tourism (including off highway vehicle use), that indirectly and directly influence water quality (Alberta WaterSMART Solutions Ltd., 2018). There are a variety of concerns for water quality in the upper portion of the Athabasca River, including low dissolved oxygen in the winter, nutrient enrichment, and trace metals, as well as data and reporting gaps (Alberta WaterSMART Solutions Ltd., 2018; Athabasca Watershed Council, 2018). High sedimentation throughout parts of the basin are also a concern for water quality conditions and suitability of habitat for fish and other biota (Athabasca Watershed Council, 2014).

The potential effects of climate change and climate variability on the Athabasca River are expected to be complex (Walsh, 2008). There has been a statistically significant trend towards declining streamflow in the Athabasca River over recent decades (Sauchyn et al., 2015; Alberta WaterSMART Solutions Ltd., 2018). These recent trends and future projections indicate that the loss of water stored as ice and snow will affect the timing and level of flows in major river basins. Climate change is expected to result in more precipitation falling as snow and earlier spring snowmelt (Dibike et al., 2018). Summer flows are likely to decrease, and winter flows are likely to remain relatively unchanged or increase slightly (Alberta WaterSMART Solutions Ltd., 2018). As water quality is closely tied to water quantity these potential changes in flow may also result in changes to water quality. For example, low flows limit the capacity of the river to assimilate pollutant loads from point sources while also exacerbating impacts of increasing water temperatures, such as influencing oxygen levels and algal growth (Athabasca Watershed Council, 2018).

Part Two: Key Components of the Framework

6. Regional Surface Water Quality Objective

The Surface Water Quality Management Framework for the Upper Athabasca River sets the following regional objective:

Surface water quality for the mainstem Athabasca River in the Upper Athabasca Region is managed so current and future water uses are protected.

The regional objective seeks to protect both human and ecological uses of the Athabasca River. Human uses include recreation and aesthetics, agriculture, source water for drinking water supplies, and Indigenous peoples' traditional practices related to the rivers. Ecological uses focus on the needs of aquatic life in the river to maintain the health and abundance of populations and species.

7. Monitoring Stations used in the Framework

The provincial surface water quality monitoring program underpins and provides the scientific foundation for the Framework. Monitoring data collected at stations from both the LTRN and TMN are used for Framework development and implementation (Figure 3).

7.1. Primary Monitoring Stations

The Framework establishes management thresholds at LTRN stations in the Upper Athabasca Region where there is a sufficient period of record and where there are land use pressures upstream of the station that can be managed by the Government of Alberta (GOA). These stations are referred to as primary stations under the Framework.

There is one primary station in this Framework: Athabasca River at Town of Athabasca (Station No: AB07BE0010).

As this is the lowermost station on the upper Athabasca River, pressures downstream of this station will be considered in the implementation of the Surface Water Quality Management Framework for the Lower Athabasca River.

7.2. Secondary Monitoring Stations

Nine other provincial monitoring stations currently exist in the basin but do not meet the criteria to be included as a primary station.

- Old Entrance, upstream of Hinton (Station No: AB07AD0100): This LTRN station has a sufficient period of record (i.e., sampling began in 2003); however, it is located just outside of Jasper National Park. There are few land-use pressures upstream of the station and jurisdiction of this land-base is held by the Government of Canada.
- Vega Ferry Crossing (Station No: AB07BD0010): This LTRN station did not have a sufficient period of record to develop triggers as monthly sampling only began in 2016.
- Seven stations in the TMN (listed in Section 5.2): These stations did not have a sufficient period of record to develop triggers as monitoring began in 2016, was paused in 2019, and resumed in 2021.

Information from these LTRN stations and the TMN stations (collectively referred to as secondary stations), will be reported as part of annual Framework reporting to inform our understanding of conditions in the basin. Specifically, the TMN stations provide information about the quality of water entering the upper Athabasca River from sub-basins across the watershed (Figure 3). This information can be used to help understand where changes in surface water quality may be occurring and what may be causing these changes (e.g., which sub-watersheds may be disproportionately contributing different indicators). Information from other monitoring conducted in the region will also be used to inform management efforts, as appropriate.

Establishing thresholds at the secondary stations identified above (i.e., promotion to primary station) and inclusion of other secondary stations will be considered upon future review of the Framework.

8. Identifying Surface Water Quality Indicators

Indicators provide information about surface water quality conditions, and the ongoing monitoring, evaluating, and reporting of each indicator provides information on whether the regional objective is being met. Indicators include biological parameters, major ions, metals, nutrients, organics, and general surface water parameters (Table 2).

8.1. Primary Indicators

Primary indicators are indicators for which management thresholds are assigned (Table 2). To be included as a primary indicator, the first two criteria and three of the remaining six criteria had to be met:

- Availability of long-term data, ideally a minimum of ten years, at the LTRN station on the Athabasca River in the Upper Athabasca Region;
- Parameters that respond to existing and anticipated development pressures and can be influenced by management actions (i.e., may be influenced by human activities);
- Parameters that exhibit a trend through time in an undesirable direction (i.e., increasing or decreasing);
- Parameters that exhibit an observed exceedance of an instream guideline, based on Environmental Quality Guidelines for Alberta Surface Waters (2018);
- Parameters that exhibit a downstream increase (and therefore loading) to the Athabasca River between the upstream Old Entrance and downstream Town of Athabasca LTRN monitoring stations;
- Parameters identified as variables of concern from wastewater characterization of point sources and from existing surface water quality studies and reports for the region;
- Parameters that were identified as a potential indicator from multivariate statistical analysis; and
- Parameters that align with work being done under the Lower Athabasca Region Surface Water Quality Management Framework.

TABLE 2: INDICATORS FOR THE UPPER ATHABASCA RIVER BASIN (PRIMARY INDICATORS UNLESS OTHERWISE NOTED)

Metals	Dissolved Aluminum	Biological	*Escherichia coli*
	Dissolved Boron	Ions	Chloride
	Dissolved Cadmium		Potassium
	Dissolved Cobalt		Sodium
	Dissolved Copper		Specific Conductance
	Dissolved Iron		Sulphate
	Dissolved Nickel	General	Total Suspended Solids
	Dissolved Strontium		pH (field)
	Dissolved Uranium		Dissolved Oxygen
	Dissolved Vanadium		Colour
	Total Cadmium	Nutrients	Total Ammonia
	Total Cobalt *		Nitrate
	Total Copper *		Total Nitrogen
	Total Mercury *		Total Phosphorus
	Total Selenium		Total Dissolved Phosphorus
	Total Zinc		Dissolved Organic Carbon

*Secondary indicator

EPA will continue to monitor water quality parameters not identified through this indicator selection process, as part of the provincial monitoring program.

The indicator list presented in the Framework may change over time in response to additional monitoring data, new contaminants of concern, consideration of different knowledge systems (i.e., Indigenous, local and scientific), or as we gain a greater understanding of the behaviour and fate of contaminants within these rivers. Any updates to the indicator list will occur as part of the regular review processes inherent to environmental management frameworks.

8.2. Secondary Indicators

Secondary indicators are parameters of concern that did not meet the criteria for inclusion as a primary indicator, and therefore do not have associated triggers or limits under the Framework.

Three secondary indicators are identified under this Framework: total cobalt, total copper, and total mercury. These metals are considered toxic to aquatic life and certain forms of mercury are known to readily bio-accumulate in the aquatic food chain (Canadian Council of Ministers of the Environment, 1999; Environment and Climate Change Canada, 2022). These parameters align with work being done under the Lower Athabasca Region Surface Water Quality Management Framework and numerous surface water quality guideline exceedances have been observed at the Athabasca River at Town of Athabasca station; however, additional criteria were not met.

Secondary indicators will continue to be monitored for and included in annual framework reporting. They will be considered for future inclusion in the Framework, with triggers and limits, as our data and knowledge increases.

8.3. Supporting Parameters

Non-fish biological indicators of aquatic ecosystem condition may be monitored for and reported on as part of investigations into related water quality indicators. These biological indicators could include measures of algal, benthic invertebrate, or aquatic macrophyte diversity and abundance.

9. Setting Management Thresholds

Management thresholds provide a value against which to compare the condition of surface water indicators to understand whether the regional objective is being met. For the purpose of the Framework, thresholds include triggers, limits, and targets. Triggers and limits, where available, are set for primary indicators and are applied at the primary monitoring station.

9.1. Water Quality Triggers

Triggers are thresholds that provide an early signal of potential changes in the condition of the water quality indicators, and, if exceeded, initiate further assessment and determination of any additional action needed. The triggers shown in Table 3 are site-specific and were calculated using baseline data from the historical dataset collected at the Athabasca River at Town of Athabasca LTRN station (AB07BE0010). Appendix A and B provide details of how triggers were set and how they will be evaluated. Tables showing the summary statistics for the data used to generate indicator triggers are presented in Appendix C.

Several considerations inform the period of record used to calculate triggers (i.e., baseline). The baseline period must be long enough to represent a range of climatic conditions which influence water quality. The selected time period

Management thresholds for surface water quality include triggers, limits, and targets, and for the purpose of the Framework, are defined as follows:

Triggers are numerical thresholds set in advance of limits as early warning signals for evaluation and proactive management.

Limits are numerical thresholds at which the risk of adverse effects on environmental quality is becoming unacceptable.

Targets are concentrations or narrative statements that management aims to achieve or do better than.

must also have sufficient data to allow for robust statistical analysis. In general, a minimum of 10 years of data was considered adequate to characterize baseline water quality condition.

Sampling began at the Athabasca River at Town of Athabasca LTRN station in 1987; however, throughout the evolution of the sampling program, different analytical methods were adopted for various parameters, meaning that some of the historic data is not compatible with more recent data. For this reason, the start date for some indicators varies, ranging from 1987 to 2007. A detailed description of these start dates is provided in Appendix A. The end date of the baseline period (i.e., 2018) represents the most recent data that was available at the time when the triggers were first calculated.

Most of the indicators exhibit seasonal differences due to the influence of climatic and environmental drivers (e.g., temperature, light availability, runoff) on water quality. To address this characteristic of the data, triggers were calculated separately for two seasons: the open-water season (April to October) and the winter season (November to March). For each primary indicator at each site, a median trigger and a peak trigger were calculated for each season, corresponding respectively to the 50^{th} and 90^{th} percentile of the datasets from the periods of record described in Appendix A. The median trigger represents longer term, chronic conditions, while the peak trigger represents short-term, acute conditions. Appendix B describes how trigger exceedances will be determined.

There are several primary indicators that are important in understanding surface water quality conditions and the health of the river, but whose concentrations are often below the level that can be detected by laboratory methods (i.e., censored data). For instances where 50 per cent and 90 per cent or more of the data is censored, the detection limit serves as the median and peak trigger value, respectively. Evaluation of statistically significant trigger exceedances in these instances will differ slightly from other indicators. Appendix A and B provide details on how trigger values are set and how exceedances will be determined for highly censored datasets.

9.2. Water Quality Limits

Under the Framework, ambient limits are based on provincially accepted surface water quality guidelines, which are defined as a “numerical concentration or narrative statement which is recommended to protect a specific use of water or other aquatic ecosystem component” (Government of Alberta, 2018, p. 3). Exceedance of a limit indicates that a current or potential future water use may not be protected. It is important to note that the limits are not intended to be “pollute up to” numbers; water quality conditions that are below limits are expected to be maintained or improved, as appropriate.

The Environmental Quality Guidelines for Alberta Surface Waters (Alberta Environment and Parks, 2018) were used to establish ambient limits under the Framework (Table 3). Indicators may have multiple guidelines for different uses, including the protection of aquatic life (PAL), irrigation, livestock watering, recreation, and aesthetics. Drinking water quality is achieved through separate performance-based treatment standards; however, meeting surface water quality guidelines also helps to support source water protection.

The most stringent use protection guideline available for each indicator was applied as an ambient limit. When the most protective guideline was for the protection of aquatic life, only chronic guidelines were used as the acute guidelines relate to short-term exposure and are not designed to be protective for exposure over extended time periods.

Many of the indicators chosen for this Framework have numeric guideline values, while others rely on narrative statements (e.g., phosphorus). Narrative statements will be considered in the interpretation of water quality monitoring data, but cannot be directly applied as a limit. Other guidelines (e.g., total ammonia, sulphate, total lead) vary according to water quality conditions (i.e., toxicity modifying factors such as temperature, hardness, or pH) and will be determined based on the specific surface water conditions at the time of sampling. For some indicators, a guideline does not currently exist. Appendix B describes how trigger exceedances will be determined.

The Environmental Quality Guidelines for Alberta Surface Waters (Alberta Environment and Parks, 2018) are reviewed and updated as new guidelines are developed by other jurisdictions or organizations and adopted by Alberta. New or revised guidelines will be incorporated into the Framework, as appropriate, upon amendment of the Environmental Quality Guidelines for Alberta Surface Waters.

TABLE 3: SURFACE WATER QUALITY TRIGGERS AND LIMITS FOR THE UPPER ATHABASCA RIVER

Primary Indicators	Unit[a]	Season	Limit	Median Trigger	Peak Trigger
Biological					
Escherichia coli	CFU/ 100ml	open	100 [c]	10 [e]	40
		winter		10 [e]	10 [e]
Ions					
Chloride (Cl^-)	mg/L	open	100 [c]	1.7	3.8
		winter		3.9	5.9
Potassium (K^+)	mg/L	open	-	1.01	2.1
		winter		1.7	2.3
Sodium (Na^+)	mg/L	open	-	6.8	12.5
		winter		17.1	22
Specific Conductance	µS/cm	open	-	250	324
		winter		419	473
Sulphate	mg/L	open	Equation [b]	25.2	39.4
		winter		49.1	61
Metals					
Dissolved Aluminum	µg/L	open	50 [b]	10.4	41.7
		winter		2.98	8.07
Dissolved Boron	µg/L	open	-	11.5	15.9
		winter		18.6	24
Dissolved Cadmium	µg/L	open	-	0.0126	0.026
		winter		0.022	0.045
Dissolved Cobalt	µg/L	open	-	0.0526	0.136
		winter		0.0354	0.146
Dissolved Copper	µg/L	open	-[f]	0.883	2.03
		winter		0.82	1.19
Dissolved Iron	µg/L	open	300 [b]	44.6	161
		winter		42	90.2
Dissolved Nickel	µg/L	open	-	0.589	1.98
		winter		0.467	1.17
Dissolved Strontium	µg/L	open	-[f]	237	326
		winter		384	473
Dissolved Uranium	µg/L	open	-	0.405	0.587
		winter		0.63	0.736
Dissolved Vanadium	µg/L	open	-	0.222	0.466
		winter		0.178	0.32

Primary Indicators	Unit[a]	Season	Limit	Median Trigger	Peak Trigger
Total Cadmium	µg/L	open	Equation [b]	0.03	0.144
		winter		0.025	0.05
Total Selenium	µg/L	open	2 [bf]	0.2 [e]	0.5
		winter		0.306	0.402
Total Zinc	µg/L	open	30 b	4.3	20.9
		winter		2	4.72
Nutrients					
Total Ammonia	mg/L	open	Equation [b]	0.05 [e]	0.05
		winter		0.05	0.085
Nitrate	mg/L	open	3 [b]	0.0051	0.089
		winter		0.13	0.213
Total Nitrogen (TN)	mg/L	open	[d]	0.265	0.907
		winter		0.475	0.61
Total Phosphorus (TP)	mg/L	open	[d]	0.038	0.246
		winter		0.012	0.021
Total Dissolved Phosphorus (TDP)	mg/L	open	[d]	0.0064	0.023
		winter		0.0072	0.015
Dissolved Organic Carbon (DOC)	mg/L	open	-	5.8	11.1
		winter		6.1	8.5
General					
Total Suspended Solids (TSS)	mg/L	open	[d]	34	255
		winter		1.3	6
pH (field)		open	min 6.5 and max 9.0 [b]	8.1	7.68, 8.39 [g]
		winter		7.65	7.28, 8.17 [g]
Dissolved Oxygen	mg/L	open	Min 6.5 [b]	9.65	8.47
		winter		10.89	8.68
Colour	TCU	open	[d]	17	69
		winter		18	28

[a] Units include: mg/L (milligram per litre), µg/L (microgram per litre), ng/L (nanogram per litre), CFU/100mL (colony forming units per 100 millilitres).

[b] Surface water quality guidelines for the protection of freshwater aquatic life (Table 1, Government of Alberta, 2018, p. 25).

[c] Surface water quality guidelines for the protection of agricultural water uses (Table 2, Government of Alberta, 2018, p. 41).

[d] Narrative guideline. The guideline will be considered in the interpretation of water quality monitoring data, but cannot be directly applied as a surface water quality limit.

[e] Indicator is highly censored; trigger value is the maximum detect limit of the dataset from the beginning of the baseline period to 2021 (See Appendix A).

[f] Total Selenium has both an alert concentration (1 ug/L) and a guideline (2 ug/L) for the protection of freshwater aquatic life (Table 1, Government of Alberta, 2018, p 25). Exceedance of the alert concentration in sensitive environments indicates the need for increased monitoring of water and other ecosystem compartments to support early detection of potential Se bioaccumulation issues and provide earlier opportunities to commence proactive management actions. The annual evaluation of surface water conditions will include consideration of the alert concentration; but the guideline will be applied as the limit.

[g] As the surface water quality guideline for pH is a range, both the 10th percentile and 90th percentile values are listed as the peak trigger.

9.3. Setting and Using Targets

By general definition, targets describe desired future conditions and can guide management direction and inform decisions about existing and future activities. For the purpose of this Framework, a target is defined as "a concentration or narrative statement that management aims to achieve or do better than" (Alberta Environment and Water, 2012, p. 7).

The regional objective is to protect human and ecological uses of the upper Athabasca River. This Framework uses triggers calculated from the historical dataset to support understanding of current conditions relative to baseline conditions. In some cases, the desire will be to improve water quality, and in these cases, targets could be used.

The identification of a target to support achievement of an improved state will include environmental, economic, and social considerations. The target setting process will be led by EPA and will include engagement with other provincial departments and agencies, local governments, Indigenous communities and organizations, stakeholders, and the public. A target setting process may be included as part of a management response or may be started without a management response being initiated. Targets would be reported through the established reporting system for the Framework.

Part Three: Framework Implementation

Monthly monitoring of LTRN and TMN stations under the provincial monitoring program is the cornerstone of Framework implementation. The Framework lays out a step-by-step process to evaluate surface water conditions and respond to potential issues that have been identified. Reporting to Albertans on each step of this process is a key component of Framework implementation.

10. Management Levels and Management Response

A management response is a series of steps to identify, investigate, and address potential surface water quality issues. Part of the management response is the assignment of management levels (1, 2, or 3) to communicate the condition of an indicator relative to thresholds and to signal the management intent. The scope of the management response is determined by the level assigned.

10.1. Management Levels

Each management level has an associated management intent (Table 4), which supports the regional objective.

TABLE 4: DESCRIPTION OF SURFACE WATER QUALITY MANAGEMENT LEVELS AND MANAGEMENT INTENT

Level	Description	Management Intent
1	Either no trigger is exceeded, or if a trigger is exceeded, no undesirable water quality conditions (e.g., trends) are detected.	Maintain regulatory and non-regulatory approaches currently in place to manage water quality to maintain or improve conditions.
2	A trigger is exceeded and preliminary assessment determines that further inquiry is required based on assessment of trends or other supporting analysis.*	Investigation of cause is initiated to determine the source of the exceedance. If necessary, development and implementation of management actions may occur to improve surface water quality to be at or below trigger. Non-regulatory tools and/or regulatory approaches may be used as required.
3	Ambient water quality limit is exceeded.	Management actions are required to improve surface water quality to below limits, using non-regulatory tools and/or regulatory approaches as required.

* Indicators that have not exceeded a trigger may also be assigned to Level 2 and an investigation initiated if there are other concerns associated with that indicator that need to be explored. (See Section 10.3.2 “Other Management Responses”.)

10.1.1. Level 1

Indicators that have not exceeded a threshold are assigned to Level 1 and are not subject to a management response. Existing non-regulatory and regulatory measures are used to manage conditions. Level 1 is also assigned to an indicator that exceeds a trigger value but is not showing an undesirable trend, and other analysis does not raise concerns.

10.1.2. Level 2

Level 2 is assigned to an indicator if the preliminary assessment determines that the exceedance represents a potential water quality issue (e.g., an undesirable trend away from baseline conditions) that requires further investigation and possible management action. An investigation of cause is then initiated. However, if no water quality issues (e.g., undesirable trends) are detected during the preliminary assessment and/or the exceedance is deemed to be due to factors such as natural variability in surface water conditions, isolated events, or natural influences, the indicator is assigned to Level 1, and the management response is closed.

10.1.3. Level 3

Indicators that exceed an ambient limit are assigned to Level 3. In many cases, a limit exceedance would be preceded by one or more trigger exceedances in previous years, such that the preliminary assessment and initial steps of the investigation are already complete by the time the limit exceedance occurs. In such cases, the assignment to Level 3 accelerates the ongoing management response to support timely management actions. If a limit exceedance occurs with no prior trigger exceedance, assignment to Level 3 initiates the investigation of cause. In these cases, analyses that comprise preliminary assessment (e.g., trend assessment) would be undertaken to inform the investigation.

10.2. Management Response

If verification and evaluation of annual monitoring data determine that a trigger or limit exceedance occurred, a management response is initiated. The last six steps in Figure 4 describe the management response process. The outcomes of one step in the management response determine the need for and extent of subsequent steps. Details of each step are provided below.

Verification and Evaluation

- Verify surface water quality data to be used in the assessment
- Calculate yearly water quality metrics and compare with thresholds
- Conduct tests for statistical significance
- Trigger and limit exceedances are reported in the annual condition report

Preliminary Assessment

- If a trigger or limit exceedance occurs, initiate a management response
- Perform statistical assessment to determine if undesirable water quality conditions (e.g., trends) are occurring
- Assign management level 2 for indicators exceeding a trigger and exhibiting undesirable water quality conditions (e.g., trends)
- Assign management level 3 for indictors exceeding a limit
- Assign management level 1 for all other indicators

Investigation

- Plan and initiate an investigation for indicators assigned management level 2 or 3
- Assess all relevant information and conduct necessary analysis to identify potential sources
- Identify and include relevant stakeholders and Indigenous communities and organizations, as appropriate

Management Actions

- If necessary, conduct assessment to understand risk of undesirable water quality conditions
- Identify/evaluate potential management actions; select actions for implementation
- Select appropriate measures and tools for implementing management actions
- Identify who needs to act

Delivery of Management Actions

- Ensure the selected management actions are implemented by relevant parties

Assess Implementation Effectiveness

- Evaluate the effectiveness of management actions

Communication

- Provide information to the public about surface water quality conditions and the management response underway; report on the achievement of regional objectives

Figure 4: Management Response Process. Verification and Evaluation determine the need for a management response, which begins with Preliminary Assessment and continues through to Communication.

10.2.1. Verification and Evaluation

Data for more than 100 surface water quality parameters are collected monthly at each LTRN and TMN station. Verification involves ensuring the integrity of the data, considering sample collection, laboratory analysis, data validation, and data reporting and storage.

Once the data from the previous year are verified, EPA compiles the reporting datasets for each indicator at each station. For primary indicators at primary stations, reporting datasets are then used to calculate metrics to compare against triggers and limits.

A **metric** is a procedure for processing monitoring data to determine an indicator value to compare to triggers and limits. In this Framework, metrics summarize parameter measurements over a specific timeframe at a specific location.

Metrics used to determine threshold exceedances include measures of central tendency (to evaluate median trigger and limit exceedances) and changes in the frequency of observed extreme values (to evaluate peak trigger exceedances).

The reporting dataset for trigger evaluation is comprised of data from the last three years, split into the open water and winter seasons. Combining multiple years of data increases the reliability of the tests used to determine the statistical significance of trigger exceedances. There are two steps in the evaluation of median and peak trigger exceedances. Step one involves the direct comparison of reporting data against the trigger values, and step two involves tests to determine the statistical significance of any difference observed in step one. A median trigger is exceeded if there is a statistically significant difference between the reporting data and the corresponding baseline dataset for the open water or winter season. A peak trigger is exceeded if there is a significant numbers of samples that exceeded the peak trigger of their corresponding baseline dataset for the open water or winter season.

The reporting dataset for limit evaluation is comprised of data from a single year, split into the open water and winter seasons. A limit is exceeded if the seasonal median of the reporting data exceeds the limit for a given indicator. Data from a single year was found to be more conservative in identifying limit exceedances than using data from a three-year window. As the determination of limit exceedances does not rely on tests of statistical significance, a smaller dataset is acceptable. For indicators where the limit is calculated using toxicity modifying factors (e.g., total ammonia), individual limits are calculated for each sample in the reporting period using guideline equations. Individual concentrations from the reporting data are then compared against corresponding calculated limits. If greater than 50 per cent of all months exceed their calculated limits for a specific parameter at a specific site within a season, this is identified as a limit exceedance.

For primary indicators at secondary monitoring stations and secondary indicators at both primary and secondary monitoring stations, evaluation includes the calculation of summary statistics for the reporting dataset (including seasonal median and 90th percentile values) and comparison with guidelines (where applicable). These results will be reported and used to support management response to threshold exceedances occurring at the primary monitoring stations.

A detailed description of methods used to evaluate surface water conditions is provided in Appendix B, including methods used to evaluate indicators with a high portion of samples below analytical detection limits.

10.2.2. Preliminary Assessment

A management response begins with a preliminary assessment, which is initiated when the verification and evaluation stage determines that a trigger exceedance occurred. The intent of the preliminary assessment is to identify whether undesirable water quality conditions (e.g., trends) are occurring or if there may be an issue with a water quality indicator that requires further investigation under the Framework.

While the determination of exceedances uses data from a single reporting period, preliminary assessment will evaluate data from longer periods of record to identify trends that may not be evident in a single reporting period. Preliminary assessment also includes use of flow data and may consider other supporting data, such as surface water quality data from other monitoring stations. Statistical analyses are selected based on the characteristics of the data (e.g., distribution, number of samples, variance). The specific methods and outcomes of these analyses will be documented in regular management response reporting.

Median and peak triggers are calculated using baseline data, so seasonal metrics could exceed the trigger values over time, but may still be within the natural range of variability and not represent an undesirable change in surface water quality. It is also possible that a trigger exceedance may be attributed to isolated events (e.g., spills) or natural circumstances that cannot be controlled (e.g., high river flows, groundwater influence). The preliminary assessment seeks to confirm whether the exceedance is within the range of expected or historical conditions and if isolated events or natural circumstances may be influencing conditions.

Preliminary assessment may require more than one year to complete, depending largely on the availability of supporting data. In these cases, the assignment of level may be delayed. The assessment will continue for each exceedance until completion, regardless of whether the same exceedance occurs in subsequent years.

The outcomes of the preliminary assessment will inform the level assignment for each primary indicator that exceeded a trigger.

10.2.3. Investigation

The purpose of the investigation is to determine potential causes of surface water quality issues identified by the evaluation and preliminary assessment, which may inform the development and selection of management actions. The scale of the investigation will depend on the management level for the indicator under investigation and the complexity of the issue.

Due to the variety of potential sources and events that influence surface water quality and the interaction between human and natural influences, identifying the cause of water quality issues is challenging. EPA will lead a process to collate and analyze existing information and data to support further understanding of the identified issue. As part of the investigation, EPA may identify additional information and data that are needed to characterize the issue. This may include analysis of data for other parameters and stations and from other monitoring programs in the region. A range of parties, including other provincial departments or agencies, local governments, Indigenous communities and organizations, non-governmental organizations, industry, other stakeholders, may be engaged to understand the regional issue. Parties that are potentially contributing to the exceedance may be asked to participate in the investigation. Part of the investigation will include recommendations for next steps.

Table 5 provides an example of questions that may be considered during an investigation, building on the questions answered in the preliminary assessment.

TABLE 5: EXAMPLE OF QUESTIONS THAT MAY BE CONSIDERED DURING AN INVESTIGATION

Questions
• What is the current extent of Indigenous and scientific knowledge available (e.g., traditional land use studies, science literature review)? Are potential sources identified in this body of knowledge or are there gaps in knowledge?
• What data are available for any potentially identified analysis, what data may need to be collected?
• How does the surface water quality indicator vary in time (daily, seasonally, and over multiple years), and space?
• What are possible major natural and anthropogenic sources in the region? To what extent are these sources influencing indicator performance?
• Are there statistically significant relationships between multiple indicators or other monitored surface water quality parameters (e.g., those that might influence the indicators), or other water-related parameters (e.g., surface water flows, groundwater)?
• Based on planning and modelling, do conditions align with environmental and development expectations for the region? Are indicators trending as predicted?
• What is the potential influence of climate change on this issue, now and in the future?

The investigation may take multiple years to complete and will be considered sufficient for the purpose of the management response when the probable cause of an exceedance is identified. Where knowledge gaps are identified or where the state of knowledge is not sufficient to meet the management intent, the investigation continues to address the identified knowledge gaps. Findings from the investigation support recommendations for next steps and may inform any future management actions.

10.2.4. Management Actions

The investigation will inform the identification and selection of management actions to meet the management intent of the assigned level. EPA will lead the identification and selection of management actions and will identify parties, including other provincial government departments and agencies, local governments, Indigenous communities and organizations, industry, and other stakeholders, to work collaboratively on this process. The starting point for this work will be to identify existing or planned initiatives that may influence surface water quality conditions and the anticipated effects of these initiatives.

Table 6 identifies examples of management actions that could be used to manage water quality as part of a management response under the Framework, representing a spectrum of options from non-regulatory measures to actions implemented through the existing regulatory system. Management actions become more stringent as the condition of surface water quality moves to more undesirable conditions, with more stringent actions generally implemented through regulatory processes. Under both the *Environmental Protection and Enhancement Act* and the *Water Act*, a Director may initiate amendments related to monitoring or reporting requirements or amendments to address adverse effects that were not reasonably foreseeable at the time of approval issuance. The tools identified in Table 6 may be applicable at the local, regional, or provincial scale. In some cases, continued monitoring may be the only recommended action, for example, if an indicator is no longer adversely trending or if other initiatives are in place that are intended to mitigate the trend.

The terms **management response** and **management action** have distinct meanings in the context of the Framework.

The management response is a set of steps that will be undertaken (all or in part) to identify and respond to changes in baseline surface water quality. Part of the management response is determining the need for management actions and selecting appropriate management actions to undertake for a particular issue.

TABLE 6: POTENTIAL MEASURES AND TOOLS FOR WATER QUALITY MANAGEMENT

Potential Measures and Tools to Enable Management Actions
• Education and awareness (e.g., education programs on reducing contaminants into the river)
• New mechanisms for managing non-regulated sources
• Additional monitoring and/or monitoring network improvements, including potential community-based monitoring programs
• Water quality modelling
• Best management practices (e.g., off-stream livestock watering systems, erosion control)
• Promotion and development of municipal programs, planning, and policies (e.g., water saving devices, green space, energy efficiency)
• Explore and co-develop practices, tools and processes that mobilize, interpret, and apply Indigenous knowledge to inform understanding and mitigation of the issue
• Revise and improve policies, plans, and performance standards for new/existing pollution sources
• Updating and developing codes of practice
• Guidance on issuance of new approvals
• Amendments to existing approvals (e.g., monitoring or modelling requirements, conditions requiring participation in regional initiatives)
• Facility-specific continuous improvement plans for variables of concern
• Restrictions on further wastewater effluent point sources or management of existing wastewater effluent point sources to allow for new sources
• Determination of maximum allowable loads
• Load apportionment among point and non-point sources
• Assignment of load-based limits to regulated sources
• Economic instruments (i.e., trading of load allocation) or other participative mechanisms for load management
• Environmental protection orders

When identifying and selecting management actions, the future potential impacts of climate change and the need for adaptation will also be considered.

The management response process does not replace any component of the existing regulatory or policy system. It will consider other initiatives in place that address the issue and will align management actions with current initiatives and commitments related to surface water quality management in the region.

10.2.5. Delivery of Management Actions

EPA will be accountable for all key decisions about management actions. Appropriate parties will be identified to support the development and implementation of management actions. Coordination requires awareness of ongoing work within the department and across levels of government, related timelines, and pressures. There will be shared responsibility amongst the parties to ensure management actions are implemented. EPA will ensure that any identified changes in regulatory requirements or management approaches are undertaken and will serve in an oversight role for actions being taken by other parties.

10.2.6. Assess Implementation Effectiveness

A key component of the management response process is the evaluation of whether management actions are effective. Annual monitoring and reporting on surface water quality serves as one measure of the effectiveness of management actions. However, with complex issues, such as control of non-point source pollution, multiple years of management may be required to detect improvement. Year-to-year variation in surface water quality can also make it difficult to assess the effectiveness of management actions. Other monitoring, modelling, and reporting will also be used, as appropriate, to help understand and evaluate the status of environmental conditions and, in turn, the effectiveness of management actions. EPA will retain overall accountability for evaluating the effectiveness of the actions.

The implementation of management actions will continue until the surface water quality indicator is managed appropriately, in alignment with the assigned management intent. Management actions are intended to incorporate the principles of adaptive management and may be adapted to reflect changes in the surface water quality conditions, industrial best practices, new knowledge and science, and other considerations.

10.2.7. Communication

Reporting on the status of surface water quality conditions and the management response process ensures that appropriate information is available for consideration by federal, provincial, municipal, and Indigenous governments to support planning, policy development, and environmental management decision-making. Additionally, the information supports appropriate design, planning, and continuous improvements by project proponents. Indigenous communities and organizations, other residents of the region, stakeholders, and the public value transparency and timeliness in reporting.

The content and details of framework reporting, described in Table 7, will be determined as part of implementation of the Framework and will depend on the current stage of management response.

TABLE 8: SURFACE WATER QUALITY MANAGEMENT FRAMEWORK REPORTS

Report	Frequency	Purpose	Content
Status of Surface Water Quality Condition Report	Annual	Report environmental conditions in the context of the frameworks.	Evaluation of monitoring results for primary indicators and their status in relation to triggers and limits in the framework. Evaluation of monitoring results for secondary indicators and for secondary stations identified in the framework. See Appendix B for the detailed content of this report.
Status of Management Response Report	Biennial (Every two years)	Report on the progress of the management response to any framework trigger or limit exceedance.	Summary of the preliminary assessment and assignment of management level; summary of recent investigation efforts and findings; progress on the identification and implementation of management actions; evaluation of effectiveness for implemented management actions; and upcoming priority work.
Technical Report (as needed)	Upon completion of significant milestones in the management response	Provide technical details of the management response.	Detailed description of the technical information gathered and analyses completed as part of the management response.

Reports and information will be publicly available on the Open Government Portal, as well as EPA and LUF webpages. Additionally, monitoring data from all of Alberta's LTRN and TMN stations are available on Alberta's Water Quality Data Portal.

10.3. Additional Considerations for Management Response

10.3.1. Closing a Management Response

A management response will continue even if the indicator does not exceed a threshold in a subsequent year. A management response may be closed if preliminary assessment results in the assignment of Level 1, if the investigation for indicators assigned Level 2 or 3 determines that the source is natural and no management actions can be identified, or if water quality conditions improve and/or the issue is no longer considered to be of concern.

10.3.2. Other Management Responses

In addition to management responses initiated under the Framework (i.e., threshold exceedances for primary indicators at the primary monitoring locations), a management response may be initiated for any issue that EPA determines needs to be explored. This includes concerns about primary indicators that have not exceeded a threshold, issues related to secondary indicators or secondary stations under the Framework, or other parameters not included in the Framework.

10.4. Framework Review and Renewal

Apart from the ongoing implementation cycle described above, the Framework is subject to periodic review to evaluate its relevancy and effectiveness in achieving the regional objective and to assess the Framework's alignment with other policies and initiatives to ensure consistency of management intent and processes. This review is intended to take place within a maximum of ten years. The Framework will also be reviewed when it is incorporated into the regional plan. These review processes offer the opportunity for amendment and continuous improvement of the Framework.

11. Roles and Responsibilities for Framework Implementation

EPA, other Government of Alberta departments and agencies, Indigenous communities and organizations, and stakeholders all have responsibilities related to managing surface water quality in relation to this Framework. EPA will provide leadership for the implementation of the Framework and will work with relevant parties as described below. These roles and responsibilities are described only briefly in the context of the Framework and will be further clarified as they continue to evolve.

11.1. Alberta Environment and Protected Areas

EPA's key responsibilities include:

- Framework implementation, including:
  - oversight and delivery of monitoring, ensuring data availability, quality, and rigour;
  - completing annual review and assessment of surface water quality data, relative to Framework thresholds;
  - initiating and leading a management response, when required, based on the assessment of data: includes investigation, identification, delivery, and evaluating the effectiveness of management actions;
  - maintaining and supporting collaborative partnerships, e.g., identifying and facilitating the role of stakeholders and Indigenous communities and organizations for management response, facilitating a multi-stakeholder process as appropriate; and
  - communicating to the public on the Framework and its implementation, i.e., report on surface water quality conditions and management response.

- Framework renewal, including:
  - reviewing and updating the Framework, continuing to adapt and refine indicators and thresholds as knowledge improves; and
  - conducting ongoing evaluation of the Framework's alignment with other policies and initiatives to ensure consistency of management intent and process.

EPA also has Framework responsibilities related to its role as a regulatory agency, as described below.

11.2. Regulatory Agencies

EPA is the primary regulator responsible for regulating activities that may impact water resources in Alberta, including activities within the industrial, municipal, agricultural, and forestry sectors. The AER is the single regulator of energy development for upstream oil and gas, oil sands, and coal production in Alberta, from initial application through to reclamation. The *Environmental Protection and Enhancement Act* (EPEA) is the primary tool used by regulators to manage potential impacts from these activities on surface water quality.

Regulatory decision makers will consider framework indicators, as well as their condition and any ongoing management response to threshold exceedances (e.g., status of and any findings from investigation) when making decisions. Specific requirements (e.g., monitoring or modelling) may be included in new or amended approvals to align with the framework and support any ongoing management response.

Regulatory agencies may be requested to support Framework investigations and provide information and analyses related to the contribution of the respective regulated activities to the observed surface water quality condition. If these activities are found to be contributing to observed conditions, the agencies may be asked to support the identification and implementation of appropriate management actions. Regulatory agencies serve as a liaison between EPA and the approval holder and oversee any management actions undertaken by the approval holder.

11.3. Indigenous Peoples and Indigenous Government Organizations

The unique knowledge, practices, and rights that Indigenous peoples have as traditional users of the land and waterways in the Upper Athabasca Region is acknowledged. Ongoing dialogue and collaboration with Indigenous communities and organizations is important to better integrate Indigenous perspectives in the planning and delivery of environmental management programs. EPA will continue to work with Indigenous communities and organizations to explore meaningful ways to participate in Framework implementation and future Framework renewal.

11.4. Watershed Planning and Advisory Councils

The Athabasca Watershed Council and Lesser Slave Watershed Council are unique stakeholders with expertise in watershed management and representation from broad interests across the region. These organizations will be well positioned to support the implementation of the Framework, specifically as related to understanding the impact of non-regulated activities (i.e., nonpoint sources) and developing management actions to address related water quality issues.

11.5. Local Governments

Local governments play a key role in Framework implementation by aligning their policies and plans with the objectives of the Framework and managing municipal activities to achieve the desired outcomes. Municipalities play a particularly important role in managing key sources of non-point source pollution and may be asked to support a management response, including the implementation of management actions, for related indicators. Local governments should consider indicator condition and any ongoing management response to threshold exceedances when making decisions, including the status of and any findings from investigations.

11.6. Other Stakeholders

Other parties potentially affecting, or affected by, the issue under investigation will be identified based on their role, representation, and expertise, and may be engaged in a collaborative process to support the management response. Relevant parties may provide information and data and/or conduct analyses to support investigation of source attribution. For example, industrial stakeholders may be asked to conduct modelling and assess how current and planned operations influence local and regional surface water quality. Relevant parties may also be asked to develop and implement management actions and evaluate their effectiveness.

Abbreviations and Acronyms

AER	Alberta Energy Regulator
ALSA	*Alberta Land Stewardship Act*
AWC	Athabasca Watershed Council
CCME	Canadian Council of Ministers of the Environment
ECCC	Environment and Climate Change Canada
EMF	Environmental Management Framework
EPA	Environment and Protected Areas
EPEA	*Environmental Protection and Enhancement Act*
GOA	Government of Alberta
LSWC	Lesser Slave Watershed Council
LTRN	Long-term River Network
LUF	Land Use Framework
TMN	Tributary Monitoring Network
UAR	Upper Athabasca Region
UARP	Upper Athabasca Region Plan
WPAC	Watershed Planning and Advisory Council (see AWC and LSWC above)
WSG	Watershed Stewardship Group

Terminology

Aquatic Ecosystem	"Aquatic ecosystem" is synonymous with the definition of "aquatic environment" under the Water Act: "the components of the earth related to, living in or located in or on water or the beds or the shores of a water body, including but not limited to: all organic and inorganic matter, and living organisms and their habitat, including fish habitat, and their interacting natural systems". A healthy aquatic ecosystem is an aquatic environment that sustains its ecological structure, processes, functions, and resilience within its range of natural variability.
Contaminant/ Pollutant	A substance in a concentration or amount that adversely alters the physical, chemical, or biological properties of the natural environment.
Cumulative effects	Combined effects of past, present, and reasonably foreseeable land-use activities, over time, on the environment.
Indicator	Parameters that are measured to provide information about environmental condition; metrics are applied to the measurements to compare with defined triggers and limits.
Limits	Numerical thresholds at which the risk of adverse effects on health or environmental quality is becoming unacceptable.
Metric	A procedure for processing monitoring data to determine an indicator value to compare to triggers and limits. In the Framework, metrics summarize parameter measurements over a specific timeframe at a specific location.
Non-point Source Pollutant	Pollution that enters a water body from diffuse or undefined sources and is usually carried by runoff.
Parameter	Chemical, biological or physical characteristics of water that are measured as part of monitoring for water quality.
Point Source Pollution	Pollution that originates from an identifiable cause or location, such as a sewage treatment plant.
Substance	From the EPEA, a 'substance' is defined as: i) Any matter that: a. Is capable of becoming dispersed in the environment, or b. Is capable of being transformed in the environment into matter referred to in a., ii) Any sound, vibration, heat, radiation or other form of energy, and iii) Any combination of things referred to in i) and ii).
Target	A concentration or narrative statement that management aims to achieve or do better than.
Toxicity	The adverse effect on the growth, reproduction, or survival of an organism.
Triggers	Numerical thresholds set in advance of limits as early warning signals for evaluation and proactive management.
Wastewater	The liquid waste generated through various industrial and municipal processes.

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Appendix A: Approach Used to Define Trigger Values

The baseline data periods used to calculate trigger values for primary indicators for the Athabasca River were as follows:

- The Athabasca River at the Town of Athabasca: Data used for general indicators (except for colour), and nutrients (except for Nitrate, and total and dissolved phosphorus) ranged from 1987 to 2018. Data for nitrate and E.coli ranged from 1998, and for total and dissolved phosphorus ranged from 2003 to 2018. For colour data started from 2008. The start date for various metals was slightly different, due to data availability and/or changes in analytical methods. Data for metals began in 2004, with the exception of total mercury, which began in 2007.

Once the baseline period of record is clearly defined for each indicator and station, each dataset was divided into the open-water (April-October) and winter (November-March) seasons and summary statistics were calculated to determine the 50th and 90th percentile values. The Turnbull method for interval-censored data (a variation of the nonparametric Kaplan-Meier estimate; Turnbull, 1976) was used to compute summary statistics using the cenfit function from the NADA Package in R (Lee, 2017).

One challenge with the Turnbull method is that it does not provide an estimate of the median when greater than 50 per cent of the dataset is censored; it simply reports the lowest detection limit. Additionally, there were changes in the limits of detection for multiple parameters throughout the historic datasets, including several parameters where the detection limits increased. To address this limitation, the maximum detection limit from the baseline and recent dataset (i.e., from the start of the baseline period to the most recently collected samples) was selected (excluding potential detection limit outliers) for each indicator, and all values in the dataset at or below this value were determined to be censored. The maximum detection limit from the baseline and recent dataset was then substituted for all censored data. For censored data that were outliers and above the maximum detection limit, their value was substituted in these limited instances. If more than 50% (or 90%) of the dataset were censored after this process, the maximum detection limit was applied as the median (or peak) trigger value. Using this approach prevents false step trends in data and facilitates the analysis of data with different detection limits. One limitation with this approach is that the detection limits will have to be reviewed on an annual basis and any significant changes (e.g., increases in the detection limit) may result in the need, in limited scenarios, to review and potentially update the summary statistics used to generate the trigger values.

The following terms are used to describe the definition and evaluation of triggers:

Historical data: All data since commencement of sampling.

Baseline data: Period of record used to calculate trigger values.

Reporting data: Period of record used in annual evaluation of threshold exceedances; a three-year rolling window for trigger evaluation and one-year period for limit evaluation.

Interim data: Period of record between the baseline period and reporting period.

Appendix B: Annual Evaluation and Reporting of Surface Water Quality Conditions

1. Evaluation of Trigger Exceedances

Changes in indicator condition relative to trigger values will be evaluated annually, using a reporting dataset consisting of the last three years of data (i.e., three-year rolling window). This dataset is first separated into the open-water and winter seasons, with each season then assessed independently.

1.1 Median Triggers

Step 1: Direct Comparison
The first step in determining median trigger exceedances is the comparison of the reporting data with trigger values. Seasonal 50th percentile values (i.e., medians) are calculated from the reporting dataset for primary indicators at the primary station. If these values are equal to or greater than the median trigger value, the indicator is flagged for further statistical analyses

Step 2: Test of Statistical Significance
For those indicators flagged in the first step, the second step of the evaluation is the test of statistical significance. For indicators where 50% or more of the baseline data is censored, the median is the maximum detection limit, excluding outliers (See Appendix A). Once the percent of censored data surpasses the 50th percentile (i.e., the median), any increase in the percent of censored data, or conversely a decrease in the percent of detected data, will have no impact on the trigger values. Accordingly, an additional screening is implemented on highly censored data prior to conducting tests for statistical significance for median trigger exceedances. In cases where 50% or more of the baseline data is censored, the percent of detected data in the reporting dataset will be compared to the percent of detected data in the baseline dataset. Any increase in the percent of detected data in the reporting dataset relative to the baseline dataset will trigger statistical tests to determine if the compliance data is significantly different than the baseline data.

Two tests are run to determine whether the difference between the reporting data and baseline data is significantly different. The non-parametric Wilcoxon rank sum test (i.e., Mann Whitney U-test) is run in R using the wilcox.exact function from the exactRankTests package (Hothorn and Hormik, 2012), using an exact one-sided test and a significance level of 0.05. If the reporting data includes censored values, the maximum method detection limit (MDL) from the baseline and reporting datasets is substituted for the test. For highly censored datasets, the cendiff function is run in R from the NADA package (Lee, 2017) with the maximum MDL again substituted for censored data. A median trigger exceedance occurs if the appropriate test indicates a statistically significant difference between the reporting and baseline data.

1.2 Peak Triggers

Step 1: Direct Comparison
The first step in determining peak trigger exceedances is the comparison of the reporting data with peak trigger values. If any of the samples in the reporting dataset is higher than the corresponding peak trigger value, the indicators are flagged for further statistical analysis. As this analysis focusses on individual samples exceeding the 90th percentile, there is no need to account for the amount of censored data in these datasets. For example, if the reporting dataset is highly censored and there are no samples greater than the baseline peak trigger, no additional tests for statistical significance would be conducted as there was no initial Step 1 trigger exceedance.

Step 2: Test of Statistical Significance
The second step of the evaluation, for those indicators flagged in the first step, is the test of statistical significance. Binomial tests are used to determine whether the frequency of observations in the reporting dataset that are above the peak trigger value is statistically significant. A peak trigger exceedance occurs if the binomial test indicates that the observed number of individual exceedances in the reporting, based on the samples collected, is likely to be greater than an acceptable degree of violation (i.e., 5%) when applied to the waterbody as a whole. The binomial test is run in R with the binom.test function from the stats package (R Core Team, 2020) running a one-sided test and a significance level of 0.05.

2. Evaluation of Limit Exceedances

The reporting dataset for limit evaluation is comprised of data from a single year, split into the open water and winter seasons. A limit is exceeded if the seasonal median of the reporting data exceeds the limit for a given indicator. Using data from a single year was found to be more conservative in identifying limit exceedances than using data from a three-year window. As the determination of limit exceedances does not rely on tests of statistical significance, a smaller dataset is appropriate for annual reporting.

For indicators where the limit is calculated using toxicity modifying factors (i.e., sulphate, total lead, total cadmium, total cobalt, total ammonia), individual limits are calculated for each sample in the reporting period using guideline equations. Individual concentrations from the reporting data are then compared against corresponding calculated limits. If greater than 50% of all months exceed their calculated limits for a specific parameter at a specific site within a season, this is identified as a limit exceedance.

3. Reporting on Surface Water Quality Conditions

Results of the annual evaluation of surface water conditions will be provided in the Status of Surface Water Condition report, along with details of the specific statistical methods used. Table B1 summarizes the evaluation results to be included in this report.

TABLE B1. SUMMARY OF EVALUATION RESULTS IN THE STATUS OF SURFACE WATER CONDITION REPORT

	Primary Indicator	Secondary Indicator*
Primary Station	Summary statistics of reporting data, including determination of trigger and limit exceedances using methods defined in this Appendix. Evaluation of limit exceedances will include the number of individual samples in the reporting data exceeding the limit value.	Summary statistics of reporting data, including comparison against guideline values where available, using methods defined in this Appendix. Evaluation of guideline exceedances will include the number of individual samples in the reporting data exceeding the most stringent guideline value. The two-step assessment process for median and peak comparisons between baseline and reporting data outlined in this Appendix will be conducted.
Secondary Station*	Summary statistics of reporting data, including comparison against guideline values where available, using methods defined in this Appendix. Evaluation of guideline exceedances will include the number of individual samples in the reporting data exceeding the most stringent guideline value.	Summary statistics of reporting data, including comparison against guideline values where available, using methods defined in this Appendix. Evaluation of guideline exceedances will include the number of individual samples in the reporting data exceeding the most stringent guideline value.

*Triggers and limits do not apply for secondary indicators or at secondary stations.

Appendix C: Summary Statistics

TABLE C1: SUMMARY STATISTICS FOR SURFACE WATER QUALITY INDICATORS FOR THE ATHABASCA RIVER AT THE TOWN OF ATHABASCA (STATION NO: AB07BE0010)

Note: n= sample size, P= percentile, BDL=Below analytical or maximum detection limit, DL=Detection Limit.

Primary Indicator	Season	Min	10th P	25th P	Median	75th P	90th P	Max	n	% detected data [a]	Max DL	Period
Escherichia coli (CFU/ 100ml)	Open	BDL	BDL	BDL	BDL	BDL	40	300	137	23	10	1998-2018
	Winter	BDL	BDL	BDL	BDL	BDL	BDL	240	93	10	10	1999-2018
Colour (TCU)	Open	3	6	12	17	37	69	140	74	100	n/a	2008-2018
	Winter	3	12	13	18	23	28	47	53	100	n/a	2008-2018
Dissolved Oxygen (DO) (mg/L)	Open	7.6	8.47	8.83	9.65	11.11	12.16	15.97	204	100	n/a	1988-2018
	Winter	7.72	8.68	9.35	10.89	12.96	13.72	14.45	134	100	n/a	1987-2018
pH (field)	Open	6.18	7.68	7.91	8.1	8.25	8.39	8.95	216	100	n/a	1988-2018
	Winter	6.77	7.28	7.44	7.65	7.9	8.17	10.1	149	100	n/a	1987-2018
Total Suspended Solids (mg/L)	Open	BDL	4.7	10	34	122	255	1680	213	95	1	1988-2018
	Winter	BDL	BDL	BDL	1.3	3.1	6	28	147	54	1	1987-2018
Total Dissolved Phosphorus (mg/L)	Open	BDL	BDL	0.004	0.0064	0.011	0.023	0.061	100	81	0.003	2003-2018
	Winter	BDL	0.005	0.006	0.0072	0.011	0.015	0.04	66	98	0.003	2003-2018
Total Phosphorus (mg/L)	Open	BDL	0.011	0.016	0.038	0.094	0.246	0.485	101	99	0.003	2003-2018
	Winter	BDL	0.008	0.01	0.012	0.015	0.021	0.057	66	98	0.003	2003-2018
Nitrate (mg/L)	Open	BDL	BDL	BDL	0.0051	0.045	0.089	0.35	140	55	0.003	1998-2018
	Winter	BDL	BDL	0.048	0.13	0.185	0.213	0.264	92	89	0.003	1999-2018
Total Ammonia (mg/L)	Open	BDL	BDL	BDL	BDL	0.05	0.05	0.37	211	41	0.05	1988-2018
	Winter	BDL	BDL	BDL	0.05	0.061	0.085	0.32	146	71	0.05	1987-2018
Total Nitrogen (mg/L)	Open	0.069	0.071	0.071	0.265	0.565	0.907	1.947	212	54	n/a	1988-2018
	Winter	0.125	0.248	0.383	0.475	0.559	0.61	1.704	146	87	n/a	1987-2018
Chloride (mg/L)	Open	BDL	1	1.2	1.7	2.4	3.8	11.3	208	97	1	1988-2018
	Winter	BDL	2.6	3.1	3.9	4.7	5.9	8.4	146	99	1	1987-2018
Potassium (mg/L)	Open	0.4	0.71	0.85	1.01	1.43	2.1	6.3	209	100	n/a	1988-2018
	Winter	0.63	1.3	1.53	1.7	1.92	2.3	18	146	100	n/a	1987-2018
Sodium (mg/L)	Open	2.7	4.5	5.6	6.8	8.9	12.5	25.3	209	100	n/a	1988-2018
	Winter	9.6	12.1	14.2	17.1	19.2	22	31.5	146	100	n/a	1987-2018
Sulphate (mg/L)	Open	2	15.5	20.1	25.2	31.6	39.4	62.4	209	100	n/a	1988-2018
	Winter	19	35.8	43	49.1	54	61	76	146	100	n/a	1987-2018
Specific Conductance (µS/cm)	Open	180	212	224	250	285	324	499	209	100	n/a	1988-2018
	Winter	270	350	382	419	449	473	530	145	100	n/a	1987-2018
Dissolved Organic Carbon (mg/L)	Open	1.2	3	4	5.8	8.1	11.1	25.1	213	100	n/a	1988-2018
	Winter	2.8	4.9	5.4	6.1	7.1	8.5	12	146	100	n/a	1987-2018

Primary Indicator	Season	Min	10th P	25th P	Median	75th P	90th P	Max	n	% detected data [a]	Max DL	Period
Total Cadmium (µg/L)	Open	0.007	0.018	0.021	0.03	0.056	0.144	0.384	76	100	n/a	2004-2018
	Winter	0.01	0.016	0.021	0.025	0.034	0.05	0.052	39	100	n/a	2006-2018 [b]
Total Selenium (µg/L)	Open	BDL	BDL	BDL	BDL	0.295	0.5	1.31	76	50	0.2	2004-2018
	Winter	BDL	BDL	0.23	0.306	0.356	0.402	0.45	39	77	0.2	2006-2018 [b]
Total Zinc (µg/L)	Open	1	1.77	2.5	4.3	10.8	20.9	52.1	76	100	n/a	2004-2018
	Winter	0.707	1.1	1.6	2	3.2	4.72	7.68	39	100	n/a	2006-2018 [b]
Dissolved Aluminium (µg/L)	Open	1	3.98	5.4	10.4	21	41.7	83	76	100	n/a	2004-2018
	Winter	1.31	1.81	2.13	2.98	4.44	8.07	23.3	39	100	n/a	2006-2018 [b]
Dissolved Boron (µg/L)	Open	6.28	8.44	9.47	11.5	12.8	15.9	19.3	76	100	n/a	2004-2018
	Winter	12.4	14.1	15	18.6	20.3	24	38.7	39	100	n/a	2006-2018 [b]
Dissolved Cadmium (µg/L)	Open	BDL	0.008	0.009	0.0126	0.018	0.026	0.040	76	99	0.002	2004-2018
	Winter	0.007	0.013	0.018	0.022	0.03	0.045	0.049	39	100	0.002	2006-2018 [b]
Dissolved Cobalt (µg/L)	Open	BDL	0.026	0.036	0.0526	0.083	0.136	0.224	76	99	0.006	2004-2018
	Winter	BDL	0.018	0.023	0.0354	0.072	0.146	0.188	39	95	0.006	2006-2018 [b]
Dissolved Copper (µg/L)	Open	0.33	0.57	0.666	0.883	1.33	2.03	2.98	76	100	n/a	2004-2018
	Winter	0.434	0.6	0.74	0.82	0.989	1.19	1.33	39	100	n/a	2006-2018 [b]
Dissolved Iron (µg/L)	Open	BDL	BDL	16	44.6	93	161	253	76	89	2	2004-2018
	Winter	BDL	13.3	24	42	65	90.2	351	39	97	2	2006-2018 [b]
Dissolved Nickel (µg/L)	Open	BDL	BDL	0.163	0.589	1.22	1.98	2.63	76	89	0.006	2004-2018
	Winter	BDL	BDL	0.217	0.467	0.92	1.17	1.81	39	90	0.006	2006-2018 [b]
Dissolved Strontium (µg/L)	Open	114	167	206	237	277	326	426	76	100	n/a	2004-2018
	Winter	200	329	350	384	428	473	511	39	100	n/a	2006-2018 [b]
Dissolved Uranium (µg/L)	Open	0.291	0.313	0.363	0.405	0.47	0.587	0.686	76	100	n/a	2004-2018
	Winter	0.334	0.519	0.567	0.63	0.677	0.736	0.74	39	100	n/a	2006-2018 [b]
Dissolved Vanadium (µg/L)	Open	0.07	0.139	0.174	0.222	0.319	0.466	0.78	76	100	n/a	2004-2018
	Winter	0.058	0.12	0.142	0.178	0.202	0.32	0.35	39	100	n/a	2006-2018 [b]
Secondary Indicators												
Total Mercury (ng/L)	Open	0.15	0.63	1.14	2.39	7.64	16.4	22.2	60	100	0.08	2007-2018
	Winter	BDL	0.357	0.46	0.512	0.66	0.9	5.17	37	95	0.08	2008-2018
Total Copper (µg/L)	Open	0.63	0.731	1.08	1.55	3.76	7.31	16.4	76	100	n/a	2004-2018
	Winter	0.438	0.707	0.811	0.9	1.18	1.44	1.62	39	100	n/a	2006-2018 [b]
Total Cobalt (µg/L)	Open	0.026	0.090	0.178	0.427	1.57	2.67	7.49	76	100	n/a	2004-2018
	Winter	0.004	0.027	0.039	0.061	0.085	0.272	0.424	39	100	n/a	2006-2018 [b]

[a] Based on censored data and data that was substituted with Max DL

[b] The datasets used to calculate summary statistics had a gap for winter 2007.