Source Water Protection Plan

Edmonton's Drinking Water System

EPCOR

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SECTION 1 – INTRODUCTION

Source Water Protection (SWP) is part of a multi-barrier approach (Figure 1) for water utilities to protect both quality and quantity of water sources. SWPP works to understand and mitigate potential risks to source water supplies through a watershed approach. The quality of a surface or groundwater source is a direct result of the natural processes and human activities that occur within a watershed or within or above an aquifer. A healthy, functional watershed with fewer human disturbances is more likely to generate high source water quality.

Although there are costs associated with protecting water sources due to monitoring, treatment and/or best management practices, there are also many benefits that generate economic vitality and growth. Communities with clean water are desirable places to live, improve quality of life, and reduce the threat of waterborne illnesses.

This plan was prepared for Edmonton's Rossdale and E.L. Smith water treatment plants (WTPs) which are operated by EPCOR Water Services Inc. (EPCOR), as part of EPCOR's due diligence to protect the communities it serves. EPCOR recognizes that it does not own most of the land within the watersheds in which it operates and is therefore committed to working with stakeholders to implement improvements and support science-based management in the watershed to protect its source water. EPCOR has a vested responsibility to ensure the drinking water provided to our customers does not pose a threat to public health and is satisfactory in its physical, chemical and aesthetic characteristics.

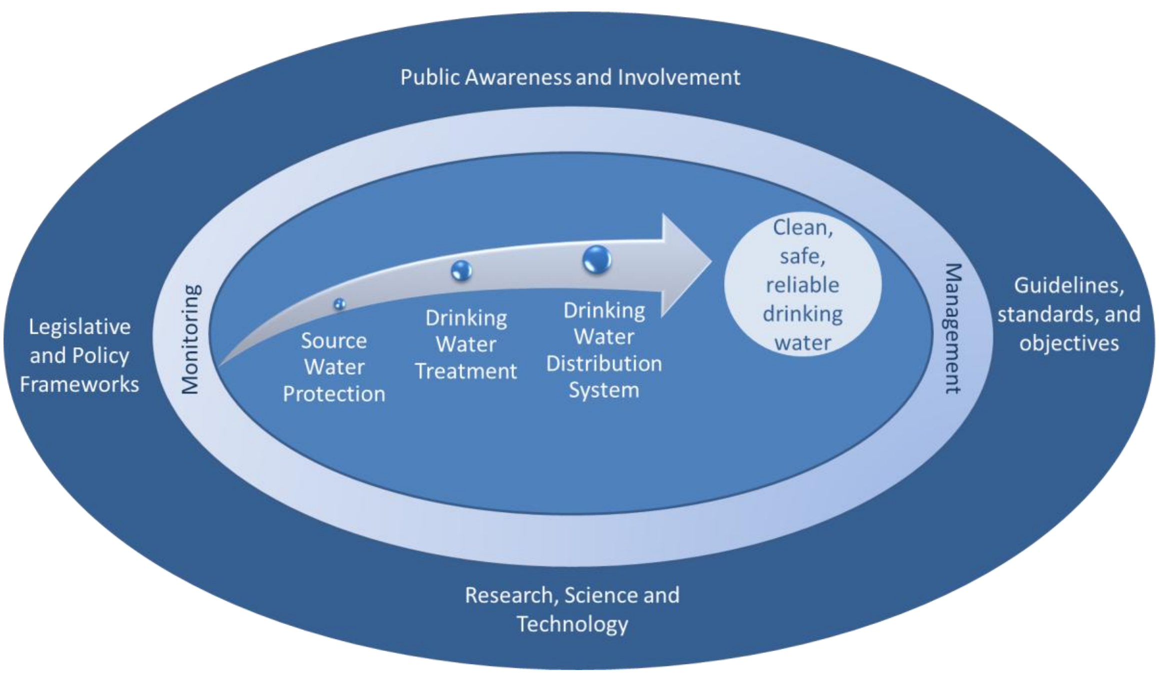


Figure 1. Components of the Multi-barrier Approach.

This plan compiles existing information on the North Saskatchewan River (NSR) and its watershed, the drinking water source for Edmonton, and uses this information to identify hazards, assess risks to source waters, and make recommendations on how to manage these risks. The plan updated regularly as new information becomes available.

Source Water Protection Planning is a strategy for water utilities designed to understand and minimize the impacts that human activities and natural events have on drinking water sources. As part of the process, it is critical to understand and characterize the watershed as the water quality in receiving waterbodies is affected by what is occurring on the land. The key components of a conceptual Source Water Protection Plan (SWPP) as defined by the Canadian Council of Ministers of the Environment (CCME) are outlined below (Figure 2).

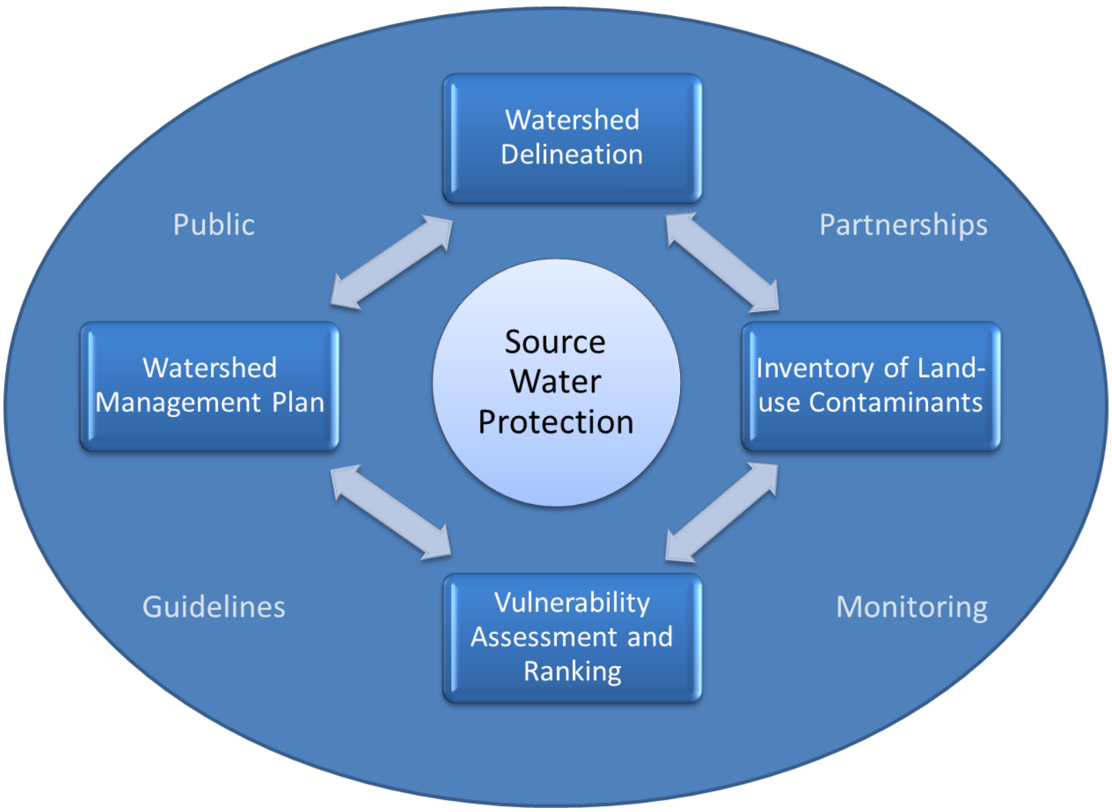


Figure 2. Components of Source Water Protection.

Similarly, the American Water and Wastewater Association (AWWA) developed a standard and a guide for Source Water Protection Plan development (AWWA G300-22). Successful source water protection programs may vary widely in their details, but successful programs share six fundamental elements:

1. source water protection plan vision and stakeholder involvement;
2. source water characterization;
3. source water protection goals;
4. source water protection action plan;
5. implementation of the action plan; and
6. periodic evaluation and revision of the entire program.

The Alberta Water Council's guide for Source Water Protection is also based on these same six elements (AWC 2020). Within this generalized framework, individual utilities may establish and maintain source water protection programs that account for their unique local conditions, incorporate the interests of local stakeholders, and reflect sustainable long-term commitments to the process by all parties.

The above elements were considered when developing the SWPP for EPCOR's Edmonton operations. As well, this SWPP addresses each of the components outlined by the CCME and provides recommendations on how to manage and mitigate risks to source waters.

SECTION 2 - SOURCE WATER PROTECTION PLAN VISION

The following is EPCOR's vision statement for the North Saskatchewan River SWPP:

- EPCOR is committed to ensuring clean and abundant water supplies for E.L. Smith and Rossdale WTPs through application of a source water protection program.
- EPCOR recognizes that source water protection is but one of the multiple barriers for ensuring the safety and quality of drinking water and that a successful plan requires input from stakeholders with whom it shares the watershed.
- EPCOR recognizes that it does not own a significant portion of the NSR watershed from which it draws raw water supply; therefore, it is committed to working with stakeholders in a collaborative watershed approach to implement management decisions that ensure a safe, secure drinking water supply for its customers.
- EPCOR recognizes that sufficient resources are required to implement the SWPP to meet its responsibility to ensure the drinking water provided to its customers does not pose a threat to public health and is satisfactory in its physical, chemical, and aesthetic characteristics.
- EPCOR recognizes that the SWPP is an "evergreen" plan and a focus on applying continual improvement principles to the 'Plan' through ongoing review is essential.

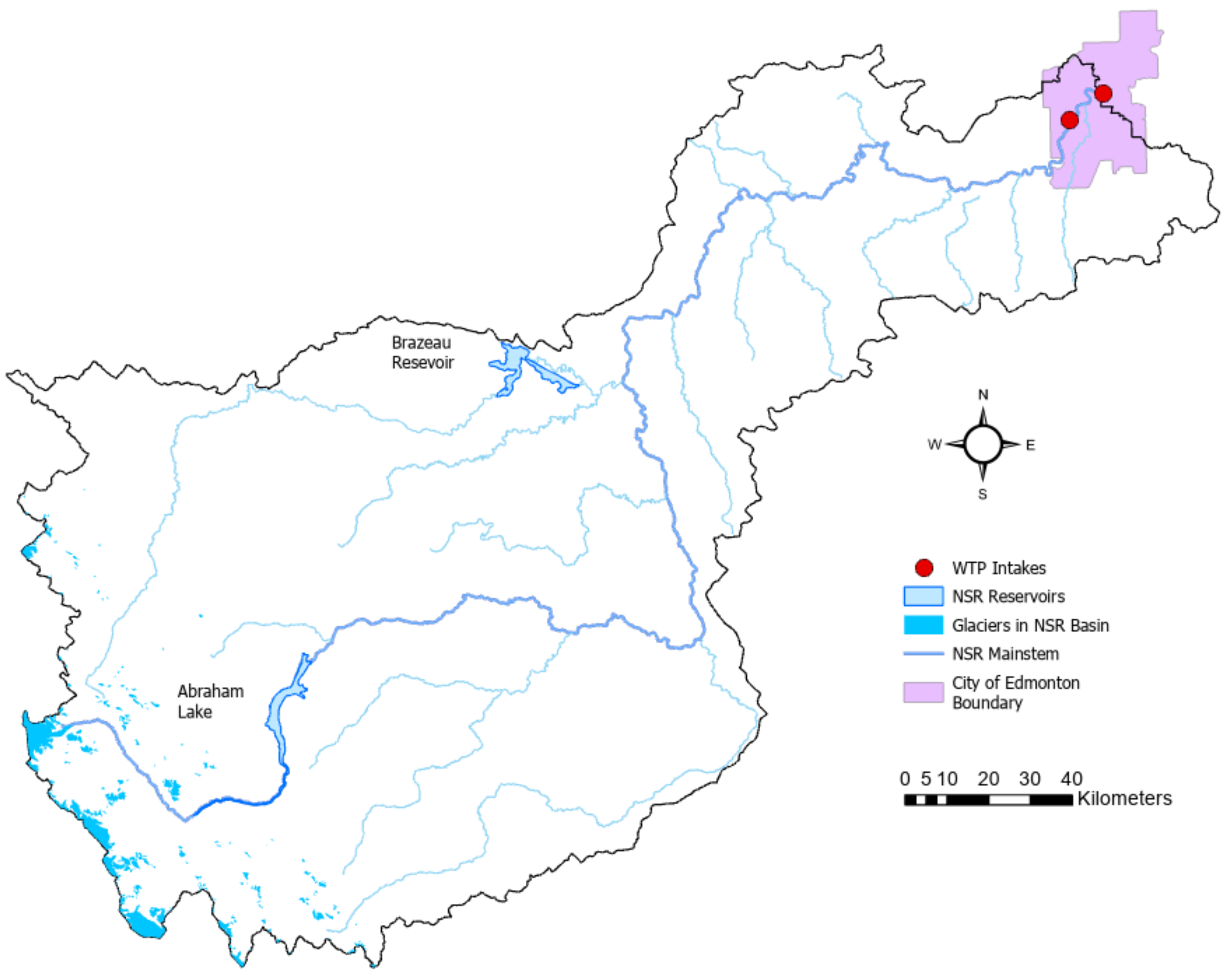
EPCOR also recognizes that there are multiple stakeholders involved in source water protection in the NSR watershed. Stakeholders include regulators, other municipalities, and water users upstream and downstream of Edmonton, Watershed Planning and Advisory Councils (WPACs), watershed stewardship groups, the Alberta Water Council, environmental non-governmental organizations and economic sectors such as agriculture, forestry, industry, oil and gas. Each of these stakeholders has an important role to play in SWP. EPCOR is engaged primarily with other stakeholders through participation on the North Saskatchewan Watershed Alliance (NSWA), which is the WPAC for the NSR, and the Headwaters Alliance and Urban Creeks Collaborative, which are comprised of upstream municipal council members and led by the NSWA. EPCOR also regularly engages other stakeholders directly.

SECTION 3 – SOURCE WATER CHARACTERIZATION

This section describes current land use and indicators of watershed health that could impact source water quality and quantity. It also includes a summary of water quality and drivers of water quantity including climate change impacts. This information allows an informed risk assessment.

3.1 Delineation of the Source Water Protection Area

Edmonton's source water protection area is the entire watershed upstream of the Rossdale Water Treatment Plant (WTP) in Edmonton, Alberta to the headwaters in the Rocky Mountains (Figure 3). For the purposes of this plan, the 'North Saskatchewan River watershed' refers to the 28,000 km^2 portion of the NSR's watershed that is upstream of Edmonton's Rossdale WTP.



Data Source: Government of Alberta [GoA] 2014

Figure 3. NSR Watershed Upstream of Edmonton.

Background on Edmonton's Water Treatment Plants (WTPs)

The North Saskatchewan River supplies raw water to both of Edmonton's WTPs: E.L. Smith and Rossdale. Raw river water is withdrawn through concrete intake structures located in the middle of the river and below the water surface at both locations. The E.L. Smith plant is located upstream of much of the city, though this is changing as Edmonton grows southward, while the Rossdale plant is located near the city centre (Figure 4). As a result, the Rossdale location experiences a greater effect on raw water quality due to stormwater runoff from the City of Edmonton's urban footprint. The Rossdale WTP has been in operation since 1903. The current plant was built in 1947 and expanded in 1955. The E.L. Smith WTP was built in 1976 and underwent a significant upgrade in 2008. E.L. Smith produces approximately 85,000 million liters per year (ML/y) of treated water, whereas Rossdale produces approximately 50,000 ML/y.

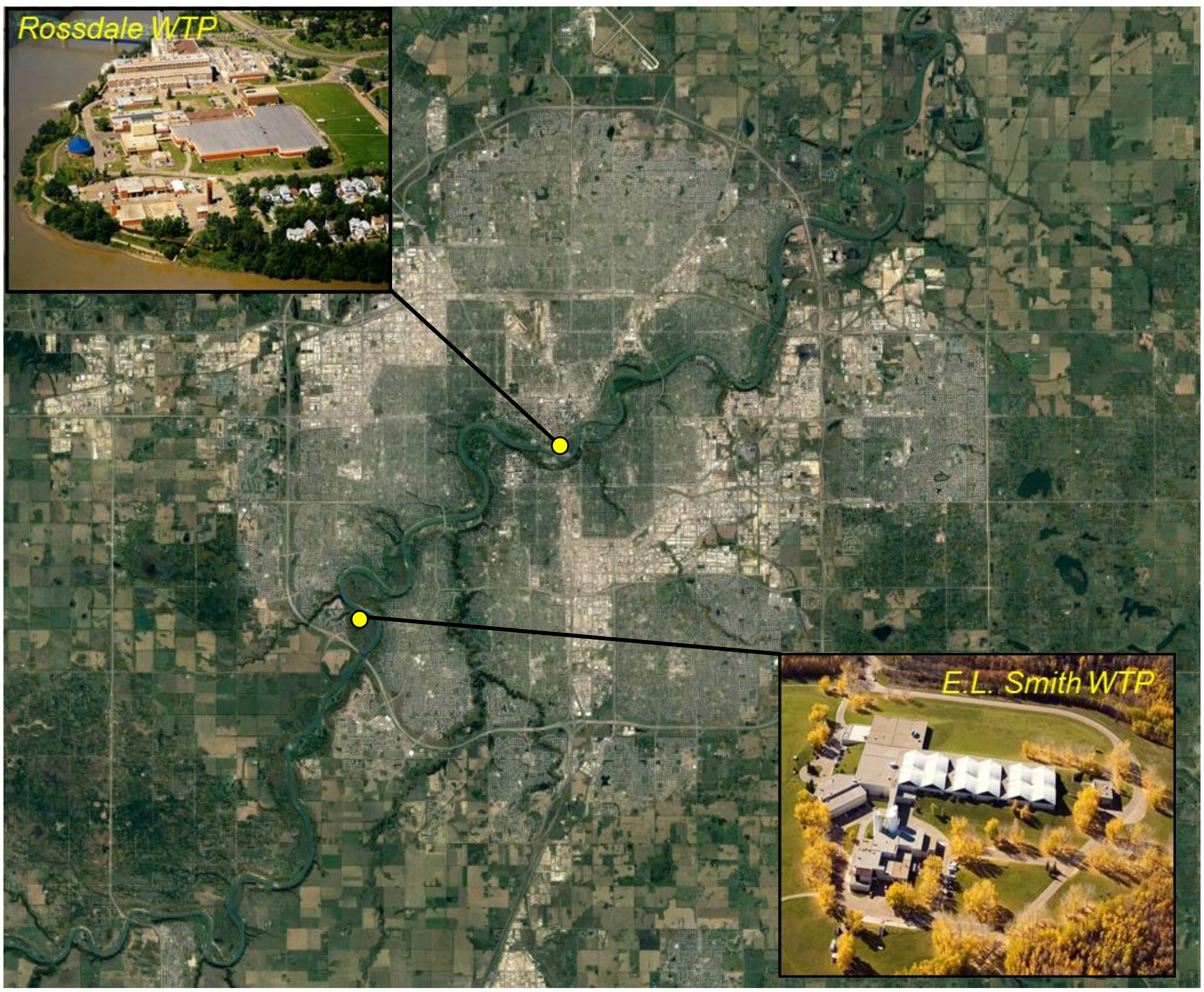


Figure 4. Location of Edmonton's Drinking Water Treatment Plants.

The process of producing drinking water at EPCOR's two WTPs includes coagulation, flocculation, filtration, and uses free chlorine, chloramine and UV light for disinfection. Both plants achieve at least a minimum of 5.5-log reduction for *Cryptosporidium* and *Giardia* and 4-log reduction for viruses. It was identified that reducing solids discharge from WTP processes during winter months would be beneficial for the NSR. In 2009, the Edmonton WTP's began to convert to direct filtration operation during the winter months which reduces solid waste discharges during these times. Since 2012, the WTPs have attempted to extend direct filtration mode of operation for up to seven months in the year (i.e. September through March); however, elevated colour (> 10 TCU) in the NSR in the fall and winter in some years has resulted in shorter periods of direct filtration.

The intake points at both WTPs are in the deepest part of the NSR, below the water surface so that oil, floating debris and ice will pass over them. Both WTPs are equipped with a turbidity, colour, temperature, pH, and ammonia on-line monitoring units. On-site water quality laboratory analysis is also completed to inform WTP processes and includes a suite of nutrients, suspended solids, colour, conductivity, hardness, chloride, bromide, bromate, fluoride, chlorine, total coliforms, total organic carbon, *E. coli*, *Cryptosporidium*, *Giardia,* pesticides, pharmaceutical and personal care products, microcystin, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and perfluoroalkylated substances (PFAS). The frequency varies depending on the parameter.

Both WTPs are designed to cope with the highly turbid water that occurs occasionally in the NSR. Turbidity of the NSR is usually less than five Nephelometric Turbidity Units (NTU) during the winter and between 10 and 60 NTU during the summer. However, the turbidity of the NSR can be as high as 7,300 NTU during large rainfall events. All turbidity values over 4,000 NTU have occurred during large rainfall events and subsequent high flow in the river during May and June rainfall events. As turbidity increases, it is more costly for the WTP to remove all the particles in the water and treat it properly for distribution. The WTPs also must treat the colour (a measure of dissolved organic matter) in the NSR. Colour is typically elevated during spring freshet and during periods of extended rainfall but is typically short-lived. High colour during spring runoff is also associated with taste and odour challenges. Moderately high colour in the NSR in the late fall and winter can also be a challenge for the WTPs to maintain operation in direct filtration and can require the plants to revert to conventional operation.

EPCOR's drinking water system does not have an upstream water quality warning station to warn the plants of a possible contaminant moving down the NSR. EPCOR has investigated the feasibility of installing an upstream monitoring station but cost and technological limitations limited feasibility. In the event of a possible spill/release that may affect the WTPs, EPCOR relies on communication from those responsible for the spill/release, Alberta Environment and Protected Areas (AEPA), the Alberta Energy Regulator (AER), the City of Edmonton's Fire Department, and EPCOR's internal team that operates the drainage system. EPCOR utilizes upstream meteorological and flow stations as well as cameras installed along major tributaries to inform when water quality in the NSR may change rapidly due to spring runoff and/or heavy rainfall events. EPCOR also receives notifications from AEPA regarding high water levels and floods that could damage the WTPs. There is work underway to develop a predictive model that uses meteorological data to predict high turbidity and colour events through machine learning. As well the SaskWatch Monitoring Program installs sondes (instruments that measure parameters in the water continuously) throughout the watershed that provide real-time water quality data and inform treatment.

3.2 Land Use/Cover and Contaminant Sources

3.2.1 General North Saskatchewan River Watershed

The headwaters of the North Saskatchewan River originate from the Saskatchewan Glacier located in the Columbia Icefield in Banff National Park. The NSR watershed drains an area of over 28,000 km^2 upstream of Edmonton. The whole NSR watershed in Alberta drains an area of approximately 57,000 km^2 and flows over 885 km through four natural regions from its headwaters to the Alberta/Saskatchewan border (Figure 5). A network of approximately 3,600 km of streams feed into the NSR along this journey through Alberta. The NSR begins in the Rocky Mountain Natural Region and Montane and Alpine subregions. These subregions are typified by cooler, mountainous landscapes with exposed rock and vegetation ranging from coniferous forests in higher elevations to mixed forests and grasslands in the valley areas. From there, the NSR flows through the Foothills subregion, where steep topography is covered by coniferous forests in the upper foothills and the rolling hills of Lower Foothills are covered with a greater mix of deciduous and coniferous forests. Just upstream of Edmonton, the NSR winds its way through the Boreal Forest and Parkland Regions, the land of which has largely been converted to agricultural or urban areas. These areas contribute runoff only during significant rainfall events and spring freshet. On a larger scale, the NSR joins the South Saskatchewan River in Saskatchewan and eventually empties into Hudson Bay as part of the Nelson River Basin.

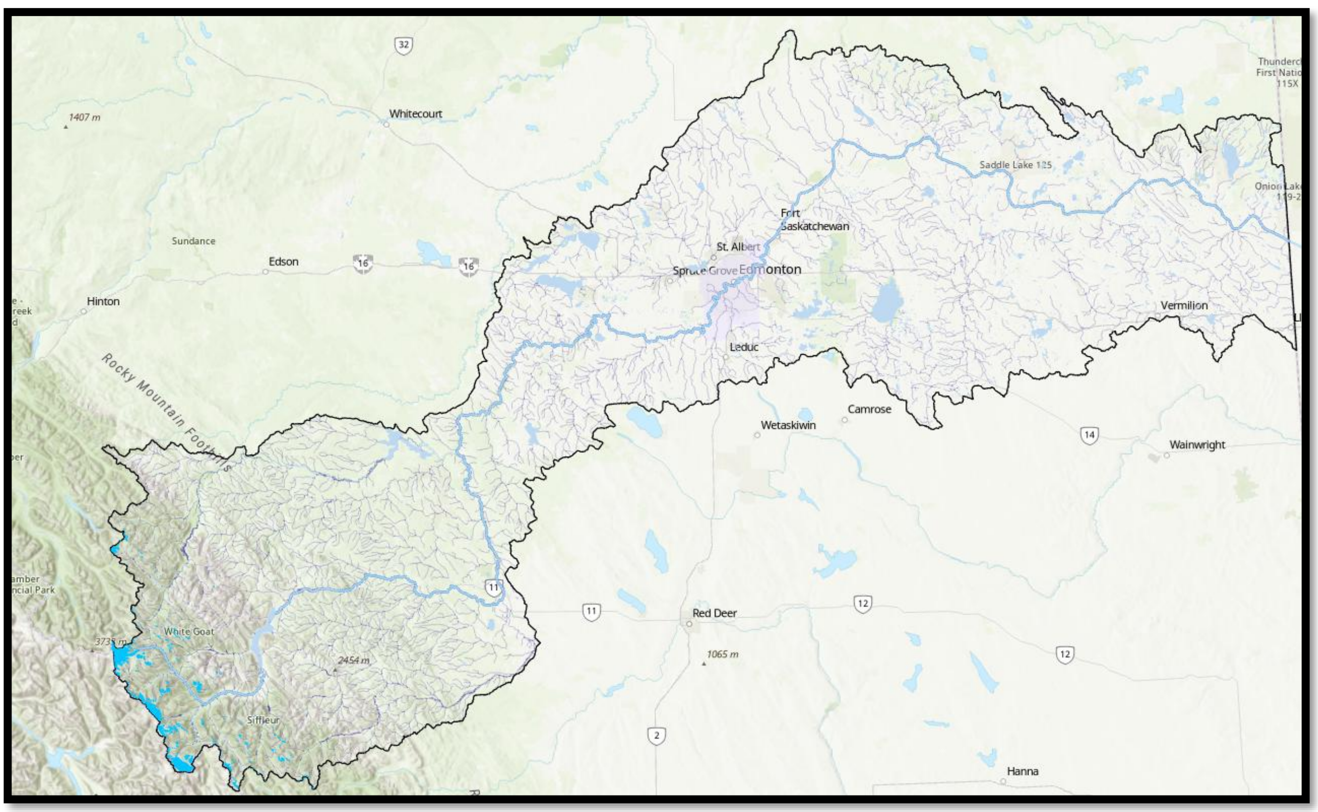


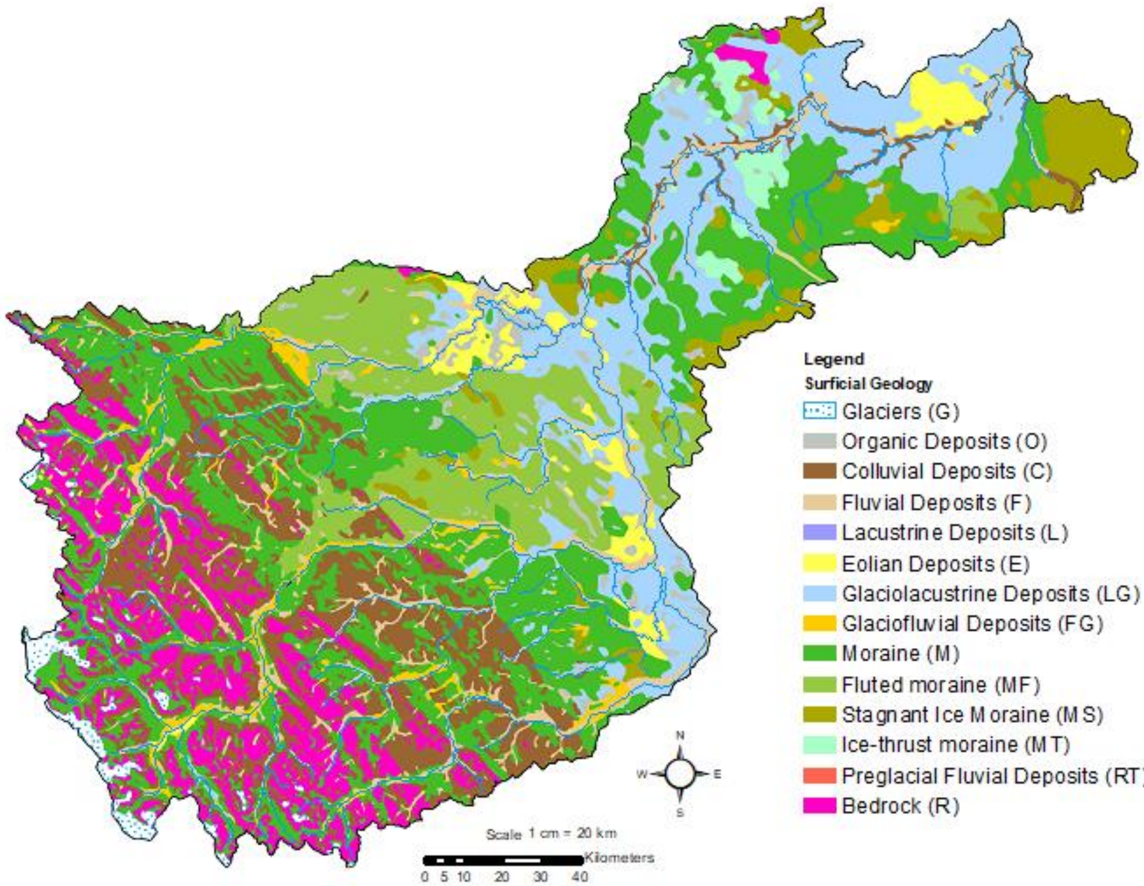
Figure 5. NSR Watershed in Alberta. Data Source: GoA 2011

3.2.2 Surficial Geology

The ancestral North Saskatchewan River flowed across the prairies for millions of years, forming multiple preglacial valleys that were subsequently buried during glaciation events (Godfrey 1993). About 27,000 years ago, a major glacier from the Canadian Shield advanced over the Edmonton region. When the glaciers retreated starting 15,000 years ago, runoff from the Rocky Mountains was blocked by the retreating ice sheets, forming large glacial lakes, including Glacial Lake Edmonton. The Edmonton River valley and NSR, as we see it today, took shape around 13,000 years ago when Glacial Lake Edmonton drained rapidly and carved out the rivers path down to the underlying bedrock. In some places the bed of the river is largely Cretaceous sedimentary rocks and there are formations that are 100 million years old, such as the Horseshoe Canyon Formation. Erosion of sediments continues today, but the rate is much less than during the initial glacial retreat. Effects of continued erosion are evident along the banks of the NSR, which form landslides into the river during higher flow periods.

The current surficial geology of the NSR basin reflects the glacial history and subsequent land drainage of Glacial Lake Edmonton. It is important to understand because the surficial geology impacts water chemistry in the NSR. The geology changes extensively between the headwaters and Edmonton (Figure 6). In the Rocky Mountains, the surficial geology is largely bedrock. In the upper foothills, the surficial geology turns largely to colluvial deposits and moraine, which are a mixture of materials such as clay, sand, pebbles, cobbles and boulders that have been moved by gravity and glacial ice, respectively. In the lower foothills, the surficial geology is largely fluted moraine, which is composed largely of glacial till that has been shaped by erosion and glaciation. Much of the surficial material in the headwaters is resistant to erosion, resulting in low sediment and particulates in the NSR mainstem and tributaries in this area. Along much of the NSR mainstem from Rocky Mountain House to Edmonton, and along many of the major tributaries in this reach, the surficial geology is composed largely of glaciolaucustrine deposits. These deposits are largely silts and clays that were deposited in glacial lakes, such as Glacial Lake Edmonton. These silts and clays are highly susceptible to erosion and are responsible for the silty and turbid nature of the NSR during periods of high flow.

The underlying geology of the NSR basin helps explain the observed water chemistry in the North Saskatchewan River- specifically high sediment during runoff periods. Human activities can result in increased erosion and generate elevated turbidity in the NSR, but the risk of negatively affecting drinking water is low as the WTPs are adapted to high sediment conditions.



Data Source: GoA 2024

Figure 6. Surficial Geology of the NSR Watershed.

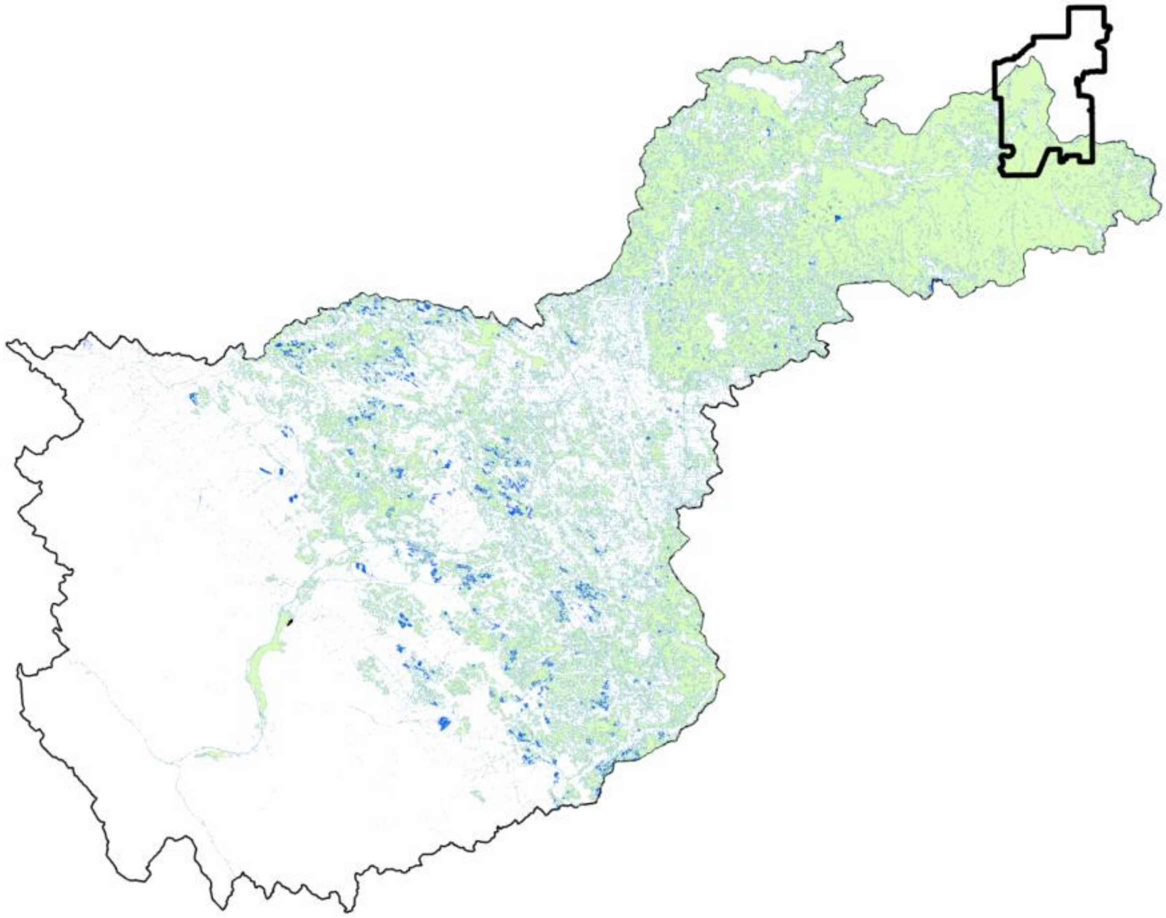
3.2.3 Human Footprint

The human footprint inventory is a metric for disturbance and or human influence in an area. It can be used as a general gauge of watershed health which can impact downstream of water chemistry or quantity. When watersheds are not healthy, they can lose their ability to filter pollutants, regulate water flow, and support diverse ecosystems, ultimately impacting water quality and biodiversity. However, the human footprint index doesn't distinguish between the type of disturbance and is best used as an early indicator of watershed health degradation. There is often disturbance threshold above which, natural processes and function are compromised and watershed health, water quality, and quantity are significantly affected. Research conducted on lake watersheds suggests that a human footprint greater than 50% will significantly alter lake water quality; however, it will depend on the watershed and the footprint type.

LOW RISK

While the human footprint in the NSR watershed is increasing, much of the recent increases are associated with forestry activity in the headwaters. Given current forestry practices including replanting and the low rate of harvest (~75 km^2 per year), impacts to water quality of the NSR at Edmonton are not considered significant, and pose a low risk to drinking water source.

The human footprint of the NSR watershed was 7,790 km^2 or 27% of watershed area in 2012; 8,600 km^2 in 2018 or 30.7% of the watershed area; and further and 8,867 km^2 or 31.7% in 2021 (Figure 7). The human footprint was calculated using Alberta Biodiversity Monitoring Institute's 2012, 2018, 2021 Wall-to-Wall Human Footprint data, which provides a comprehensive representation of human footprint in Alberta. The human footprint includes attributes and features related to energy, forestry, and agriculture industries, as well as urban development. This metric includes roads, dwellings, cutblocks, seismic lines, transmission lines, urban areas, reservoirs, well sites, etc. From a watershed perspective, given that just one third of the NSR watershed has a human footprint suggests that the watershed has a relatively low impact currently. The implication is that if hydrological function, forest succession, and natural disturbance regimes, for example, are maintained on at least 70% of landscape, then water chemistry and quantity would be maintained within its natural range. This assumes that water chemistry and quantity are driven by non-point sources rather than point sources, which is largely true for the NSR basin upstream of Edmonton. The human footprint is extremely low in the upper reaches of the watershed where most of the water originates, and extremely high in the areas near Edmonton; most of the disturbance of the NSR occurs between Drayton Valley and Edmonton. That said, permanent human footprint of the watershed upstream of Edmonton beyond 40% could have negative impacts on water quality and should be avoided.



Data Source: ABMI 2018 & 2021

Figure 7. Human Footprint in NSR Watershed in 2018 (green) and 2021 (blue and green).

3.2.4 Population and Municipal Boundaries

The NSR Watershed is divided by six rural county boundaries: Clearwater, Yellowhead, Brazeau, Wetaskiwin, Parkland and Leduc, as well as Jasper and Banff National Parks (Figure 8). The majority of the population is in the small urban municipal towns of Rocky Mountain House, Drayton Valley and Devon who have similar populations of approximately 7,000 people each (Table 1).

Table 1. Population and Growth of Municipalities in NSR Watershed

Community	2011	2016	2019	2022	% Change
Rocky Mountain House	7,161	6,792	6,668	6,603	-1% in last 5 years
Drayton Valley	7,389	7,426	7,373	6,802	-6% in last 5 years
Devon	6,751	6,734	6,779	6,689	-1% in last 5 years

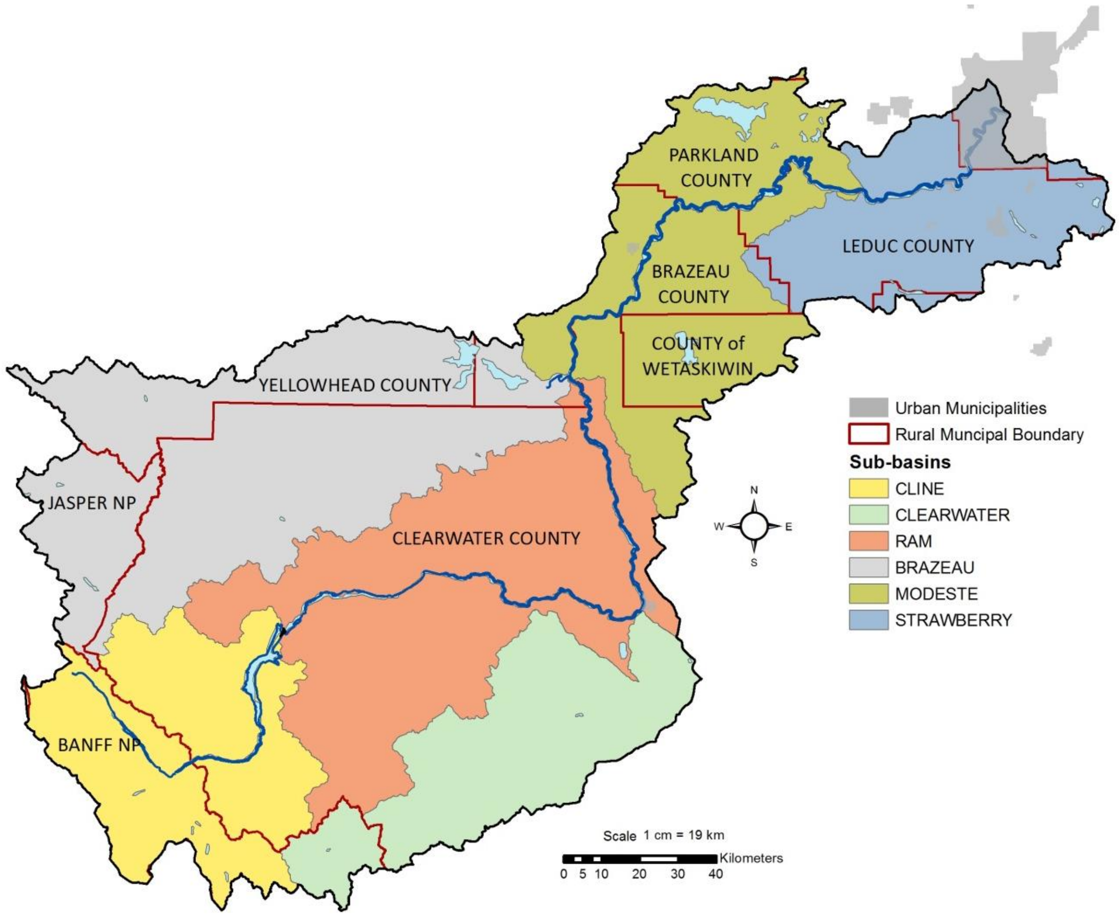
Source: GoA (2022)

The surrounding rural counties of Clearwater (12,099: -1% 5-year growth), Brazeau (7,962: -1% 5-year growth), Parkland (34,487: 4% 5-year growth) and Leduc County (14,547: 1% 5-year growth) combine for total population of just under 69,000, although not all this population is within the NSR watershed boundaries. Large portions of Yellowhead and Wetaskiwin counties are outside the NSR watershed and would contribute little to the overall population. In total, there are 18 hamlets, eight summer villages, four villages and five towns (which include Devon, Drayton Valley and Rocky Mountain House) scattered throughout the watershed. Population density in the headwater region is low and most of the population is located within the Drayton Valley to Edmonton corridor (Figure 9). It is estimated that approximately 90,000 people live in the NSR basin upstream of the City of Edmonton.

A significantly larger population lives upstream of the Rossdale WTP due to the inclusion of the drainage areas in south and west Edmonton, as well as the towns of Leduc and Beaumont. It is estimated that an additional ~550,000 people live in this area, and population is rapidly growing. The populations of Leduc and Beaumont increased 11% and 18%, respectively between 2017 – 2022. Edmonton's population grew 11% during this period, and much of this growth occurred in the southern edges of Edmonton. It is important to note that wastewater generated by the population within the greater Edmonton region is treated at the Gold Bar Wastewater Treatment Plant, located downstream of both WTPs. Stormwater impacts on water chemistry from this urbanized area are considered further in Sections 3.2.4 and 3.3. In general, stormwater runoff impacts are related to land use rather than population.

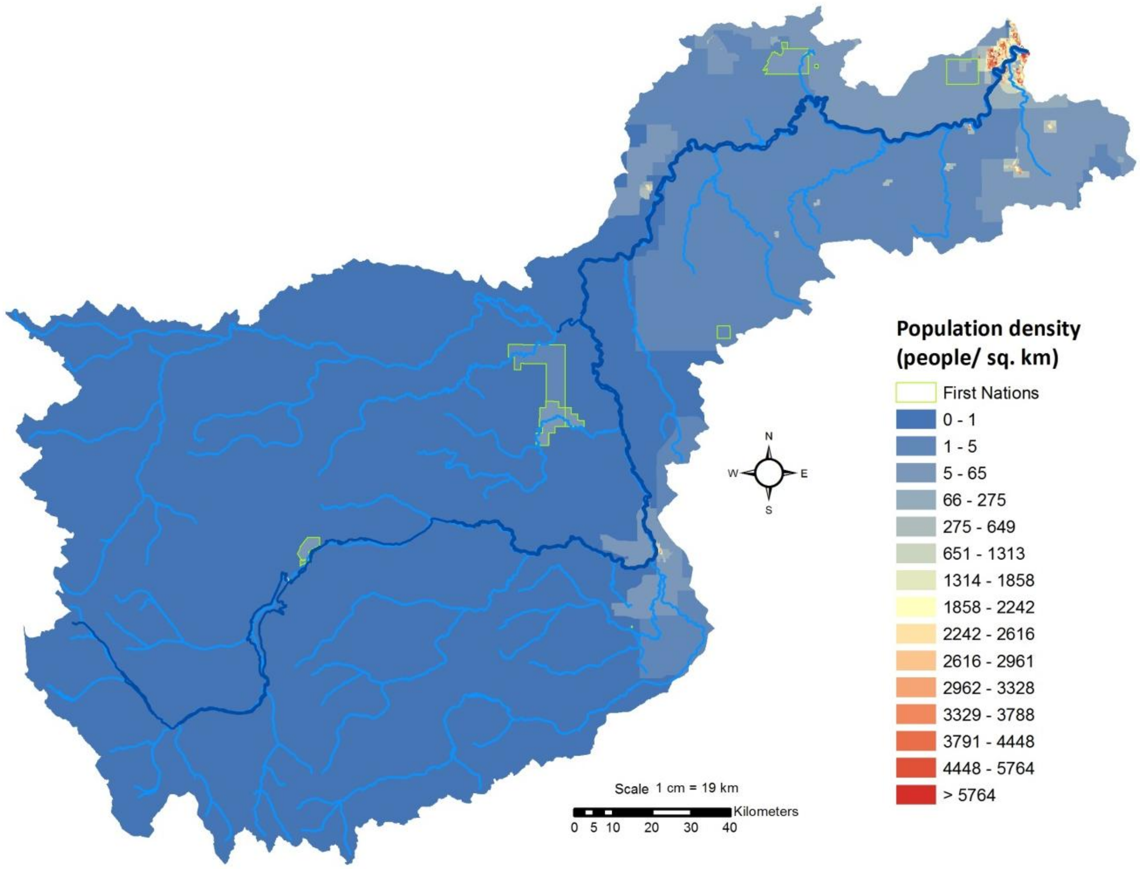
LOW RISK

The risk of increased human population in relation to spills, wastewater, and stormwater are considered in subsequent subsections. The risk to drinking water associated with increased populations alone is considered low.



Data Source: GoA 2024 & 2011

Figure 8. Sub-basins (as defined by Water Survey of Canada) and Municipal Boundaries in the NSR Watershed.



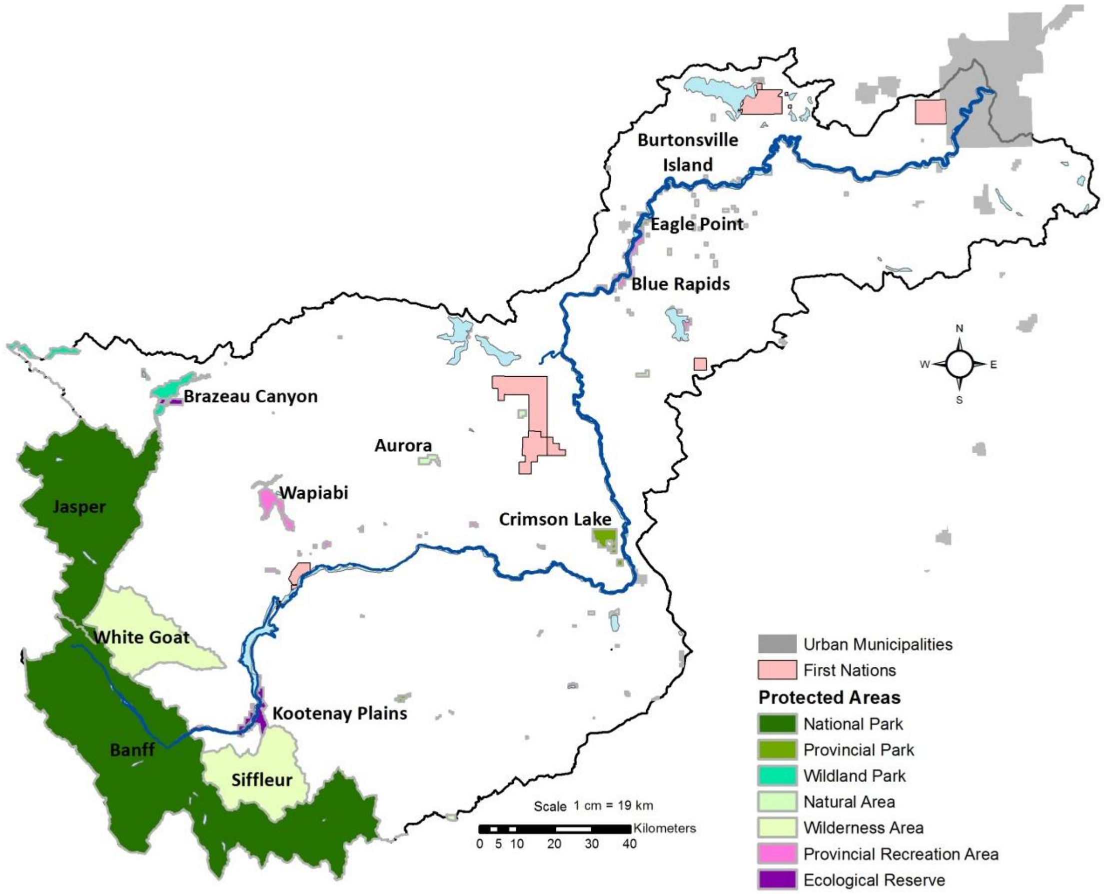
Data Source: Statistics Canada 2023, GoA 2014

Figure 9. Population Density in the NSR Watershed.

3.2.5 Parks and Protected Areas

Parks and protected areas are important for maintaining ecological and watershed integrity through limiting disturbance and human footprint. The area of the NSR watershed that is comprised of parks and protected areas is 17% (Figure 10). Although parks and other areas differ in their level of protection, in general within their management mandates, environmental protection is forefront. Banff and Jasper National Parks comprise 3,376 km^2 or 12% of the NSR watershed and provide protection for the critical headwater areas (Table 2).

White Goat and Siffleur Wilderness Areas provide an additional 870 km^2 of protection, equating to 3% of the watershed area upstream of Edmonton. Outside of the National Parks, all parks and protected areas combine to just under 5% of the total watershed area.



Data Source: GoA 2024

Figure 10. Parks and Protected Areas in the NSR Watershed.

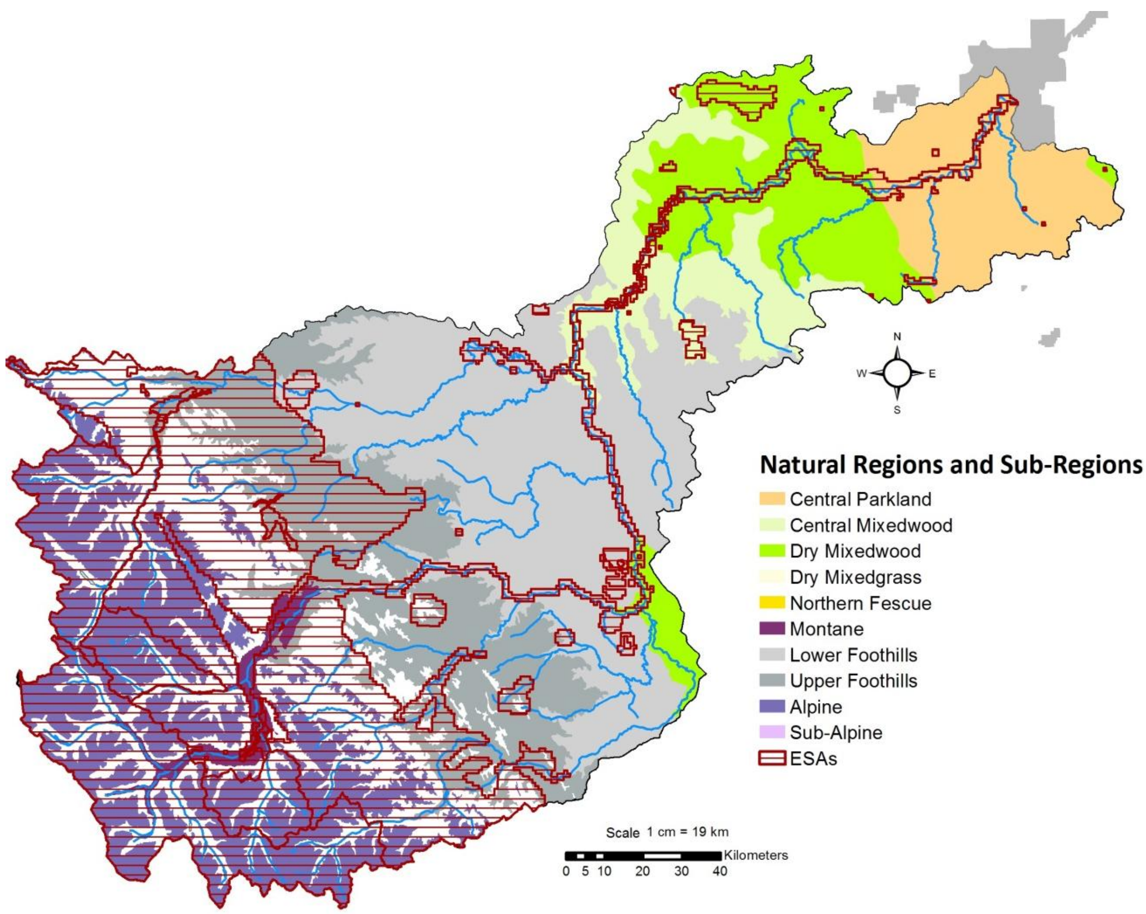
Table 2. Types and area of Parks and Protected Areas in the NSR Watershed.

Type	Number	Area (km^2)
Environmental Reserve	2	46
Natural Area	29	72
National Park	2	3,376
Provincial Park	4	58
Public Recreation Area	38	102
Wilderness Area	2	870
Wildland Park	2	222
Grand Total	**79**	**4,746**

Almost half (46%; 12,487 km^2) of the upstream of Edmonton is categorized as an environmentally significant area (ESA) (Figure 11). ESAs are generally defined as areas that are important to maintain biological diversity, physical landscape features and/or other natural processes on the landscape (Fiera 2014). They provide a good start for prioritizing areas of conservation and help inform land use planning for multiple uses. Most of the distribution of the ESA is in the headwater areas and includes the Rocky Mountain and Foothills natural regions (80%) as well as the Boreal natural region (14%). The riparian areas along the banks of the NSR, as it travels to Edmonton, are also considered environmentally significant areas. ESAs represent areas that are important for the long-term care and viability of biodiversity, soils, water and other natural attributes. Although ESAs do not have legislated protection, they are a valuable tool to inform land use decisions.

OPPORTUNITY

Much of the water supply and critical ecosystem function occurs in the designated ESA. Protecting these areas would ensure long-term protection of water supply and quality in the NSR.



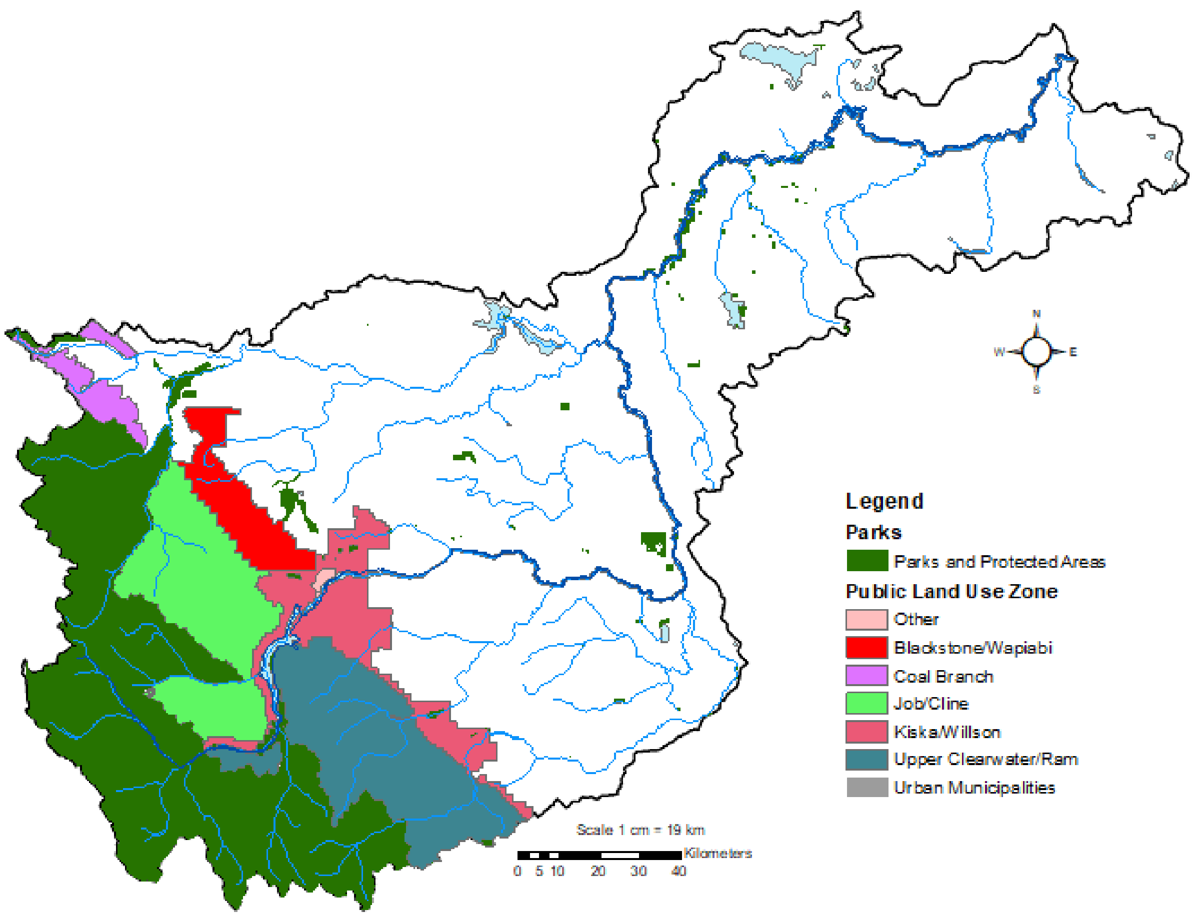
Data Source: GoA 2022

Figure 11. Environmental Significant Areas and Natural Sub-Regions in the NSR Watershed.

Although not considered parks or protected areas, there are 4,810 km^2 of the NSR watershed adjacent to the National Parks that are designated Public Land Use Zones (PLUZ; Figure 12). A PLUZ is an area of public land to which legislative controls apply under authority of the *Public Land Administration Regulation* to manage multiple uses on the landscape including industrial, commercial, and recreational. For example, the government can designate if activities such as off-highway vehicle use, motorboat use, random camping, or hunting, for example, are permitted. Forestry and oil and gas activity may also be permitted in PLUZ. The land use conditions are designed primarily to protect areas containing sensitive resources and manage conflicting land-use activities. Within PLUZ, off-highway vehicles must remain on designated trails to ensure that sensitive habitats, including stream beds, are protected. In the PLUZ in the NSR watershed, there are no significant industrial activities. Logging is permitted within PLUZs.

LOW RISK

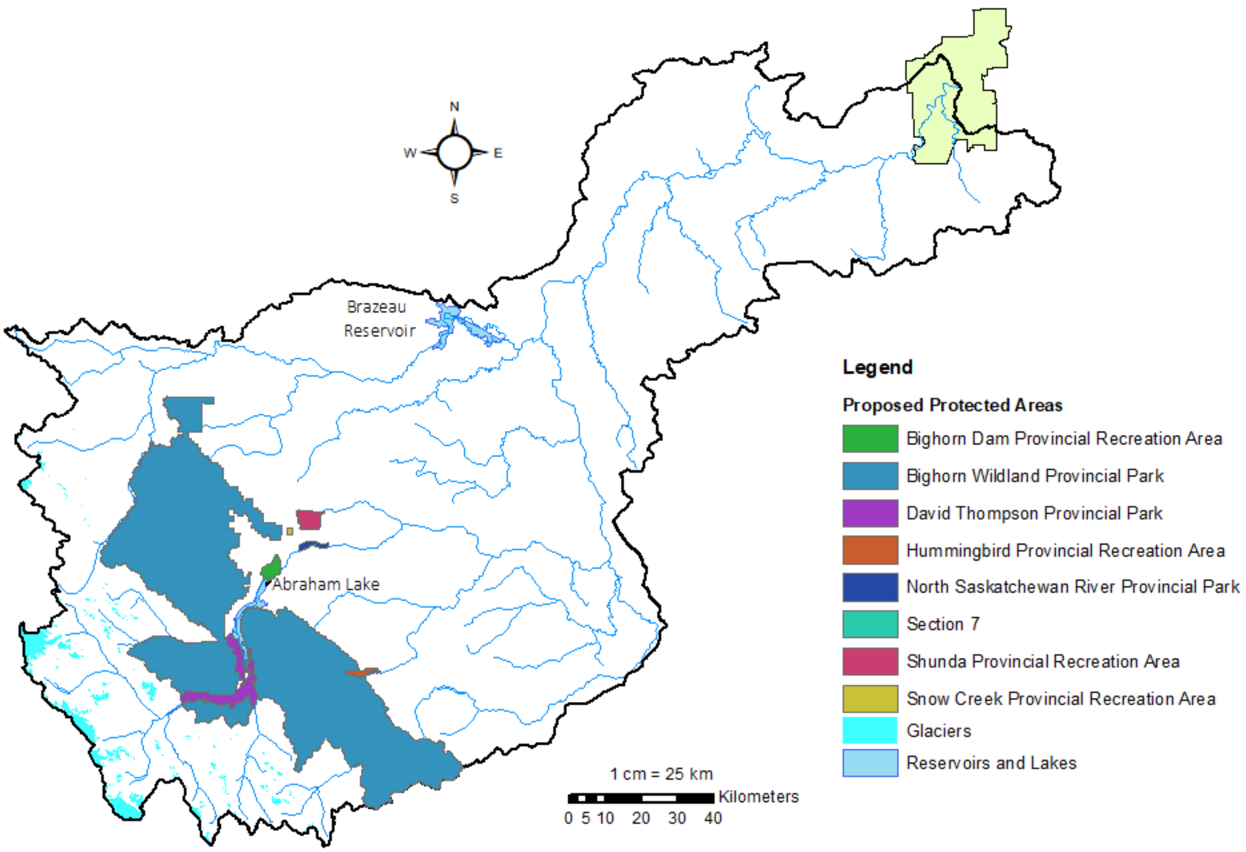
Recreational activity in protected areas, and human activity in PLUZ can have impacts on local water quality; however, the impact to water quality in Edmonton is not significant at this time. Continued management is needed to ensure activities to not impact local or downstream water chemistry. Additional protection of the headwater areas would be welcome.



Data Source: GoA 2020

Figure 12. Public Land Use Zones (PLUZs) in the NSR Watershed.

The Bighorn backcountry is an area of public lands to the east of Banff and Jasper National Park in the headwaters of the NSR that has received calls for increased protection due to unregulated recreation and resource development. The size and boundary of the Bighorn backcountry is not defined and differs among various organizations. Generally, the area of the Bighorn backcountry is 5,000 to 6,700 km^2 covered by the existing PLUZ (Figure 13). In November 2018, the Government of Alberta announced eight new parks covering over 4,000 km^2 in the Bighorn Backcountry. This plan was reversed in 2019 in favour of using the ongoing regional planning process to evaluate land use in the area. Depending on the outcome of this process, parks and protected areas could total ~8,700 km^2 and 31% of the NSR watershed upstream of Edmonton which would add significant protection for source water.



Data Source: GoA 2020

Figure 13. Previously Recommended Park Areas in the NSR Watershed.

3.2.6 Municipal Wastewater Treatment Facilities and Stormwater

Stormwater

Storm sewer outfalls drain runoff from roads and urban areas into the NSR including upstream of the WTP intakes. Stormwater typically has elevated concentrations of sediments, nutrients, pathogens, metals and pesticides from urban runoff. The stormwater from upstream communities is not significant, and most of the impacts to water quality in the NSR are from urban runoff in the City of Edmonton. EPCOR monitors the largest storm sewer outfalls in Edmonton and estimates the total loading to the NSR as part of its Environmental Monitoring Program which is described in greater detail in Section 3.3.

LOW RISK

Stormwater negatively impacts water quality in the NSR for short durations; however, the impacts are small compared to the range of water quality observed in the NSR. The WTPs are designed to treat pollutants most commonly associated with stormwater, and the overall risk to the ability to treat drinking water is low.

There are currently only two storm sewer outfalls located upstream of the E.L. Smith WTP; however, further growth of the City of Edmonton may result in additional storm sewer outfalls being built upstream (Figure 14). There are 29 storm sewer outfalls that drain directly to the NSR that are located upstream of the Rossdale WTP. There are an additional 17 storm sewer outfalls located in ravines or creeks that drain into the NSR upstream of the Rossdale WTP. The total stormwater area that drains upstream of Rossdale is 430 km^2 and at times can make upwards of 10% of the flow in the NSR.

Although storm sewer outfalls are designed to convey stormwater, under some conditions, sewage can enter to storm sewer system and be released to the NSR through:

- Improper interconnections;
- Leakage of double barrel pipes;
- Sewage lift stations; and
- Blocked and/or backed up sewers.

EPCOR has been active in identifying and sealing-off interconnections, replacing double barrel pipes, and maintaining and repairing lift stations to eliminate any sanitary inputs into the river. For double barrel pipes, storm flow and sanitary flow are combined in one pipe with vertical separation down the centre of the pipe. Over time, the separation can fail and this allows mixing of sanitary with storm water. EPCOR has also developed a bacterial source tracking program that helps identify outfalls where sewage is present, which allows tracing back and fixing the problem areas.

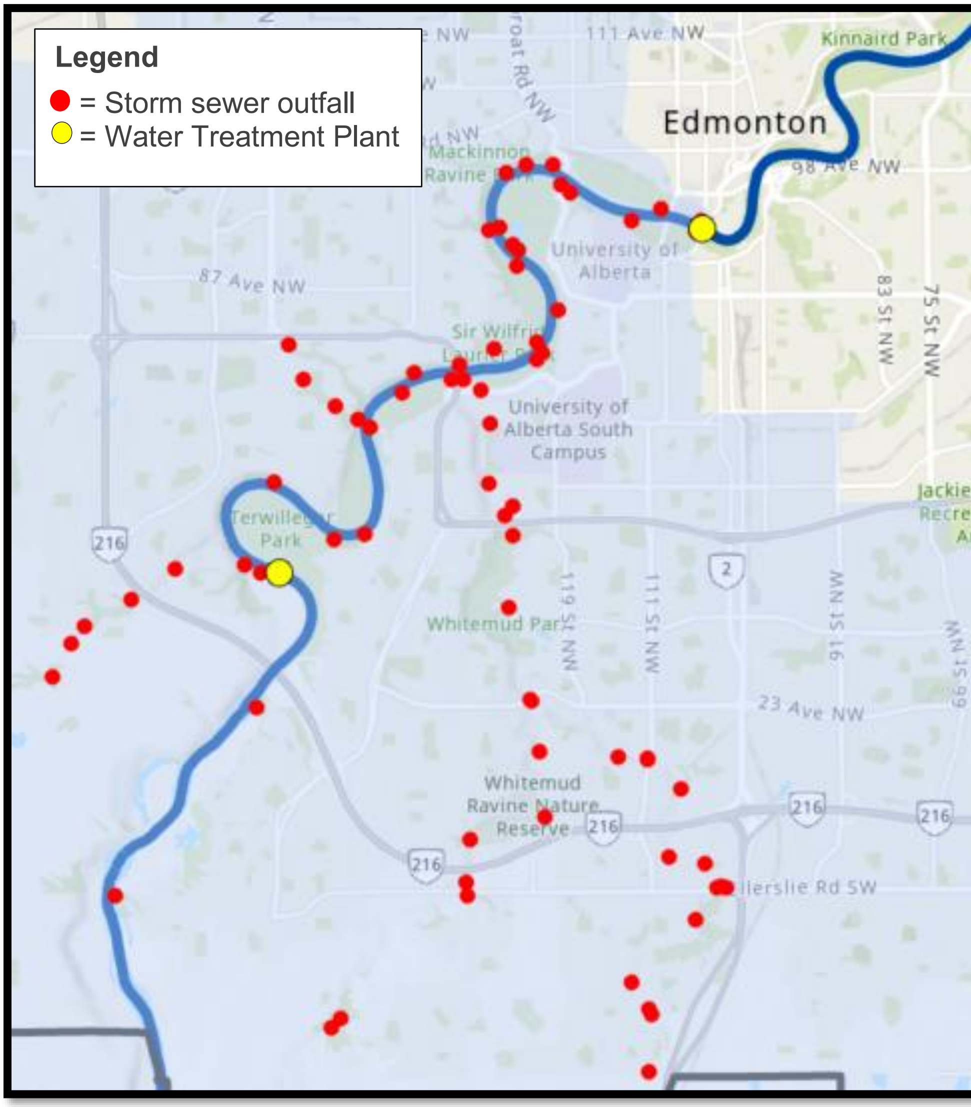
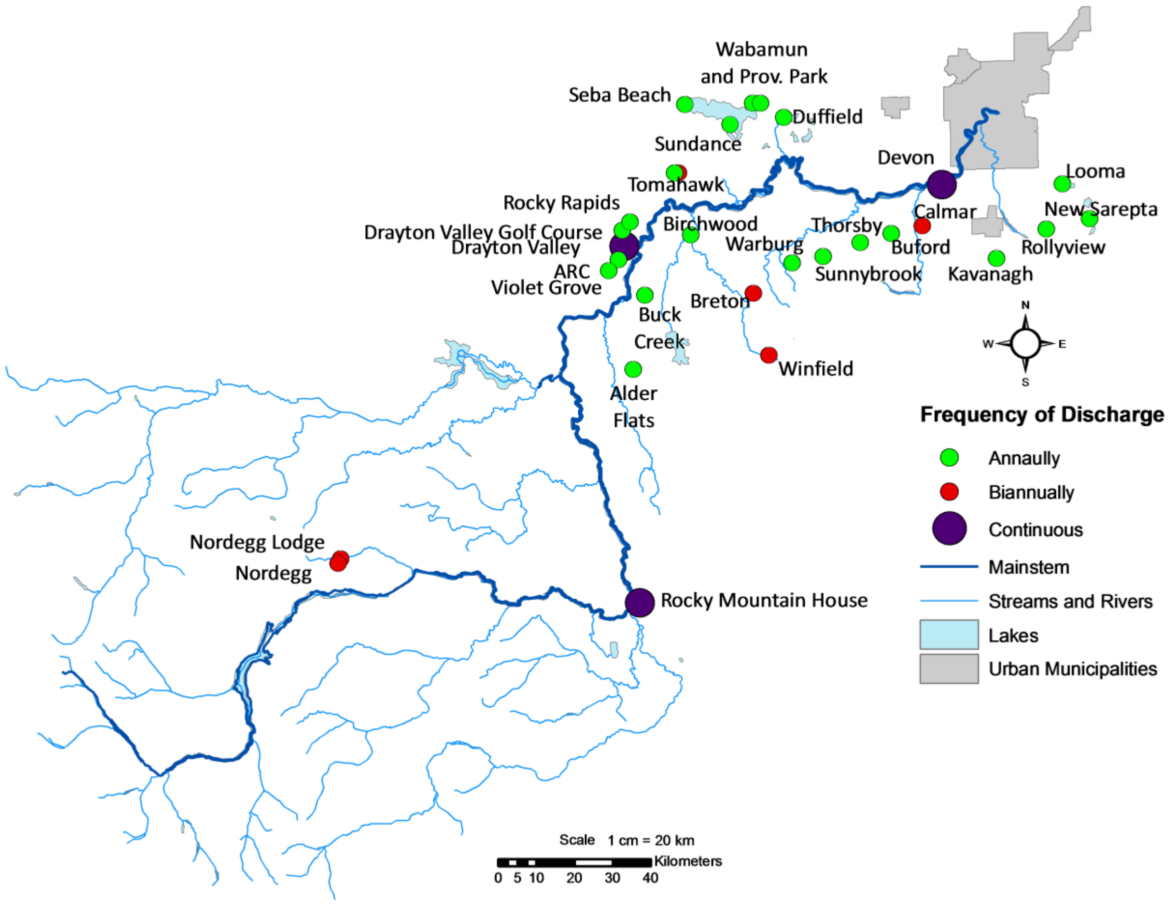


Figure 14. Storm Sewer Outfalls Located Upstream of the E.L. Smith and Rossdale WTPs (from City of Edmonton 2020).

In terms of overall stormwater management, EPCOR continues to invest in a mixture of grey and green infrastructure to manage stormwater within Edmonton as part of its Stormwater Integrated Resource Plan (SIRP). Although flood mitigation is the main driver, there will also be water quality improvements through the implementation of green infrastructure. The SIRP approach is to capture stormwater volumes in dry ponds prior to reaching the storm trunk network to provide additional capacity in the pipes in the immediate path of the storm. The addition of low impact development (LID) features throughout the catchment area is intended to retain these volumes and reduce the impact on the entire pipe network as storms travel across the community. The plan includes tunnels, trunks and sewer separation in locations where, due to configuration of the community, there is limited space to install additional ponds or LID components to fully capture the expected water volumes during a major storm event.

Wastewater Treatment Plants

Upstream of Edmonton, there are three mechanical wastewater treatment plants (WWTPs) that discharge effluent continuously to the NSR (Rocky Mountain House, Drayton Valley and Devon) and 27 municipal sewage lagoons that discharge periodically to the NSR or tributaries of the NSR (Figure 15).



Data Sources: GoA 2020, AECOM 2009

Figure 15. Municipal Wastewater Facilities in the NSR Watershed.

Table 3. Wastewater Treatment Facilities in the NSR Watershed (AECOM, 2009)

Name	Size	Treatment	Freq.	Discharge Point
Alder Flats	Hamlet	Lagoon	1/yr	Rose Creek
ARC Resources	Field Stn.	Lagoon	1/yr	Unnamed drainage to NSR
Birchwood VG	Devel.	Lagoon	1/yr	Modeste Creek
Breton	Village	Lagoon	2/yr	Modeste Creek
Buck Creek	Hamlet	Lagoon	1/yr	Buck Lake
Buford	Hamlet	Lagoon	1/yr	Unnamed drainage to NSR
Calmar	Town	MAL	2/yr	Conjuring Creek
Devon	Town	MAS	Cont.	NSR
Drayton Valley	Town	MAL	Cont.	NSR
Drayton Valley	Golf Crs.	Lagoon	1/yr	Unnamed tributary to NSR
Duffield	Hamlet	Lagoon	Evap.	n/a
Kavanagh	Hamlet	Lagoon	1/yr	Discharge to slough
Looma	Hamlet	Lagoon	1/yr	Unknown
New Sarepta	Village	Lagoon	1/yr	Unknown
Nordegg	Hamlet	MAL	2/yr	Long Lake
Nordegg Resort Lodge	Resort	Lagoon	2/yr	Shunda Creek
Rocky Mountain House	Town	MAL	Cont.	NSR
Rocky Rapids	Hamlet	Lagoon	1/yr	Unnamed Tributary to NSR
Rollyview	Hamlet	Lagoon	1/yr	Unknown
Seba Beach	Sum. Village	Lagoon	Evap.	n/a
Sundance	Plant	Lagoon	1/yr	Lake Wabamun
Sunnybrook	Hamlet	Lagoon	1/yr	Strawberry Creek
Thorsby	Village	Lagoon	1/yr	Weed Creek
Tomahawk	Hamlet	Lagoon	2/yr	Tomahawk Creek
Tomahawk School	School	Lagoon	1/yr	Tomahawk Creek
Violet Grove	Hamlet	Lagoon	1/yr	Unnamed Creek to NSR
Wabamun	Village	Lagoon	1/yr	Unnamed Creek NSR
Wabamun	Prov. Park	Lagoon	1/yr	Unnamed Creek to NSR
Warburg	Village	Lagoon	1/yr	Strawberry Creek
Winfield	Hamlet	Lagoon	2/yr	Poplar Creek

Note: MAL = mechanically aerated lagoon, MAS = mechanically activated sludge, Evap. = Evaporative Lagoon

Water quality data from most wastewater facilities is limited. As set out in the *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* (GoA 2013a) wastewater lagoons are not required to conduct any water quality monitoring, and aerated lagoons for smaller communities are only required to collect weekly CBOD samples during periods of discharge. However, a small amount of data, typically only BOD and TSS, is available for the majority of sites listed in Table 3. Monitoring at the wastewater treatment plants in Rocky Mountain House, Drayton Valley and Devon is limited to a small number of parameters (Table 4). Devon recently commissioned a new WWTP, which is now fully operational.

Table 4. Wastewater Monitoring Requirements in the NSR Watershed

Community	Parameters	Frequency	Effluent Limits	Average Daily Effluent (m^3/d)
Rocky Mountain House	CBOD	Weekly grab	< 25 mg/L	2,379
	TSS		n/a	
Drayton Valley	BOD	Weekly grab	< 25 mg/L	4,999
	TSS		n/a	
	Total coliforms		< 1,000/100 mL	
	Fecal coliforms		< 200/100 mL	
	Chlorine residual	Daily Grab	< 2.0 mg/L	
	Volume	Daily Total	n/a	
Devon	CBOD	Daily Composite	< 20 mg/L	2,200
	TSS	Daily Composite	< 20 mg/L	
	Ammonia	Daily Composite	< 5 mg/L June - Nov < 10 mg/L Dec - May	
	Total Phosphorus	Daily Composite	< 1 mg/L	
	Volume	Daily Total	n/a	
	pH	Daily Composite	6.5 - 8.5	
	Total coliforms	5 samples/week	< 1,000/100 mL	
	Fecal coliforms	5 samples/week	< 200/100 mL	
	Acute lethality	quarterly grab	n/a	

Only an estimated 30,000 rural residents in the watershed are serviced by wastewater treatment facilities (lagoons or continuous-discharge mechanical treatment). The remaining 60,000 individuals are likely serviced by private septic systems. Municipal effluents contribute a consistent but low concentration of parasites (*Cryptosporidium* spp. and *Giardia* spp.) to the NSR and its tributaries (CABIDF 2002). Most discharges from lagoons occur over a three week period in October and, if two discharges per year are permitted, they most often occur in April or early May.

LOW RISK

Wastewater treatment facilities and lagoons have small impacts on water quality in the NSR at Edmonton due to low populations and effluent guidelines that manage downstream release of waste. Populations in these communities are not significantly increasing. The overall risk to source water is low.

The three upstream WWTPs (Rocky Mountain House, Drayton Valley and Devon) are relatively small, and would not significantly affect water quality at EPCOR's intakes for measured parameters such TSS, BOD, nutrients and pathogens, assuming effluent limits are maintained. Similarly, the reported discharge volumes of lagoons are small, and the loads of TSS and BOD would likely have little effect on the water quality in the NSR at EPCOR's intakes. Nutrient and pathogen data is generally not available from lagoon discharges, but the small discharge volumes suggest that the resulting impact to water quality at EPCOR's intakes would be relatively low. Water quality data on pharmaceuticals, pesticides and other contaminants of emerging concern are not available for these WWTP and lagoons, but it is assumed that they are a source of these parameters in the NSR.

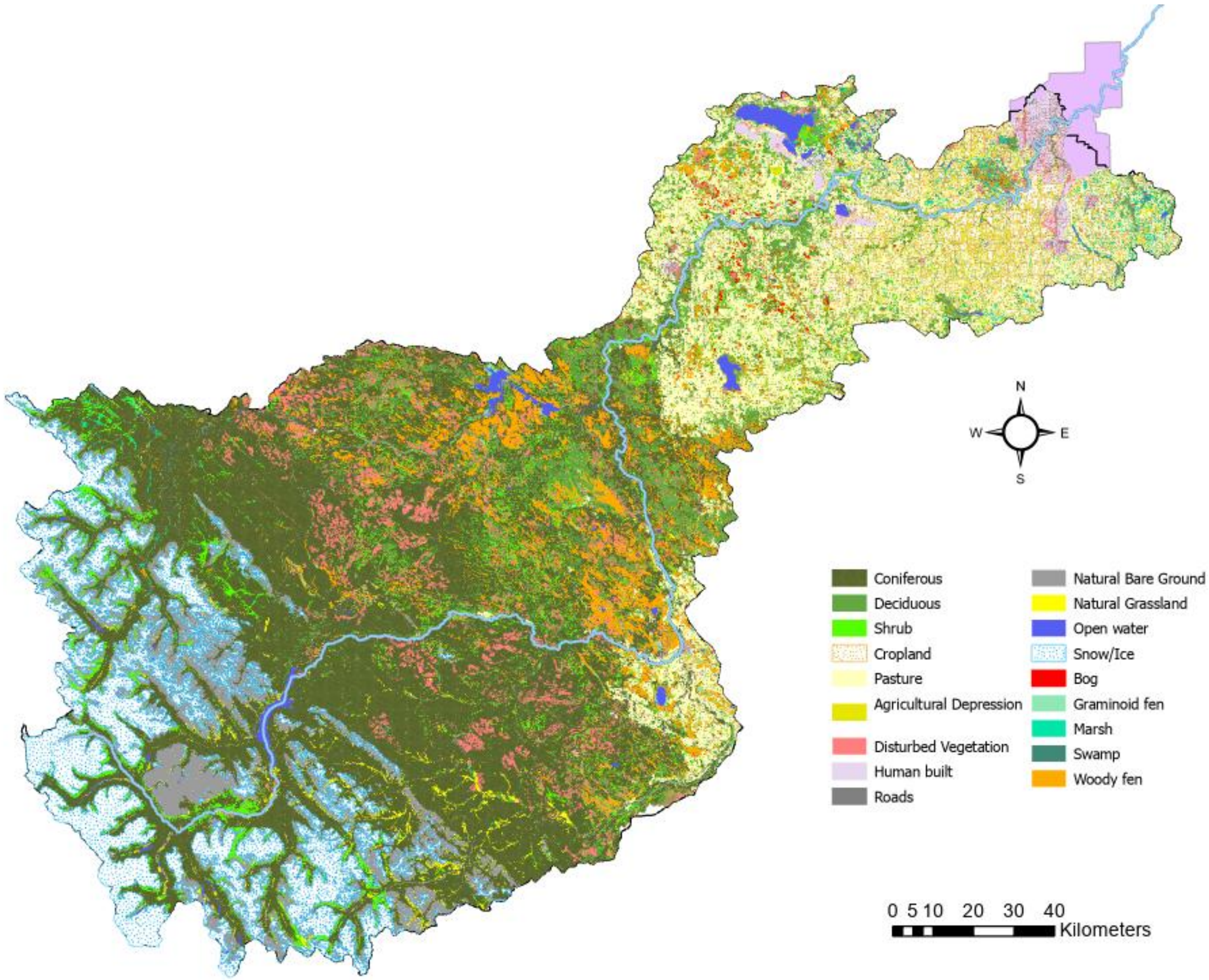
RISK MODIFIER

Innovative methods for wastewater lagoon management are being implemented in the North Saskatchewan Watershed. For instance, in Parkland County lagoon operators use evaporators to reduce lagoon volumes. Also, a portable membrane filtration system is being piloted in the county with hopes of effectively refining lagoon effluent.

3.2.7 Land Cover

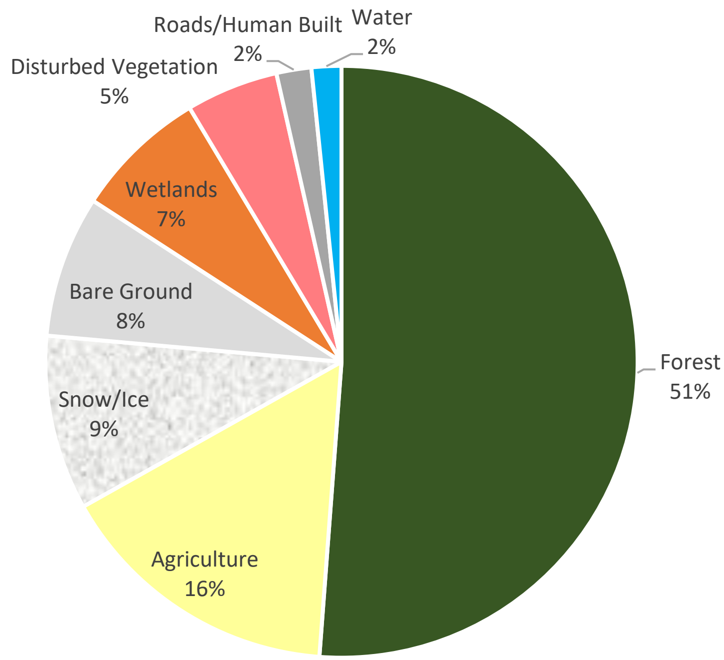
Land cover is an indicator of watershed disturbance and can indicate the risk of contaminants reaching downstream waterbodies. For example, there is evidence that with increased percent agricultural land in a watershed, there are increased nutrient and bacterial levels in downstream waterbodies. It is important to note land cover is based on a satellite image taken at a single point of time. Also, it provides a general indication of disturbance but does not determine land use (what activities are occurring on the land). For example, there are many different types of cropping practices (row crop versus broadcast) that could occur on the land base and they would all be classified as 'cropland'.

The majority of the NSR watershed is in forest cover (51%; Figure 16 and 17). Of that, 38% is conifer forest, 7% is deciduous, and 5% is shrub. Agricultural land cover is the greatest anthropogenic footprint in the watershed at 16%. The agricultural land cover is concentrated in the lower part of the watershed, where soils are favourable for agriculture, whereas the headwater areas remain largely forested or rock (i.e., mountains).



Data Source: 2017/18 SPOT6/7 Imagery NSWA

Figure 16. Land Cover in the NSR Watershed



Data Source: 2017/18 SPOT6/7 Imagery NSWA

Figure 17. Percent of the Watershed in each Land Cover Type.

3.2.8 Agriculture Land Cover and Use

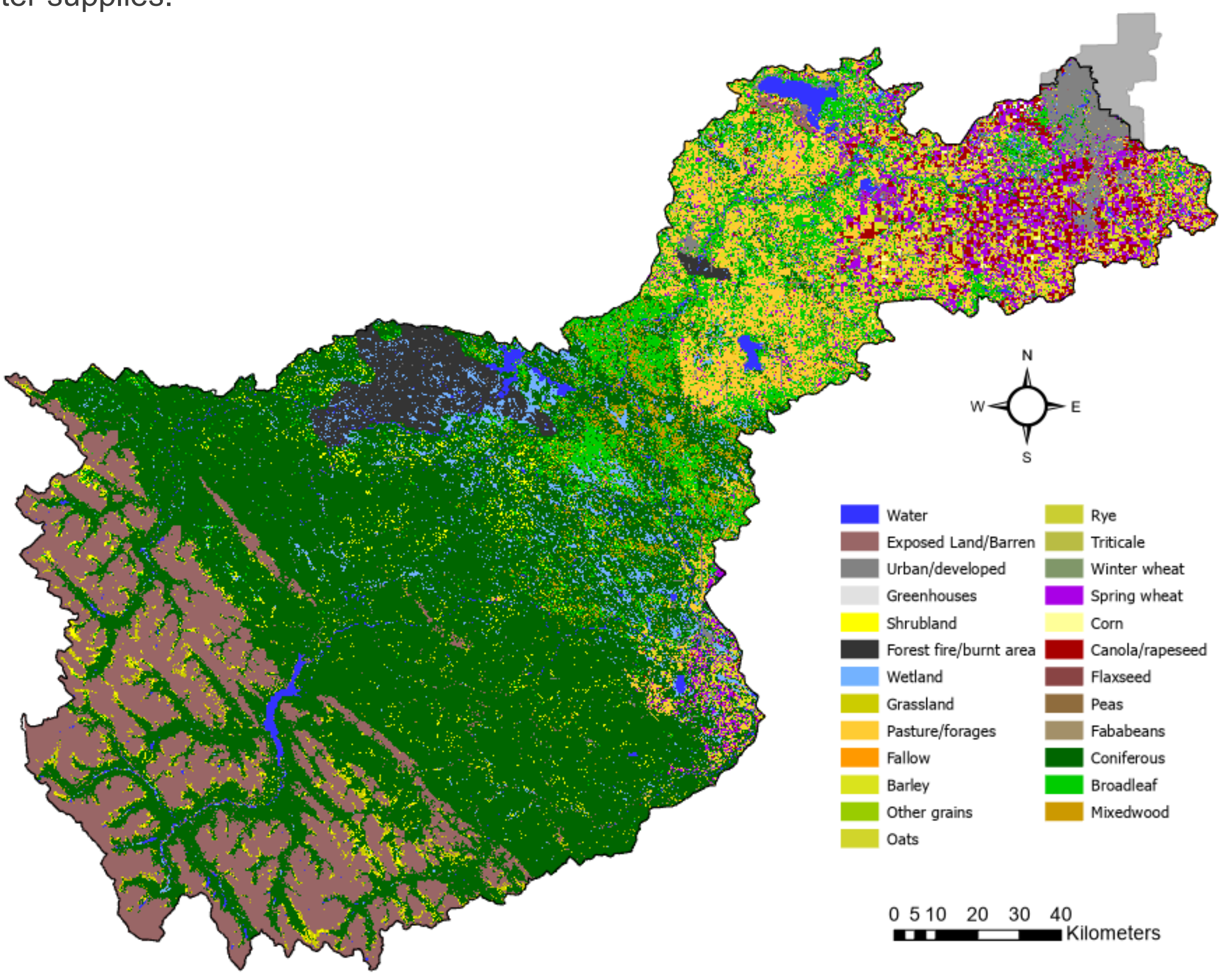
As mentioned in Section 3.2.5, land used for agriculture makes up just under one sixth of the NSR watershed. However, in the lower part of the watershed from the Edmonton region and east, about 85% of the land area is used for agriculture and food production. Specifically, land used for agriculture in Leduc and Wetaskiwin counties is over 81% of the land base, whereas in Parkland County, it is over 66% of the county's land base.

LOW RISK

Water quality in the NSR is impacted by agricultural activities in the watershed largely during spring runoff. However, EPCOR's WTPs are designed to treat pollutants most commonly associated with agricultural activities. Crop types, total cover are not changing, and the number of livestock are steady. The overall risk to drinking water is therefore low.

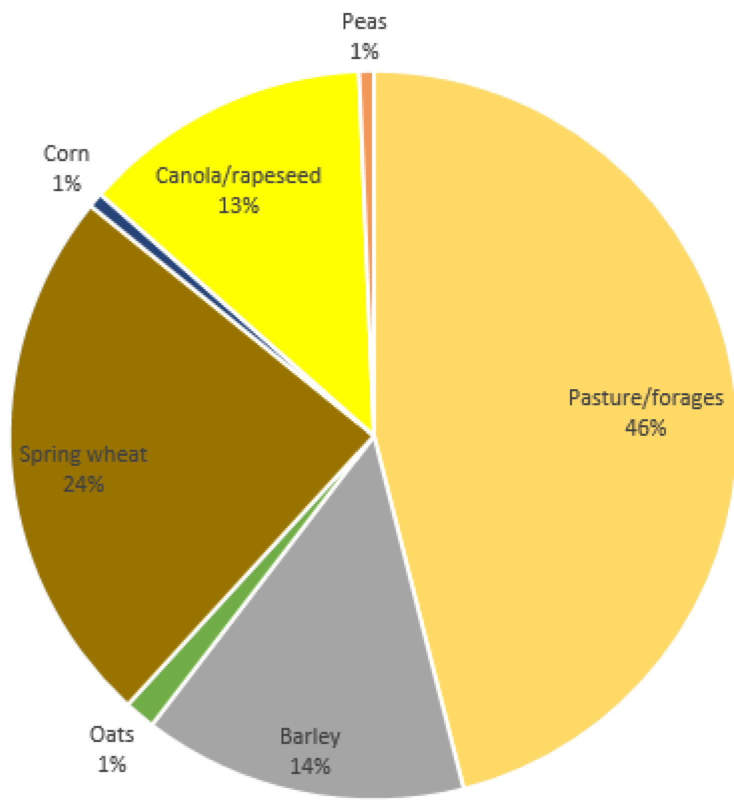
In the areas around Drayton Valley, perennial crops, such as forages (hay and pasture) are the predominant agricultural land cover type, whereas, closer to Edmonton and near Rocky Mountain House, cropped land is more common (Figure 18). Livestock typically graze on pasture but may also utilize some hay lands and wooded or treed areas at certain times of the year, if they are fenced. Cattle on pasture often use remote watering systems because agricultural producers limit livestock access to waterbodies as a common practice to protect water quality and to protect herd health.

In 2016, of the 4,100 km^2 of land that is classified as annual and perennial crops by satellite imagery, the majority is in forages [hay or pasture] (45%), followed by wheat (21%), canola (17%), and barley (9%). In 2021, 4,273 km^2 of land was classified as crops (15% of watershed) and of that most was forage/pasture (46%), 13% was canola, 14% was barley, and 24% was spring wheat (Figure 19). Other crops such as oats, potatoes, beans, corn, and peas are grown, but comprise a small percentage of cropped area (less than 1% combined). Most agricultural producers conserve their soil and limit risk to surface water quality by common practices such as direct seeding, reduced tillage, sustainable crop rotations, employing 4R technologies (Right product, Right place, Right rate & Right time), integrated pest management and farm implements/equipment that utilize GPS. Since 1996, the incidence of summerfallow (bare ground subject to wind and water erosion) has been nearly eliminated in the NSR watershed. For the past two decades, agricultural producers have adapted to these advanced land conservation and management, productivity and accountability practices since instatement of Maximum Residue Levels (MRL's) on major crop commodities. The agricultural communities in the NSR appreciate that their enterprises and livelihoods depend on healthy soils and quality water supplies.



Data Source: Agriculture and Agri-Food Canada 2023

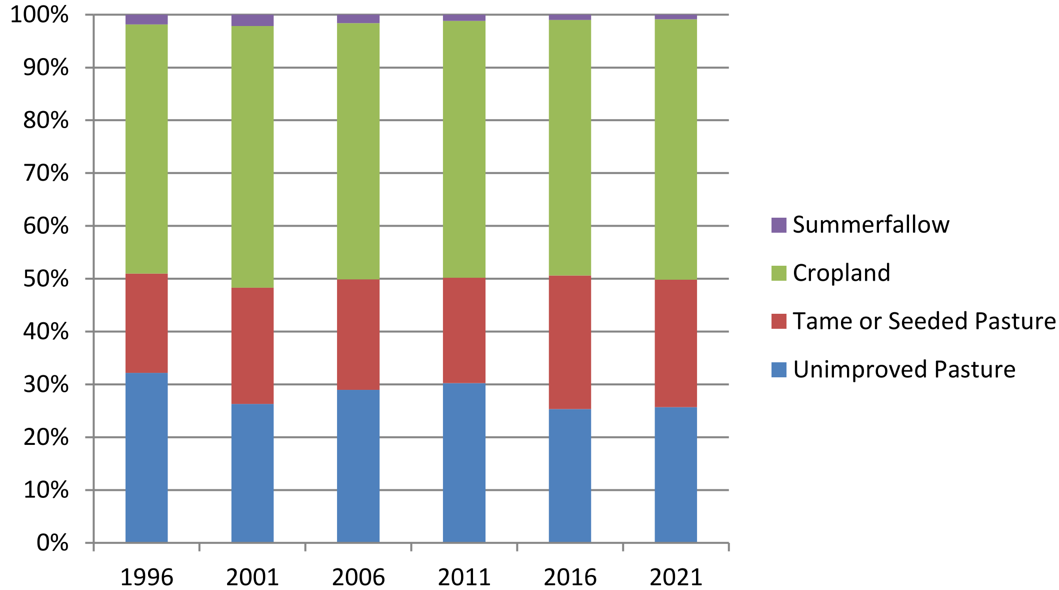
Figure 18. Agricultural Land Cover (2023) in the Watershed.



Data Source: Agriculture and Agri-Food Canada 2023

Figure 19. Percent of Agricultural Land Cover in Each Use Category.

The Federal Government collects census data every five years which provides a snapshot of agricultural practices. These statistics are indicative of numbers at a single point in time (the day of the survey), are based on the number of farms reporting, and may not reflect current numbers. As well, reporting is based on farm headquarters and the reported data may not necessarily be in the watershed. They do provide an indication of the change of agricultural practices at the watershed scale. Data for manure production and livestock numbers were aggregated at the watershed scale for census data which is collected every 5 years (1996 to 2021). Census data show that the agricultural land in the NSR watershed is divided approximately evenly between pasture and crops, and that this ratio does not change substantially year to year (Figure 20).



Data Source: Agriculture and Agri-food Canada 2021.

Figure 20. Agricultural Land Use Reported by Census of Agriculture in the NSR Watershed from 1996 to 2021.

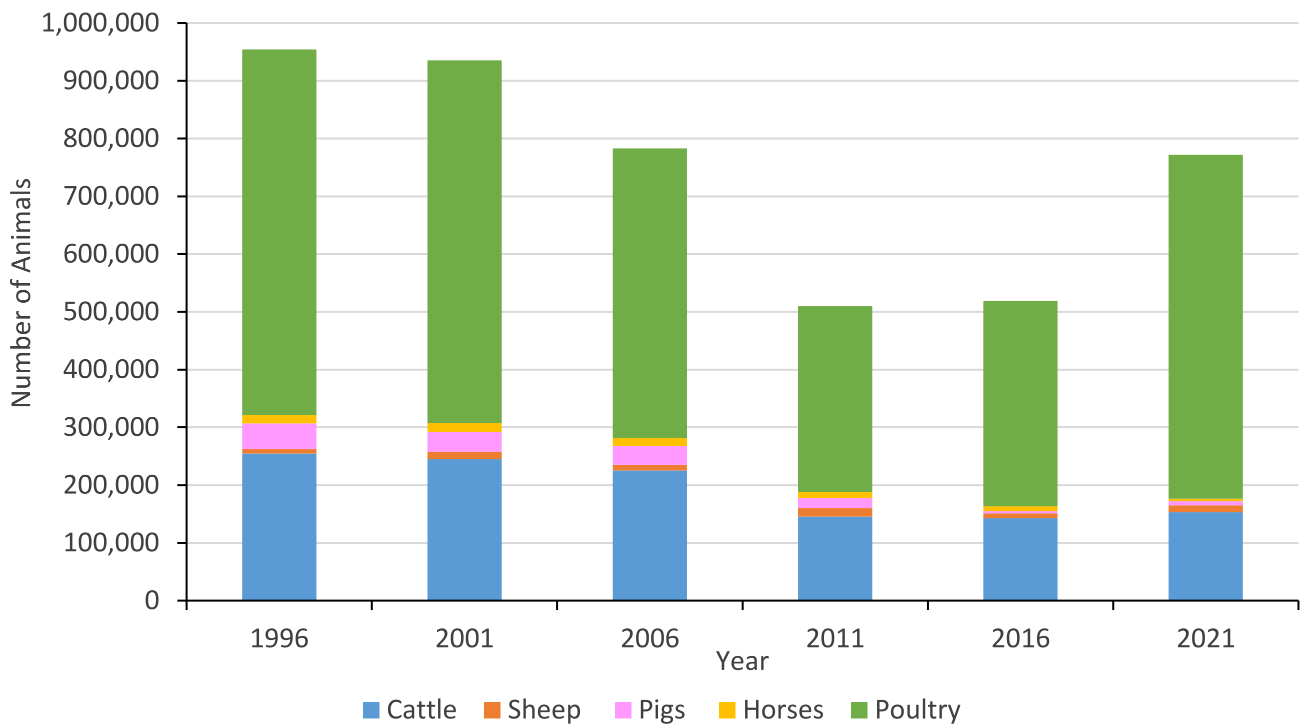
Areas of higher livestock density within a sub-watershed can lead to impacts on downstream aquatic systems, often because of waste production and physical access of livestock to waterbodies. Within the NSR watershed, there were approximately 150,000 cattle; just under 8,000 pigs; 11,500 sheep; and 4,300 horses in 2021. The numbers of livestock declined between 1996-2016 but increased from 2016 to 2021 (Table 5, Figure 21). There are significantly fewer cattle on the landscape than there were in 1996.

The decline in number of farms and overall livestock numbers reflected in the NSR watershed is part of a national trend (Statistics Canada 2017). There were also over 1,300 fewer farms in the NSR reporting cattle from 1996 to 2021. Statistics Canada has reported that national,y there are fewer farms, and fewer cattle in Canada, and this trend appears to hold true for the NSR watershed as well (Statistics Canada 2017). This is a result of the BSE crisis in 2003, more farmers retiring, fewer intergenerational farm transfers, farm consolidations or relocations and other external market factors.

Table 5. Livestock Numbers in the Watershed by Livestock Type and Census Year.

Type/Year	1996	2001	2006	2011	2016	2021
Cattle (#)	254,463	244,591	225,515	145,596	142,928	152,998
Sheep (#)	7,686	13,366	9,468	14,564	8,197	11,593
Pigs (#)	44,527	34,466	33,107	17,356	3,481	7,693
Horses (#)	14,267	14,779	12,945	10,775	8,332	4,305
Poultry (#)	633,169	628,055	502,116	321,264	356,215	595,153
Total Large	**320,943**	**307,202**	**281,035**	**188,291**	**162,938**	**176,590**
Total	**954,112**	**935,257**	**783,151**	**509,555**	**519,152**	**771,743**

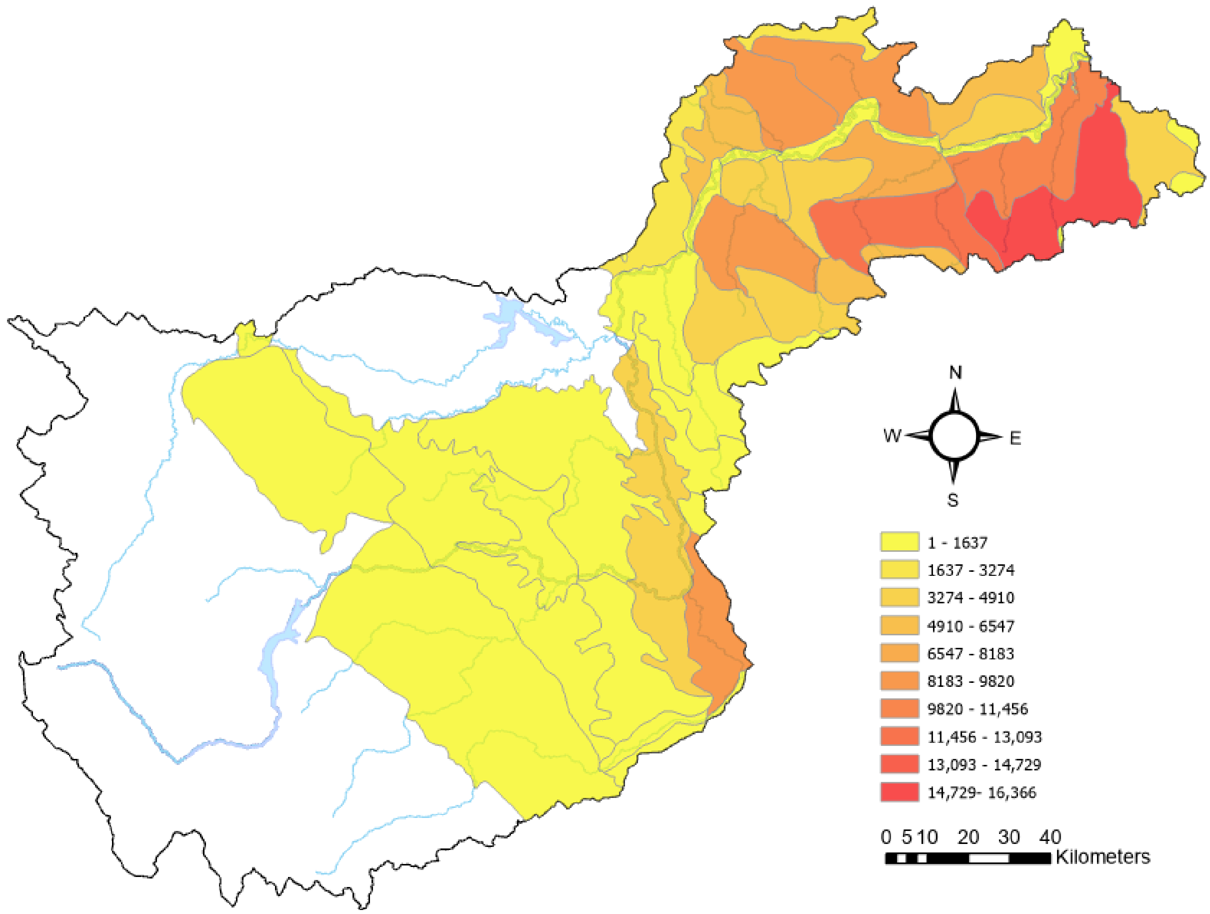
Data Source: Agriculture and Agri-food Canada 2021



Data Source: Agriculture and Agri-food Canada 2016

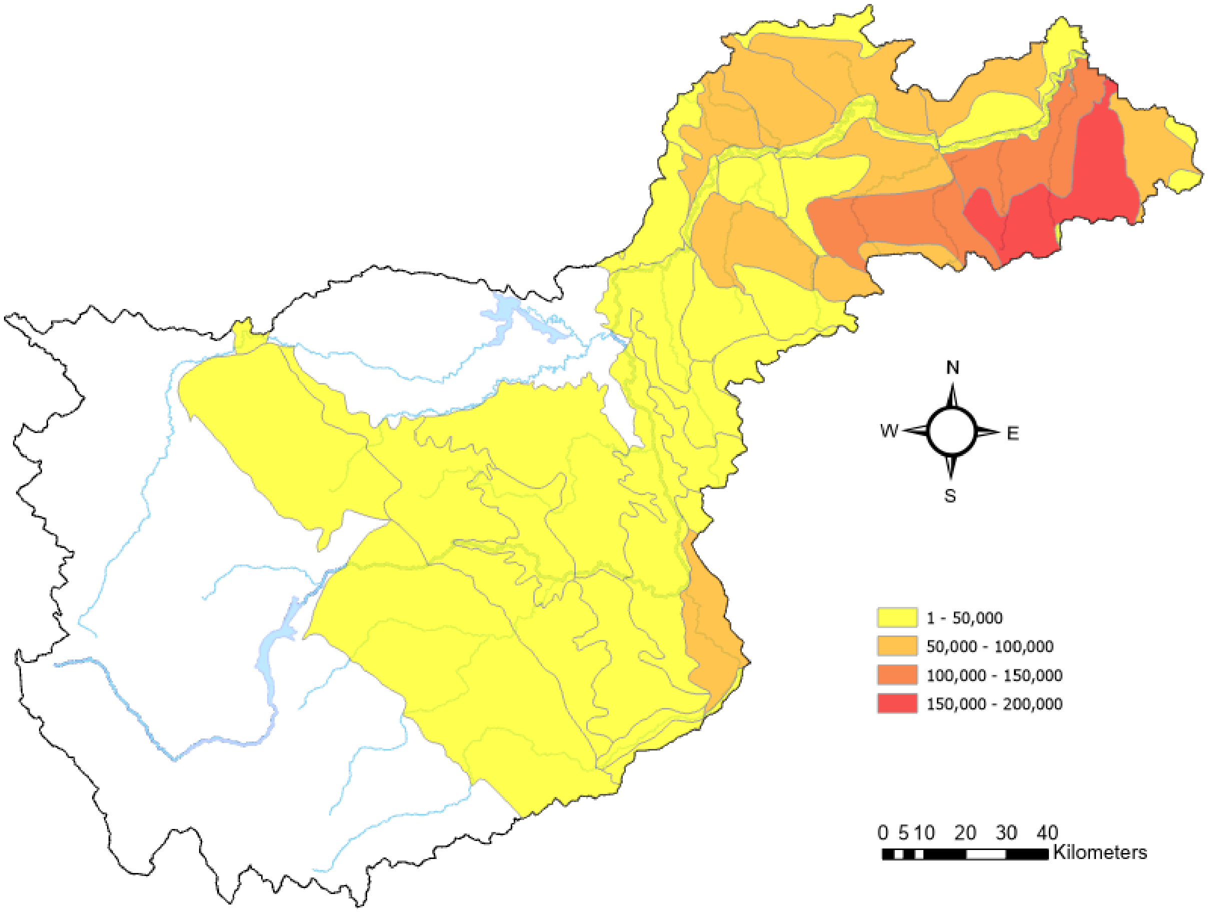
Figure 21. Total number of Poultry, Horses, Pigs, Sheep and Cattle Reported in the NSR Watershed by Census Year.

Both the total number of cattle and manure production show that most of the livestock in the NSR watershed are concentrated in the lower part of the watershed (Figure 22 and Figure 23). There are also 31 confined feeding operations in the watershed. As expected, manure production in the basin mirrors livestock numbers (Figure 243 and 24).



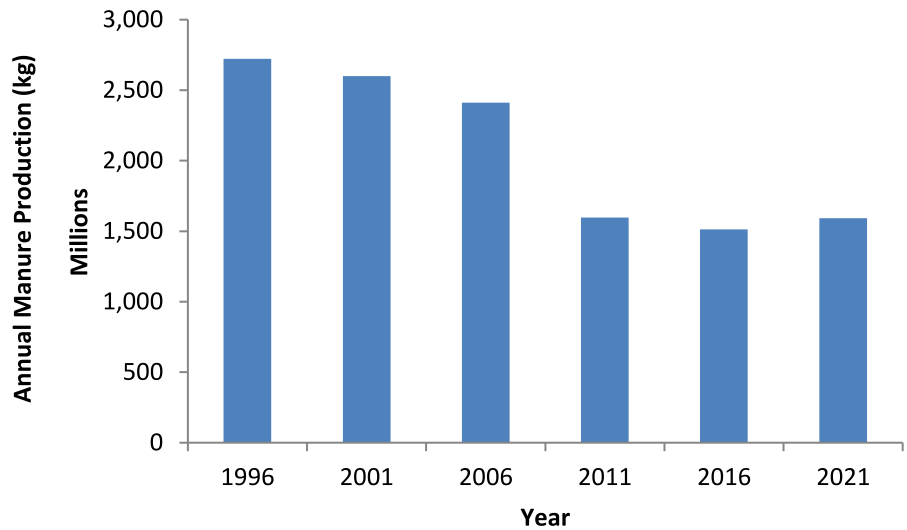
Data Source: Agriculture and Agri-food Canada 2021

Figure 22. Total Cattle Reported in the NSR Watershed in 2021.



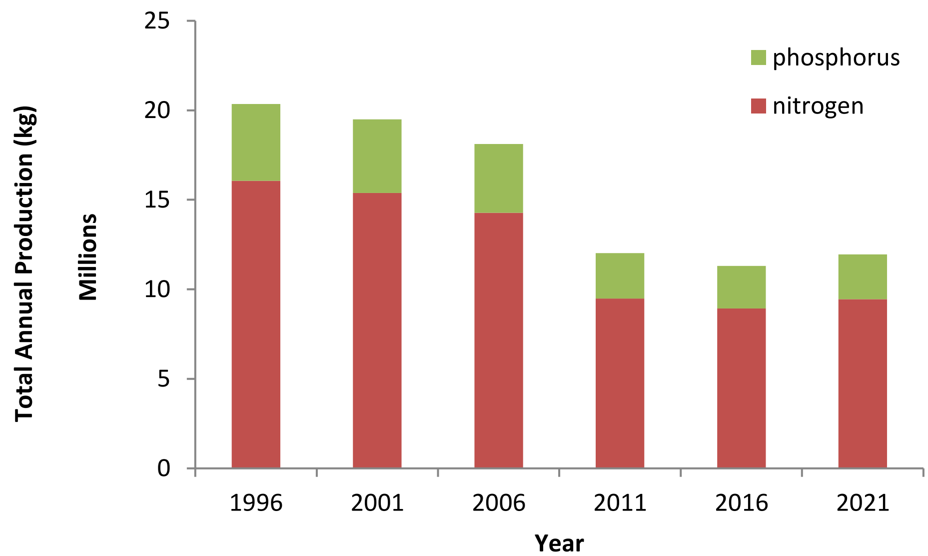
Data Source: Agriculture and Agri-food Canada 2021

Figure 23. Manure Production (tonnes) reported from All Livestock in the NSR Watershed in 2021.



Data Source: Agriculture and Agri-food Canada 2021

Figure 24. Estimated Annual Manure Production from All Livestock in the NSR Watershed by Census Year.



Data Source: Agriculture and Agri-food Canada 2021

Figure 25. Estimated Annual Phosphorus and Nitrogen Manure Production from All Livestock in the NSR Watershed by Census Year.

The area of land in the NSR watershed that uses pesticides [pesticides include herbicides, insecticides & fungicides] has steadily increased between 1996 and 2021 (Table 6). Since 1996, many of the most toxic and persistent pesticides have been de-registered and are no longer available for use. All commercial applicators must be certified, and agricultural producers are encouraged to do the same and employ the 4R technologies. The Alberta 'Blue Book' produced annually by Alberta Agriculture provides a thorough list of available crop protection chemicals, safety and application guidelines, and cultural alternatives. The Census of Agriculture does not provide information regarding the total amount of pesticides used, only the area over which it was spread. The area of land that fungicides and insecticides were added has quadruped between 1996 and 2021; however, it remains a small percentage of overall agricultural land (< 3%). For herbicides, the increase between 1996 and 2021 was 67% on an area representing approximately 5% of the source watershed. The area of manure application more than quadrupled between 2006 and 2011 but went down to the lowest area to date in 2016. Manure is estimated to be applied to less than 1% of the source watershed. Fertilizer use has remained relatively consistent in the last 20 years and is applied to approximately 5% of the area of the source watershed.

Table 6. Area of Land (km^2) that Pesticides, Manure, and/or Fertilizer were added by Census year.

Addition	1996	2001	2006	2011	2016	2021
Fungicide	70	56	116	152	304	486
Insecticide	20	32	70	41	116	123
Herbicide	934	981	1,074	1,177	1,378	1559
Manure	246	285	315	1,379	172	*
Fertilizer	1,559	1,475	1,474	1,263	1,453	1,620

Data Source: Agriculture and Agri-food Canada 2016. *No data for 2021.

Best Practices in Agriculture to Manage Impacts

Recognizing the impact that agricultural activities can have on receiving water bodies, landowners, often in partnership with stewardship groups, have worked hard to implement beneficial/best management practices (BMPs). BMPs are specific to each type of land use and are intended to prevent bare ground, control runoff, and optimize inputs and resources. These practices include nutrient, crop and manure management, better storage of fuel, riparian management and reduction of the use of pesticides.

A BMP success story for Alberta was the promotion of conservation tillage which significantly reduced the amount of summer fallow to previous levels; this resulted in significant reductions in soil erosion. In the NSR watershed summer fallow was 105 km^2 in 1996 and only 48 km^2 in 2016. The area of conservation tillage increased from 331 km^2 in 1996 to 469 km^2 in 2016. In 2011, over 551 farms of 3,022 reported using buffers around waterbodies.

EPCOR recognizes the importance of agricultural BMPs to improve water quality and quantity from agricultural areas. Agricultural streams are elevated in ammonia and organic material (colour), particularly during spring runoff. Improved water quality in the NSR could result in reduced operating costs for EPCOR's WTPs and reduce taste-and-odour events that can affect the aesthetic quality of our drinking water. BMPs also function to keep water on the land, instead of rapidly entering the river. Improved hydrology within our watershed has the potential to help offset significant impacts of flooding and drought to our WTPs. EPCOR has supported several initiatives relating to the implementation and researching the effectiveness of implementing BMPs in the watershed.

EPCOR provided funding for two research projects in the Modeste and Strawberry Creek sub-watershed that evaluated ecosystem services, such as improvements in water quality and quantity, by implementing BMPs. These projects are utilizing the Integrated Modelling for Watershed Evaluation of BMPs (IMWEBs) model that was by Wanhong Yang from the University of Guelph. IMWEBs is a watershed model that evaluates water quality and quantity improvements of over 30 BMPs, including crop and nutrient management, grazing and manure management, irrigation, conservation tillage, marginal land conservation, riparian buffer management and wetland restoration. Output from IMWEBs is based on the implementation of BMPs on individual fields and can scale up these field-level benefits into overall watershed scale improvements. This project is integrated with the NSWA's Riparian Web Portal which will help target areas for improvement in riparian health.

ALUS Canada is an NGO that partners with municipalities and farmers to help to implement BMP projects on the ground. ALUS has partnered with Brazeau, Parkland, Wetaskiwin, and Leduc counties to implement BMPs. ALUS is also involved in the IMWEBs projects described above, as the output from these models will help ALUS prioritize their efforts to achieve the highest benefits. EPCOR has financially supported ALUS in their work to implement BMPs upstream of Edmonton in the past.

The North Saskatchewan Watershed Alliance has led extensive work assessing the health of riparian habitat in the Modeste and Strawberry Creek sub-watersheds utilizing satellite imagery. Note, the sub-watersheds used in this study do not align with the true hydrological watershed boundaries. They are based on the Hydrologic Unit Code (HUC), which merges multiple smaller watersheds together into a single HUC.

Riparian habitats are the transition between terrestrial and aquatic habitats and provide key ecosystem services such as improving water quality, reducing erosion and slowing the release of water. Changes in land use have frequently resulted in the loss of riparian intactness, which can have negative impacts to water quality, and ultimately require increased treatment at EPCOR's WTPs. Based on the NSWA's analysis, the Strawberry sub-watershed has considerably more riparian habitat that is considered not intact compared to the Modeste watershed (Figure 26). The higher intactness of riparian areas in the Modeste sub-watershed is due to a number of streams in this watershed that are located outside agricultural areas. Creeks within agricultural areas were similarly impacted in the Modeste and Strawberry watersheds. A map of the Strawberry watershed shows that the lowest riparian intactness typically occurs along unnamed tributaries and the upper reaches of named tributaries (Figure 27). At these locations, creeks are likely small, intermittent and poorly defined and may be more susceptible to damage by agricultural activities. In contrast, creeks typically had high intactness closer to their confluence with the NSR, likely because at these locations the creek is larger and more defined and agricultural activities are more likely to be set back further in these areas.

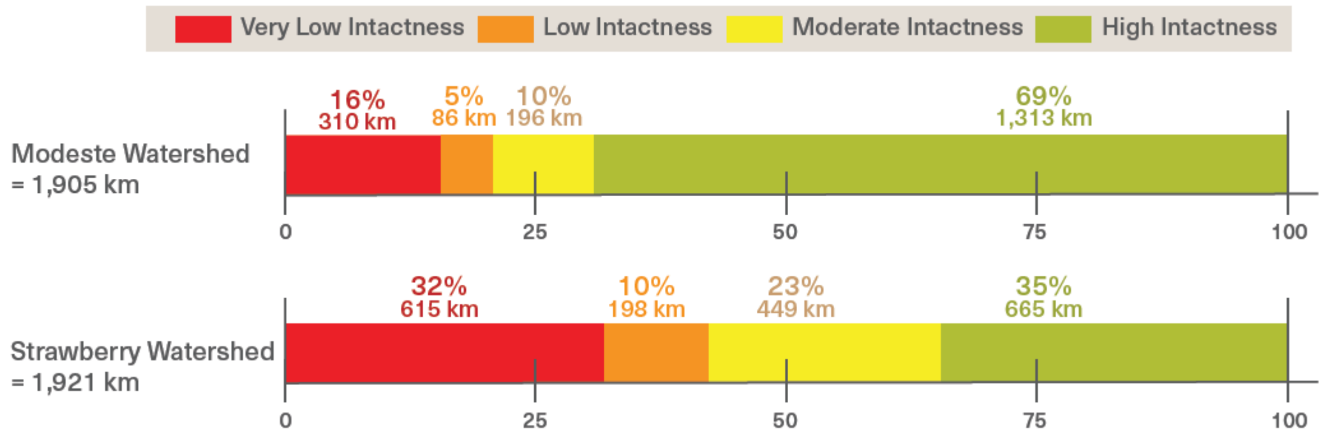


Figure 26. Summary of Riparian Intactness from the Modeste and Strawberry Watersheds (from Fiera 2018a and 2018b)

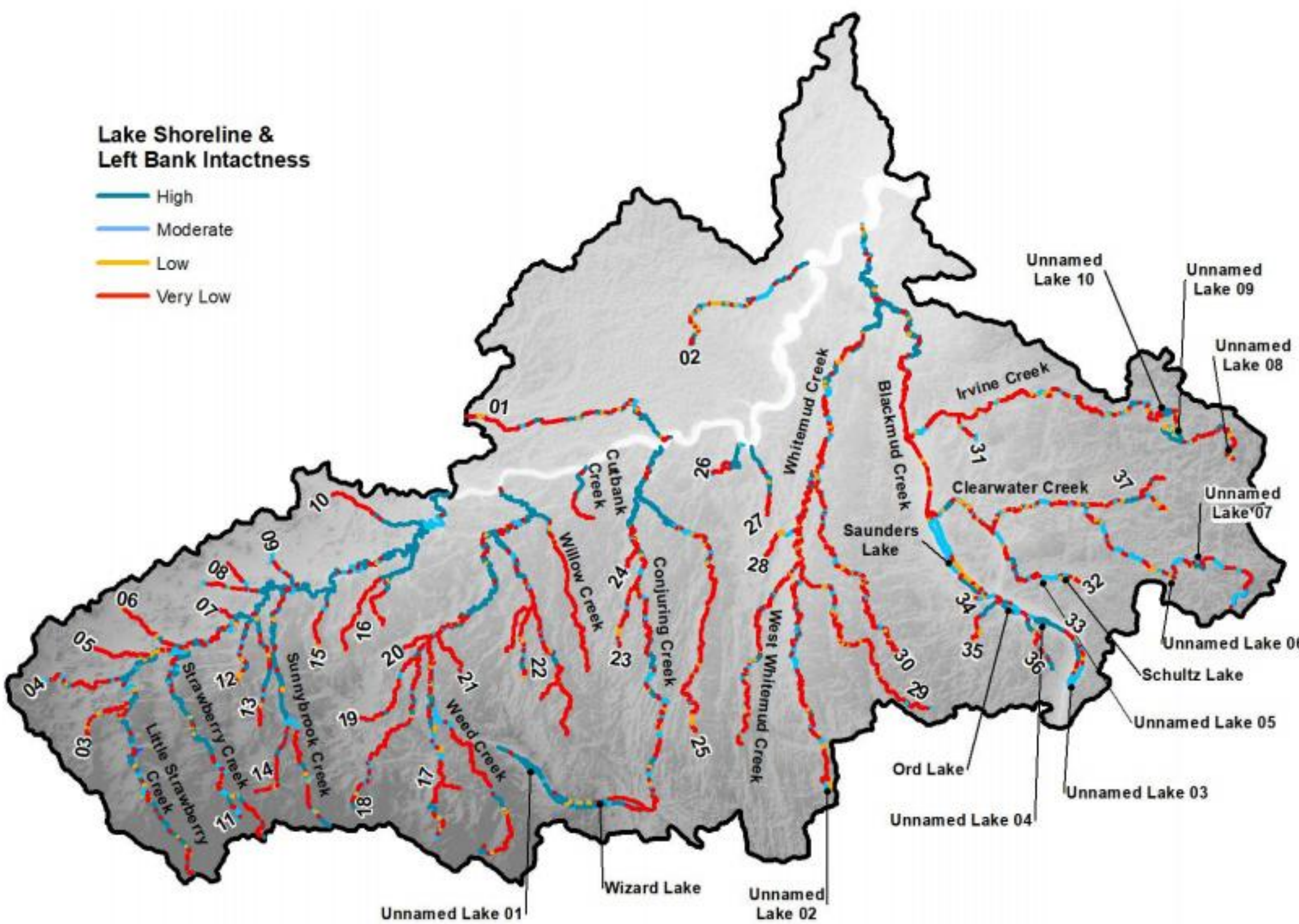


Figure 27. Riparian Intactness Measurements from the Strawberry Subwatershed (Source: Fiera 2018a)

The NSWA's work on riparian habitat extends beyond assessing intactness and includes the assessment of the resulting "pressure" of the land that would impact the riparian area. Utilizing this information, NSWA has highlighted areas that have a high value for conservation or restoration so that efforts and resources can be focused on areas that would generate the greatest benefit. The NSWA has developed a Riparian Web Portal which shows riparian health in an easy-to-use interface. The portal is used to share riparian data, showcase riparian projects on the ground, and connect landowners with restoration and conservation programs.

3.2.9 Industrial Activities

Chemicals are transported throughout the watershed through pipelines, roads, or train routes, and therefore, there is a risk of contamination to the NSR from spills. Routes that pose the highest risk are ones that allow movement of chemicals across the NSR or its tributaries. In terms of transportation corridors, there are many public roads and highways located in the basin upstream of Edmonton. Each transportation corridor is not a potential hazard in itself; however, the traffic which uses the corridors could be a potential hazard depending on the type of material being carried, the probability of a spill/release to the environment and watershed and/or the location in relation to a surface water source. Industrial activities that discharge to receiving waterbodies are also of concern for water quality.

Dangerous Goods Routes

Within Edmonton, there are several dangerous goods routes that cross the NSR upstream of the WTPs. Just upstream of E.L. Smith, the Anthony Henday Bridge crosses the NSR and is designated as a dangerous goods route but, being a newer bridge, has spill containment infrastructure (Figure 28). The Quesnell bridge is also a designated as a dangerous goods route and is located upstream of the Rossdale WTP. This bridge does not have containment built onto the bridge deck. Other river crossings upstream of the Rossdale WTP include the Groat Road Bridge, High Level Bridge and Walterdale Bridge, with only the Walterdale having containment for runoff. The High Level and Walterdale Bridges are designated 24-hour truck routes (green line). While these bridges are not considered dangerous goods routes, traffic crossing these bridges could still be carrying dangerous goods. Additionally, the Anthony Henday also crosses the Blackmud, Whitemud and Horsehills creeks which drain to the NSR upstream of the Rossdale WTP, and Whitemud Drive also crosses Whitemud Creek. Again, newer brides like Waterdale and Henday bridges have containment areas to capture runoff and spills to prevent them from going directly to the NSR.

MEDIUM TO LOW RISK

Due to their proximity to WTP intakes, the wide variety of potentially pollutants transported, and the limited options for treatment, spills from bridge decks are a medium-low risk to source water. The volume of material that is transported is limited and shutting off intakes for 24-48 hours provides some risk mitigation.

Upstream of Edmonton, there are six highway crossings along the NSR. These include Highway 60 near Devon, Highway 770 near Genesee, Highway 759, Highway 22 near Drayton Valley, and Highways 11 and 11A near Rocky Mountain House.

A roadside truck survey conducted by the City of Edmonton in 2012 found that 4.3% of trucks over 4,500 kg were transporting dangerous goods (City of Edmonton 2013). A majority of the dangerous goods were various types of petroleum products (Figure 29).

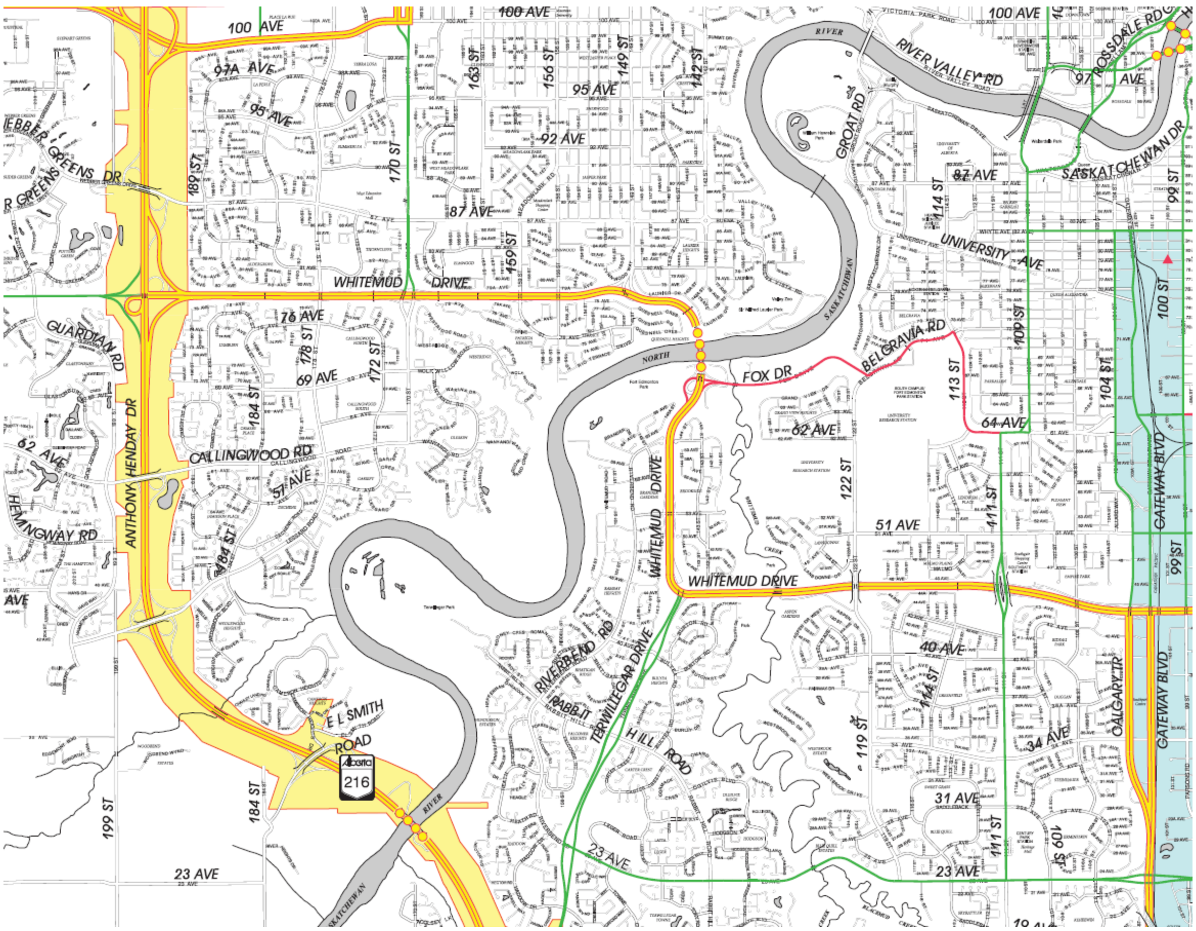
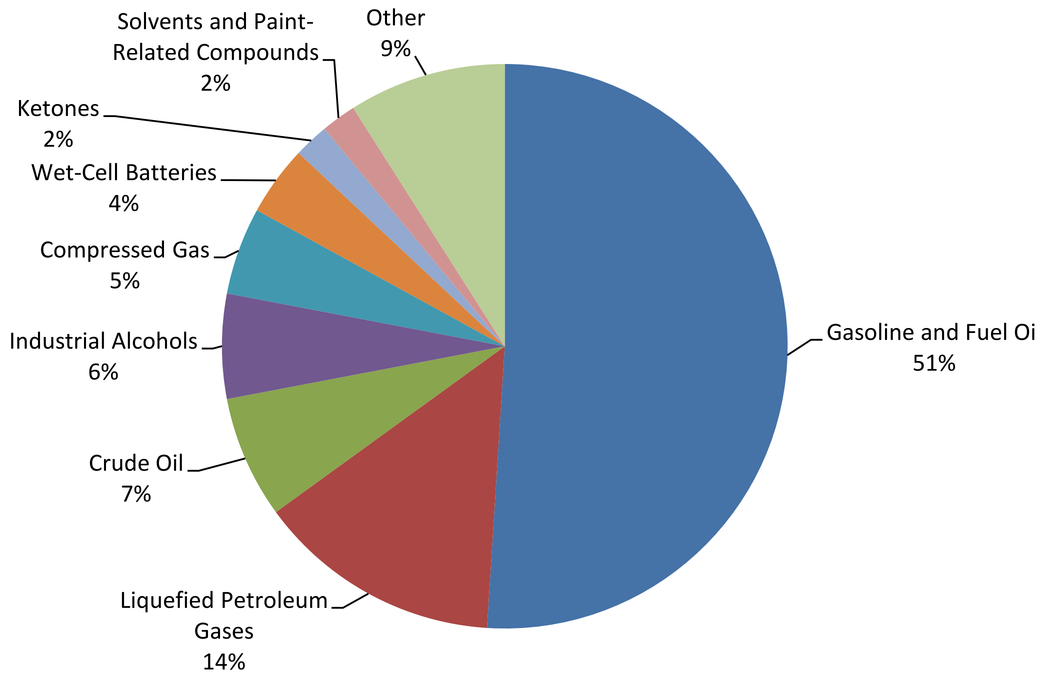


Figure 28. Dangerous Goods Truck Routes and River Crossings with Edmonton Boundaries Upstream of WTPs (Source: City of Edmonton 2015).



Data Source: City of Edmonton 2013

Figure 29. Types of Dangerous Goods Carried in Roadside Truck Survey.

Industrial Discharges

MEDIUM TO LOW RISK

Due to the wide range of potential pollutants used and produced by industrial operations, and limited options for treatment, industrial operations are a medium-low risk to drinking water.

There are few heavy industrial operations upstream of Edmonton aside from oil and gas facilities. Several coal-fired power plants were located upstream of Edmonton near Wabamun Lake, but were either decommissioned, or were converted to natural gas between 2021 and 2024. Operational plants include Capital Power's Genesee station and TransAlta's Keephills and Sundance stations. TransAlta announced that the Sundance station would be temporarily decommissioned in 2025. Cooling water used for thermoelectric power generation at the Genesee, Keephills and Sundance plants represent the largest water diversion use in the upstream basin. However, since most of the water is used for once-through cooling water purposes, there are no significant impacts from a drinking water source perspective associated with discharges back to the river from these thermoelectric facilities. While the plants currently run on natural gas, which is not expected to have an impact on water quality, these plants operated for decades burning coal, and the resulting fly ash was landfilled near these plants. It is assumed that the fly ash is secured and poses little risk to the river or groundwater.

Light industrial operations exist within Edmonton and other municipalities. While these operations do not directly discharge to the NSR, they have the potential to release pollutants into the groundwater as well as stormwater infrastructure that drains to the NSR. catch basins have some containment built in for small spills and, when reported, are removed by vac trucks before they travel downstream.

Roads and Seismic Lines

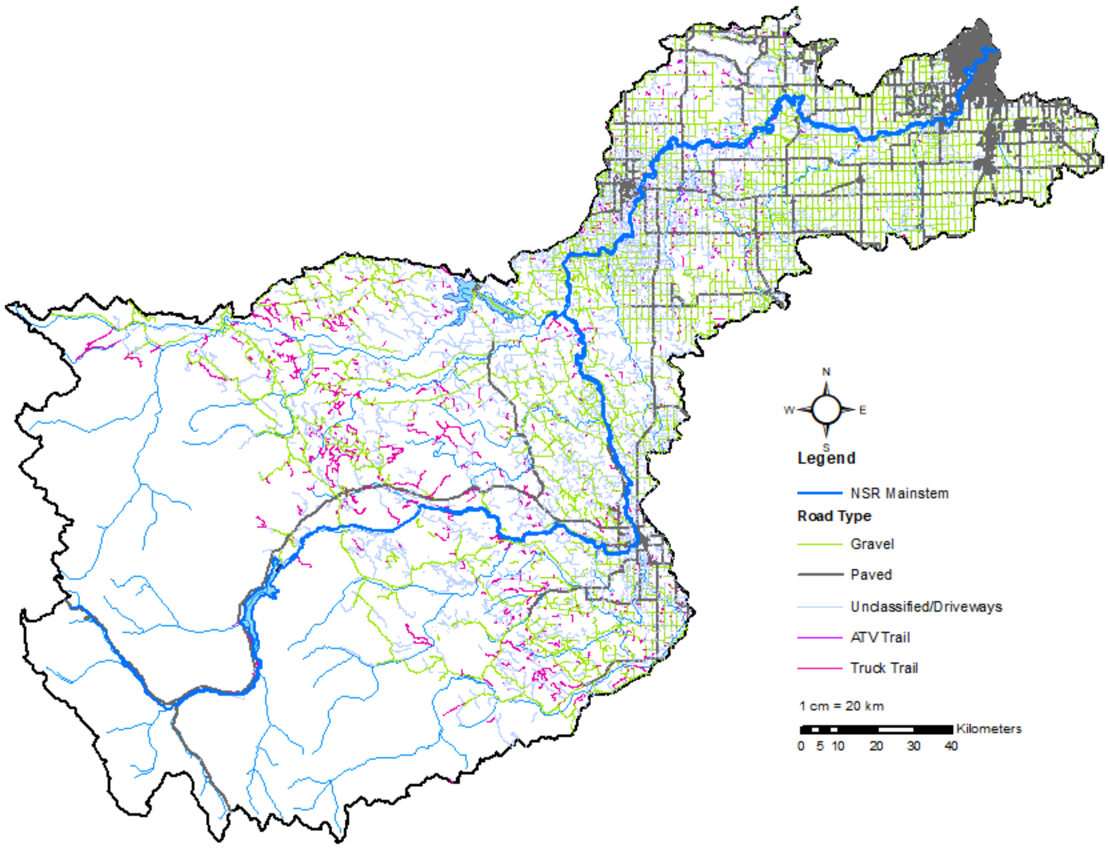
LOW RISK

While roads and seismic lines fragment habitat, increase runoff and erosion, and impact local water quality the impact to water quality in Edmonton is small. This is because the is high natural variability in water chemistry in the NSR and EPCOR's WTPs are designed to treat water within this range.

Roads and seismic lines are specific examples of linear disturbances that can negatively impact watersheds. Roads, and trails, particularly those used for off-highway vehicles, can alter the flow and water quality in headwater streams and negatively impact the soils, vegetation, and animals in these watersheds (Farr et al. 2017).

Roads and seismic line abundance was calculated using data from ABMI's (2021) linear disturbance layer. There are a total of 23,950 km of roads and truck trails in the NSR watershed equating to a density of 0.86 km/km^2, an area of 290.94 km^2, and 1% of the watershed area (Figure 30). There has been an increase of road area of 2.75% from 2018 to 2021. Paved roads comprise 4,974 km and cover 91 km^2 of the watershed. However, in rural areas, paved roads extend only approximately 2,000 km and cover less than 50 km^2. Gravel roads, consisting of mainly county maintained roads, comprise 6,846 km in length and 77 km^2 in area. Most of the paved and gravel roads are concentrated in the lower portion of the watershed between Edmonton and Drayton Valley. There are 56 km of designated ATV trails and this has stayed the same since 2018.

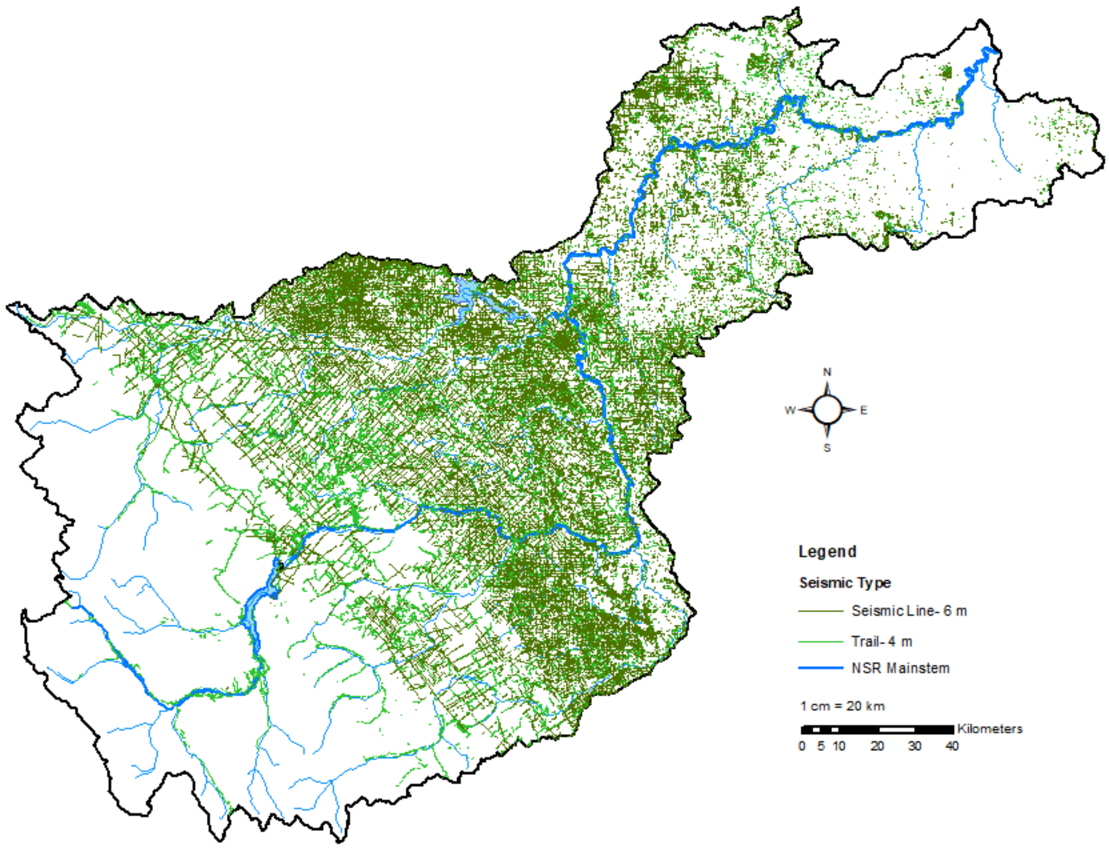
Alberta Environment and Sustainable Resources Development (now AEPA) summarized the thresholds at which various animals are impacted by road densities: 0.4 km/km^2 for grizzly bear, 1.25 km/km^2 for black bear and 0.62 km/km^2 for elk (AESRD 2012a). They also summarized the relationship between road density and bull trout populations and found that moderate risk to bull trout populations occurred at densities of 0.1 – 0.2 km/km^2, high risk occurred at 0.2 – 0.6 km/km^2, very high risk occurred at densities of 0.6 – 1.0 km/km^2 and bull trout were extirpated at densities 1.0 km/km^2. Work conducted by the U.S. Forest Service shows that habitat effectiveness for grizzly bears, an indicator species, decreases as road densities increase. At road densities of 0.8 km road/km^2, habitat effectiveness is reduced to 50%; at road densities of 1.6 km road/km^2, habitat effectiveness is further reduced to 25%. To meet the U.S. Forest Service established management goal of maintaining habitat effectiveness in occupied grizzly bear habitat at 80%, road densities should be maintained below 0.3 km/km^2. Based on the literature values, road densities in the NSR watershed are high enough to have a notable an effect on each of the species described above. Road densities are low in the headwaters and increase with proximity to Edmonton. It is recognized that while there is likely little direct relationship the abundance and health of these indicator species and source water quality species are indicative of general watershed health. If these components have been compromised it likely the integrity of the watershed and its ability to perform ecosystem services (i.e., maintain water quality) has also been compromised. The linear disturbance values we see in the NSR are high and will be important to monitor as indicators of watershed health.



Data Source: ABMI 2021

Figure 30. Roads in the NSR Watershed in 2021.

Seismic lines typically range in width from three meters (low impact) to six meters (pre-low impact). Once a seismic line revegetates, it often becomes a trail-like feature and has been categorised as such in ABMI's data layer. Based on ABMI's 2021 data, there are 25,117 kilometers of seismic lines in the watershed, which make up 202 km^2 of area. Most of the seismic lines are located between Drayton Valley and Rocky Mountain House in the upper portion of the watershed; however, little seismic activity has occurred in the headwaters (Figure 31). Trails make up 30 km^2 of the watershed with a cumulative length of ~9000 kilometers.



Data Source: ABMI 2021

Figure 31. Seismic Lines in the NSR Watershed in 2021.

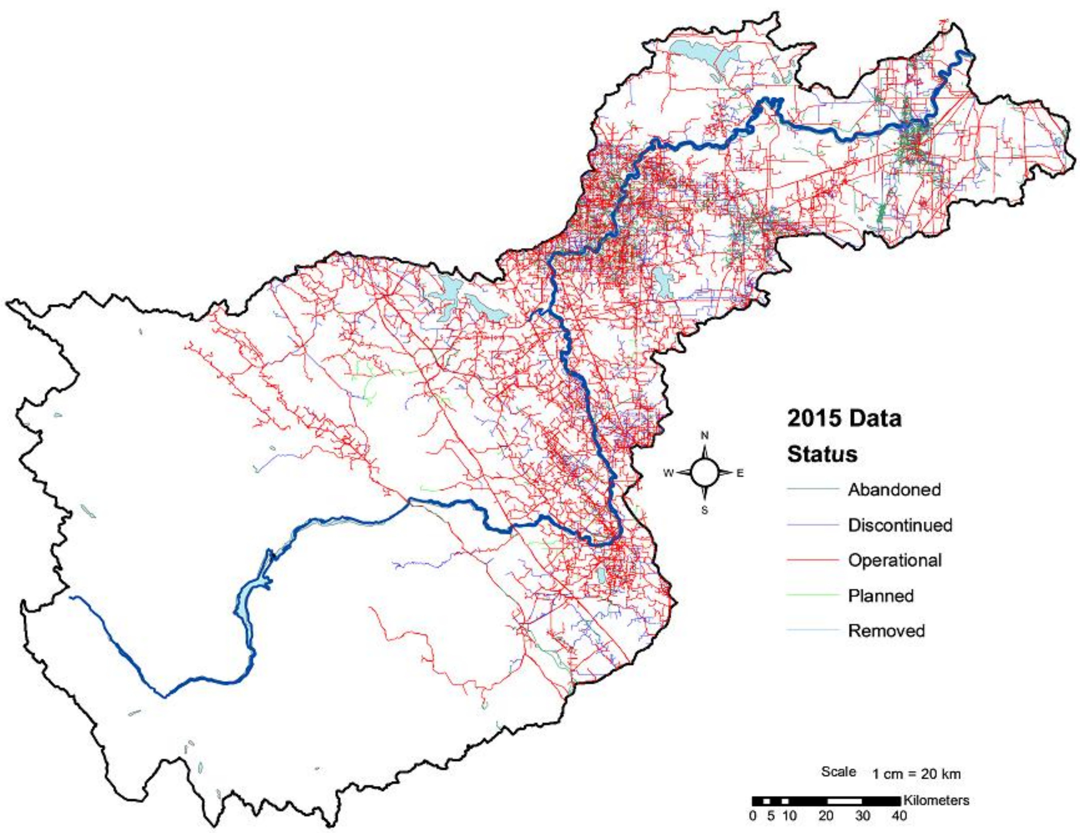
Pipelines

Based on the Alberta Energy Regulator's 2015 data, there are 31,953 km of pipeline in the NSR watershed. Of that, 21,847 km of pipeline is operational. The highest densities are near Drayton Valley, Devon and Rocky Mountain House (Figure 32). There is 4,773 km of abandoned pipeline, 5,008 km of discontinued pipeline, 10 km of pipeline that has been removed, and, as of 2015, 314 km of pipeline that was pending construction.

The average age of the operational pipelines is just over 20 years old, although many of the pipelines established in the early 1940s and 1950s have been converted or upgraded.

MEDIUM-HIGH RISK

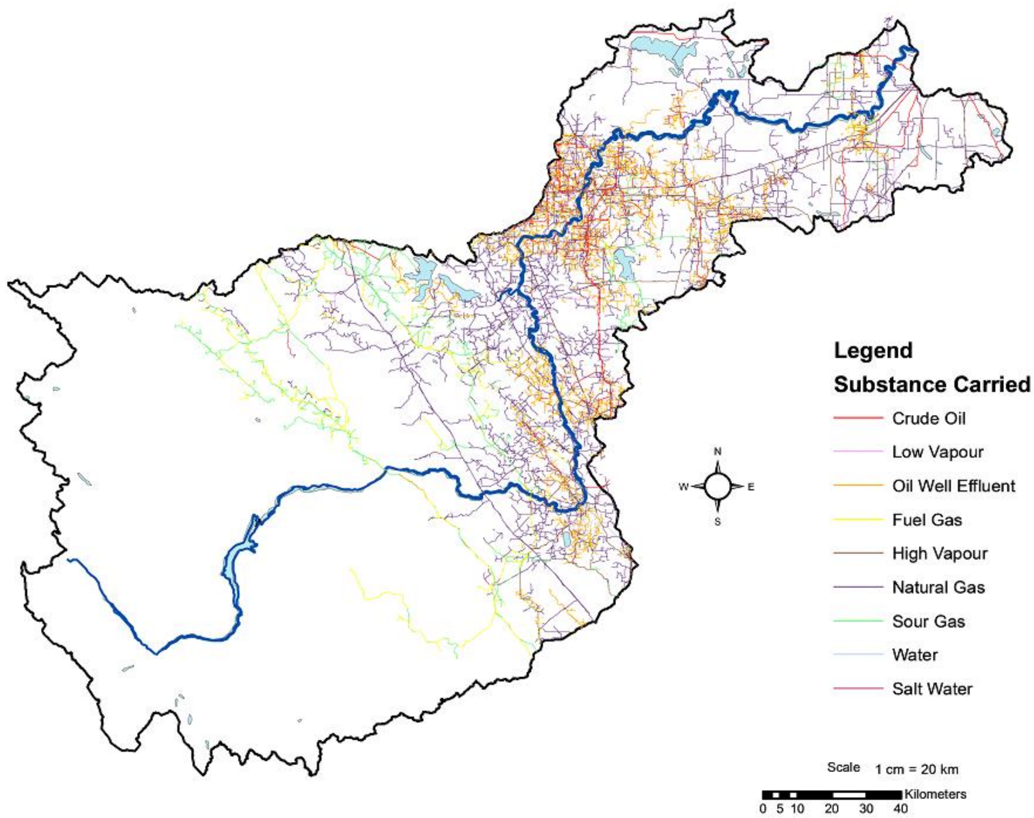
Pipeline breaks have the potential to release large volumes of hydrocarbons directly to the NSR impacting water quality in for days/weeks, potentially making water untreatable. EPCOR's WTPs have submerged intakes, allowing some hydrocarbons to bypass WTPs but, depending on the activity of the hydrocarbon, some may still enter. Activated carbon can be by the WTPs which may be able to treat contaminated water. Emergency plans from pipelines companies also reduce risk, but the risk to drinking water remains medium-high.



Data Source: Alberta Energy Regulator 2017a

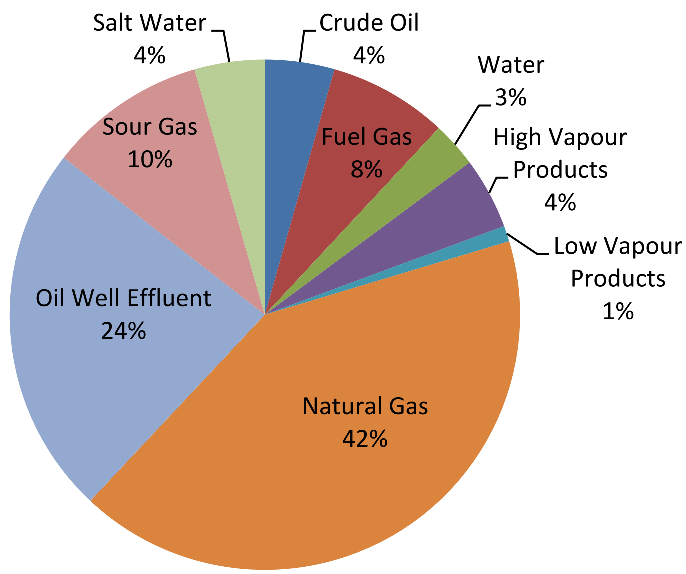
Figure 32. Pipelines in the NSR Watershed in 2015 by Status.

Of operational pipelines, over half carry natural gas (42%) or sour natural gas (10%) (Figure 33 and Figure 34). High vapour products (HVP) comprise 4%; salt water comprises 4%; and surface and potable water comprise 3% of the pipeline length. Substances that are potentially more challenging from a water treatment perspective comprise a total of 37% of the length of pipeline in the watershed and include oil well effluent (24%), fuel gas (8%), low vapour products (1%), and crude oil (4%).



Data Source: Alberta Energy Regulator 2017a

Figure 33. Operational Pipelines in the NSR Watershed by Substance Carried.



Data Source: Alberta Energy Regulator 2017a

Figure 34. Percent of Total Length of Operational Pipelines in the NSR Watershed by Substance Carried.

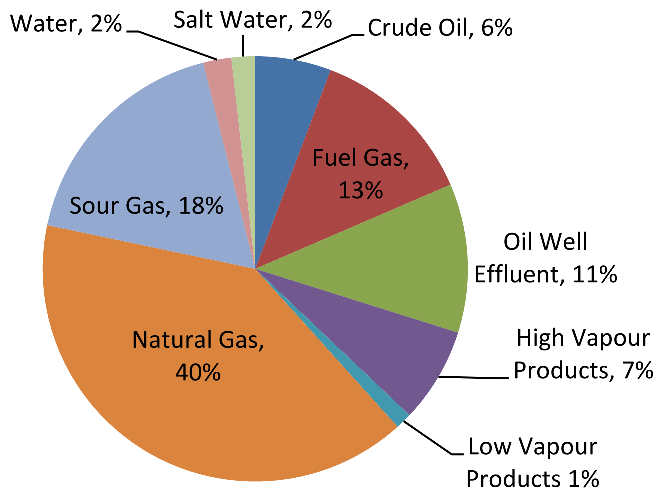
From the perspective of source water protection, both pipeline density and the substance carried by pipelines is important in terms of assessing the risk to source water. Additional important considerations are the location of the pipeline relative to the mainstem and major tributaries of the NSR, and the distance from the WTP intakes. There are nearly 4,000 km of pipeline located within 250 m of the NSR mainstem and its major tributaries (

Table 7). There are an estimated 380 operational pipelines that cross or intersect the mainstem and major tributaries in the NSR basin upstream of Edmonton, and of these, 119 pipelines cross the NSR mainstem. Of these pipelines, 58% carry natural or sour gas, 7% carry high vapour products, and 4% carry fresh or salt water. These products are a low risk to source water protection in the event of a release into the NSR. However, 11% of pipelines crossing the NSR or a major tributary carry oil-well effluent, 6% carry crude oil and 1% carry low vapour products such as diesel, which are of high risk to source water protection should a spill occur (Figure 35). The pipelines which carry crude oil are shown in Figure 36.

Table 7. Pipelines in the NSR watershed as a function of location to the NSR mainstem and major tributaries.

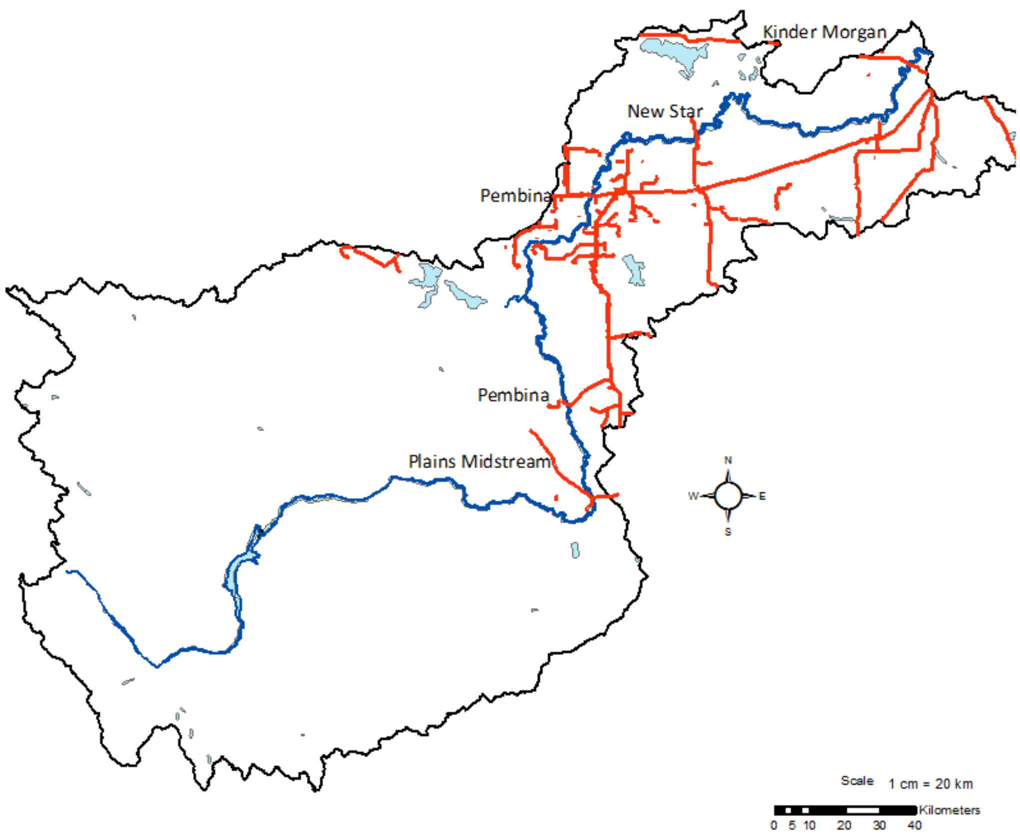
Substance	Description	Code	# Pipelines Crossing Major Tributary or Mainstem	# Pipelines Crossing Mainstem	Length of Pipeline within 250 m of NSR or Tributary (km)
Crude Oil	Blended Crude Bitumen, Crude Oil, Sour Crude Oil, Synthetic Crude Oil	CO	19	6	228
Fuel Gas	Fuel Gas	FG	35	5	504
Water	Potable Water, Surface Water	FW	17	14	85
High Vapour Products	Butane, Ethylene, Propane, Pentanes, Liquid Ethane	HV	22	8	286
Low Vapour Products	Condensate, Diesel Fuel, Gasoline, Heating Oil, Hydrocarbon Diluent, Kerosene, Solvents	LV	8	3	49
Natural Gas	Methane, Synthetic Natural Gas, Natural Gas With 10 Mol/kmol Or Less Of Hydrogen Sulfide Content	NG	146	39	1,580
Oil Well Effluent	Multiphase Fluids	OE	68	27	448
Sour Gas	Natural Gas With More Than 10 Mol/kmol Of Hydrogen Sulfide Content	SG	47	4	702
Salt Water	Salt Water	SW	18	13	71
Total			**380**	**119**	**3,953**

Data Source: Alberta Energy Regulator 2017a



Data Source: Alberta Energy Regulator 2017a

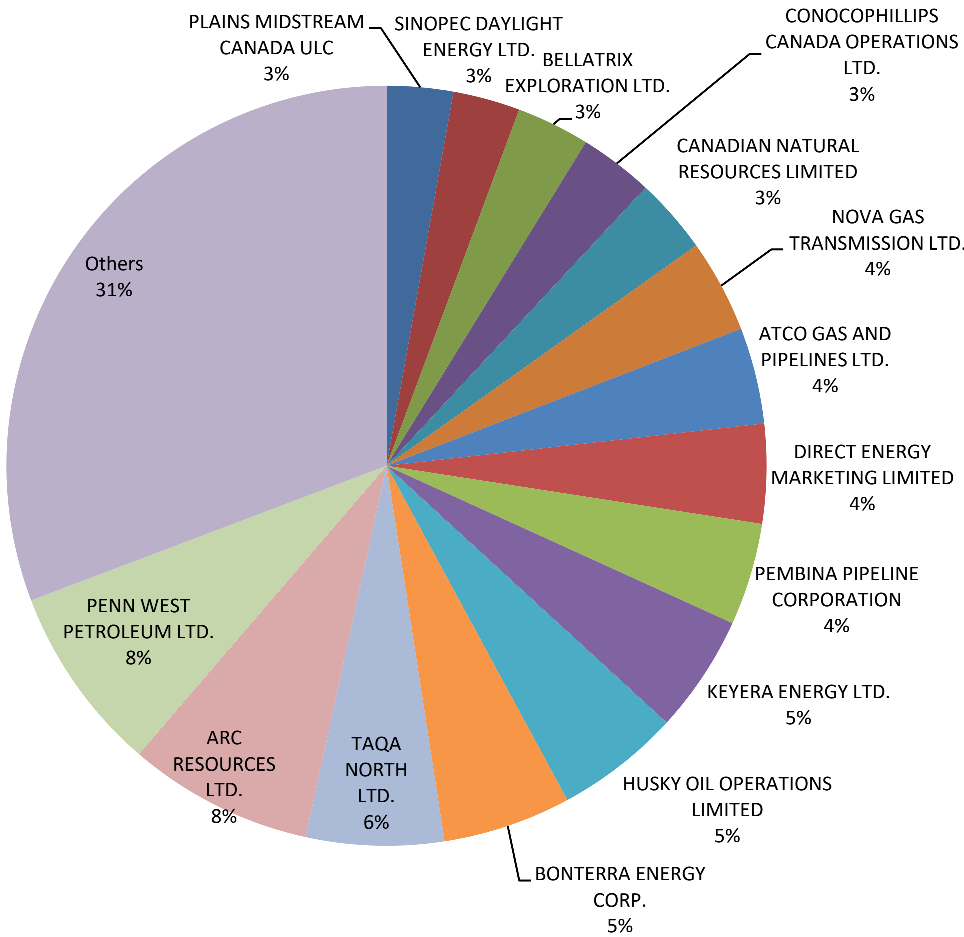
Figure 35. Materials Transported by Pipelines Within 250 Meters of the NSR Mainstem and its Major Tributaries in 2015.



Data Source: Alberta Energy Regulator 2017a

Figure 36. Operational Crude Oil Pipelines in the NSR Watershed.

There are 204 companies who share ownership of pipelines in the watershed. The highest percent ownership is at 8% and is shared by Penn West and ARC Resources (Figure 37). Of the companies operating in the watershed, 64 operate pipelines that cross the NSR mainstem and its major tributaries. Of those, crude is transported only by Kinder Morgan, New Star Energy Ltd., Pembina Pipeline Corporation, and Plains Midstream Canada UCL.



Data Source: Alberta Energy Regulator 2017a

Figure 37. Ownership of Operational Pipelines in the NSR Watershed.

The Alberta Energy Regulator works to ensure that the design, construction, operation and maintenance of pipelines complies with Alberta's *Pipeline Act*, *Pipeline Regulation*, and applicable Canadian Standards Association standards. The Alberta Energy Regulator's pipeline inspection program considers the potential risks of individual pipelines such as the products, location, size, failure history and operator's compliance history. Pipelines that have greater potential risks, such as those that are near waterbodies, or have a poor compliance history, receive greater scrutiny (Alberta Energy Regulator, 2017b). As well pipeline companies have operational centers where operators are surveying pipeline pressures and assessing possible leaks 24 hours a day.

Due to the large number of oil and gas facilities and pipelines located in the NSR basin, the likelihood and consequence of a spill / release to the environment was determined to have an inherent medium-high risk to Edmonton's drinking water system (see Section 3.5). Given that many of the pipelines are located a considerable distance upstream, advanced warning is anticipated to occur before the spill reaches the WTP intakes. However, the Kinder Morgan / TransMountain Pipeline crosses the NSR approximately 9 km upstream of the Rossdale WTP, and a spill would reach the intake in under two hours. The responsibility to notify downstream users of a spill belongs to the party responsible for the spill; however, depending on the nature and timing of the event, EPCOR's WTPs could be notified by the Alberta Energy Regulator, Alberta Environment and Protected Areas or the Alberta Emergency Management Agency. EPCOR is engaged in conversations with industry and regulators to ensure that EPCOR's WTPs are promptly notified in the event of a spill.

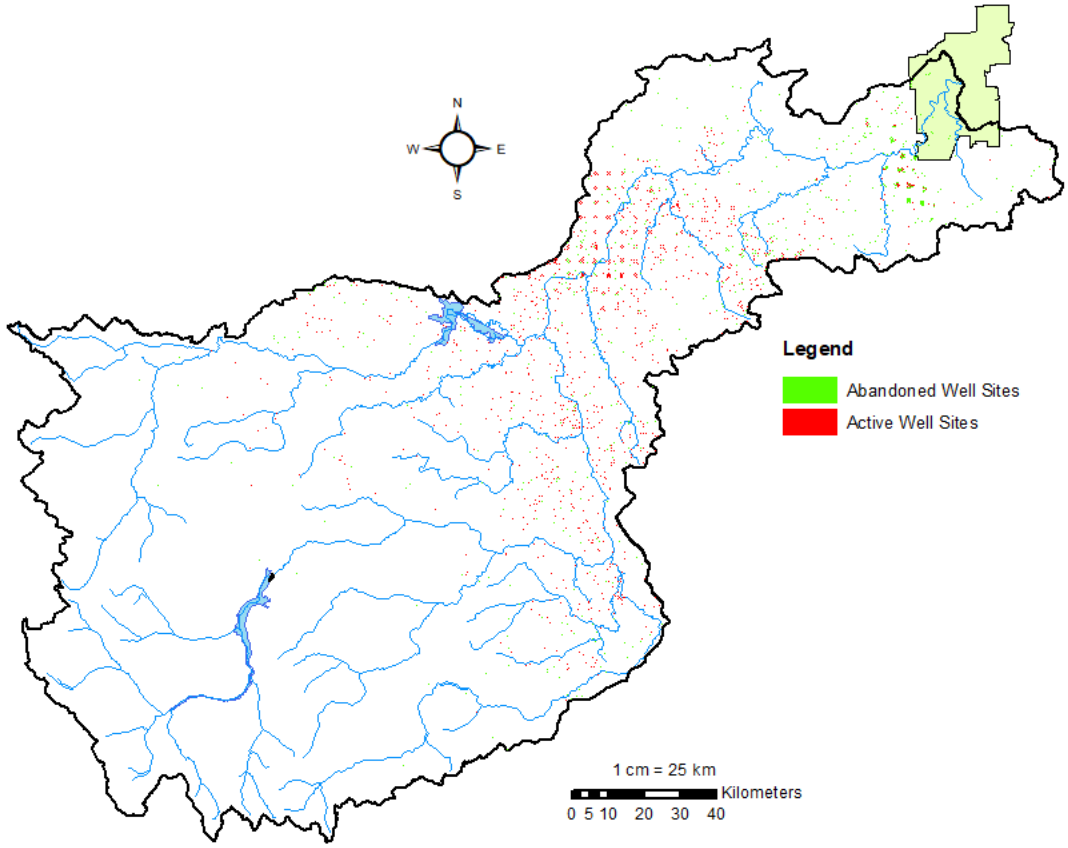
EPCOR can implement a number of control measures in the event of a spill including monitoring on the NSR and at the WTP intakes and shutting off raw water intakes until the spill has passed. Additionally, depending on the product spilled and how it mixes in the NSR, the product may not enter the submerged WTP intakes. Lastly, the WTPs may be able to fully remove all contaminants and continue to produce safe drinking water. These control measures were determined to reduce the inherent risk and result in a medium-low residual risk (see Section 3.5). Although there is a low likelihood of a significant oil pipeline spill reaching EPCOR's WTP intakes, the consequence could be high, as it could result in the shut-down of the WTP intakes for several weeks or months. Communities on the NSR in Saskatchewan downstream of Edmonton were forced to shut off their intakes and find alternate sources of water after the Husky Energy pipeline spill into the NSR in Saskatchewan in July 2016.

Well Sites

As of 2021, there were 9,016 active wells, whereas in 2018 there were 9,710 active wells comprising an area of 137 km^2. Of these approximately 50% were oil wells and 30% were gas wells and the remaining wells were cased or other types of wells. Additionally, there were 6,656 abandoned well sites comprising an area of approximately 96 km^2 in the watershed. Most of the active well sites were located near Drayton Valley; however, most of the abandoned well sites were located closer to Edmonton (Figure 38). The oldest oil and gas wells were drilled in the 1940s.

MEDIUM LOW RISK

Well sites have the potential to release large volumes of hydrocarbons; however, the spill would first occur on land before entering the NSR, reducing the likelihood and impact of a catastrophic spill reaching EPCORs intakes, making the risk to drinking water medium-low.

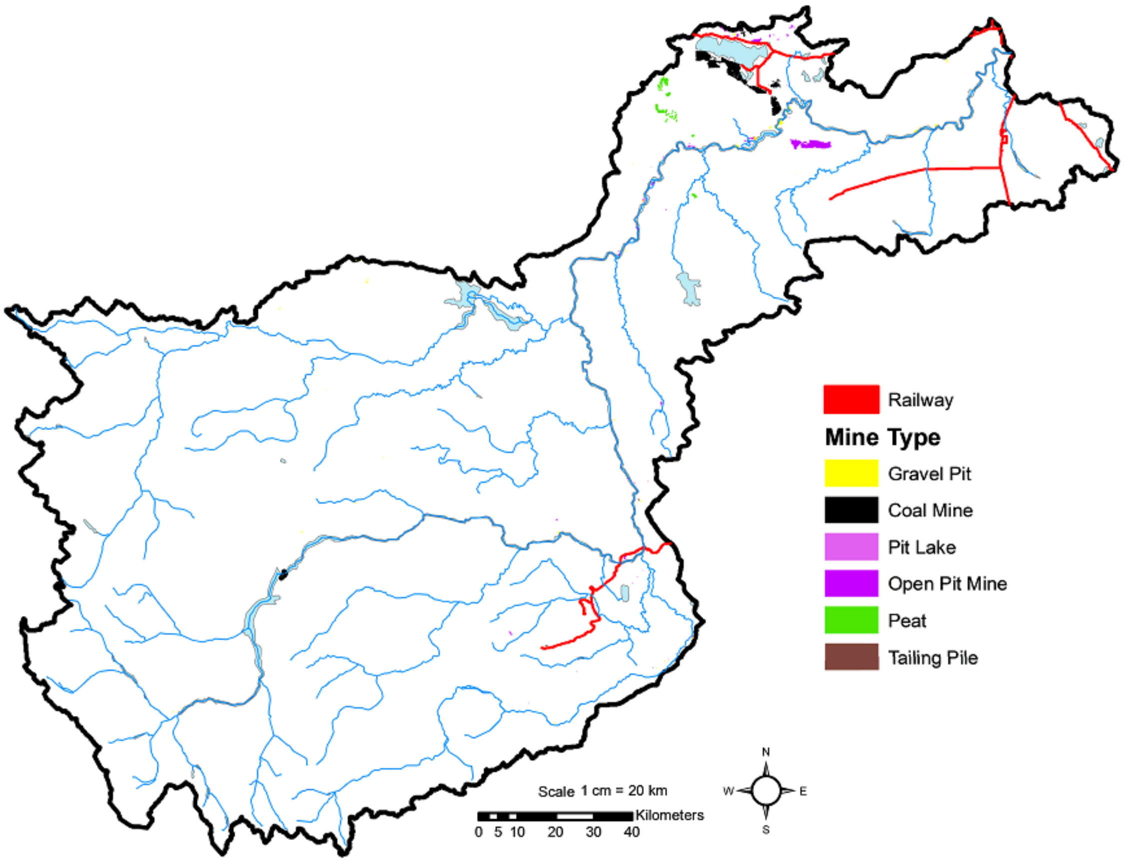


Data Source: AMBI 2018

Figure 38. Map of Well Sites in the NSR Watershed in 2018.

Railways

There are relatively few railways in the NSR watershed. There are only two rail crossings of the NSR mainstem, and both are located near Rocky Mountain House (Figure 39). There are also railways located near Lake Wabamun, and a railway crosses several tributaries of the NSR a short distance upstream of Edmonton. Risks of rail spills affecting the NSR is low due to few crossings.



Data Source: ABMI 2018

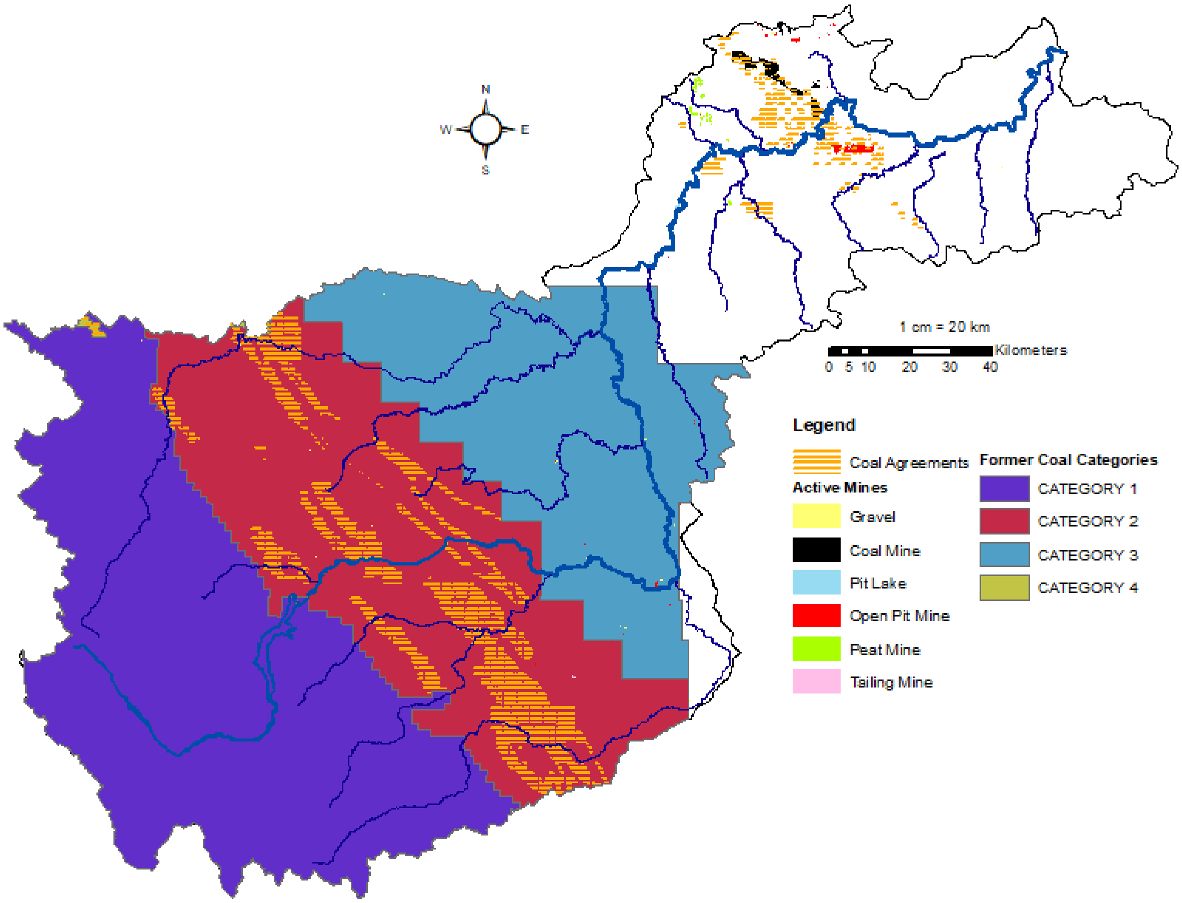
Figure 39. Map of Mines and Railway Lines in the NSR Watershed.

Mines (Coal, Gravel)

There is currently relatively little coal mining activity in the NSR watershed; 54 km^2 of the watershed categorized as coal mine and 26.9 km^2 is categorized as open coal pit mine (0.3% of watershed). Coal mining was limited to the areas near Wabamun Lake Area, which drain into Wabamun Lake or pit lakes (1.5 km^2) (Figure 40). Wabamun Lake connects to the NSR through Wabamun Creek; however, because of a weir at the outlet, water from Wabamun Lake does not overflow into the creek very often. Coal mining in the area stopped in 2021/2022 when the nearby power plants converted to natural gas and the mines have been decommissioned.

LOW RISK

Given the absence of coal mining in the headwaters and that coal mines near Wabamun Lake have been decommissioned, the risk of coal mines affecting water quality in the NSR is currently negligible. Gravel and peat mining occur in very small areas of the watershed and are unlikely to significantly affect water quality in the NSR. The risk of mining activities to drinking water is currently low.



Data Source: GoA 2020

Figure 40. Map of Coal Mines, Agreements, and Active Mines in the NSR Watershed.

Coal mine development in Alberta is guided by the Government of Alberta's Coal. This policy came into effect in 1976. The Coal Policy was rescinded in July of 2020 and was cited by the Government of Alberta as being obsolete. In this period, restrictions on category 2 and 3 lands were removed whereas protection of category 1 lands remained. Due to public outcry, the Coal Policy was reinstated on Feb 8th, 2021. It is expected the current Coal Policy will be reviewed in the coming years and replaced by a new policy. This is being completed through the Coal Modernization Initiative and a final plan will be completed in late 2025.

The scope of the current policy is wide-ranging and includes a land use classification system which divided the Rocky Mountains and Foothills in Alberta into four main categories. The categories dictate where and how coal leasing, exploration and development can occur. There is no mining or exploration allowed in category 1 lands which generally include National and Provincial Parks and other protected areas. Surface mining is generally not permitted on category 2 lands, which include parts of the Rocky Mountains and the Foothills, and exploration and underground development is limited. Exploration is allowed on lands listed as category 3 under the normal process, but development in these areas is still somewhat restricted. Category

4 lands consist of the remaining areas, where coal mining is permitted. There are no category 4 lands within the NSR watershed. The City of Edmonton and EPCOR worked together to complete and publish a more detailed risk assessment on the potential effects of coal mining in 2021. EPCOR has also completed a detailed risk assessment and literature review that outlines potential effects to aquatic ecosystems, source water, and other water uses and that work informs this SWPP. The assessment here is limited only to drinking water source risks at Edmonton and does not include other risks or locations (i.e., aquatic health/headwaters areas).

Although the active mine area is currently small, there are coal deposits, coal fields, and associated coal agreements that have not yet been developed. Specifically, there are 1,510 km^2 (just over 5% of watershed) of coal agreements in place that are all located in Category 2 in areas categorized as high-volatile bituminous coal (Figure 40). Of the remaining agreements, 327 km^2 is under the normal approval process and 15 km^2 is under category 3. Coal agreements are leases issued by the Government of Alberta that give the holder the exclusive right to recover coal within these areas and allows exploration to proceed with a permit. In 2019-2020 seven exploration permits were granted for approximately 320 km^2 total area. However, a coal agreement does not grant permission to develop a mine. In order to develop a mine, the holder of a coal agreement requires a mine permit and a mine licence from the Alberta Energy Regulator (AER). Under the *Environmental Protection and Enhancement Act* (*EPEA*), an environmental impact assessment (EIA) would be required, which allows the AER to examine the effects that the proposed project may have on the environment, and determine if the project is in the public interest. An approval issued by the AER under *EPEA* outlines the obligations and responsibilities for design, construction, operation and reclamation of the coal mine. Following the completion of mining activities, reclamation certificates issued under *EPEA* certify that all reclamation requirements have been met and that companies have done everything they can to return land to a state functionally equivalent to what was there before development took place. It is not clear if, under new regulations, if coal mining would be economically feasible for any areas in the NSR basin. However, there have been no new mining licence applications in the NSR basin recently.

While open pit or surface coal mines have the potential to affect water quality and quantity in a number of ways, the impacts to drinking water quality in Edmonton are expected to be minimal due to the relatively small footprint (<5% of the watershed) and the dilution capacity of the NSR. This does not mean that coal mine impacts are not important for streams in the headwaters of the North Saskatchewan River in terms of water quality and aquatic ecosystem health, just that from an Edmonton drinking water perspective, source water quality is not expected to change in a significant way. That said, due to emerging science of selenium fate and transport and long-term mining effects that can be set in motion by the physical alteration of the headwater areas with low remediation potential, it is critical that modelling assessments be completed before any mining activity is permitted. This is particularly true at a watershed scale where the cumulative effects of mining need to be considered.

The removal of surface vegetation and construction of roads have the potential to increase erosion, and therefore increase suspended solids, turbidity and the volume of runoff. Mine waste can also result in acidification, elevated metals and total dissolved solids. However, coal mines would require Environmental Assessments and Aquatic Effects Monitoring programs required by the AER and AEP under *EPEA*, which are designed to limit downstream impacts to water quality. Mines would presumably install tailings dams/ponds in order to capture flows and reduce suspended solids and metals. With these control measures in place, it is assumed that impacts to water quality will be relatively small and localized. Given the anticipated government requirements, the distance downstream of EPCOR's WTPs, the assimilative capacity and existing water quality of the NSR, again it is anticipated that the impacts to water quality in Edmonton would be negligible from a drinking water perspective.

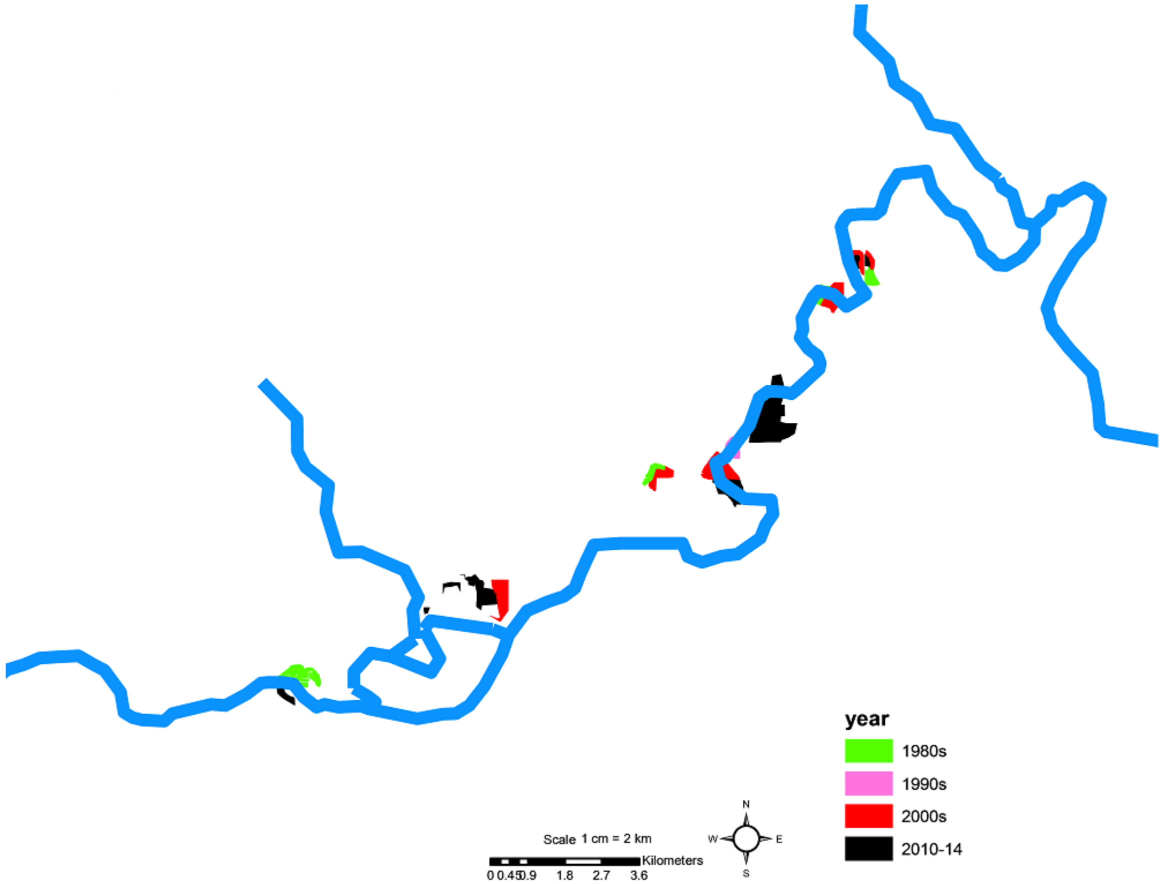
Selenium is a parameter of concern that has been associated with coal mining effects globally and in Alberta's mountain regions. From a drinking water treatment perspective, it anticipated to have a negligible effect; background levels in the NSR are very low (<0.5 µg/L) and two orders of magnitude lower than current Health Canada Guidelines (50 µg/L). Selenium is an essential element for humans and other organisms, but can be toxic in elevated concentrations, and it can bio-accumulate within tissues and result in decreased fish reproduction and viability. Elevated selenium has been well documented downstream for open pit coal mines in the Rocky Mountains. For example, Luscar Creek and Gregg River, which are directly downstream of mining activities, have average concentrations of 17 µg/L (<2 µg/L upstream) 7 µg/L (upstream <1 µg/L), respectively. When rocks that are high in selenium are brought the surface, runoff can enter downstream waterbodies leading to impacts in aquatic life. Alberta Environment and Parks' water quality guideline is 2 µg/L for selenium for the protection of aquatic life, and there is an additional 'alert concentration' of 1 µg/L. The alert concentration indicates the need for increased water quality and aquatic ecosystem monitoring to support early detection of potential bioaccumulation of selenium. It would be expected that new coal mines would be expected to meet these guidelines, particularly considering that once selenium rich rock is exposed, remediation is very costly and difficult.

EPCOR monitors selenium in the NSR at the WTP intakes monthly, and concentrations are very low and far below guidelines. At the E.L. Smith WTP, 60% of samples have been at or below the detection limit of 0.2 µg/L, and the highest recorded concentration was 0.5 µg/L, 100 times below the drinking water quality guideline. Similar results were found at AEPA's sampling at Devon, where 82% of samples were at or below 0.2 µg/L; however, elevated selenium (i.e. 1.2 to 6 µg/L) was detected in three samples during the 1990s. The low concentrations of selenium in the NSR, the large assimilative capacity of the river in Edmonton, robust water treatment, and the high drinking water guideline compared to protection of aquatic life guidelines, means that increases in selenium and impacts to drinking water are not expected in Edmonton. Should any coal mining be approved it would be recommended that a cumulative modelling approach be taken where rates of selenium loading be quantified on a watershed scale (with all potential mines included). Specifically, a calibrated and validated water quality model that includes selenium geochemical processes and quantifies expected concentration changes in relation to protection of aquatic life guidelines should be developed. Again, this is because once disturbance occurs it is very difficult to mitigate and effects on water quality and subsequently fish and overall aquatic ecosystem health.

The largest risk from an open-pit coal mine to Edmonton's drinking water source water is the possibility of a mine disaster such as the failure of a tailings dam. Waste pits, end-pit lakes, and tailings dams are structures utilized to retain runoff and/or wastewater from mine operations. The volumes contained within these structures can be large, and typically are high in solids, metals and other parameters. In 2013, a tailings dam at the Obed Mountain coal mine near Hinton AB failed, releasing over 1 million cubic meters of wastewater elevated in arsenic, metals and PAHs into the Athabasca River. In 2014, a tailings dam at the Mount Poly gold and copper mine (not a coal mine) in B.C. failed, releasing 24 million cubic meters of mine waste into Quesnel Lake. While the failure of tailings dams are rare occurrences, they can have an extreme impact to downstream water quality. Without specific details of a proposed mine or tailings pond, it is not possible to make a definitive statement regarding the potential impacts of the failure of a tailings dam on the water quality in Edmonton; however, such a release would likely be a significant event and could require the WTPs to close their intakes. It is impossible to estimate how long water quality in the NSR would remain impacted following a mine disaster; however, water quality could remain significantly impaired for a number of days. Potential impacts of having to shut down the WTPs for an extended period could include implementing demand management, boil water advisories, or do-not-consume advisories.

Peat mining is the next largest mining activity, by area, in the watershed. Like active coal mines, peat mining is also limited to the upland areas away from direct drainage into the NSR, and comprises 13 km^2 of the watershed. Due to the small area of peat mining and the location in the watershed, water quality impacts from this activity are expected to be negligible.

Gravel mining consists of only 10 km^2 of the watershed but is largely located along the mainstem of the NSR. In fact, 60% of the gravel mining area is within 500 meters of the NSR mainstem (Figure 41). There are 194 gravel pit extraction areas along the NSR, mostly clustered near the town of Tomahawk (south of Wabamun Lake) and near Rocky Mountain House. Since 2000, 6 km^2 of new gravel pits were dug in 106 new pits. The new pits were typically dug next to existing pits. Parts of the NSR riverbed is gravel-bed with significant near-surface sand and gravel deposits. As these deposits are typically connected to surface water features, including key tributaries and the river's mainstem, gravel extraction can be of concern due to the potential impact to the aquifer and increase of sediment entering the river. In 2016, the Government of Alberta's started a review of the sand and gravel program to address growing public concern over impacts to waterbodies.



Data Source: GoA 2020

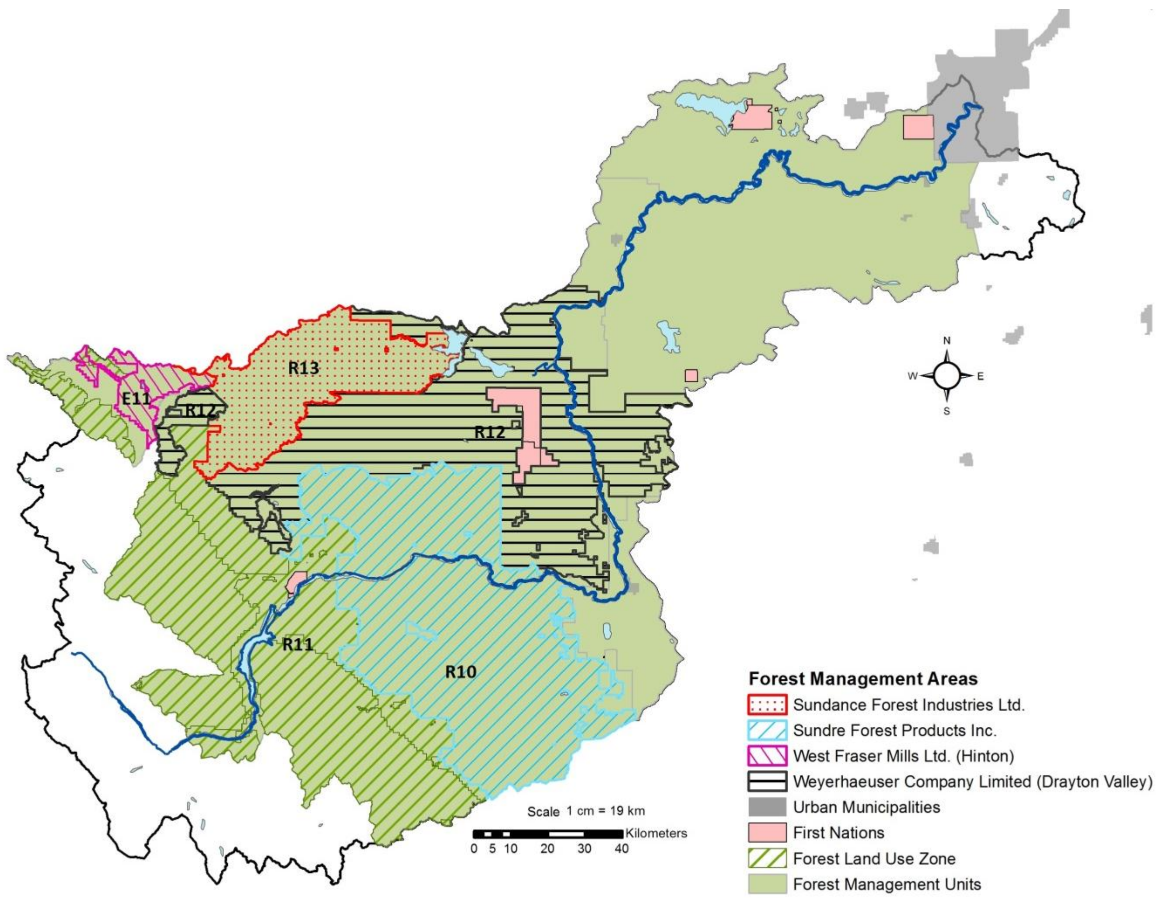
Figure 41. Map of Gravel Pits Along the Mainstem NSR South of Wabamun Lake.

3.2.10 Forestry and Forest Disturbance

Most of the forestry activity in the North Saskatchewan River watershed is located in the upper watershed (Figure 42). The forest is a mix of coniferous and some stands of mature deciduous forest. These forests are critical to source water quantity and quality in the watershed, and the loss of forest and perennial vegetation can affect watershed hydrology. Land disturbances due to loss of forests and uncontrolled access have the potential to cause significant land erosion, leading to increased amounts of sediment, organic material and nutrients entering the NSR and its tributaries. These events could cause challenges for EPCOR's WTPs, particularly during spring runoff and/or heavy rainfall events.

LOW RISK

While forest harvesting can impact local water quality, current harvesting practices and low harvesting rates do not significantly impact water quality in Edmonton. EPCOR's WTPs are designed to treat pollutants most commonly associated with runoff and erosion, and the overall risk to drinking water is low.



Data Source: GoA 2020 & 2024

Figure 42. Forest Management Areas in the NSR Watershed.

The headwaters of the NSR are located in the Green Area, which is primarily publicly owned Crown land where resources are managed for forestry, watershed protection, biodiversity, tourism and recreation, fish and wildlife, oil and gas development, and conservation. Much of the Green Area is divided among various Forest Management Units (FMUs), which are administered by the Province. Within each FMU there are several Forest Management Areas (FMAs), which are managed using Forest Management Agreements and Plans that are written by forestry companies who operate within the FMA. The total area held by FMAs in the NSR watershed is 10,018 km^2 or 36% of the watershed. The largest FMA in the watershed is held by Sundre Forest Industries (16% of the watershed) followed by Weyerhaeuser (14%), Sundance (5%) and West Fraser Mills (1%). As part of each of the company's forest management plan, they must demonstrate that they consider the effect of harvesting on environmental aspects of the watershed, including water quality and biodiversity.

Sundre Forest Products: FMA is 16% of the watershed. They harvest in the headwaters including the NSR mainstem, Ram and Clearwater watersheds. They have a comprehensive mountain pine beetle plan which includes targeting the most susceptible stands of pine for harvest.

Weyerhaeueser: FMA is 14% of the watershed. Their FMP has a detailed plan to address mountain pine beetle; an Eastern Slope Integrated Plan that outlines critical wildlife areas; and goals to maintain integrity of watersheds.

Sundance Forest Industries: FMA is 5% of the watershed. They harvest mostly in the Brazeau and Nordegg watersheds, was the first company in Alberta certified under the American Forest and Paper Association's Sustainable Forestry Initiative (SFI) Program.

West Fraser Mills Ltd.: FMA is 1% of the watershed.

Harvesting and the regeneration practices are important, as these activities ensure that the forest industry that Alberta and Canada's forested watersheds remain healthy and sustainable. The Government of Alberta regulates harvest levels by specifying an allowable annual cut (AAC), which is the annual level of harvest allowed in a forest area over five years to ensure long term sustainability. The Government of Alberta approves AACs which vary over time and reflect the area available for harvest and the forest management strategies applied to that area. AACs are updated due to changes in forest growth and yield data, the area available for timber harvest (may change to land use designations such as parks), FMA boundaries, statistical analysis methods, wildfire and pest/disease infestations, and provincial management strategies. AACs are approved separately for coniferous (*e.g.,* lodgepole pine or white spruce) and deciduous (*e.g.,* trembling aspen) groups. In Alberta, AACs are set for Forest Management Units (FMUs).

Provincially, actual harvest levels have generally fallen below the AAC level because of market conditions or business decisions. Specifically, from 2009 to 2013 only 77% of the AAC of coniferous and 50% of deciduous was harvested.

In the NSR watershed clearcutting is the primary method for harvesting timber. For example, in 2018 all timber harvesting consisted of clear cutting. All areas of provincial Crown land that are harvested for timber are required to be regenerated. Regeneration can occur naturally (i.e., natural seeding, root sprouting and fire) or by using artificial (direct seeding and seedling planting) means; in general, in Alberta is an equal split between the two regeneration methods. Successful regeneration of harvested areas ensures that forest lands continue to produce timber, but also continue to provide key ecosystem services, such as storing carbon, regulating water quality and quantity, and providing wildlife habitat and recreation opportunities. Standards and regulations for achieving successful regeneration address the following: species composition, density and distribution; age and height of the regenerating trees; and the distribution of various forest types and age classes across the landscape.

The provincial government also monitors compliance of forest operations and timber production through audits, field inspections, as well as mandatory self-reporting by forest companies and individuals. In 2008, a new forestry inspection program called Forest Operations Monitoring Program (FOMP) was introduced to help complement existing initiatives. Compliance is considered very high for the province and forested enforcement actions have shown a steady decrease from 90 enforcement actions in 2008, to 20 in 2015 (Alberta Agriculture and Forestry 2017). This decrease is determined to be the result of greater awareness of legislative requirements as a result of FOMP. A total of 2,600 FOMP inspections were conducted in 2015.

Harvesting Rates

Forestry harvest rates in the NSR were assessed using ABMI's cutblock data. A cutblock is defined as areas where forestry operations have occurred (clearcut, selective harvest, salvage logging, etc.). Less than 1% of the total watershed and less than 2% of the FMA area was harvested each decade from 1920s through the 1980s (Figure 43 and Figure 44). However, forest harvesting rates have increased since the 1980s. In the 1990s, a total of 1.8% of the watershed and 5.0% of the FMA area was harvested. In the 2000s, a total of 2.1% of the watershed and 6.0% of the FMA area was harvested. From 2010 to 2021 an additional 3.3% of the watershed and 9.3% of the FMA area was harvested.

From 2000 to 2021 (~20 years) a total of 5% of the watershed and 15% of the FMA area has been harvested for timber. Annual rates of harvest vary from year to year but in the last 10 years an average of 75 km^2 or 0.25% of watershed per year are harvested for timber. This results in about a 6% harvest rate per decade of the FMA area. While it is known that forest harvesting activities can have negative effects on downstream water quality; most of the research appears to be focused on the effects measured at small sub-watershed scales. Current research is suggesting that contemporary harvesting practices can result minimal increases of sediment, nutrients, and organic material to downstream waterbodies compared to harvesting practices used 20 – 40 years ago (Silins et al. 2020). Considering regeneration, which takes a few years, and the low rate of harvest, impacts to water quality at Edmonton are not expected to be significant. Further, the impacts from harvesting practices are small compared to natural disturbances such as floods and wildfires. EPCOR is financially supporting the *for*Water Network which is conducting research on how forest management practices and events such climate change and forest fires will impact water quality and water treatability of source water at downstream WTPs. That research has shown that organic matter and sediment can be higher downstream of harvested watersheds but in Edmonton that increased is largely masked by the high natural variability in organic material and sediment.

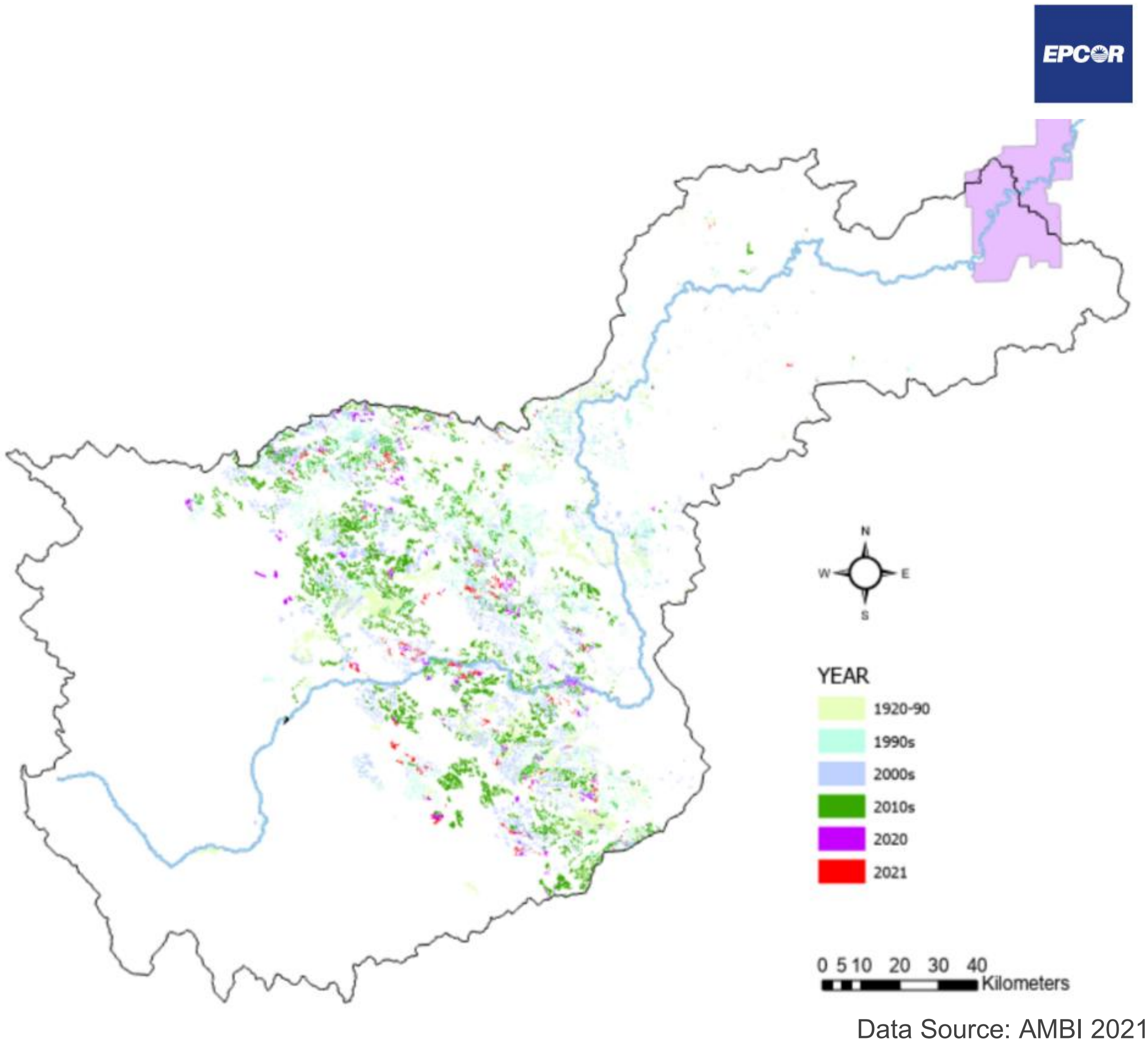
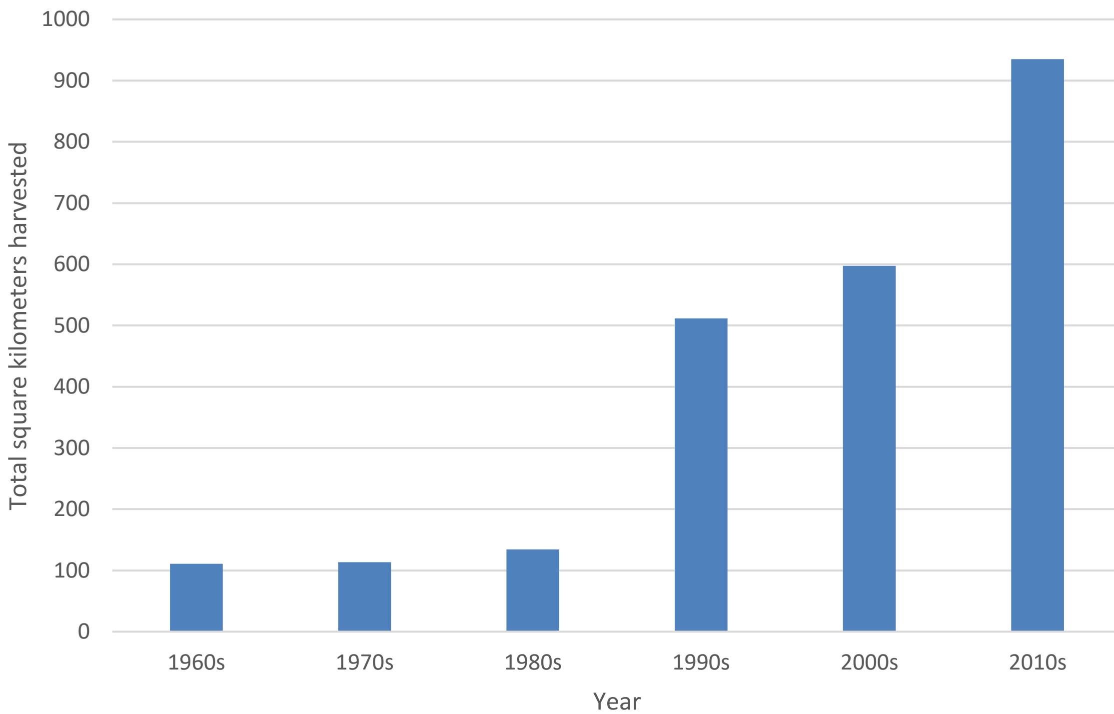


Figure 43. Harvested Areas in the NSR Watershed (Last Decade 2010-2021).

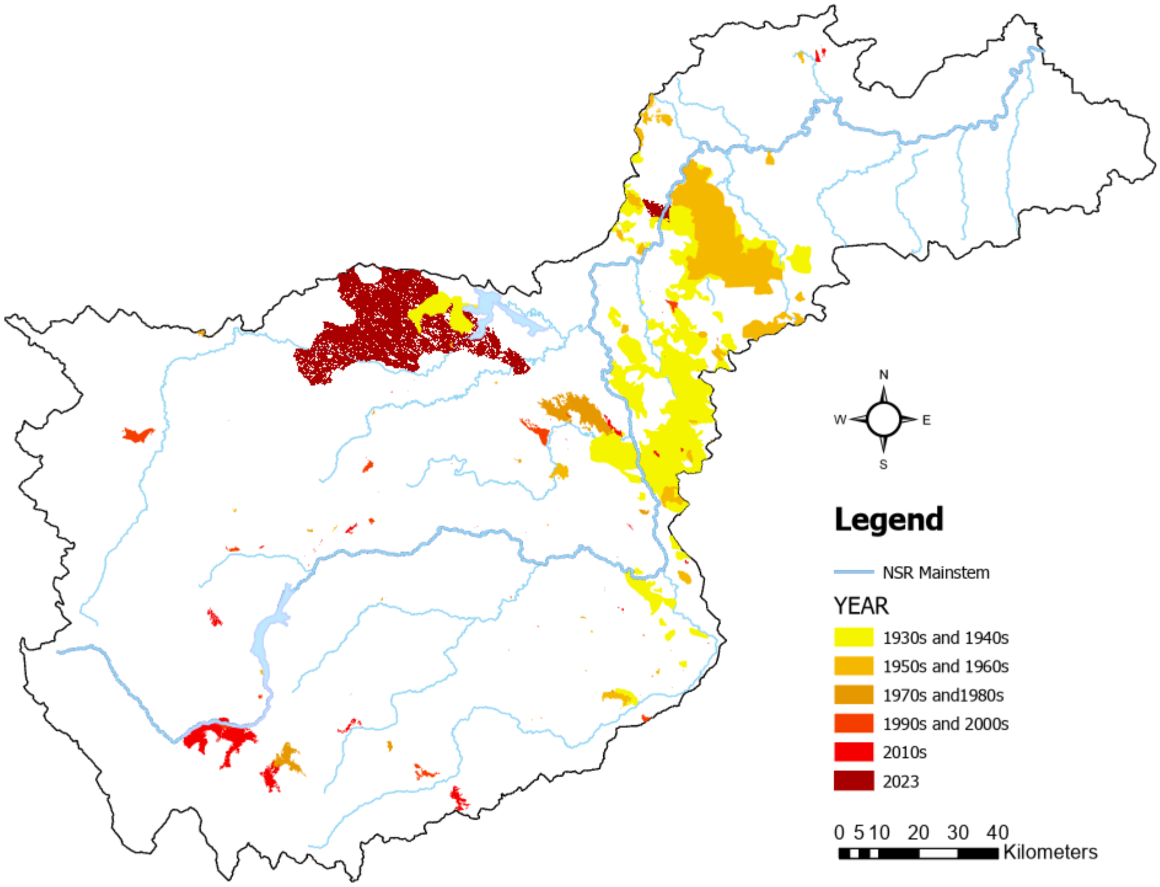


Data Source: ABMI 2021

Figure 44. Total Harvested Area in the NSR Watershed by Decade.

Wildfires

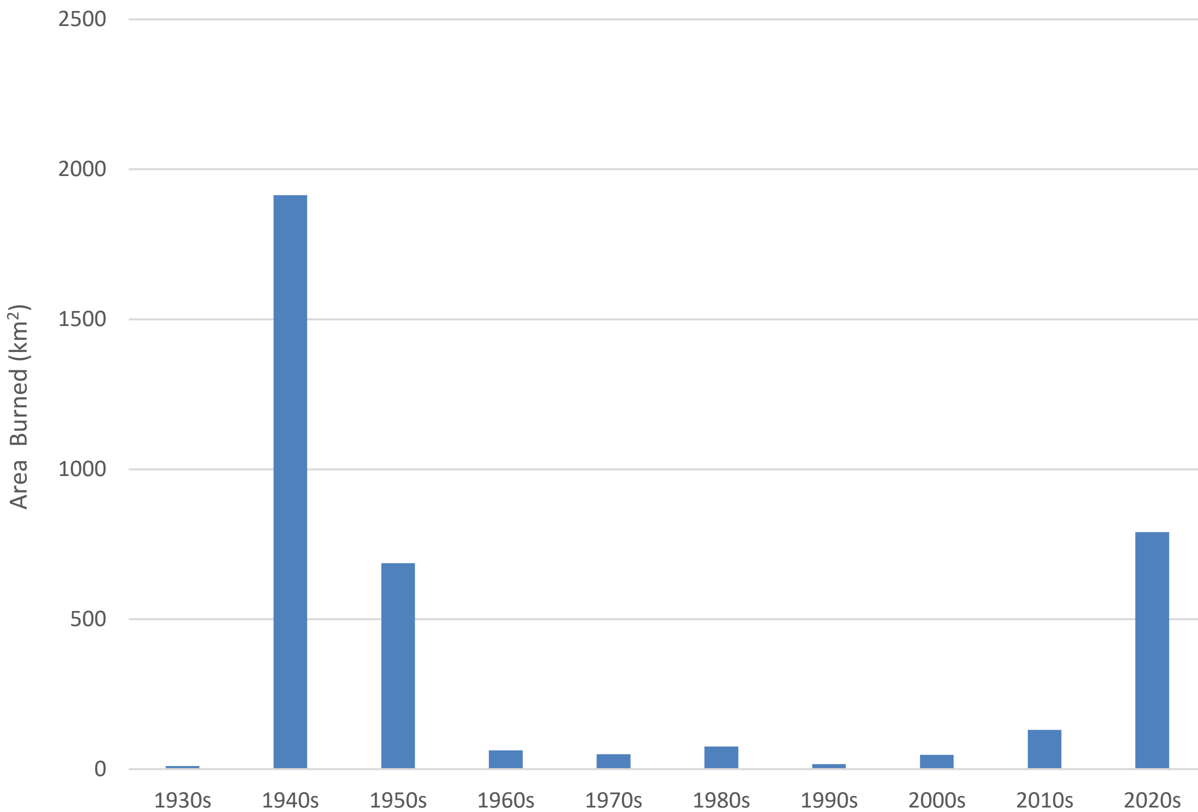
Since 1934, a total of 2,686 km^2 of the watershed has experienced a wildfire, with a majority of the wildfires occurring between Drayton Valley and Rocky Mountain House (Figure 45). Relatively little of the upper watershed has experienced a fire since 1930s. Most of the forest fires that have occurred in the NSR watershed occurred during the 1940s and 1950s (Figure 46). Forestry management practices (see Section 3.2.9) in the headwaters may have resulted in fewer fires; however, there are still large sections of the headwaters of the NSR that have experienced neither forestry activities nor a wildfire since records began in the 1930s. In 2023, there was a significant fire in the watershed burning 776 km^2 (3% of watershed) of area upstream of Brazeau Reservoir. EPCOR watershed scientists monitored creeks draining the area and did not denote a significant enough water quality change that would impact the ability to treat water at Edmonton



Data Source: GoA 2019 & ACI 2023

Figure 45. Wildfires in the NSR Watershed between 1931 and 2023.

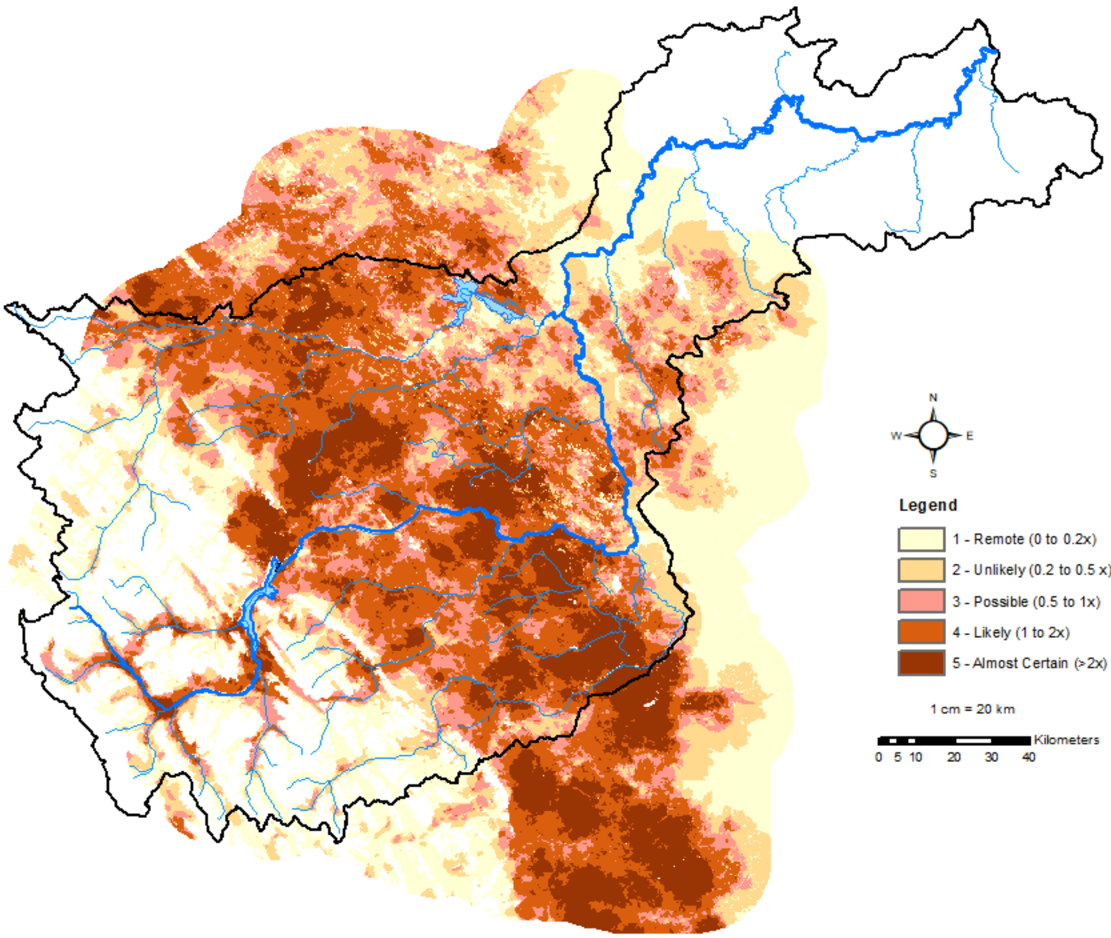
Prior to the 20th century, the fire regime in Alberta's montane region was dominated by frequent, small, low-severity fires as traditional burning in these areas by Indigenous people was common (Farr et al. 2018). More recently, the frequency of fires has decreased due to the end of traditional burning practices and increased fire suppression. This has resulted in the aging of Alberta's forests. AESRD (2012b) demonstrated that over 20% of Alberta's forests were categorized as "over-mature" in 2011. The frequency, severity and size of wildfires along Alberta's eastern slopes are anticipated to increase due to older forests and climate change that is anticipated to result in warmer and drier conditions and a longer fire season.



Data Source: GoA 2019 & ACI 2023

Figure 46. Area Burned by Wildfires in the NSR Watershed between 1931 and 2019.

Forest fires can have a wide range of effects on downstream water quality and quantity (Sham 2013). The loss of vegetation and ecosystem function can result in increased runoff, increased peak flows, flooding and increased erosion. Water chemistry can also change after forest fires, including increases in colour (dissolved organic carbon), turbidity, nutrients and metals such a lead or arsenic. A study conducted in the headwaters of watersheds in the Rocky Mountains in southern Alberta found that large forest fires resulted in a doubling of DOC, a tripling of turbidity, and increased phosphorus for several years post-fire (Emelko et al. 2011, 2016). This has raised concerns across water utilities across Canada. Following the 2016 wildfires in Fort McMurray, increased concentrations of suspended sediment, nutrients, organic carbon, and metals were found in the Athabasca River following precipitation events (Emmerton et al. 2020). This study demonstrated that wildfires can impact water quality in large rivers that have low-relief and wetland-dominated landscapes, and can impact water treatment costs similar to other studies that have focused on smaller, steeper, and more hydrologically connected headwater streams. A recent study by Robinne et al. (2019) calculated an exposure risk of wildfires ability to impact drinking water sources in Alberta. The North Saskatchewan watershed above Edmonton had a 'moderate' risk compared to other regions in Alberta, largely due the cooler and wetter headwater regions of the NSR contributing to fewer and smaller wildfires. Alberta Agriculture and Forestry developed a model for the province indicating the likelihood of where wildfires will occur (Figure 47).



Data Source: Alberta Agriculture and Forestry 2019b

Figure 47. Relative likelihood of fire based on Alberta Agriculture and Forestry's BurnP3 model

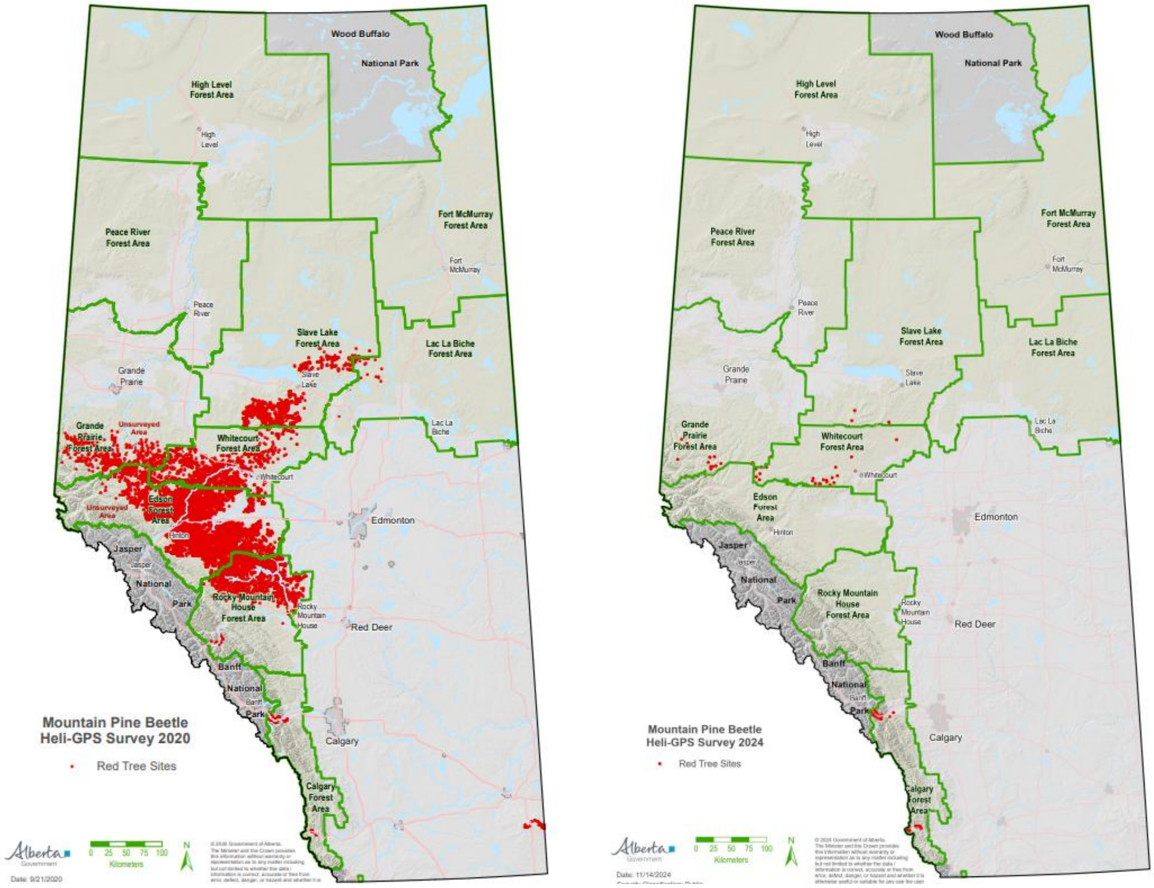
In summary, wildfires in the NSR watershed can impact water quality in the NSR in Edmonton; however, the likelihood and risk of significant impacts to EPCOR's WTPs is relatively low. Most wildfires in Edmonton's headwaters are anticipated to be a small percentage of the watershed and infrequent, as wildfires that are deemed to have been "significant" by Alberta Agriculture and Forestry (personal communication, McLoughlin, 2018) such as the 2014 Spreading Creek fire, burned less than 0.6% of the watershed. Additionally, the Bighorn and Brazeau dams likely attenuate the impacts of wildfires in these sub-watersheds, due to settling of suspended material and the dilution of flushes from burned areas. However, the effects of smaller scale wildfires are unlikely to be noticed amongst the highly variable water quality of the NSR and this was seen after the 2023 fire where 3% of the watershed burned and effects were within the range of natural water chemistry that is seen in the river. More significant impacts would be expected if a significant portion (i.e. > 20%) of the watershed were burnt; however, a wildfire of this scale is unprecedented in the last century and is unlikely to occur in the future (personal communication, McLoughlin, 2018).

Mountain Pine Beetle

The mountain pine beetle (*Dendroctonus ponderosae*) is a small (< 1 cm) insect with a lifecycle that is spent mostly beneath the bark of pine trees and are native to temperate pine forests from Mexico to central British Columbia. They play an important role in pine forests because their preference for stressed and over-mature (80+ years) trees allows for the development of a younger forest. However, when populations of mountain pine beetle grow, they can attack young and healthy trees and cause significant and widespread mortality of pine forests. The loss of functional tree cover can negatively impact a watershed through rising water tables, increases in streamflow due to reduced evaporation, earlier run-off patterns, and increased soil erosion; all of which can cause increased turbidity and decreased water quality. Large abundances of dead trees could increase the risk and severity of forest fires; however, research in the US Pacific Northwest suggests that mountain pine beetle infestations are not correlated with the frequency of forest fires and may actually reduce the severity of forest fires (Meigs et al. 2015, Meigs et al. 2016)

Cold winter temperatures have historically prevented mountain pine beetles from establishing in Alberta, as winter temperatures below -40 ^{o}C result in significant beetle mortality (AESRD 2010). Localized outbreaks of mountain pine beetle occurred in Alberta in the 1940s and again in the 1970s. Forest management practices and cold temperatures resulted in the extermination of beetle populations from Alberta. In 1997, a third wave of mountain pine beetle infestation was detected in a number of locations in Alberta. By 2005 mountain pine beetle had become firmly established in western Alberta and the outbreak was declared as an emergency. Large populations of beetles arrived from British Columbia in 2006 and 2009 resulting in large infestations into west-central Alberta. The upper reaches of the NSR have a lot of lodgepole pine and therefore effects of a pine beetle infestation could be significant. As it stands water quality and hydrology have not shown impacts but the infestation, though widespread, hasn't impacted a significant number of trees to date.

Aerial surveys conducted by Alberta Agriculture and Forestry since 2005 indicate that mountain pine beetle was first detected in the NSR basin in 2011 in a small location upstream of Abraham Lake, and in isolated locations around the Brazeau Reservoir. Aerial surveys in 2017 showed very few infected trees in the NSR basin. However, by 2019 the number of infected trees dramatically increased, particularly in the Brazeau sub-watershed, Aerial surveys between 2019 and 2022 continued to show large abundances of infected trees in the Brazeau sub-watershed; however, the number of infected trees dropped off sharply in 2023 and were absent from the watershed in 2024 (Figure 48). The government of Alberta reports that mountain pine beetle populations have declined by 98% and that populations have returned to endemic levels (GoA 2025). It is believed that cold winters significantly reduced populations. Large wildfires in the Brazeau sub-watershed in the summer of 2023 may have also affected populations, however, the area of infected trees was much larger than the areas burnt by wildfires.



Data Source: GoA 2025

Figure 48. Provincial mountain pine beetle heli-surveys in 2020 (left) and 2024 (right).

3.2.11 Wildlife

The vast forest and steep canyon walls of the NSR headwaters area provides important winter habitat for bighorn sheep and elk. A diversity of other mammalian wildlife is found within the watershed, including coyote, beaver, muskrat, cougar, moose, deer, bear and other small mammals. It should be noted that wildlife, such as beaver, muskrats and coyotes, have contributed to parasite values in the NSR.

LOW RISK

While wildlife contribute fecal material to the river, the WTPs are designed to treat bacteria and parasites, and the risk to source water is low. Wildlife populations are not increasing with the exception of beaver which are reestablishing across the basin after near eradication in the early 1900s.

The mainstem of the NSR also has many species of fish and contains a higher diversity of fish species than any other waterbody in the province. Fish species in the NSR system from its headwaters to the Saskatchewan border include: Lake Sturgeon, Goldeye, Mooneye, Lake Chub, Pearl Dace, Emerald Shiner, River Shiner, Spottail Shiner, Northern Redbelly Dace, Finescale Dace, Fathead Minnow, Flathead Chub, Longnose

Dace, Quillback, Longnose Sucker, White Sucker, Mountain Sucker, Silver Redhorse, Shorthead Redhorse, Northern Pike, Mountain Whitefish, Cutthroat Trout, Rainbow Trout, Brown Trout, Bull Trout, Eastern Brook Trout, Trout-Perch, Burbot, Brook Stickleback, Spoonhead Sculpin, Iowa Darter, Sauger and Walleye. Of note is Lake Sturgeon, which is often referred to as a 'living dinosaur' because of its bony plates and leather-like tissue rather than the scales that cover most other fish. The population in the North Saskatchewan system is in a vulnerable state, consisting of possibly fewer than 1000 fish (Alberta Lake Sturgeon Recovery Team 2011). For that reason, it is classified as Threatened under Alberta's Wildlife Act. At EL Smith WTP, EPCOR operates a Fish Return System which is designed to gently deposit fish downstream, ensuring they are not harmed by the water treatment process.

3.3 Water Quality

An integral part of EPCOR's Watershed Protection Program includes gathering scientific data to assess source water quality and quantity, fostering collaborative long-term monitoring programs to evaluate source waters and effluent impacts, and participating in research partnerships to understand evolving contaminants of concern. This work also includes investigating linkages between water quality and quantity and environmental influences (land use, climate change, etc.), as well as evaluating water quality in both the mainstem NSR and its tributaries. EPCOR's involvement with monitoring is accomplished through partnerships with either provincial and/or federal agencies, Watershed Planning and Advisory Councils, stewardship groups, municipalities, as well as through independent EPCOR initiatives.

North Saskatchewan River Upstream of Edmonton

The following sections describe historical and current water quality monitoring programs in the mainstem NSR and its tributaries. Water quality trends are also summarized.

3.3.1 North Saskatchewan River Mainstem Water Quality

Water quality monitoring in the NSR was first initiated in the 1950s in response to pollution problems within the City of Edmonton. At that time, municipal wastewater, which included domestic sewage and industrial wastes, received only primary treatment. Untreated sewage was discharged into the river during rainfall events, garbage was disposed along the riverbank, and accidental oil spills at industrial sites were common. Additionally, the population of Edmonton almost doubled in the 1950s, and many new industrial plants were constructed. With these pressures, it is not surprising that the first report on water quality in 1951 noted elevated bacterial levels, extremely low dissolved oxygen levels, odour problems, visible garbage, grease deposits and oil. Measurements of these basic water quality parameters resulted in pollution control orders to be issued to Edmonton by the Provincial Board of Health in the 1950's.

Water quality conditions persisted until about 1960 when Edmonton constructed a secondary sewage treatment plant, packing plant wastes were diverted to lagoons, and garbage disposal along the riverbank was discontinued. Additionally, the newly constructed Brazeau dam increased winter flows and the assimilation capacity of the river during this critical time. Despite improvements, water quality downstream of the City of Edmonton continued to reflect the impacts of Edmonton's municipal wastewater. Further improvements to water quality in the NSR accompanied upgrades in treating municipal wastewater, including biological nutrient removal and ultraviolet treatment between 1998 - 2005 at the Gold Bar Wastewater Treatment Plant, and in 2005 at the Arrow Utilities Wastewater Treatment Plant (formerly Alberta Capital Region). The Gold Bar WWTP utilizes Enhanced Primary Treatment which reduces the amount of untreated overflow that enters the NSR during wet weather flows.

Water Quality Programs: Historical and Present Day

Alberta Environment and Protected Areas (AEPA) Monitoring Programs

Long-term sampling of the NSR by AEPA is part of the Long-Term River Network Project (LTRN). Sites are located at Saunders Campground (near Nordegg), Rocky Mountain House, Devon, and Pakan. Monthly sampling was done independent of flow conditions, which limits the ability to calculate loads accurately. To address this limitation, the LTRN sites underwent enhanced sampling between 2008 and 2012, with a focus on higher flow events. LTRN data is available from Devon and Pakan from 1987 to present. LTRN sites were established at Rocky Mountain House and Saunder's Campground in 2003 and 2015, respectively. In 2009, the LTRN at Rocky Mountain House moved a few kilometres upstream to be located upstream of the influence of the Clearwater River. LTRN data are used to evaluate long-term trends in water quality and AEPA produces updated trend-analysis reports. The most recent report was completed in 2012 for data collected from 1987 to 2011. Anderson (2012) concludes that water quality downstream of Edmonton has shown marked improvement with respect to nutrient levels and bacteria, and these improvements coincide with enhanced wastewater treatment and reductions in loadings from point sources. Additionally, lower nutrient concentrations and smaller releases of oxygen-consuming material have resulted in improved dissolved oxygen concentrations in NSR downstream of Edmonton. Water quality also improved between 1987 and 2011 at Devon, but the improvements were smaller than those downstream of Edmonton, presumably due to the existing good water quality upstream of Edmonton, and smaller point sources of loading located upstream.

Beyond the LTRN program, AEPA has collected water quality data at a number of locations in the NSR dating back to 1953. While this data is available electronically, much of it was collected prior to the establishment of the upstream dams or was collected over a relatively short period of time. AEPA also completed two synoptic water quality monitoring studies on the NSR mainstem and major tributaries. Synoptic sampling involves following a plug of water down the river over a time period to quantify changes due to tributary and point source inputs. These particular studies followed the plug of water as it moved from the NSR headwaters down to the border with Saskatchewan. A total of 17 mainstem sites were sampled. The first study occurred between 1985 and 1989, included 12 synoptic sampling events. The second study, which occurred in 2008 and 2012, included six synoptic sampling events.

The synoptic surveys included the following water quality parameters: routine water chemistry; coliforms; *Cryptosporidium*; *Giardia*; metals; organics; bacterial source tracking; biological aquatic ecosystem health indicators (planktonic and benthic algae); pesticides; and nutrients. EPCOR partnered with AEPA on this initiative in 2008 and 2012 to complete *Cryptosporidium* and *Giardia* analysis, which otherwise would not have been done. A summary report of the

2008 and 2012 synoptic surveys was completed by Hutchinson (2014). Conclusions made in this report include:

- The NSR naturally increases in nutrients, turbidity and some metals as the river flows from the mountains to the prairies;
- Increased nutrients are found downstream of Edmonton, but the magnitude of this effect has declined considerably since the 1980s in response to upgrades at the waste water treatment plants;
- Periods of increased flow in the NSR correspond to increased concentrations of nutrients, turbidity, metals, bacteria and pathogens both upstream and downstream of Edmonton; and
- Runoff events result in discharges from combined sewer overflows in Edmonton and bypasses at the Gold Bar Waste Water Treatment Plant, resulting in large increases in bacteria downstream of Edmonton.

Environment and Climate Change Canada

Environment and Climate Change Canada (ECCC) operates two water quality monitoring stations on the NSR: one at Whirlpool Point in the headwaters, and the other at the Alberta-Saskatchewan Border (Prairie Provinces Water Board [PPWB] site). Data are available from the early 1980s on, and sites are sampled monthly for a similar suite of parameters as at the LTRN sites. While the two ECCC stations provide important information about water quality conditions and trends in the North Saskatchewan River, they are of limited relevance to source water protection as the Whirlpool point location is located upstream of the Bighorn dam, and the site Alberta Saskatchewan border is far downstream of Edmonton. While the data from these stations are not considered further in this document, is worth mentioning that data from these sites were used by the North Saskatchewan Watershed Alliance to propose site-specific water quality objectives for the NSR. In addition, the PPWB used this data to conduct a trend analysis on water quality data from 1988 to 2008 (PPWB 2016) highlighting improvements in water quality in the NSR downstream of Edmonton.

EPCOR Water Treatment Plant Intake Data

Since the early 1980s, EPCOR has routinely monitored water quality in the NSR at the Rossdale and E. L. Smith Water Treatment Plants (WTP) raw water intakes. Digitized data for major parameters are available from 1995 to present, with a smaller number of parameters being available back to 1981. The frequency of monitoring is dependent on the parameter. Turbidity, colour, conductivity, pH, and temperature, are measured continuously through online analyzers. Ammonia is also monitored using online analyzers during key periods such as spring-off. A VOC analyzer has been installed at the Rossdale WTP. Due to their operational

Open Data Initiative: Since 2023 EPCOR has published its water quality data collected as part of the intake program and creek monitoring program on DataStream. In 2025 AEPA followed and now all NSR data can be found on DataStream.

importance, colour, turbidity and VOCs are measured daily, or more frequently, using on-site laboratories. Bacteria such as total coliforms and *E. coli* are measured daily at Rossdale and weekly at E.L. Smith. *Cryptosporidium* and *Giardia* are generally measured weekly to monthly, depending on the plant and time of the year. Microcystin, an algal toxin, was measured monthly, but is now monitored quarterly. Nitrate and ammonia, chloride, bromide, bromate, sulphate, alkalinity, total organic carbon and fluoride are measured weekly, or more frequently during key periods. Total and dissolved phosphorus, total Kjeldahl nitrogen, select metals, total suspended solids, total dissolved solids (TDS), total and free chlorine, and sulfide are measured monthly. Pharmaceuticals, pesticides and contaminants of emerging concern such as polycyclic aromatic hydrocarbons (PAHs) and perfluoroalkylated substances (PFAS) are also measured at the WTPs.

A summary of EPCOR's intake water quality for key parameters is found below. For simplicity, this report is limited to turbidity, colour, pathogens and select pharmaceuticals and pesticides and contaminants of emerging concern as they are key parameters of concern for drinking water treatment.

- **Turbidity-** is a measure of cloudiness in water and is also can be used as a proxy for sediment levels. Increased turbidity can be caused by soil erosion, stormwater, runoff from disturbed landscapes, and algae, to name a few. Elevated turbidity increases the costs of water treatment.

- **Colour-** in water can be an indicator of the extent of plant matter decay, other organic matter, algae growth, and minerals (i.e., iron or manganese). The impact that colour has on surface water is usually one of aesthetics, however it may also be an indication of toxicity or the presence of pathogens. Colour is also associated with taste and odour concerns in drinking water. High colour can challenge a WTP's ability to produce drinking water and also increases the cost of water treatment.

- ***Cryptosporidium*** and ***Giardia*** species are protozoan parasites that cause gastrointestinal illness and infect mammals. In humans, the main causes of disease are *C. parvum*, *C. hominis* and *G. lamblia*. Along with indicating a direct risk of human infection, its presence indicates that the water is contaminated by fecal matter.

Current water quality in the NSR mainstem

Turbidity at a Glance

Turbidity

Median annual turbidity is slightly higher in the NSR at the Rossdale WTP intake compared to the E. L. Smith WTP intake. While this difference is statistically significant, turbidity is only 3% higher at Rossdale. This difference is likely attributable to increased inputs from tributaries and storm runoff within Edmonton. Due to the similarity of turbidity values and seasonal patterns between E. L. Smith and Rossdale WTP, data is only presented for the Rossdale WTP.

Sediment concentrations in the NSR are highest during spring runoff and during summer storms. The source of the sediment is from watershed runoff and re-suspension or erosion of the riverbed and shore.

Sediment concentrations in the river are closely associated with higher flows in the NSR, both as a function of re-suspension of bed sediments and increased sediment inputs from the watershed during runoff periods. In years where precipitation and river flows are higher, sediment concentrations in the river are also higher. On a smaller timescale, sediment concentrations in the river are also highest during peak flow/runoff events (Figure 49). Because the occurrence of high sediment concentrations in the NSR are dependent on hydro-climatic patterns, it is not predictable from year to year. For example, in 2016 sediment peaked in April due to spring runoff, and again in late July and late August corresponding to large amounts of precipitation and flow; however, values were atypically low during the late spring and summer due to a prolonged period of dry conditions and low flows. Typically, peaks in turbidity occur in March and April, corresponding to spring runoff and again in June and July, corresponding with large precipitation events. In general, turbidity will rise above 100 NTU during spring runoff and during three to four large rain events throughout the year.

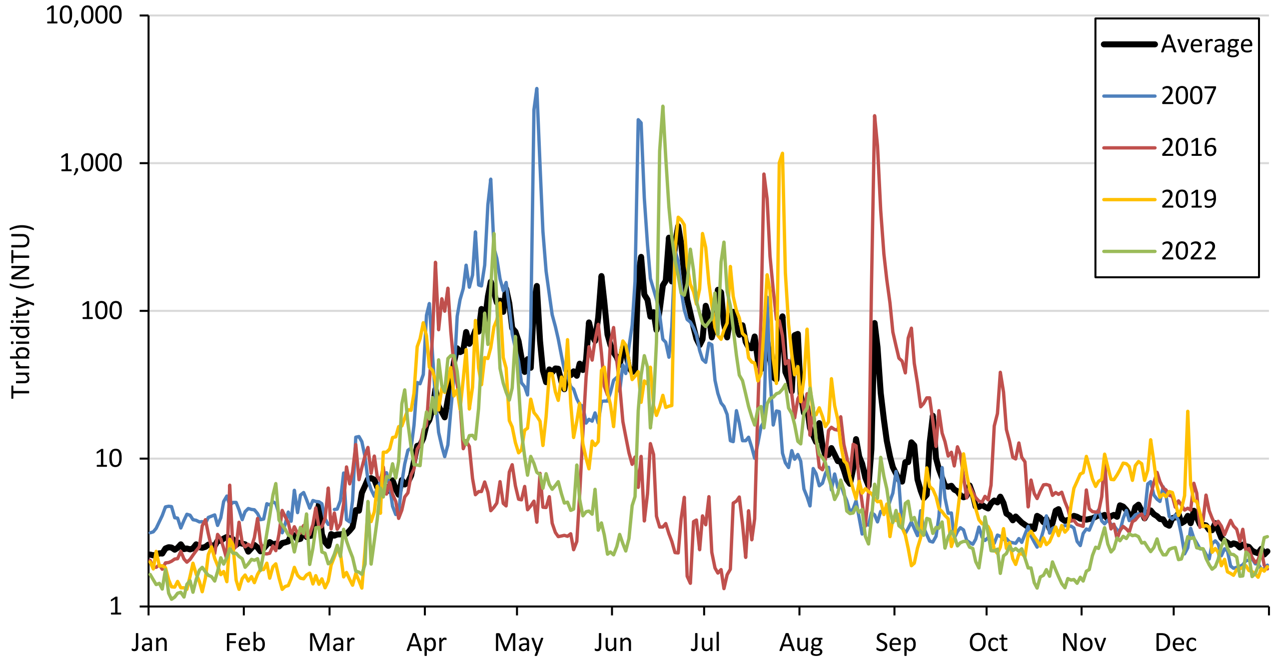


Figure 49. Daily Mean Turbidity at Rossdale WTP Intake Average from 1997 to 2024 and Select Years (2007, 2016, 2019 and 2022).

Although there is high interannual variability, neither median nor peak sediment levels (as measured by turbidity) have changed significantly in the NSR in the last 30 years (Figure 50). Further, a 'heat map' of average weekly turbidity does not show any trends of turbidity increasing earlier or later in the year, neither does it show that peak turbidity values are becoming more extreme (Figure 51). Thus, there is no evidence that the river is experiencing increased loads or concentrations of sediment. This is not surprising as the watershed land use has not substantially changed.

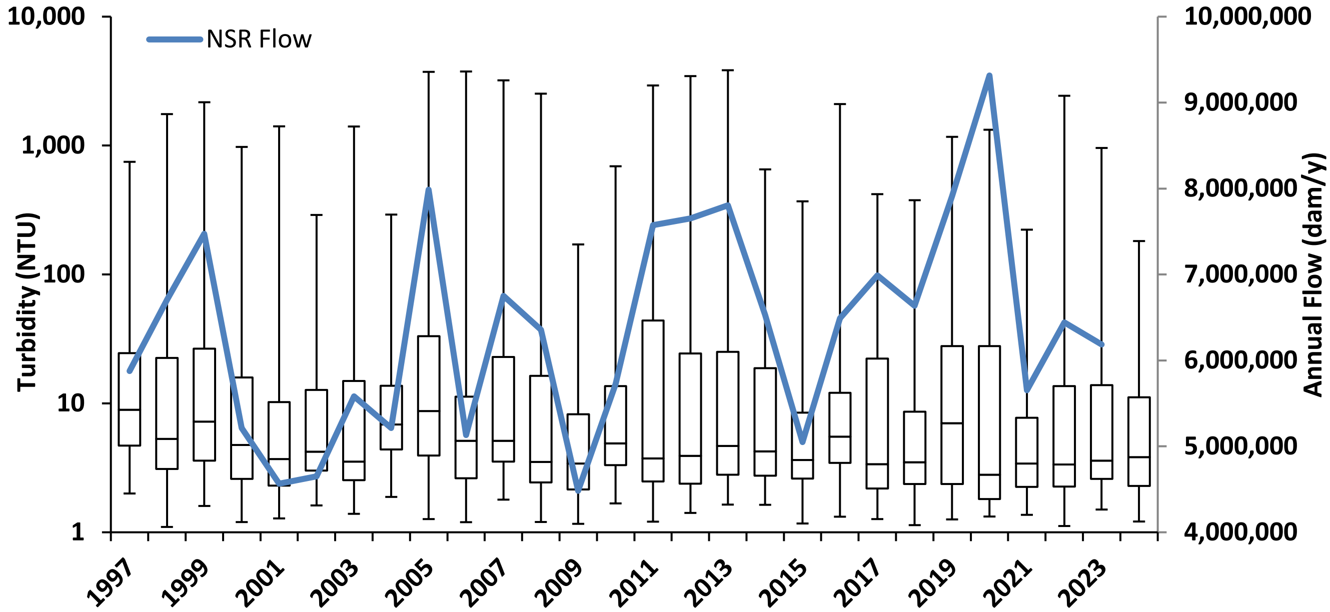


Figure 50. Turbidity at Rossdale WTP Intake 1997 to 2024 Showing Minimum, First Quartile, Median, Third Quartile, and Maximum Values, and Total Annual Flow in the NSR.

Week	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22	'23	'24
Jan 01	3	3	3	3	2	2	2	3	2	2	4	2	1	2	3	3	2	3	3	2	2	2	2	3	2	1	2	2
Jan 08	3	3	3	4	2	3	3	4	2	3	4	2	2	2	2	3	2	3	3	2	2	2	1	2	2	1	2	3
Jan 15	5	2	3	2	3	3	2	4	2	2	4	3	3	3	2	3	3	3	2	3	2	2	2	2	2	2	2	3
Jan 22	4	2	3	2	4	2	2	3	3	3	5	2	2	3	3	3	2	6	5	3	2	2	2	2	2	2	3	2
Jan 29	7	2	2	2	3	2	3	2	3	2	4	2	2	3	2	2	2	4	3	3	2	2	2	2	2	2	3	2
Feb 05	4	2	3	2	3	2	3	3	2	2	5	3	2	3	3	2	3	4	2	3	2	2	2	2	2	4	3	2
Feb 12	5	2	3	2	3	4	3	4	2	2	4	3	2	4	3	2	2	4	3	4	5	2	2	2	2	3	3	2
Feb 19	17	2	2	3	4	2	2	5	2	2	5	3	2	4	3	3	2	5	4	3	5	2	2	2	3	3	3	2
Feb 26	4	2	4	4	4	3	2	3	4	2	4	4	2	4	3	2	3	4	3	4	3	2	2	2	2	2	3	3
Mar 04	5	3	2	3	5	3	2	6	14	2	9	3	2	4	3	6	4	7	6	8	3	1	2	2	3	2	2	2
Mar 11	3	3	5	4	6	3	9	7	46	2	7	4	2	4	5	4	2	12	21	9	5	2	5	2	3	4	3	5
Mar 18	21	5	9	8	4	3	13	7	7	3	6	4	3	4	4	4	3	7	9	5	5	4	15	2	5	13	3	6
Mar 25	26	5	9	12	4	7	10	9	10	6	34	4	4	5	6	5	10	4	28	11	32	4	49	2	3	13	3	3
Apr 01	23	12	22	18	4	4	15	12	136	17	34	5	4	13	10	15	21	9	34	107	31	2	33	1	3	31	4	5
Apr 08	37	41	214	13	5	22	39	23	137	43	109	15	29	22	140	19	11	162	126	30	82	5	33	3	8	29	14	15
Apr 15	361	89	327	14	12	57	126	33	171	86	332	29	58	39	60	44	73	112	41	6	191	151	49	91	49	57	40	23
Apr 22	150	29	88	86	89	82	503	47	37	28	161	19	77	14	309	141	172	294	12	6	176	160	58	186	22	86	80	67
Apr 29	92	17	86	46	31	79	82	8	15	11	367	93	11	16	192	77	55	59	9	5	36	144	16	76	7	22	26	12
May 06	18	7	31	23	14	127	89	7	30	10	716	40	19	9	41	34	29	31	10	5	58	37	25	102	18	7	24	52
May 13	13	28	26	86	13	160	141	6	35	7	40	136	10	6	48	14	22	28	7	3	31	29	30	26	22	6	17	27
May 20	34	71	21	37	10	62	68	8	106	17	20	138	10	78	104	14	113	103	5	44	126	24	13	440	28	5	19	24
May 27	56	63	26	13	61	108	282	31	13	11	29	749	10	36	156	8	121	65	5	47	144	17	33	68	38	3	13	33
Jun 03	65	25	14	13	16	49	69	22	73	9	603	134	13	29	62	786	102	46	15	11	95	11	43	173	20	11	14	14
Jun 10	47	45	6	176	11	37	69	73	268	16	207	278	8	274	69	491	30	23	14	6	183	16	28	68	29	548	22	10
Jun 17	192	244	37	43	30	86	26	31	1210	886	129	102	12	58	1139	137	1329	88	11	3	63	9	222	54	87	367	418	11
Jun 24	133	377	23	22	23	20	18	18	309	41	66	52	16	48	168	98	358	29	7	3	20	6	192	38	13	139	117	8
Jul 01	19	448	773	51	10	11	11	44	95	11	35	64	12	19	79	52	102	23	7	2	8	58	90	303	18	146	56	87
Jul 08	39	101	344	481	7	17	8	135	48	9	15	35	73	74	135	46	53	11	4	4	9	74	100	198	17	51	26	24
Jul 15	50	44	365	119	23	13	5	45	25	4	33	15	21	145	58	60	59	8	8	254	7	20	79	33	5	21	16	9
Jul 22	16	24	96	55	50	11	5	14	16	8	14	14	7	36	75	218	55	20	5	71	7	31	367	49	5	26	17	8
Jul 29	11	36	42	22	503	9	4	7	10	7	8	9	6	13	25	72	33	9	3	22	2	14	38	21	3	20	5	4
Aug 05	7	11	31	13	20	7	6	9	6	4	7	5	37	10	12	30	18	11	2	13	3	8	22	13	3	9	7	20
Aug 12	39	12	24	9	10	5	7	5	6	5	5	4	5	11	6	18	11	3	2	13	2	6	10	7	2	5	10	11
Aug 19	34	15	15	6	6	5	3	8	12	3	4	4	4	7	4	14	8	5	2	510	2	3	6	6	4	4	34	14
Aug 26	14	8	18	3	3	5	4	9	47	3	6	3	3	5	3	8	8	4	2	168	3	4	4	3	6	6	21	7
Sep 02	15	7	15	8	2	4	2	76	8	2	4	2	2	3	3	4	5	3	3	46	2	2	3	2	12	4	6	14
Sep 09	6	5	10	4	2	3	2	18	135	12	4	2	2	4	3	3	3	2	3	20	3	3	6	2	5	4	6	4
Sep 16	5	7	9	3	2	3	2	15	32	24	4	2	2	6	2	2	4	2	5	11	8	4	5	2	3	3	3	2
Sep 23	7	4	8	2	1	4	2	6	11	29	3	2	3	6	1	2	6	2	17	6	5	4	5	2	3	3	2	3
Sep 30	5	3	8	2	2	4	2	5	10	23	3	2	3	12	2	2	4	2	6	19	3	4	3	2	2	2	2	2
Oct 07	11	6	6	3	2	3	3	4	5	7	3	2	4	5	2	2	4	2	3	10	2	3	2	2	2	2	2	2
Oct 14	9	8	5	3	2	3	3	6	5	6	3	2	6	4	2	2	4	2	3	6	3	2	3	2	2	2	2	2
Oct 21	12	5	5	4	3	4	4	8	5	6	3	3	3	4	2	2	3	2	3	5	3	3	3	3	6	2	4	2
Oct 28	7	5	4	3	2	5	5	7	4	7	3	3	3	4	4	3	3	2	4	4	4	3	8	5	3	2	3	2
Nov 04	5	3	4	4	3	4	6	7	4	5	4	4	4	4	5	5	3	3	3	5	4	4	8	4	3	3	3	3
Nov 11	8	5	4	9	2	4	3	7	4	5	4	3	3	5	5	4	6	5	3	3	3	4	9	4	4	3	2	3
Nov 18	7	4	5	3	2	5	2	6	5	4	5	3	3	5	4	3	6	4	4	5	2	4	9	3	6	3	3	5
Nov 25	5	3	4	3	4	4	3	5	5	3	5	4	3	3	3	2	4	2	3	6	2	3	5	4	4	2	4	8
Dec 02	8	4	4	5	3	4	3	7	5	3	3	8	3	3	3	2	3	2	3	5	2	4	7	2	3	3	4	4
Dec 09	11	4	4	3	2	3	3	5	4	3	2	3	3	3	3	2	4	3	2	4	2	4	3	2	4	2	3	3
Dec 16	4	4	3	3	2	3	4	4	2	3	2	2	2	3	3	2	4	3	2	3	2	3	2	2	2	2	3	3
Dec 23	2	3	3	1	2	2	3	3	2	3	2	2	2	3	3	2	3	2	2	2	1	5	2	2	2	2	2	3

Figure 51. 'Heat Map' of Weekly Average Turbidity Values at Rossdale WTP, 1997 to 2024.

Note: darkest blue colours represent the lowest colour values and darkest red colours represent the highest colour values

Changes in land use, such as logging, agriculture and linear developments can result in increased erosion and could generate increased turbidity in the NSR; however, modern best management practices aim to reduce erosion and increases in turbidity from these practices are likely relatively small compared to the natural variability of the NSR. Wildfires have the potential to increase sediments in the NSR; however, typically the areas burned in the watershed are relatively small, and the two upstream dams (Bighorn and Brazeau) would capture sediments from areas upstream of the dams. In 2023, there was a significant fire in the watershed burning 776 km^2 (3% of watershed) of area upstream of Brazeau Reservoir. EPCOR watershed scientists monitored creeks draining the area and did not denote a significant enough water quality change that would impact the ability to treat water at Edmonton. The Brazeau Dam also dampened the effects as water quality leaving the dam was not significantly impacted. Given this and the high natural sediment loads of the NSR, it is unlikely that wildfires would generate changes in turbidity to the extent that it would create significant challenges for the WTPs unless a significant portion of the watershed burned.

Climate change could result in turbidity either increasing or decreasing in the NSR. Climate models generally predict increases in total precipitation through more frequent and intense storm events and more snow falling as rain, which could increase both runoff and erosion, resulting in increased turbidity. Increased flows in the NSR will also result in increased resuspension of solids and increased bank erosion. Climate models also predict periods of increased evaporation which will lead to drier soil conditions in the agricultural areas, potentially reducing spring runoff influences on the NSR mainstem. More work, including modeling will be required to determine if climate change is expected to generate significant changes in turbidity and colour in terms of peaks and seasonality.

Elevated turbidity typically does not cause operational challenges for EPCOR's WTPs, which can treat highly turbid water as experienced during floods of the NSR; however, elevated turbidity does require additional alum to treat the water and increases operational costs. Low turbidity in the NSR is also required by the WTPs to convert to direct filtration, a mode of operation that the WTPs enter each fall/winter that requires less treatment and therefore lower operational costs and minimizes water quality impacts on the NSR. To date the conversion of the WTPs to direct filtration has typically not been hindered by turbidity.

Daily mean turbidity values over 100 NTU occur around 6% of the time, whereas 78% of the time daily mean values are below 20 NTU. Turbidity values in the NSR over 1,000 NTU occur less than 0.4% of the time; however, these periods can present difficulties for WTP operation. From a WTP operation perspective, understanding the probabilities around turbidity values on a week-by-week basis is of value. For example, before the beginning of March, daily mean turbidity is below 10 NTU 90% of the time based on historical data (Figure 52). By early April, turbidity is below 10 NTU less than 50% of the time, and by mid-April, turbidity is below 10 NTU less than 10% of the time. Historical data can provide some insight into the most likely periods in which turbidity will be high in the NSR and allow WTP operators to adapt.

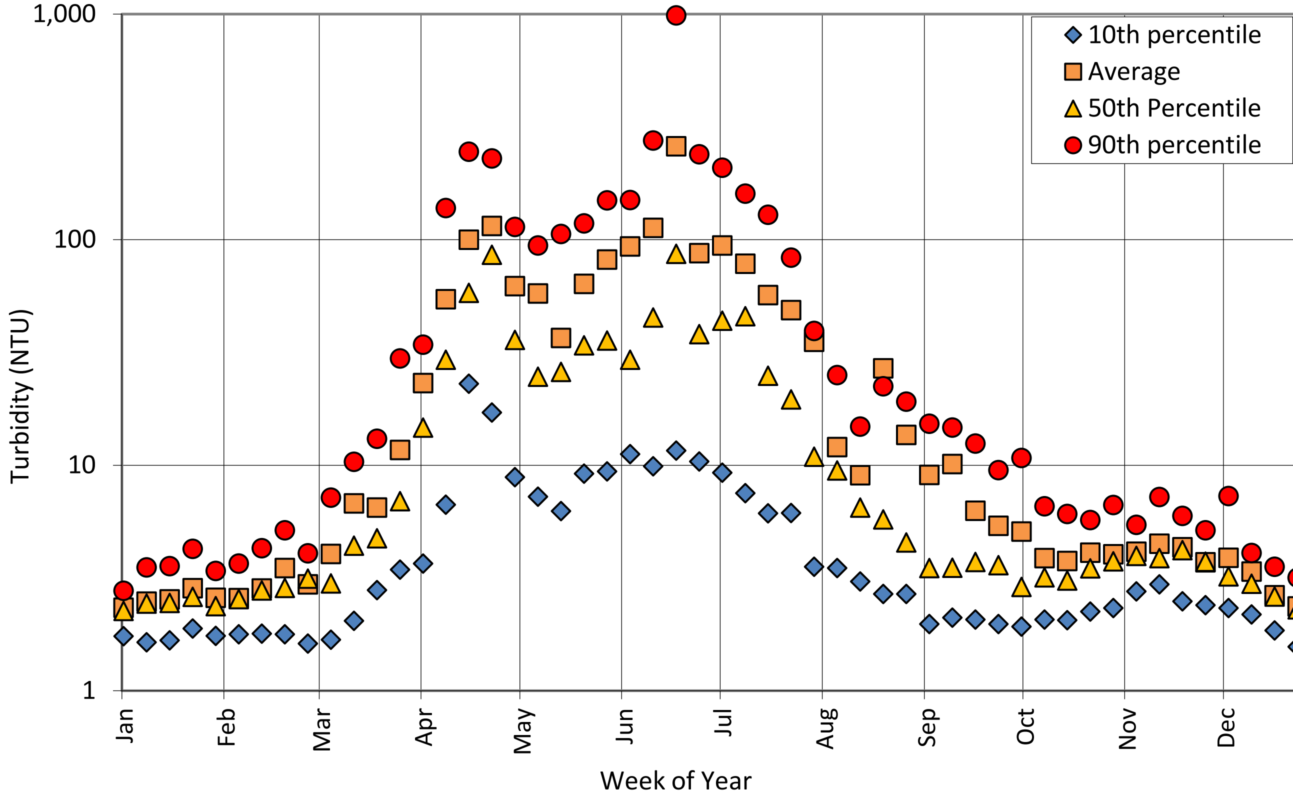


Figure 52. Turbidity at Rossdale WTP Intake for 1997 to 2024 Compiled by Week of the Year.

Colour

Colour is a measure of the clarity of the water and is linked closely to the amount of fine organic matter present. This material largely originates from decomposing vegetation including animal waste and crop material from agricultural areas and forested/wetland areas. It can affect drinking water treatment processes and is therefore a parameter that is measured constantly at the WTPs intakes. Like turbidity, median annual colour is slightly higher in the NSR at the Rossdale WTP intake compared to the E. L. Smith WTP intake. While this difference between the two WTPs is statistically significant, colour is only 3% higher at Rossdale. The higher colour values at Rossdale are attributable to increased inputs from tributaries and storm runoff within Edmonton.

Colour is a key parameter that can affect the ability and the cost of WTPs to produce drinking water. Each spring, elevated colour requires that the WTPs dose powdered activated carbon as part of the treatment process, resulting in increased operational costs. High colour events associated with summer precipitation events have also occasionally required the WTPs to dose powdered activated carbon. Colour is typically the key variable in determining when WTPs can convert to direct filtration, a mode of operation that the WTPs enter each fall/winter that requires less treatment and therefore lower operational costs. In some years, elevated colour in the fall has significantly delayed the conversion to direct filtration. Elevated colour during the winter months or early spring has also caused the WTPs to convert back to conventional operation prematurely.

Like turbidity, colour is highest in months when flow is greater, but overall, is highest during the spring runoff period (April and May) rather than during summer storms (Figure 53). This is due, in part, to increased inputs of particulate and organic matter from spring melt which has accumulated over the winter months. This accumulation includes manure that has amassed in livestock winter feeding areas and standing crop vegetation that has decomposed under the snow. While colour is typically highest during spring runoff, large precipitation events in the summer and fall can generate elevated colour if the watershed gets wet for an extended period.

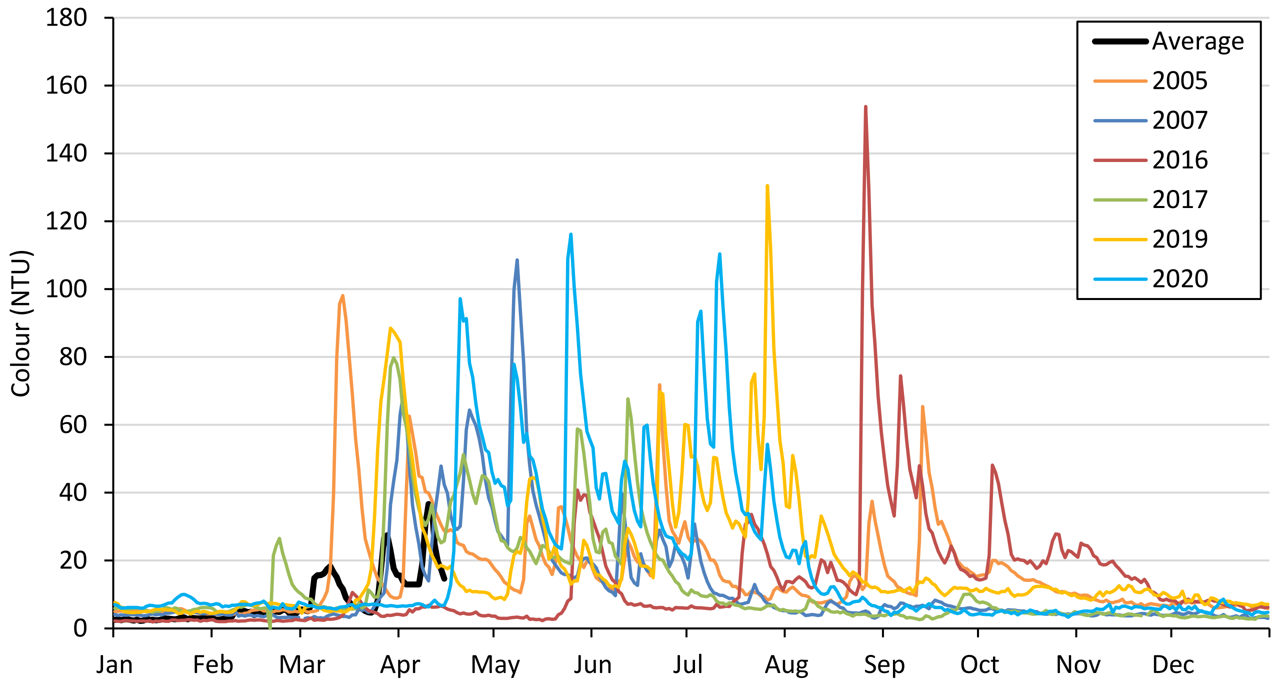


Figure 53. Daily Mean Colour at Rossdale WTP Intake Average from 1997 to 2024 and Select Years (2005, 2007, 2016, 2017, 2019 and 2020).

Average annual colour is variable from year to year and there does no long-term trend of median or peak colour values increasing (Figure 54). Despite the absence of a distinct trend, there have been several instances in recent years where elevated colour has resulted in operational challenges at the WTPs. In 2016, a large precipitation event in late August resulted in a large spike in colour up to 200 TCU, which is the highest value measured at the WTPs. This large increase in colour affected the ability of the WTPs to produce drinking water and production could not keep up with the demand and voluntary water restrictions were put into place. Colour in the NSR quickly dropped and the WTPs were able to resume drinking water production. Colour continued to remain elevated into the fall and winter of 2016, at levels not previously recorded during this time of year. This elevated colour significantly delayed the WTPs from switching production to direct filtration, which typically occurs in late fall or early winter when colour and turbidity values in the NSR are typically low. An early melt in February

2017 resulted in elevated colour and required the WTPs to prematurely stop direct filtration. Large precipitation events in July 2019 resulted in the second largest colour peak recorded. Elevated colour has also been observed during the late fall and winter during some recent years, and in January 2020 and 2024, colour was high enough to cause the WTPs to switch from direction filtration to conventional treatment. Given the instances of high colour events in recent years, there is an increased desire to understand if colour in increasing in the NSR, or if this falls within historic variability. A 'heat map' of 27 years of average weekly colour values (Figure 55) does reveal few trends:

- The period of 2018 – 2020 (and to a lesser extent 2016 – 2020) stands out as a period with some of the highest weekly average colour values and prolonged periods of elevated colour. While there have been years with similarly high colour values and prolonged periods of elevated colour (i.e., 2005, 2011) the period of 2018 – 2020 does stand out.
- The period of 2021 – 2024 had some of the smallest peak colour values and did not have sustained periods of high colour.
- The trend of elevated colour in 2018 – 2020 and lower colour in 2021 – 2024 corresponds well with the hydroclimatic conditions of these years, with elevated NSR flows in 2018 – 2020 and reduce NSR flows in 2021 – 2024.
- While the earliest spring runoff occurred in 2017, the second earliest spring runoff occurred in 2005, and there does not appear to be an identifiable trend of earlier or more intense spring runoffs.

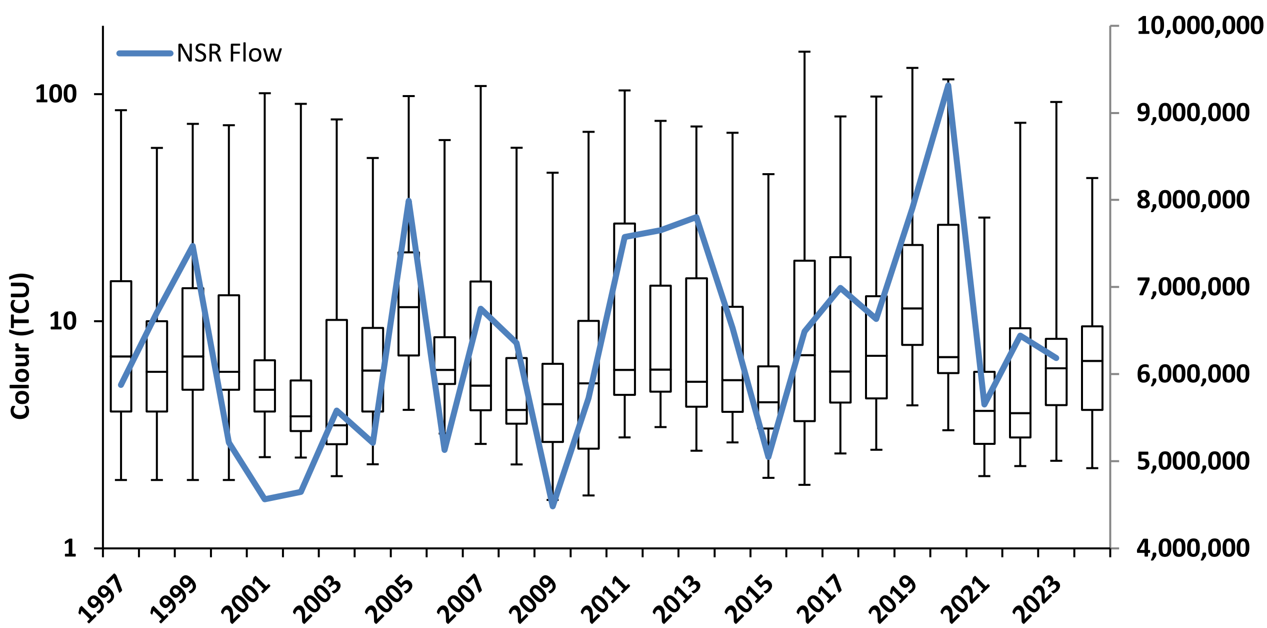


Figure 54. Colour at Rossdale WTP Intake 1997 to 2024 Showing Minimum, First Quartile, Median, Third Quartile, and Maximum Values, and Total Annual Flow in the NSR.

Week	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22	'23	'24
Jan 01	5	3	5	4	5	4	3	4	5	7	4	3	6	3	5	5	5	5	4	2	6	3	6	6	5	4	4	6
Jan 08	5	5	6	5	4	4	3	4	5	6	4	3	6	3	5	5	5	6	4	2	5	4	5	6	5	4	3	6
Jan 15	4	6	6	6	4	3	3	4	5	6	5	3	5	2	6	6	4	7	5	2	6	4	5	8	4	4	4	12
Jan 22	4	5	6	6	5	3	3	3	5	6	5	4	4	2	6	8	5	7	5	2	5	4	5	9	4	3	3	10
Jan 29	4	3	6	6	4	4	3	4	4	6	4	3	4	2	5	8	5	6	4	2	6	4	5	7	5	3	4	8
Feb 05	4	4	5	6	4	4	3	5	4	6	4	4	4	2	5	7	5	7	4	2	6	5	6	7	5	3	4	9
Feb 12	3	4	5	6	4	4	3	3	5	6	4	4	4	2	5	6	4	6	4	2	6	5	7	7	7	3	4	7
Feb 19	4	4	5	5	4	4	3	3	5	7	3	3	4	2	5	5	4	5	4	2	20	4	7	6	6	4	4	7
Feb 26	3	3	5	5	4	3	3	3	5	6	3	3	4	2	4	5	4	5	3	3	10	3	6	7	7	3	4	7
Mar 04	4	3	3	4	4	3	3	3	13	8	4	3	4	2	4	5	4	5	6	3	6	3	6	6	6	3	4	7
Mar 11	3	3	4	3	8	3	5	3	81	7	4	3	4	2	4	4	3	6	35	6	6	3	6	6	8	3	4	7
Mar 18	6	11	6	5	10	3	6	4	26	6	6	4	4	2	3	5	3	6	19	6	9	4	21	7	12	22	3	31
Mar 25	38	16	13	21	5	4	7	6	10	6	33	5	4	4	4	7	4	4	18	4	59	5	81	7	6	32	3	10
Apr 01	60	11	29	13	5	3	32	8	45	42	41	4	4	5	6	27	49	5	22	5	47	3	50	7	4	21	3	9
Apr 08	25	8	66	7	5	15	49	4	35	29	31	6	19	3	63	17	26	42	14	6	30	6	21	7	4	10	5	9
Apr 15	45	6	33	5	5	54	26	3	26	12	38	5	17	2	64	15	41	33	10	5	42	79	15	55	4	4	5	7
Apr 22	34	7	21	5	6	55	37	4	21	8	54	4	9	3	62	16	46	57	9	4	42	69	11	63	3	5	5	6
Apr 29	25	9	34	5	10	21	50	4	15	6	35	9	6	6	48	25	28	43	8	3	28	47	10	41	3	15	9	6
May 06	16	7	21	6	7	15	42	4	20	5	75	11	6	7	32	27	15	32	7	3	24	26	31	61	6	11	9	18
May 13	13	8	16	26	7	31	57	6	21	5	27	33	5	4	25	13	9	25	6	3	22	17	30	33	11	8	8	19
May 20	22	13	16	16	6	33	33	6	29	5	16	25	8	21	27	11	14	29	6	15	28	15	16	71	19	9	6	16
May 27	23	10	10	13	8	26	28	11	18	8	19	37	10	24	41	12	50	34	5	34	37	10	20	55	21	9	8	22
Jun 03	15	9	9	13	6	18	20	10	13	6	17	24	7	20	25	15	41	29	5	15	24	9	13	39	9	8	6	15
Jun 10	15	8	8	34	7	12	19	15	21	7	20	43	7	51	25	41	27	21	5	7	47	18	24	42	17	28	6	10
Jun 17	25	17	9	35	10	11	15	16	37	31	22	30	7	25	69	28	32	24	5	6	23	13	39	40	10	44	46	8
Jun 24	44	20	12	20	8	8	14	8	29	13	20	22	12	16	45	20	30	16	5	6	13	7	45	24	6	38	37	8
Jul 01	17	49	39	20	8	5	9	8	24	7	20	14	7	12	28	17	19	15	5	6	10	19	43	63	5	43	24	12
Jul 08	20	39	43	59	6	5	8	24	16	5	10	12	35	13	60	13	14	11	4	7	8	17	40	80	5	35	19	9
Jul 15	24	24	47	45	9	5	6	22	11	5	9	12	15	48	39	13	19	9	6	24	6	12	43	35	5	14	16	6
Jul 22	14	15	28	35	17	4	5	10	10	4	8	8	7	33	46	44	17	7	7	22	6	13	80	38	4	9	11	6
Jul 29	10	12	17	25	65	3	4	6	11	6	5	6	4	13	30	33	12	6	4	14	5	9	44	22	3	7	8	5
Aug 05	7	8	12	14	22	4	4	6	8	9	4	5	12	9	15	21	10	7	3	15	7	8	25	17	3	6	8	8
Aug 12	10	7	14	12	9	4	5	7	8	8	7	4	8	9	12	14	9	5	3	16	5	7	23	10	2	4	9	9
Aug 19	21	16	12	9	7	3	4	5	13	5	5	4	7	9	9	11	7	5	4	44	4	5	15	8	2	3	19	9
Aug 26	8	6	8	7	6	3	4	9	26	4	5	6	4	8	7	8	7	4	4	75	4	6	12	6	4	5	27	9
Sep 02	9	6	8	9	5	3	3	31	12	3	7	4	3	6	6	6	7	4	3	52	4	6	11	5	7	4	13	12
Sep 09	8	4	6	12	4	3	3	29	36	4	7	4	3	8	6	6	5	4	6	38	3	5	13	6	4	3	9	6
Sep 16	9	4	7	8	5	3	3	25	29	27	7	4	3	14	5	5	4	5	8	22	4	7	11	6	4	3	7	5
Sep 23	9	4	6	7	4	3	3	22	17	30	6	4	3	13	4	4	4	4	8	16	9	12	12	5	3	3	7	4
Sep 30	6	4	6	6	4	3	3	11	18	18	6	4	3	10	5	4	3	4	6	29	7	18	11	4	3	3	6	4
Oct 07	5	6	6	6	4	4	2	8	17	10	5	3	2	8	4	5	4	4	5	26	5	14	10	5	3	3	7	3
Oct 14	5	13	5	5	4	4	2	8	14	8	5	3	3	6	4	5	3	4	4	19	4	13	12	5	3	3	6	4
Oct 21	6	12	4	5	3	5	2	10	11	10	4	3	3	5	4	5	4	4	3	24	4	14	11	5	4	3	6	3
Oct 28	5	8	4	5	4	4	3	8	10	9	4	3	3	5	5	5	4	4	3	23	4	9	9	5	3	3	7	3
Nov 04	5	6	3	5	3	4	3	7	8	7	4	4	2	5	6	5	5	3	3	20	4	8	10	6	3	3	6	3
Nov 11	4	5	4	4	4	4	2	8	8	6	4	4	2	5	6	5	5	4	3	17	4	6	12	6	3	3	6	3
Nov 18	4	5	4	5	3	4	2	7	7	6	4	4	2	5	10	5	5	4	3	13	4	7	11	6	3	3	7	3
Nov 25	3	4	4	4	4	4	3	6	7	5	4	4	2	5	6	5	5	4	3	8	4	8	10	6	3	3	8	4
Dec 02	4	5	5	4	4	3	3	5	8	6	4	4	2	4	5	5	5	5	3	8	3	7	9	6	3	5	7	4
Dec 09	5	5	6	5	4	3	4	6	7	5	4	4	3	4	6	5	6	4	3	8	3	7	8	6	3	4	7	3
Dec 16	4	6	6	6	4	3	4	5	7	4	4	5	3	5	6	5	6	4	3	7	3	7	8	6	3	3	5	3
Dec 23	3	7	5	6	4	3	3	5	7	4	3	6	3	5	5	5	5	3	2	6	3	6	7	5	3	5	6	3

Figure 55. 'Heat Map' of Weekly Average Colour Values at Rossdale WTP, 1997 to 2024.
Note: darkest blue colours represent the lowest colour values and darkest red colours represent the highest colour values

In summary, while the period of 2018 – 2020 (and to a lesser extent, the period of 2016 – 2020) does stand out in terms of elevated colour values and prolonged periods of elevated colour, this trend has not continued through 2021 – 2024, and is explainable by the hydroclimatic variability of these periods. More work will need to be done to determine if hydroclimatic variability is increasing over time.

Climate change is expected to have a variety of effects on colour in the NSR. Longer growing seasons, wetter winters, and increased decomposition of organic material in soils is anticipated to result in increased export of organics (measured by colour; Ritson et al. 2014). Increased precipitation, particularly through more frequent and intense storm events will increase runoff and loading of colour in the NSR during these events. Periods of droughts or dry conditions will result in reduced runoff and colour; however, Ritson et al. 2014 observed that large flushes of colour occur following the first rainfall after a period of prolonged dry conditions, which is what appears to have occurred during the high colour event in 2016.

While colour in the NSR is highest during the spring and summer months, elevated colour during the winter months can present a challenge to the WTPs. Each fall/winter, the WTPs convert to direct filtration, a mode of operation that that requires less treatment and therefore lower operational costs. In order to remain in direct filtration, colour must remain below ~ 10 TCU. While colour values during the winter months are typically < 5 TCU, there have been instances of elevated colour during the winter months in some years, most notably in early January 2020 where elevated colour required the WTPs to convert back to conventional operation prematurely. During the winter months, the majority of the flow in the NSR originates from the Bighorn and Brazeau dams upstream. The Bighorn dam is located in the headwaters of the NSR and receives water primarily from alpine environments, and that water within the reservoir is typically low in colour (< 2 TCU). In contrast, the Brazeau dam receives more water from foothill regions that have a lot of fen and bog habitat, and as a result, typically has much higher colour during the fall and winter months (5 – 20 TCU). Even in years where the colour in the Brazeau dam is high, the resulting colour in the NSR at Edmonton typically remains below 10 TCU due to the diluting effects of the Bighorn dam and other surface and groundwater contributions to the NSR.

Where problems have occurred in the past is when colour in the Brazeau dam is high, and TransAlta decreases the flow from the Bighorn dam and increases the flow from the Brazeau dam. TransAlta regularly does this each winter to manage ice conditions below the dams to help avoid ice jams and shifting/collapsing the ice on the NSR (TransAlta pers. comm. 2018). TransAlta's normal practice is to maintain a daily average flow of ~ 99 m^3/s from the two dams. During periods of ice formation, flow from one dam may be restricted, but compensated by the other. When the colour is high in the Brazeau dam, and the majority of the flow in the NSR is originating from the Brazeau dam, this can increase colour in Edmonton; which has caused the WTPs to exit direct filtration prematurely.

EPCOR is highly interested in being able to predict the timing and magnitude of increases of colour due to the impact to WTP operation. It is known that colour increases shortly after creeks such as Modeste, Strawberry, Weed and Conjuring open in the spring and begin loading colour to the NSR. Historically, EPCOR relied upon in-person visual observations from these creeks to determine when spring runoff had started. Beginning in 2019, EPCOR, in conjunction with AEPA as part of the SaskWatch Monitoring Program, began installing cameras on creeks upstream of Edmonton. These cameras provide real-time photos of the creeks that are highly useful for determining when spring runoff begins, or when large storm events may generate higher colour values in the NSR.

EPCOR developed a spring runoff prediction tool to predict when colour would increase at the WTPs. This simplistic tool is based on a multiple regression model that includes a number of different temperature metrics (i.e., the minimum temperature over the past five days, the average temperature over the past two days, etc.) and the day-of-year. This tool appears to predict the timing of colour increases well; however, there are certainly limitations to this approach, including the inaccuracy of temperature forecasts and extreme swings in temperature (i.e., several days above 10 ^{o}C, followed by several days below -10 ^{o}C). The most significant limitation of the tool is that it is unable to predict the magnitude of the colour increase. EPCOR understands that the magnitude of colour increase during spring runoff is dependent upon the depth of snowpack, the rate in which it melts, and the soil moisture; however, predictions are still coarse.

Mean daily colour values over 15 TCU (which is the Canadian Drinking Water Quality Guideline aesthetic objective for treated water) occurred around 20% of the time since 1997, at both plant intakes. The timing of high colour in the NSR is important from a treatment perspective as it is linked to taste and odour concerns, which require the addition of carbon to remove. Using historical data, the probabilities of colour by week has been compiled (Figure 56). This data shows that, for example, by the beginning of March, colour is below 10 TCU over 90% of the time, but by early April, there is 50% chance that colour will be above 10 TCU and a 10% chance it will be above 45 TCU. Again, predicting the timing of colour spikes in the NSR is difficult as it is driven by hydroclimatic and runoff patterns, which are difficult to model and predict on a watershed scale. However, historical data can provide some insight into the most likely periods in which colour will be high in the NSR.

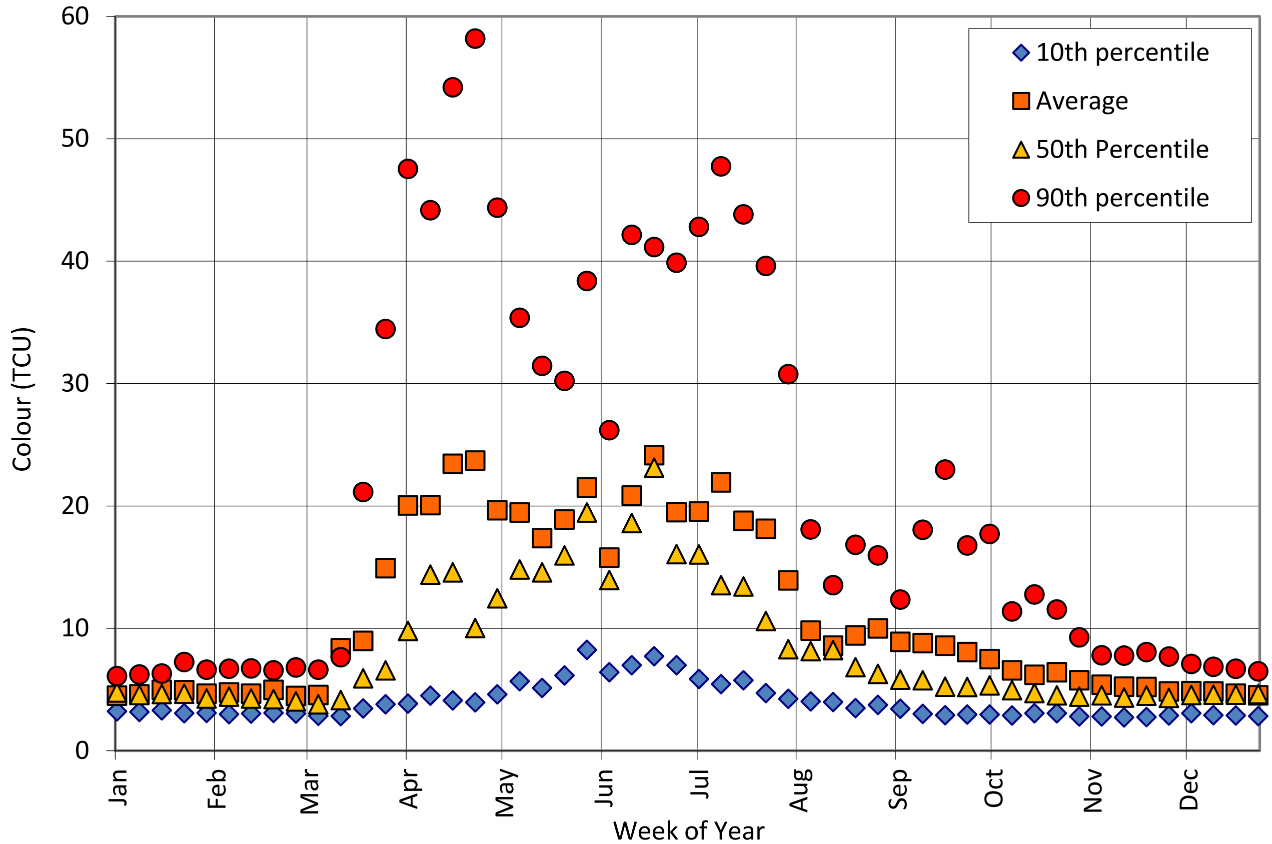


Figure 56. Colour at Rossdale WTP Intake for 1997 to 2024 Compiled by Week of the Year.

Indicator Bacteria

A variety of indicator bacteria have been monitored at the WTP intakes over the years. Fecal coliforms were measured by membrane filtration until 2008. With the introduction of Colilert™ testing (i.e., defined substrate technology), EPCOR slowly began to move away from membrane filtration, and in 2005 began enumerating *E. coli* and total coliforms.

Since 2005, concentrations of total coliforms and *E. coli* have been measured weekly at the E.L. Smith intake and daily at the Rossdale intake. The increased frequency of testing at the Rossdale intake is related to the increased risk of source water contamination from storm sewers outfalls located upstream. Storm sewers can discharge high loads of *E. coli* into the NSR, particularly during storm events.

E. coli showed no discernible trend between 2005 and 2016; however, a notable shift occurred between 2017 and 2020, with increased concentrations measured at both WTPs (Figure 57). A plot of the individual samples (not shown) showed that mid-way through 2020, *E. coli* concentrations rapidly returned to pre-2017 values. It is believed that the Devon WWTP was the source of the elevated *E. coli*, as it was undergoing upgrades during this period. As *E. coli* concentrations were continually elevated throughout the year, it indicates that the *E. coli* was being loaded to the NSR from a point source. As concentrations were elevated at both WTPs, this indicates that the source of the *E. coli* was upstream of Edmonton; however, concentrations were not elevated in samples collected by AEPA at the Devon LTRN located a short distance above the Devon WWTP. The Devon WWTP was only required to measure TSS and BOD from its effluent during this period, thus it is unknown if it was the source of elevated *E. coli* loading. Conversations with WWTP staff indicated that their effluent had notably higher TSS and BOD loads until their WWTP completed upgrades in 2020, which seems to correspond to when *E. coli* concentrations dropped.

E. coli is mobilized by precipitation and runoff events, as evidenced by the highest concentrations during summer months, followed by spring (Figure 58 and Figure 59). *E. coli* is typically low in the NSR during the winter months, but can be elevated in some years, due to cross connections resulting in wastewater entering in Edmonton's stormwater system, and *E. coli* was highly elevated in 2017 – 2020, presumably due to Devon's WWTP.

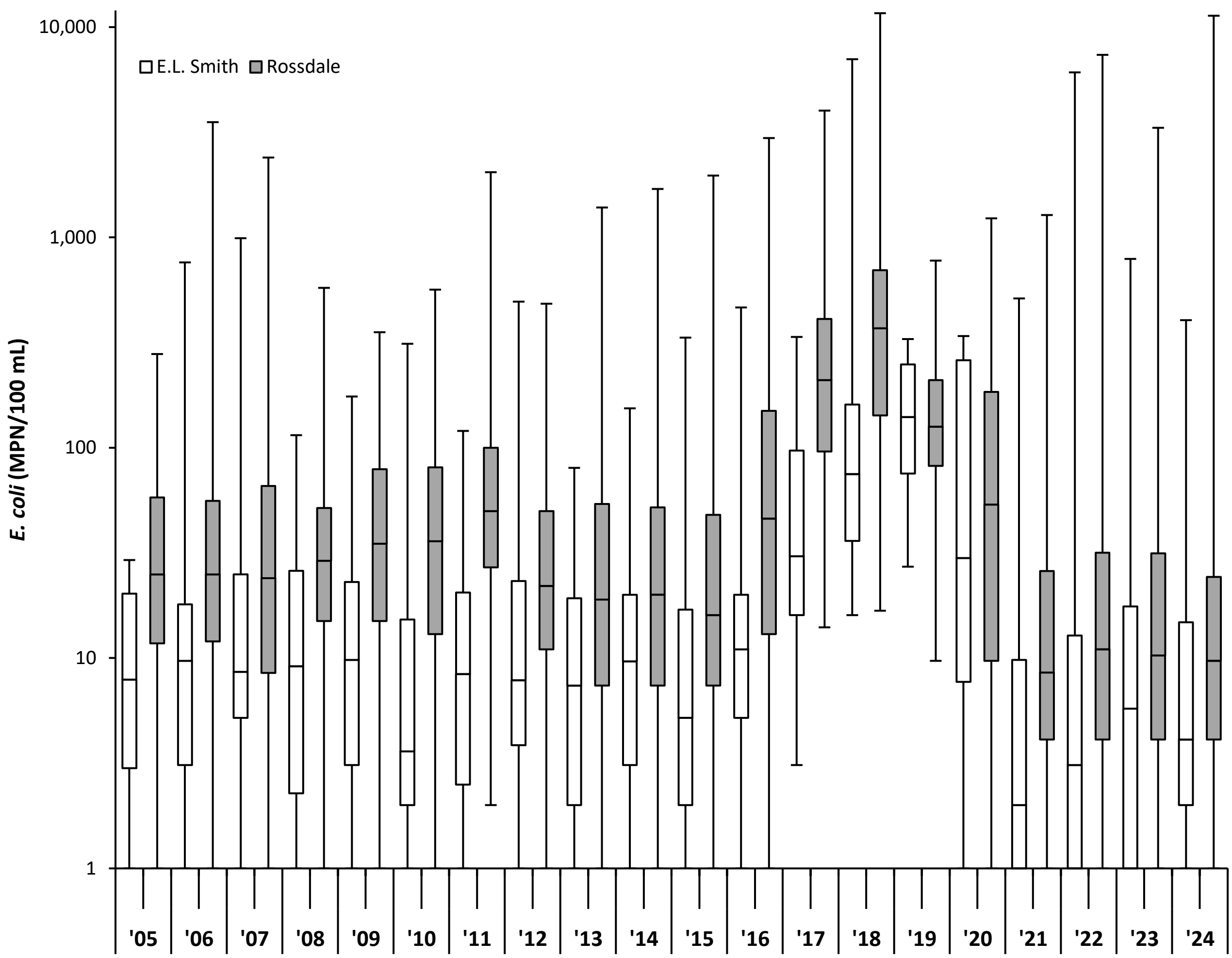


Figure 57. *E. coli* Concentrations in Rossdale and E. L. Smith Raw Water (2005-2024).

Week	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22	'23	'24
Jan 01	6	20	4	16	39	8	72	21	7	1	9	14	38	532	102	124	4	2	2	7
Jan 08	9	22	4	4	15	28	26	9	6	1	4	10	41	557	170	115	7	2	1	10
Jan 15	2	12	4	6	18	11	26	7	31	16	9	10	109	788	93	195	9	5	1	16
Jan 22	13	13	7	2	17	8	80	14	8	29	104	20	54	677	66	179	6	14	9	5
Jan 29	30	12	8	2	85	5	68	17	6	11	12	39	58	560	44	108	4	1	2	24
Feb 05	13	9	8	3	71	6	69	19	9	3	12	38	58	675	87	171	5	16	8	5
Feb 12	12	13	17	19	72	17	61	26	36	6	33	45	265	784	103	181	8	6	5	7
Feb 19	9	39	18	34	48	7	49	17	20	3	100	41	240	953	201	174	16	2	3	15
Feb 26	73	8	9	39	168	77	22	17	34	2	33	200	120	752	74	198	19	5	9	12
Mar 04	228	34	47	58	100	80	20	44	25	24	115	173	57	893	27	199	35	3	3	19
Mar 11	90	32	66	26	82	89	40	34	25	171	216	51	246	916	149	215	50	39	10	65
Mar 18	66	47	121	21	56	37	46	22	25	61	85	50	413	1,095	157	256	17	81	72	40
Mar 25	95	97	156	21	43	53	74	26	104	55	153	16	413	978	107	260	3	18	35	18
Apr 01	78	102	28	26	49	10	230	39	182	108	148	18	286	904	46	362	2	21	18	15
Apr 08	29	48	45	36	109	10	150	38	124	68	39	11	153	1,278	81	344	5	10	14	3
Apr 15	27	36	85	15	28	8	56	17	249	34	18	8	202	954	58	251	7	10	8	2
Apr 22	14	19	35	36	14	132	44	24	86	56	6	46	221	381	71	89	2	13	8	4
Apr 29	8	27	130	66	10	125	26	23	53	14	8	10	103	263	123	173	2	23	6	8
May 06	12	33	109	30	29	43	18	9	9	7	58	11	38	436	71	20	29	6	22	22
May 13	35	15	17	30	15	32	12	9	2	16	18	9	101	487	126	5	24	12	10	12
May 20	30	46	15	53	11	200	53	41	12	29	11	281	243	487	100	213	56	27	18	14
May 27	14	19	10	33	14	52	19	9	78	125	9	83	210	418	128	54	14	10	14	5
Jun 03	90	16	109	60	21	44	41	86	28	47	21	92	151	451	202	171	14	21	18	7
Jun 10	85	36	65	56	12	51	103	98	26	26	14	93	182	962	187	183	35	122	19	6
Jun 17	213	87	99	29	35	38	323	25	74	54	18	24	340	413	233	56	23	88	262	3
Jun 24	30	21	130	29	24	137	112	27	70	32	15	107	127	412	156	86	12	111	20	6
Jul 01	21	22	96	77	93	61	58	99	44	63	5	65	126	411	72	216	21	340	13	34
Jul 08	27	101	40	73	103	175	562	248	38	30	11	234	116	1,085	179	211	24	53	9	21
Jul 15	42	40	70	74	35	340	198	506	66	35	116	228	218	551	291	61	34	39	23	10
Jul 22	61	60	53	52	51	58	340	473	52	192	20	119	423	457	203	63	202	25	400	29
Jul 29	28	45	34	31	36	38	56	116	23	38	9	390	299	283	178	55	29	24	331	6
Aug 05	25	45	24	34	22	48	182	116	18	28	7	416	483	398	240	36	13	17	1,025	239
Aug 12	21	15	14	29	28	67	59	41	32	20	22	91	400	407	135	24	11	9	962	186
Aug 19	44	31	20	22	48	44	55	58	25	9	20	297	310	361	136	41	20	12	141	36
Aug 26	32	26	51	31	51	37	46	22	116	30	12	80	197	83	133	20	27	16	32	20
Sep 02	30	4	61	24	40	27	72	31	76	19	92	80	121	83	109	5	27	7	35	20
Sep 09	69	99	71	19	15	48	35	15	20	39	45	37	392	248	180	21	18	10	19	9
Sep 16	20	87	44	32	29	34	53	14	35	10	61	38	647	131	278	8	11	8	3	8
Sep 23	12	47	16	33	26	20	25	19	18	20	14	13	291	80	263	13	6	13	6	30
Sep 30	25	27	7	40	79	28	41	36	9	6	18	81	372	54	141	11	8	23	5	7
Oct 07	11	16	9	13	87	20	48	28	4	12	4	60	223	76	113	17	4	8	3	5
Oct 14	53	46	18	7	106	12	32	8	3	14	6	66	163	41	168	4	1	3	4	5
Oct 21	16	16	7	8	52	37	27	9	4	15	18	42	146	60	140	4	16	3	8	3
Oct 28	13	33	10	16	38	16	120	9	9	11	37	19	228	187	173	9	4	5	5	3
Nov 04	20	22	19	20	6	3	23	27	3	12	24	47	207	112	143	11	2	13	4	3
Nov 11	9	20	9	16	15	13	35	13	20	8	19	118	72	111	232	8	3	13	5	5
Nov 18	6	15	8	9	17	192	171	5	13	32	4	25	292	108	170	8	3	40	6	2
Nov 25	7	32	27	6	40	20	75	8	6	28	7	8	267	56	107	10	8	4	3	4
Dec 02	13	20	51	35	107	26	85	20	6	5	8	39	512	97	234	9	10	10	15	53
Dec 09	24	9	6	39	111	42	74	13	2	36	4	19	881	126	180	6	5	6	7	13
Dec 16	13	8	7	24	40	63	54	10	2	6	11	6	586	150	132	9	3	3	4	5
Dec 23	39	4	3	100	16	95	46	7	2	3	12	22	660	137	175	5	4	2	5	3

Figure 58. 'Heat Map' of Weekly Geometric Mean of *E. coli* at Rossdale WTP, 2005 to 2024.

Note: darkest blue colours represent the lowest colour values and darkest red colours represent the highest colour values

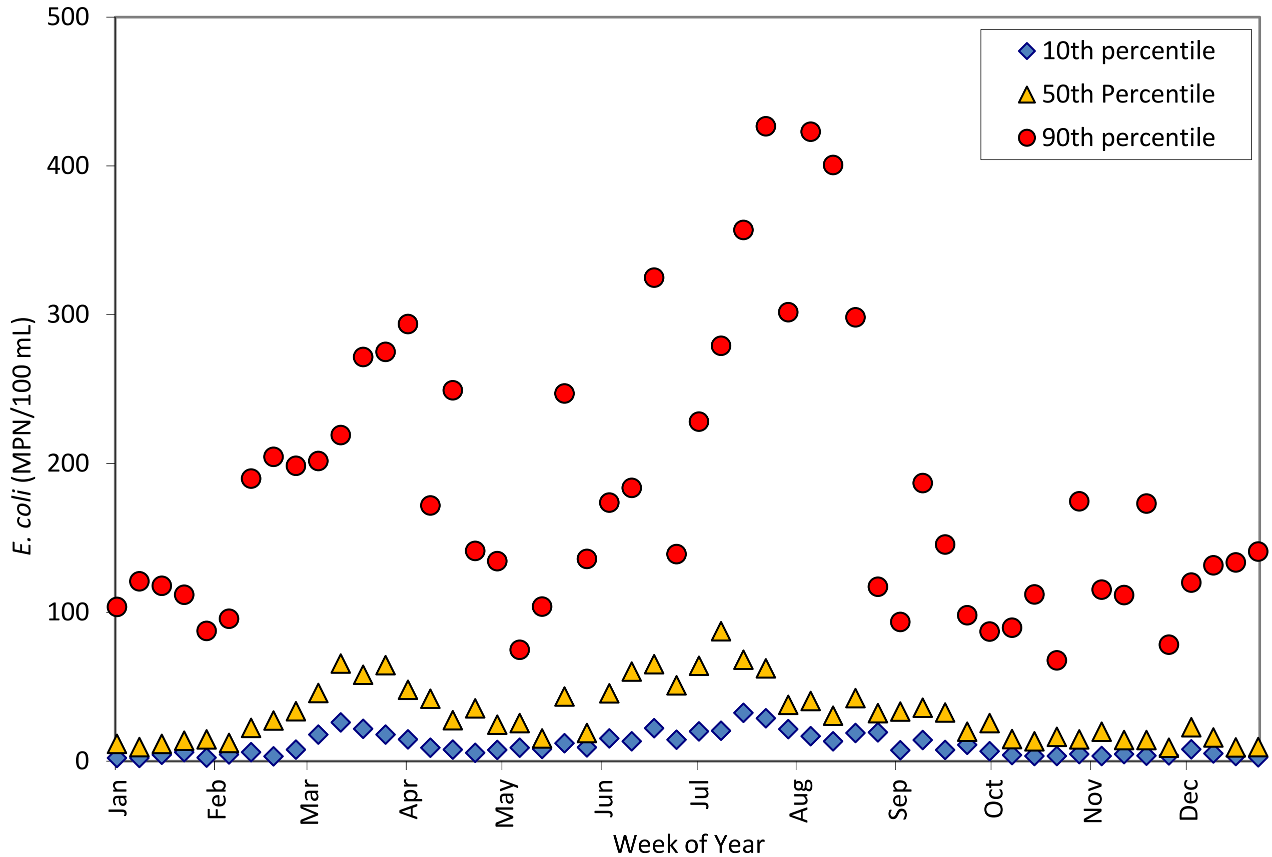


Figure 59. Geometric mean of *E. coli* at Rossdale WTP Intake for 1997 to 2024 Compiled by Week of the Year.

E. coli concentrations in the NSR are typically of low concern for drinking water, as both the E.L. Smith and Rossdale WTPs treat the raw water from the NSR using chlorination and UV disinfection. However, *E. coli* is regularly measured at the raw water intakes as an indication of possible contamination of the source water. To evaluate the water quality in the NSR, *E. coli* concentrations can be compared to the Alberta recreational water quality guidelines. It should be noted that the exceedances of the recreational water quality guidelines have no impact on the safety of the drinking water supply and this comparison is made only for illustrative purposes to show the relative health of the NSR.

The Alberta recreational water quality guideline for *E. coli* is that the geometric mean over a 30-day interval is below 100 MPN/100 mL. Additionally, no more than 10% of samples should exceed 320 MPN/100 mL over a 30-day interval. As this guideline is a recreational guideline for swimming in water, it should largely only be applicable between the months of May to September. Excluding the period of 2017 – 2020 (when *E. coli* was elevated in the river due to the Devon WWTP), recreational guidelines at E.L. Smith were exceeded the first and second guideline for 1% and 8% of the months, respectively. *E. coli* concentrations were higher at Rossdale and exceeded the first and second guidelines for 8% and 15% of the months respectively. However, between 2017 and 2020 when *E. coli* concentrations were elevated, the number of months exceeding the two guidelines increase to 30% and 35% at E.L. Smith and to 80% and 85% at Rossdale.

In summary, recreational contact guidelines were occasionally exceeded at E.L. Smith and were exceeded more frequently at Rossdale. During the period of 2017 – 2020, guidelines were exceeded more frequently, and almost continuously at Rossdale. While urban stormwater has typically been seen as a major source of *E. coli*, sources upstream of Edmonton are also capable of causing greater and nearly continuous exceedances. These trends also indicate that parameters that have otherwise been consistent for years can suddenly shift due to changing conditions upstream. To account for the potential for rapidly changing *E. coli* concentrations in raw water from both upstream sources and the urban stormwater, EPCOR reviews raw water *E. coli* data biweekly.

Cryptosporidium and Giardia

Since the infective stages of *Cryptosporidium* and *Giardia*, oocysts and cysts respectively, are shed with feces, the presence of *Cryptosporidium* and *Giardia* in a water source indicates that the source has been exposed to fecal contamination. *Cryptosporidium* and *Giardia* have been associated with several waterborne disease outbreaks, such as the outbreak of *Cryptosporidium* in North Battleford in 2001. *Cryptosporidium* and *Giardia* in the NSR present a low risk to the drinking water due to the level of multi-barrier treatment provided by the WTPs (i.e., physical removal, chemical and UV treatment).

Human population densities, livestock densities, manure application to land, impervious land cover, and sanitation systems will impact the occurrence, distribution, and concentration of potential sources of fecal contamination, and therefore impact concentrations of *Cryptosporidium* and *Giardia* in the NSR. Elevated concentrations of *Cryptosporidium* and *Giardia* can impact drinking water safety and recreational water use. The infective stages of *Cryptosporidium* and *Giardia* are monitored monthly most of the year. In the fall/winter, when river water quality is high and the plant relies on direct filtration for drinking water treatment, samples are collected on a weekly or bi-monthly basis. While the concentrations of protozoan parasites might seem high, it is important to note that US EPA Method 1623 used for detection neither provides information on viability of organisms (i.e., counting dead and alive organisms) nor does it provide information on species detected, where only a few are relevant to human health. As a result, the counts produced are conservative in nature. It should also be noted that the detection limit of both *Cryptosporidium* and *Giardia* can vary by an order of magnitude or two and can complicate how trends are assessed. For this report, samples that were below the detection limit are plotted separately at the value of the detection limit. While *Cryptosporidium* and *Giardia* samples have been collected since 1998, the current methodology has been in place since 2006. Concentrations of *Cryptosporidium* and *Giardia* were similar at the E.L. Smith and Rossdale intakes, but only data from the Rossdale WTP are presented below.

Concentrations of *Cryptosporidium* have been steadily declining, and samples that are below the detection limit occur more frequently in recent years (Figure 60). Concentrations of *Giardia* show a long-term decline, but concentrations have remained steady over the past 10 years. (Figure 61). The declines of *Cryptosporidium* and *Giardia* could be related to the decline in cattle in the watershed, and/or improvements in agricultural practices but could also be changes in analytical methods. EPCOR is investigating potential laboratory analysis issues. There are strong seasonal trends of *Cryptosporidium* and *Giardia* with peak abundances of both species occurring during the spring freshet (Figure 62).

The species of *Cryptosporidium* is also important as some *Cryptosporidium* species/genotypes are not considered infectious to humans. The fraction of *C. hominis* and/or *C. parvum*, the dominant human infectious forms of the parasite, are important in assessing risk to drinking water. Some preliminary work has shown *C. andersoni* is the dominant form in many Alberta basins including the NSR however more research is needed to understand seasonal changes in pathogen loads.

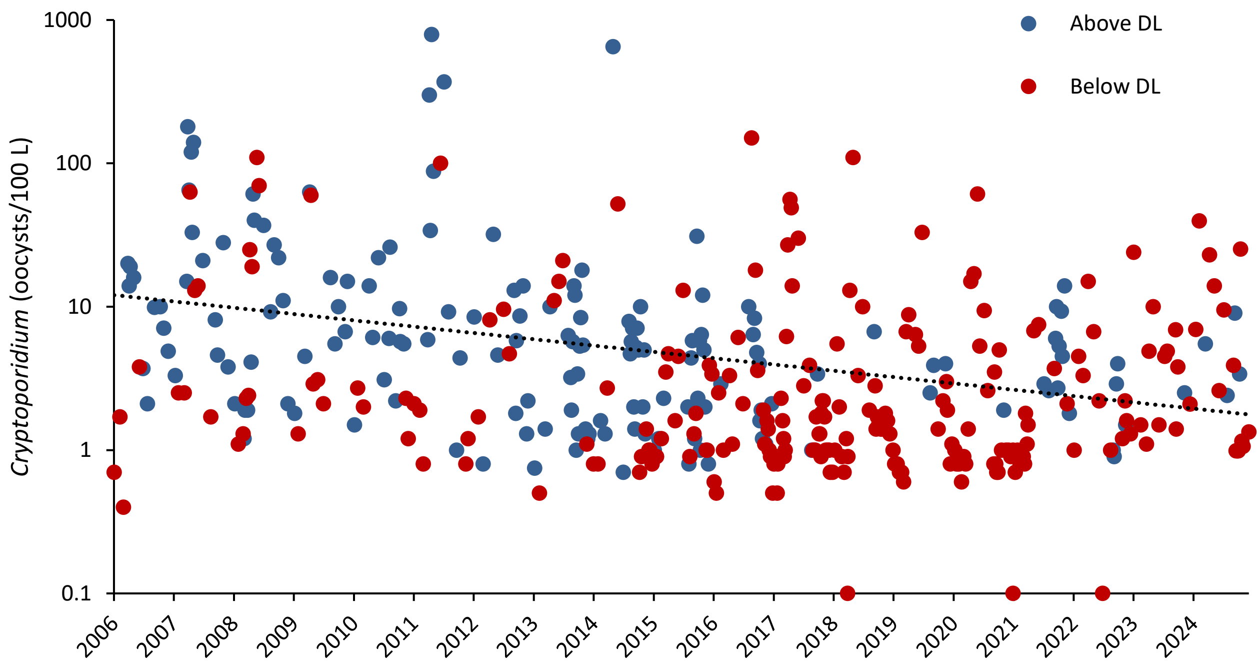


Figure 60. *Cryptosporidium* Concentrations in Rossdale Raw Water (2006-2024).

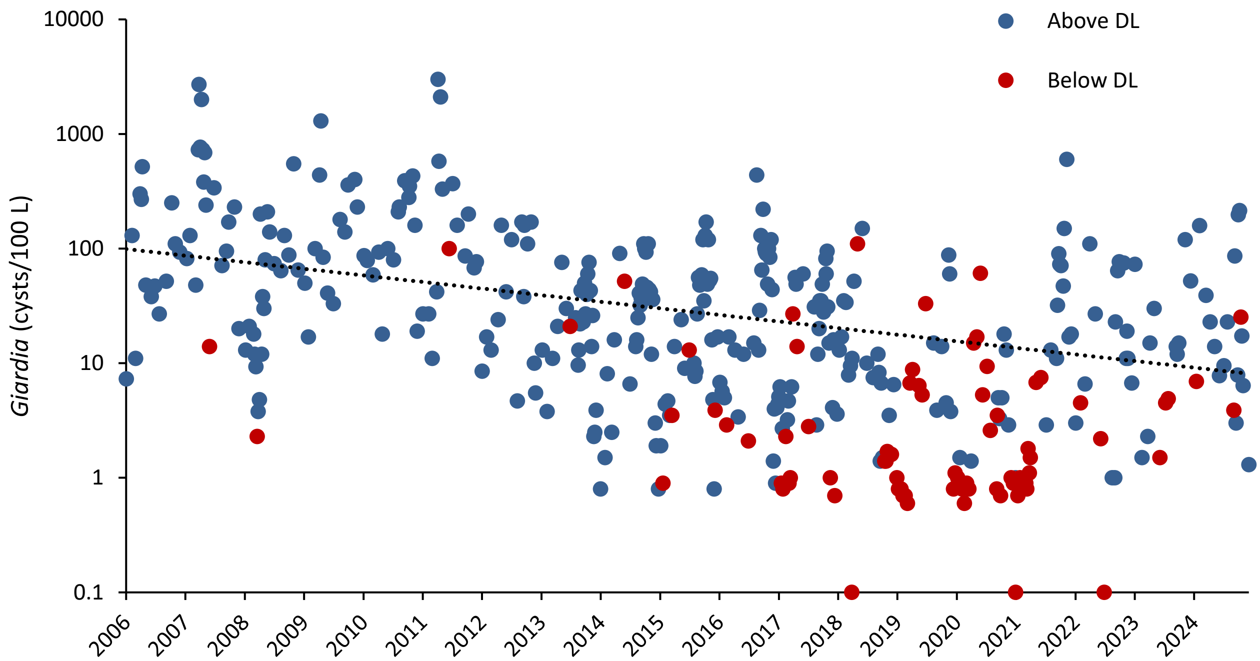


Figure 61. ***Giardia*** **Concentrations in Rossdale Raw Water (2006-2024).**

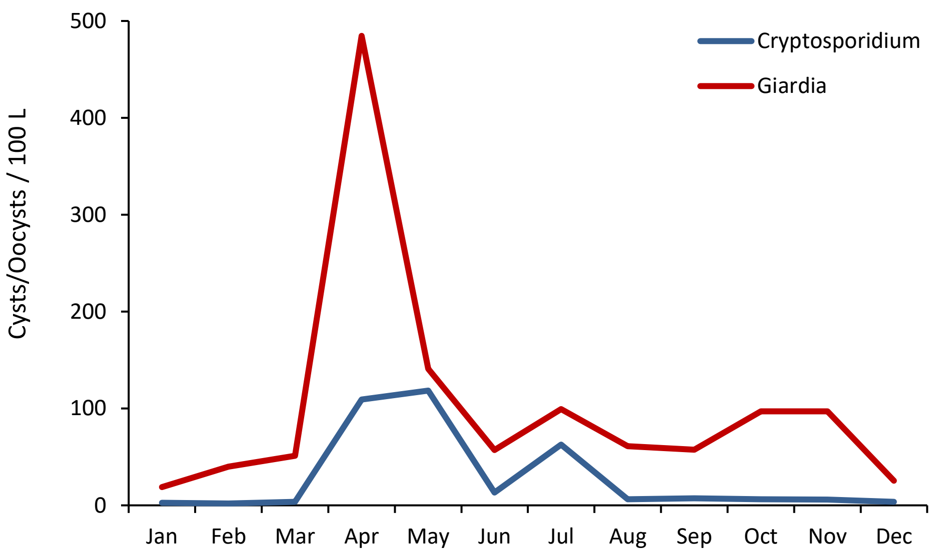


Figure 62. Monthly Average Concentrations of *Cryptosporidium* and *Giardia* at the Rossdale WTP of Samples Above the Detection Limit (2006-2024).

Microcystin

Several species of cyanobacteria (also known as blue-green algae) have the ability to produce cyanotoxins which have negative effects to human health. The concentrations of toxins can become elevated particularly during an algal bloom and can persist in the environment after the bloom is over. These toxins can be ingested, inhaled or absorbed through the skin. The persistence of toxins in the environment can potentially affect downstream users, where the bloom may not be directly observed. Microcystins are typically considered to be most important class of cyanotoxins, and microcystin-LR has been the prevent and studied microcystin (Health Canada 2017). Health Canada drinking water quality guidelines are based on the toxicity of microcystin-LR; however, the maximum allowable concentration is 1.5 µg/L of total microcystins (Health Canada 2020a). Health Canada has also recommended a precautionary level of 0.4 µg/L of total microcystins in treated drinking water. Health Canada recently released a proposed recreational water quality guideline of 10 µg/L total microcystins (Health Canada 2020b). Alberta's recreational water quality guidelines for microcystin-LR are set at 20 µg/L (GoA 2018), and the US EPA guideline is 8 µg/L (US EPA 2019).

Microcystin has been measured monthly at the WTPs between 2017 and 2022 and quarterly since 2023. The highest concentration of microcystins detected is 0.27 µg/L with 84 % of the samples being below the detection limit of 0.1 µg/L (Figure 63). Microcystin was detected at both the E.L. Smith and Rossdale WTPs at similar frequencies and concentrations. Microcystin was detected roughly evenly throughout the year, including the winter months (Figure 64). The detection of microcystin during the winter months suggests that either cyanobacteria are present in the upstream dams, or cyanobacteria may be persisting in the river under the ice. Beginning in 2023, microcystin has been measured quarterly at a higher detection limit (0.2 µg/L).

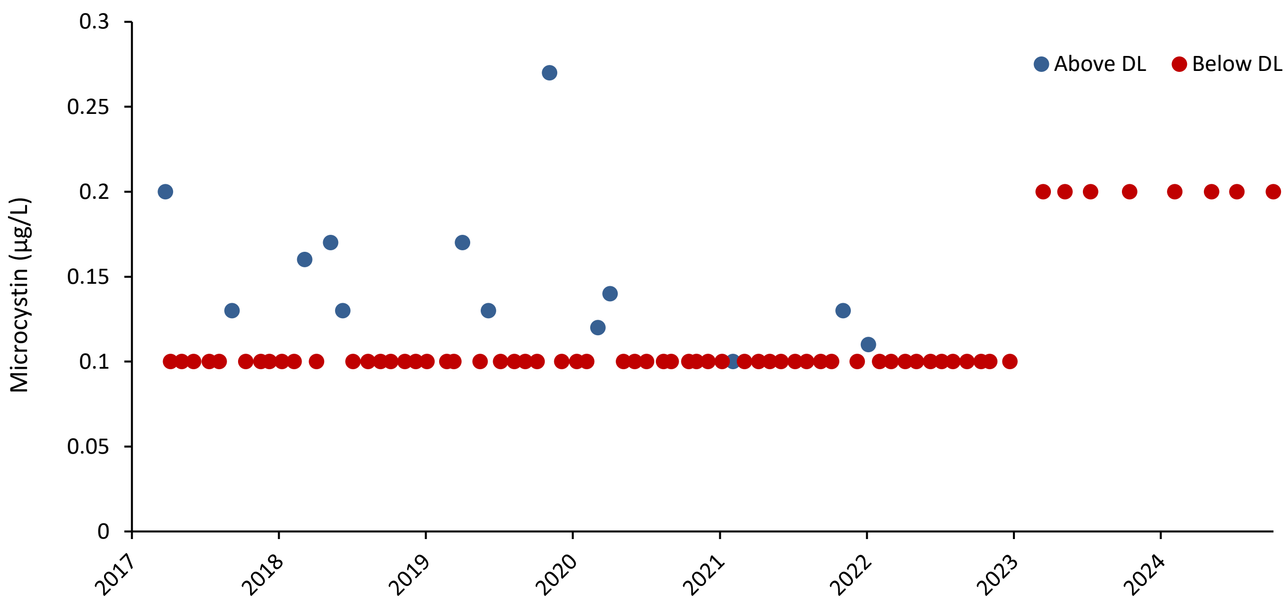


Figure 63. Microcystin concentrations in Rossdale Raw Water (2017-2024).

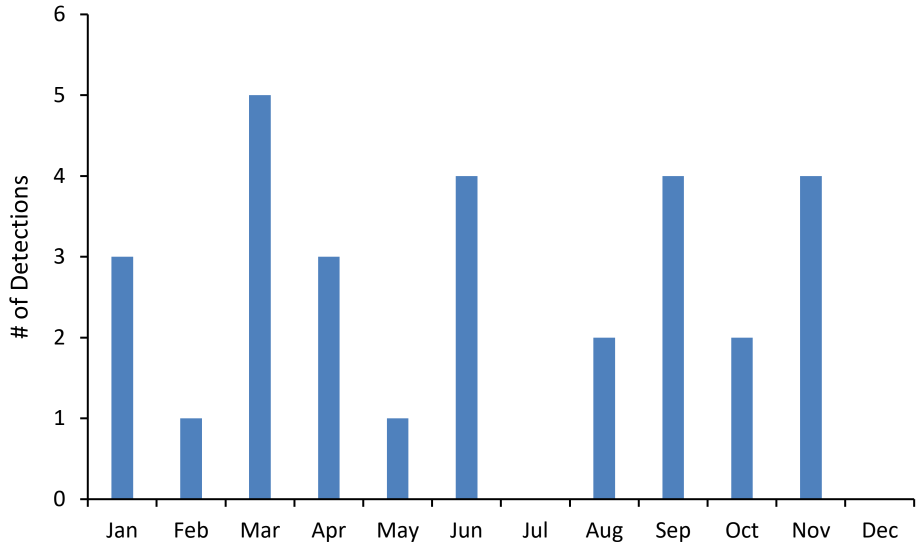


Figure 64. Number of Detections of Microcystin per Month in E.L. Smith and Rossdale Raw Water (2017-2024).

Contaminants of Emerging Concern

Contaminants such as pesticides, pharmaceuticals, and other trace organics are low in the NSR at WTP intakes. Beginning in 2004, EPCOR began monitoring raw and treated water for contaminants such as pesticides, phthalates, pharmaceuticals, Polycyclic Aromatic Hydrocarbons (PAH), phenols, hormones, steroids, and other personal care products (PCP). Samples were generally collected quarterly at both WTPs and analyzed for over 230 parameters, with variation among the parameters analyzed each year. In 2019 EPCOR conducted a critical review focused on compounds such as pharmaceuticals, hormones, and pesticides. EPCOR recognized that considerable effort was being spent analyzing for parameters that were regularly below detection limits, had very low concentrations when they were detected, and did not have human health guidelines. EPCOR refocused its monitoring to prioritize analyzing parameters that align with provincial and human health guidelines. EPCOR continually assesses its monitoring programs and takes a risk management approach for what analytes to include within annual monitoring plans. As a result, many parameters that were previously monitored stopped being analyzed in 2021. Since monitoring commenced in 2004, 178 raw water intake samples (E. L. Smith and Rossdale combined) have been analyzed for parameters of emerging concern.

The number of detections in that period was low (247 detections out of over 27,000 tests), particularly considering that analytical detection limits for measured parameters are very low (typically ng/L). Of the detections, 37%, of the detections were low level phthalates, 27% were pesticides, 23% were pharmaceuticals, and 13% were PAHs (Table 8). Except for four PAHs, concentrations of each parameter were below Alberta Surface Water Quality Guidelines and the Alberta Environmental Quality Guidelines for the Protection of Aquatic Life. Concentrations were always below the Canadian Drinking Water Quality Guidelines, with most concentrations being several orders of magnitude below the applicable guideline.

In 2011 and 2012, EPCOR also collected additional samples for pharmaceuticals, hormones/sterols and personal care products. Three samples were collected from each water intake for a total of six samples. These samples were tested for a wider range of parameters than the quarterly samples described above, and were tested for 150 parameters, only 36 of which were also tested for in the quarterly samples. These samples were also analyzed at lower detection limits than the quarterly samples. The number of detections in these samples was low (24 out of a possible 900 tests; Table 9). Several parameters (i.e., acetaminophen, cotinine and DEET) were found in concentrations that were below the method detection limits of the quarterly samples, suggesting that these parameters could be present, but not detected by the quarterly sampling. None of the detected parameters have corresponding drinking water quality guidelines; however, two parameters have guidelines for the protection of aquatic life. Alpha ethinyl estradiol was found to exceed the Alberta Surface Water Quality Guideline for the Protection of Aquatic Life (0.5 ng/L). Measured concentrations of nonylphenol were three and four orders of magnitude below the chronic and acute guidelines, respectively.

There are several possible sources of these compounds to the NSR. Phthalates are ubiquitous in our environment as they are used as softeners in plastics or resins, and sources include wastewater plants, leachate from landfills and industrial discharges. Pesticides are used in forestry, agricultural, and municipal land uses, and enter the NSR through runoff. Pharmaceuticals are typically the result of human use and are therefore found in wastewater treatment plant effluent; however, some parameters could be due to animal use and could be enter the river through runoff. PAHs are found in coal tar and fire smoke and likely enter the river through runoff.

Table 8. Summary of Trace Organics Detected in Quarterly Sampling at E.L. Smith and Rossdale Raw Water Intakes from 2004 to 2024.

Parameter	Category	Number of Samples	Number of Detections	Maximum Concentration (µg/L)	Alberta Surface Water Quality Guideline (µg/L)	Canadian Drinking Water Quality Guideline (µg/L)
2,4-D	Pesticide	174	19	0.094	4	100
2,4-Dinitrophenol	Pesticide	142	2	0.1	-	-
Acetaminophen	Pharmaceuticals	136	2	0.1	-	-
Aldrin	Pesticide	174	1	0.007	-	-
Aminomethyl phosphonic acid	Pesticide	74	1	3.41	-	-
Amoxicillin	Pharmaceuticals	32	1	0.05	-	-
Benzo(a)anthracene	PAH	142	4	0.059	0.018	-
Benzo(a)pyrene	PAH	174	1	0.023	0.015	0.04
Benzo(b)fluoranthene	PAH	142	2	0.2	-	-
Benzo(b,j,k)fluoranthene	PAH	142	2	0.05	-	-
Benzo(e)pyrene	PAH	92	0	0.02	-	-
Benzo(k)fluoranthene	PAH	134	1	0.6	-	-
Bis(2-ethylhexyl) phthalate	Phthalates	142	28	2.1	16	6*
Bromoxynil	Pesticide	174	1	0.007	5	30
Butylbenzylphthalate	Phthalates	142	26	0.7	-	-
Caffeine	Pharmaceuticals	132	12	0.04	-	-
Carbamazepine	Pharmaceuticals	132	1	0.0034	10	-
Chrysene	PAH	142	3	0.0558	-	-
Ciprofloxacin	Pharmaceuticals	136	2	0.06	-	-
Clindamycin	Pharmaceuticals	136	2	0.01	-	-
Clodinafop-propargyl	Pesticide	142	1	0.08	-	-
Cotinine	Pharmaceuticals	142	1	0.015	-	-
Diazinon	Pesticide	174	2	0.004	0.17	-
Dicamba	Pesticide	174	1	0.015	10	110
Diethyl phthalate	Phthalates	142	14	0.3	-	-
Di-n-butylphthalate	Phthalates	142	21	0.7	19	-
Di-n-octyl phthalate	Phthalates	142	4	0.2	-	-
Enrofloxacin	Pharmaceuticals	136	1	0.02	-	-
Fluoranthene	PAH	142	2	0.203	0.04	-
Fluorene	PAH	142	2	0.009	3	-
Fluroxypyr	Pesticide	142	3	0.024	-	-

Table 8. Summary of Trace Organics Detected in Quarterly Sampling at E.L. Smith and Rossdale Raw Water Intakes from 2004 to 2024. Continued.

Parameter	Category	Number of Samples	Number of Detections	Maximum Concentration (µg/L)	Alberta Surface Water Quality Guideline (µg/L)	Canadian Drinking Water Quality Guideline (µg/L)
Fluoxetine	Pharmaceuticals	136	1	0.01	-	-
Gemfibrozil	Pharmaceuticals	132	1	0.003	-	-
Glyphosate	Pesticide	112	4	3.282	800	280
Ibuprofen	Pharmaceuticals	132	3	0.023	-	-
Imazamox	Pesticide	142	1	0.017	-	-
Imazethapyr	Pesticide	142	2	0.05	-	-
Indeno(1,2,3-cd)pyrene	PAH	142	1	0.01	-	-
MCPA	Pesticide	174	2	0.009	2.6	350
MCPP	Pesticide	142	4	0.038	13	-
Metconazol	Pesticide	22	1	0.006	-	-
Methylnaphthalene	PAH	43	1	0.007	-	-
N,N-diethyl-m-toluamide (DEET)	Pharmaceuticals	104	9	0.324	-	-
Naphthalene	PAH	142	2	0.012	1	-
Naproxen	Pharmaceuticals	132	8	0.02	-	-
Norfloxacin	Pharmaceuticals	142	2	0.07	-	-
Perylene	PAH	121	2	0.012	-	-
Phenanthrene	PAH	142	4	0.092	0.4	-
Picloram	Pesticide	174	6	0.054	29	-
Propiconazole	Pesticide	142	1	0.042	-	-
Pyrene	PAH	142	2	0.015	0.025	-
Quinclorac	Pesticide	142	1	0.018	-	-
Retene	PAH	121	3	0.038	-	-
Salicylic acid	Pharmaceuticals	132	10	0.24	-	-
Thiamethoxam	Pesticide	142	2	0.052	-	-
Triclopyr	Pesticide	142	8	0.02	-	-
Trifluralin	Pesticide	148	3	0.009	0.2	-

Note: * = US EPA guideline as no Health Canada Guideline was available.

Table 9. Summary of Trace Organics Detected in Additional Sampling at E.L. Smith and Rossdale Raw Water Intakes from 2011 to 2012.

Parameter	Number of Detections [a]	Concentration range (ng/L)
Acetaminophen	2	19-21
Alpha-Ethinyl Estradiol	3	15-56
Amitriptyline	1	1.5
Amphetamine	1	1.5
Androstenedione	2	26-29
Benzoylecgonine	4	1-2
Benztropine	3	0.33-0.79
Beta-Sitosterol	1	533
Caffeine	4	37-46
Cholesterol	4	49-508
Ciprofloxacin	1	10.7
Cocaine	2	0.18-0.29
Cotinine	4	3.3-7.7
DEET	6	3.1-7.8
Diltiazem	1	0.33
Diphenhydramine	1	2.4
Enalapril	1	0.38
Erythromycin	1	0.29
Flumequine	1	1.5
Metformin	4	36-74
Naproxen	2	3.3-3.6
Nonylphenol	1	6.6
Sulfamethoxazole	1	1.1
Valsartan	2	4.1-9.5

[a] a total of six samples analyzed.

Beginning in 2018, EPCOR began collecting quarterly samples for per- and polyfluoroalkyl substances (PFAS), which are a large family of synthetic chemicals found in a wide range of consumer products such as non-stick products, food packaging, polishes, waxes, paints, cleaning products and fire fighting foams. The two most studied PFAS compounds, perfluorooctane acid (PFOA) and perfluorooctanesulfonic acid (PFOS) are highly persistent in the environment, are classified as and/or possible carcinogens associated with adverse health outcomes and have maximum allowable concentrations in drinking water established by Health Canada. PFOS was phased out of fire fighting Other PFAS compounds are still used in foams but are expected to be less toxic because of their chemical structure. They still have screening values established by Health Canada. Since monitoring began in 2018, PFOS, PFOA or any PFAS compounds have not been detected in the raw or treated water. PFAS compounds were monitored weekly in the summer of 2023 following a large wildfire and subsequent large rain event; however, no PFAS parameters were detected.

To determine the possible risk from PFAS compounds from firefighting foams, EPCOR reached out to fire services in upstream communities and counties to determine which types and quantities of foams are being used (Table 10). The Edmonton International Airport and Parkland County use a product that contains 6:2 flurotelomer sulfonate, which has a Health Canada screening value. Most of the upstream communities use a product (FireAde) that is reported to contain PFOA at concentrations of 80 µg/L and may contain other PFAS compounds (City of Calgary, 2020). Alberta Wildfire uses retardants that do not contain PFAS compounds (personal communication, D. Thomas, 2020). Therefore, wildfires that do not burn urban environments are not anticipated to be sources of PFAS.

For many fire-fighting products, it is difficult to determine if they contain PFAS compounds, and which specific compounds, as this information is considered proprietary on Safety Data Sheets and manufacturers have not responded to EPCOR's requests for information. However, given that upstream municipalities typically do not use large volumes of foam, the concentrations in the NSR are anticipated to be well below Health Canada Guidelines. However, if a single community were to discharge their entire stock in a single event, and if a majority of this product entered the river, there theoretically would be enough PFAS to exceed Health Canada guidelines and screening values for a short period of time in the NSR at Edmonton. Such an event would not likely be caught by our quarterly testing and therefore municipalities should report spills/releases of these products.

Table 10. Summary of Fire Fighting Foams Used by Upstream Communities.

Community / Location	Product being used	Estimated amount used per year	Contains PFAS?
Edmonton International Airport	Ansulite 3% AFFF (Formula DC-3)	1,000 L	Yes: 6:2 fluorotelomer sulfonate
City of Edmonton	Niagara 1-3 alcohol resistant film forming fluroprotein foam concentrate	1,000 L	Suspected PFAS
Leduc County	FireAde Mil 3% AFFF Fire Fighting Foam	2,000 L	Calgary suggests FireAde contains trace PFOA
City of Leduc	Angus Fire Hi-Combat A Foam concentrate	300 L	Unknown
Town of Devon	FireAde 3% FireAde 0.1% - 1.0%	FireAde 3%: 60 L FireAde 0.1-1%: 240 L	Calgary suggests FireAde contains trace PFOA
County of Wetaskiwin	FireAde Fire Fighting Agent	100 L	Calgary suggests FireAde contains trace PFOA
Parkland County	Niagra Foam Ansulite Fire Aid A/B Silvex Class A	Niagra Foam: 20 L Ansul light: 200 L Fire Aid A/B: 800 L Silvex Class A: 700 L	Ansulite contains 6:2 fluorotelomer sulfonate
Drayton Valley / Brazeau County	T-Storm SFFF ALCOSEAL 3/6% AR-FFFP FlameOut Fire Suppressor AFFF	T-Storm: 600 L ALCOSEAL: 120 L FlameOut : 400 L	Alcoseal contains fluorosurfactants, suspected PFAS. T-storm and FlameOut do not appear to contain PFAS
Clearwater County	FireAde - Class A&B	800 L	Calgary suggests FireAde contains trace PFOA
Alberta Wildfire	Phos-Check WD-881C Class A Foam Concentration	Unknown	No

Taken together, these results demonstrate that contaminants such as pesticides, pharmaceuticals, phthalates, and PAHs are present in the NSR; however, they are found in very low concentrations and are typically not detected. Additionally, most of the trace organics that have been tested for, have never been detected. The concentration at which these parameters have been detected are typically several orders of magnitude below drinking water quality guidelines and surface water quality guidelines for the protection of aquatic life. Some of these parameters are also found in EPCOR's drinking water reservoirs, suggesting that they are not fully removed through conventional water treatment. Assessing the risk associated with these compounds is challenging as many parameters do not have water quality guidelines.

A study by the World Health Organization (2012) concluded that impacts of pharmaceuticals in drinking water is unlikely to impact human health, and that concentrations in drinking water are generally more than 1000-fold below the minimum therapeutic dose. A study conducted by the Water Research Foundation (2015) found that a person would need to drink 100,000,000 glasses of water to obtain a therapeutic dose and there is no definitive links between pharmaceuticals in drinking water and human health.

While some PAHs are known to be carcinogenic, a study by the World Health Organization (2003) concluded that it is not possible to directly assess the risk on PAHs on humans due to the lack of human data, and that risk is likely due to exposure to mixtures of PAHs, and not individual PAHs. It should be noted that PAHs were relatively infrequently detected in the NSR. Additionally, the most extensively studied PAH, benzo[a]pyrene, due to its potential effects on human heath, has only been detected once, with concentrations below drinking water quality guidelines.

Compared to many other waterbodies, the risk associated with many of these compounds are presumably lower in the NSR given the relatively low population and development upstream of Edmonton. However, this area is an area of ongoing research, and additional knowledge of the effects of combinations of low concentrations of contaminants of emerging concern is required before risk can properly be assessed.

Spills on the NSR

Chemical spills can enter the NSR through a variety of pathways including industrial discharges, storm sewer outfalls, overland flow, tributaries, and directly into the NSR itself. Many of the locations and methods of spills being introduced to the NSR are covered in Section 3.2. EPCOR's WTPs recognize the threat of spills to drinking water quality and have developed lines of communication with provincial regulators (AEPA and AER), EPCOR's drainage operators, and the City of Edmonton fire department to directly contact the control rooms of the WTPs in the event of a spill on the NSR. EPCOR has run exercises to test these lines of communication.

While notable spills have occurred in the NSR, none have directly impacted EPCOR's WTPs, but highlight the risk represented by spills. In 2016, the Husky Energy Pipeline spilled 225,000 L of crude oil in the NSR near Maidstone, Saskatchewan. This spill significantly impacted the downstream communities of North Battleford and Prince Albert, which were forced to shut down their water intakes for months and find alternative water supplies. In 2005, 800,000 L of fuel oil spilled into Lake Wabamun when a train derailed; however, the spill was contained within Lake Wabamun. In August 2019, 40,000 L of oil emulsion spilled into Washout Creek near Drayton Valley, and the spill was contained within the creek.

Several smaller spills have occurred within Edmonton and been reported to EPCOR's WTPs, as the material entered the drainage system and the NSR. These spills have typically been sewage or diesel and have typically been small volumes and have not impacted the WTPs but highlights the potential risk of spills entering the NSR in close proximity to the WTP intakes.

In 2017, EPCOR engaged Stantec to provide a summary of the risks of a hydrocarbon spill upstream of Edmonton. Stantec (2017) identified that the three primary modes of hydrocarbon transport are pipeline, rail and truck. Pipelines were the highest risk due to the large number of pipelines located upstream (see Section 3.2.7) and that the average pipeline spill volume is 12,259 L. Pipelines were also reported to have 1.5 incidents per 1,000 km of pipeline. Of these incidents, 88% resulted in leaks, and 5% resulted in ruptures. While rail lines were identified as a source of hydrocarbon spills, there are few rail lines upstream of Edmonton, and the only one which crosses the NSR is in Rocky Mountain House far upstream of Edmonton. While truck transport is also a source of hydrocarbon spills on the NSR, there are few crossings (see Section 3.2.7), and the maximum volume carried by a truck is relatively small compared to other potential spill sources. Stantec's report also explored preliminary options of the WTPs ability to be able to treat water to meeting drinking water quality guidelines, despite a hydrocarbon spill on the NSR. Lastly, Stantec's report also explored options of alternative water supplies, and this is discussed in greater detail in Section 3.3.3.

EPCOR has conducted studies with Natural Resources Canada exploring how hydrocarbon spills change over time, and how EPCOR's WTPs could treat a hydrocarbon spill with powdered activated carbon, which the WTPs use to treat water with high colour/organic material in the spring. Preliminary studies show that the WTPs could treat raw water that has been contaminated with crude oil and gasoline.

EPCOR's Stormwater Environmental Monitoring Program

Since 1991, stormwater quality and quantity have been monitored within Edmonton as part of the Environmental Monitoring Program (EMP). Prior to 2017, the EMP was conducted by the City of Edmonton, but is now managed by EPCOR. The EMP currently has three focus points: The quantification of loads to the NSR from the combined sanitary system and stormwater system; mainstem monitoring at four intake locations within/downstream of Edmonton; and monitoring water quality in tributaries.

> The EMP program monitors discharges from storm and combined sewer outfalls and tributaries within the City of Edmonton boundaries.

The EMP maintains a network of continuous monitoring stations that are located at five of the largest storm sewer outfalls (i.e., 30th Avenue, Groat Road, Quesnell, Kennedale and Belgravia) and the largest combined sewer overflow (CSO) (i.e., Rat Creek). The stations include flow monitoring equipment and automated water samplers, which automatically collect water quality samples during runoff events and to send out emails once the sampling has started. Supplementary manual base flow samples are collected twice per month from the four largest stormwater outfalls. The parameters monitored for the EMP have varied through time and among sites and events, but the most frequently monitored parameters include total suspended solids (TSS), chloride, ammonia, nitrate + nitrite, total phosphorus, and *E. coli*. Beginning in 2021, metals, colour, fluoride, sulphate, and total organic carbon are also monitored. Other less frequently monitored parameters include pesticides, pathogens and volatile organic compounds.

The EMP has shown that storm sewer outfalls and tributaries increase TSS, chloride, nitrogen, ammonia, total phosphorus, and *E. coli* concentrations in the NSR, particularly during precipitation and runoff events. For suspended solids although storm sewer outfalls creeks within Edmonton do affect water chemistry, upstream sources are the overall net contributor (Figure 65). Notable increases of TSS form urban runoff typically only occur during the spring and fall when flows in the NSR are low and a local storm occurs (Figure 66). This affects the Rossdale WTP only as a small portion of the unmonitored storm sewer outfalls are located upstream of the E.L. Smith WTP. Wedgewood Creek and Whitemud Creek, as well as the 30th Avenue, Groat Road, Quesnell and a larger portion of the unmonitored storm sewer outfalls are located upstream of the Rossdale WTP. TSS concentrations are slightly higher at the Rossdale WTP compared to the E.L. Smith WTPs, due to additional loading of TSS from the creeks and storm sewers.

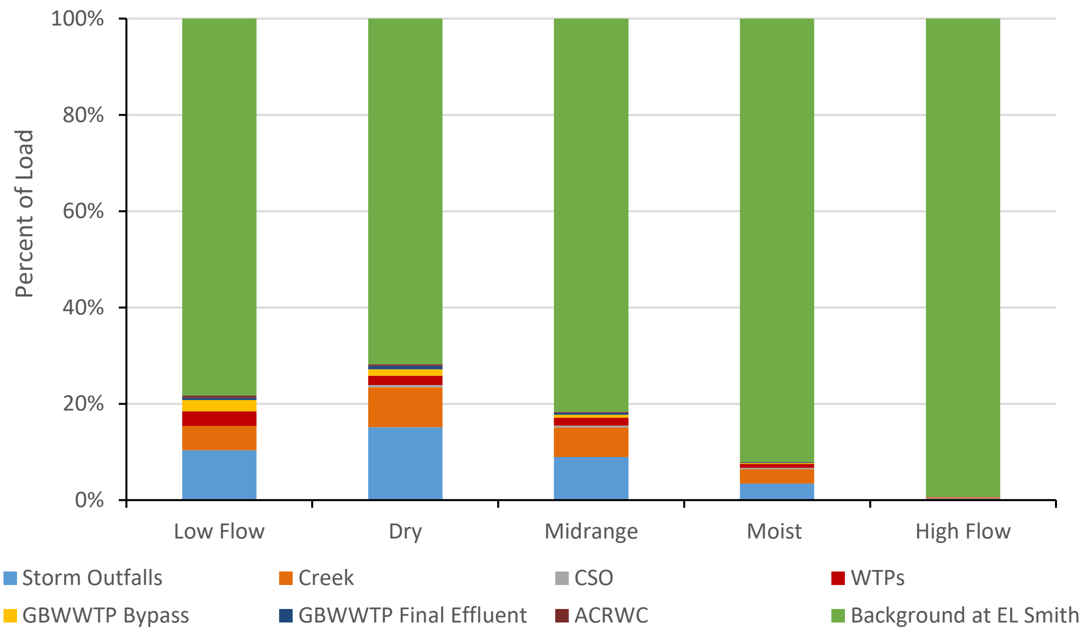


Figure 65. Sources of TSS Loading in the NSR Under Varying Flow Categories, 2010 – 2024.

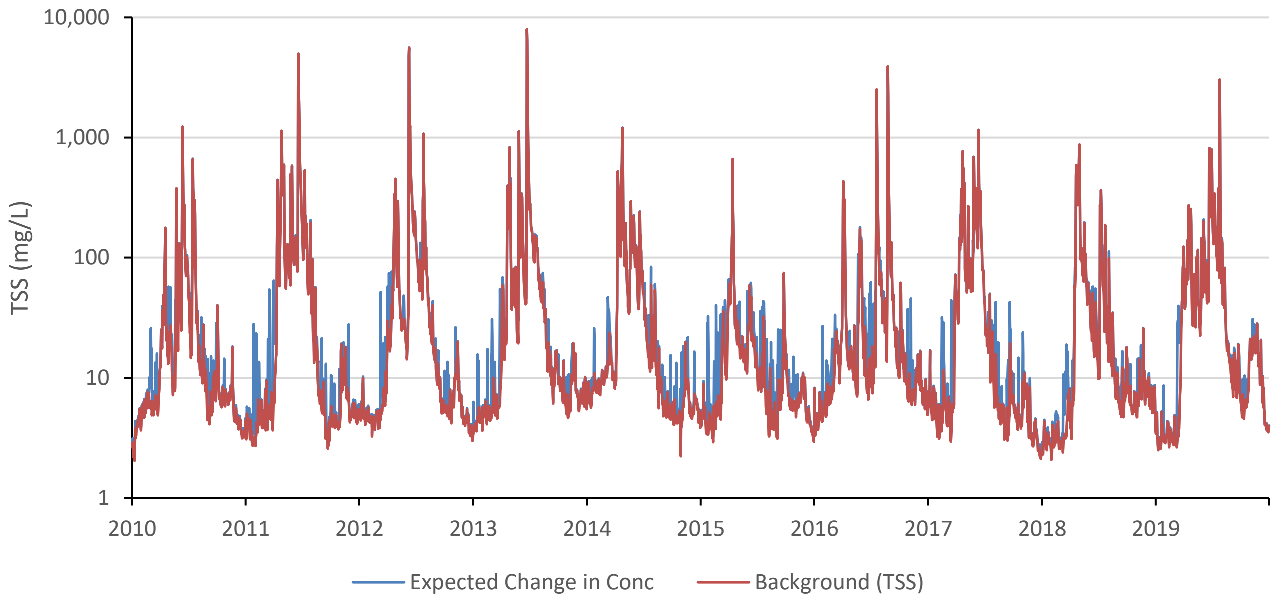


Figure 66. Estimated Upstream and Downstream TSS in the NSR, 2010 – 2019.

Pesticides can be found in stormwater discharges but are still several orders of magnitude below drinking water quality guidelines and represent a low risk to source water. A total of 17 different pesticides have been detected at stormwater outfalls, most of which have also been detected in the NSR at the WTP intakes. Pesticides are also detected more frequently at Rossdale compared to E.L. Smith, indicating that stormwater is source of pesticide loading to the NSR.

Metal concentrations are also elevated in stormwater but represent a minimal risk to drinking water due to dilution in the NSR. Metals are largely transported attached to particulate material and are removed from drinking water in the treatment process, further reducing risk.

Edmonton also has numerous stormwater management facilities and constructed wetlands. While the major function of these waterbodies is to retain stormwater flows and prevent flooding, they also provide an opportunity to improve stormwater quality. Monitoring of these waterbodies show that they effectively remove *E. coli* from stormwater, and that TSS, phosphorus and metals are also removed, but the trends are variable and inconsistent among the sampled waterbodies. EPCOR is also building low impact development (LIDs) features across the stormwater system for the purpose of preventing localized flooding, but also for improving stormwater quality.

3.3.2 Tributary Water Quality

A total of 64 named tributaries flow directly into the NSR, upstream of Edmonton. Of these tributaries, 44 enter the NSR upstream of Rocky Mountain House, whereas the remaining twenty enter between Rocky Mountain House and the Rossdale WTP. The major contributing tributaries in terms of annual flow to the NSR are the Cline, Clearwater, Ram, Baptiste, and Brazeau rivers (Figure 67). Most of the flow from the headwaters is from snowpack accumulation and subsequent melt during the summer months. The NSR mainstem is dammed by the Bighorn Dam creating Abraham Lake. The Cline River joins the NSR at Abraham Lake, whereas the Bighorn, Clearwater and Ram rivers flow into the NSR downstream of the Bighorn Dam. Another dam occurs in the basin on the Brazeau River, which is dammed just upstream of its confluence with the Nordegg River, creating the Brazeau Reservoir. Major tributaries that flow into the NSR are summarized in Table 11.

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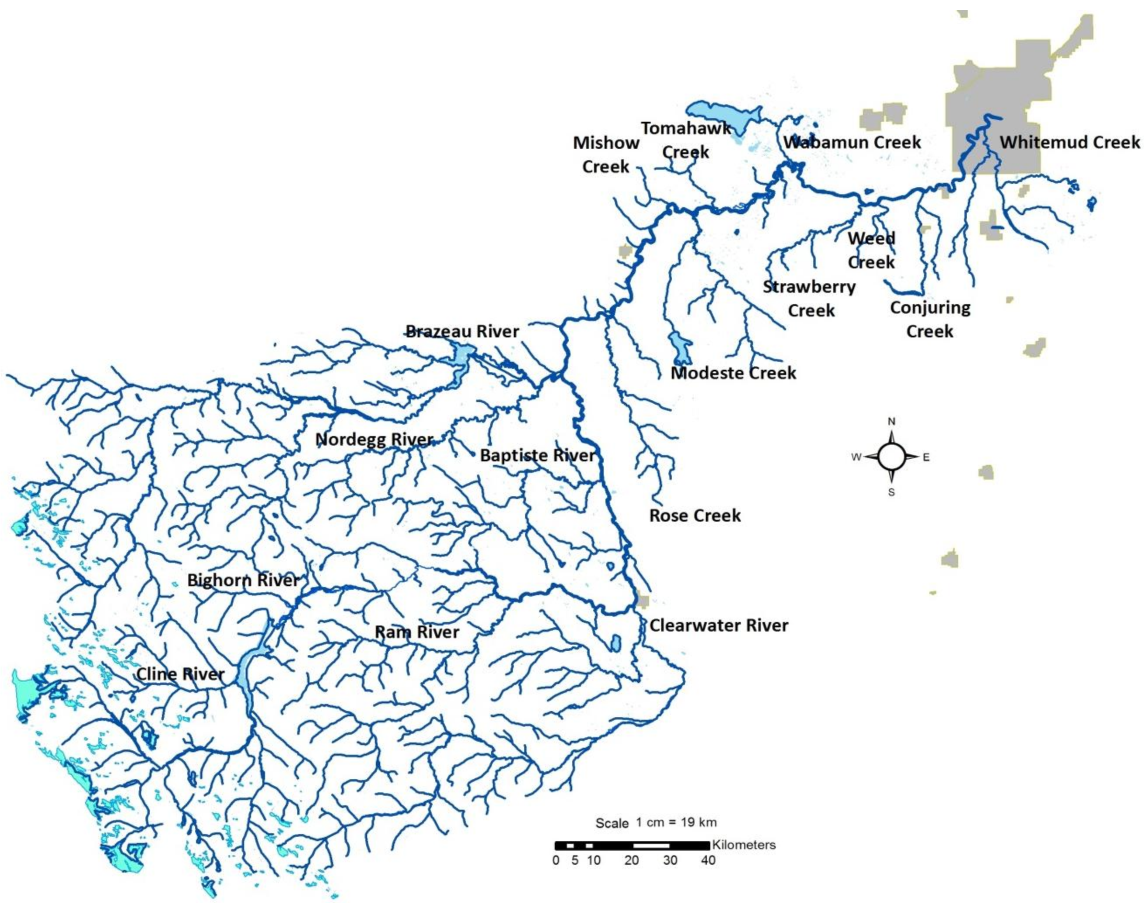


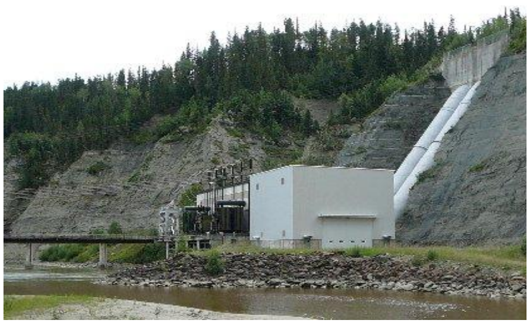
Data Source: GoA 2020

Figure 67. Major Tributaries in the NSR Watershed above EPCOR's WTPs.

Table 11. Major Tributaries to the NSR.

Location in basin	Name	Notes
Headwaters: Rocky terrain mixed with forested landscapes. Largely undisturbed. Cline River joins the NSR at Abraham Lake, which is dammed by the Bighorn Dam.	Cline River	• Enters Abraham Lake • 10 tributaries
	Howse River	• Enters NSR u/s of Abraham Lake
	Mistaya River	
	Siffleur River	
	Clearwater River	• 18 tributaries • Enters NSR at RMH
	Ram River	• 12 tributaries • Enters NSR at RMH
	Bighorn River	• Enters NSR d/s of Bighorn Dam
Upper-reach: Largely forested with major human use of forestry and oil and gas extraction.	Baptiste River	• Enters NSR just d/s of RMH
	Nordegg River	• Enters NSR via Brazeau River
	Brazeau River	• Enters NSR d/s of RMH • Flows into Brazeau Reservoir
	Rose Creek	• Watershed a largely forested/wetland
Mid-reach: Largely agriculture based landuse dominated by pasture and cow-calf operations.	Modeste Creek	• Small creeks that flow significantly only during runoff events in open water season
	Tomahawk Creek	
	Wabamun Creek	
	Strawberry Creek	
	Mishow Creek	
	Weed Creek	
	Conjuring Creek	
Within city: Urban environment.	Whitemud Creek	• Whitemud Creek is influenced heavily by stormwater inputs

Historical and Current Monitoring Programs



Brazeau River Power Plant

Water quality data has been collected for many of NSR tributaries over the past 40 years. Historically mid-reach tributaries have received more attention because of specific projects investigating the influence of agricultural activities on water quality. Water quality data for headwater and upper-reach tributaries has historically been less available due in part to the difficulty accessing these streams and the limited development in these areas. Previous SWPP plans describe these historical programs for conciseness only the current program is described. The lack of water quality data on the headwater tributaries has limited the ability to determine drivers of water chemistry and apportion to watershed condition however, water quality monitoring headwater tributaries has improved with the WaterSHED program and so have load estimates.

SaskWatch Monitoring Program

The historical monitoring programs have provided a significant amount of data; however, they have project specific and not comprehensive enough to understand drivers of river loads. To address the gap of these monitoring programs, EPCOR spearheaded a Water Quality and Aquatic Ecosystem Working Group in Partnership with the North Saskatchewan Watershed Alliance to address monitoring challenges in the North Saskatchewan River basin. This group identified a need for a scientifically defensible, sustainably funded, long-term water quality and aquatic ecosystem health monitoring program for the North Saskatchewan River and its major tributaries. The goals of this program are to:

1) allow the assessment of drivers of water quality and quantity
2) understand the effects of continued land use change and population growth pressures
3) to inform planning at the regional, source water, and municipal scale.

In 2016, EPCOR Water Canada put forward a request for up to one million dollars per year for four years from the Edmonton Rate Payers for an environmental monitoring program for the North Saskatchewan River and was supported by Edmonton City Council. This funding led to the formation of the SaskWatch Monitoring Program (formerly WaterSHED), which is lead by a steering committee consisting of EPCOR, Alberta Environment and Protected Areas, the North Saskatchewan Watershed Alliance and the City of Edmonton. The Program was designed in 2018, monitoring and flow station installation began in 2019. Funding of the program is committed through 2027.

The monitoring was program is based on a mass balance approach with paired water quality and quantity data and representative sub-watersheds were chosen based on hydrological response and watershed characteristics (Figure 68). To understand the link between watershed characteristics, climate, and water quality and quantity, the program is designed to be long-term. To be useful it must capture inter-annual variability (wet and dry years) and seasonal variability (ex. fast spring melt) across headwater watersheds to parkland/agriculture dominated watersheds.

In 2023, urban creeks within the City of Edmonton boundary, previously sampled by EPCOR, were added to the SaskWatch program and include 12 sites among 7 creeks: Fulton, Gold Bar, Horsehills, Whitemud, Blackmud, Mill, and Wedgewood. Flow gauges were installed on Gold Bar Creek and Wedgewood Creek in 2025. These tributaries are sampled by CreekWatch and funded directly by EPCOR.

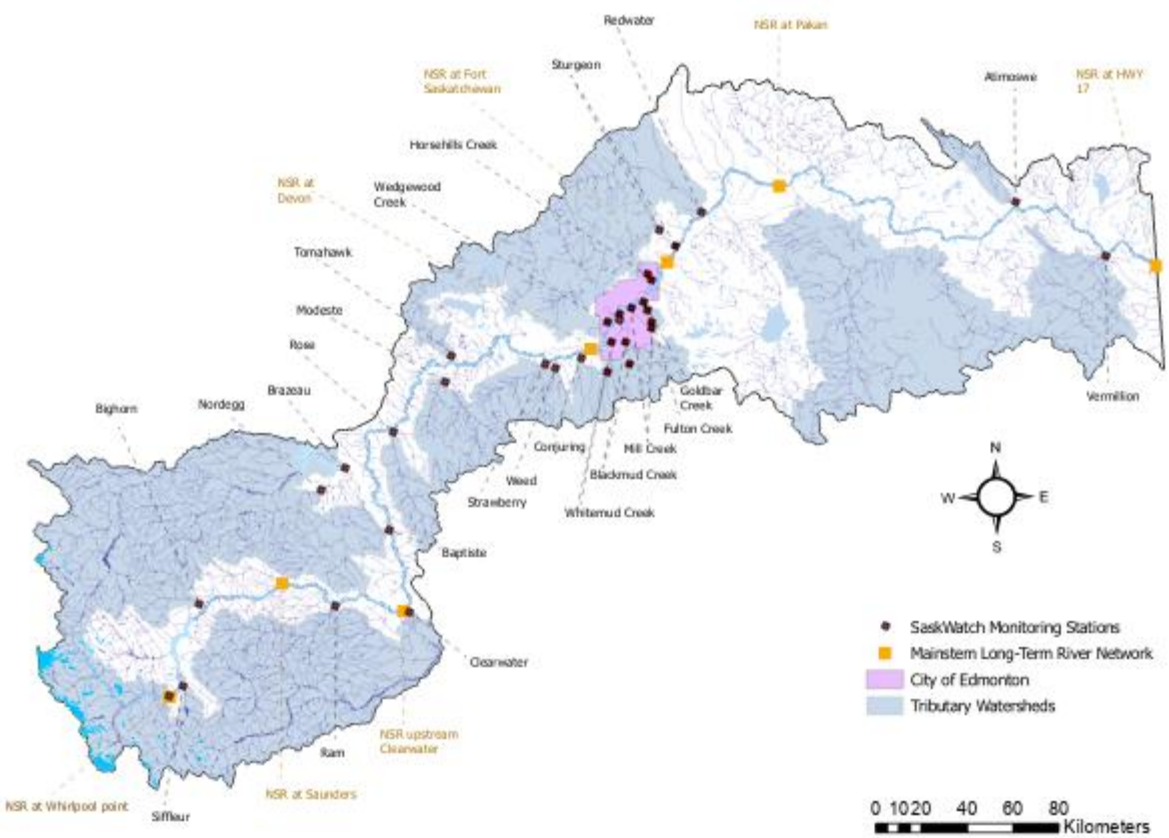


Figure 68. SaskWatch Monitoring Program Locations and Tributary Watershed Areas.

Tributary Water Quality Summary

For this report, water quality was summarized for tributaries using stations nearest to the confluence with the NSR. In most cases, samples were collected in the early 1980s, late 1990s, and more consistently throughout the 2000s. For the headwater tributaries, a smaller number of samples have been collected, whereas some of the mid-reach streams have been sampled over 200 times for some parameters (

Table 12). Additionally, some programs did not sample during high-flow events, whereas other programs intentionally targeted these events. As a result, it is difficult to fully compare the water quality amongst the upstream tributaries. With these data limitations in mind, a general trend of increasing concentrations of most parameters from headwater reaches to mid-reach tributaries is evident (Figure 69 and Figure 70). Some of these changes can be accounted for by natural phenomenon such as soil type, underlying geology, and ecoregion differences; however, human land use plays a significant role as well (see section 3.2). Median and maximum concentrations of parasites, sediment, nutrients, and organics are notably higher in mid-reach tributaries than in more pristine headwater and upper reach tributaries.


Prairie Creek. Photo credit; Gary Lewis of Clearwater Landcare

Understanding and quantifying contributions from tributaries becomes important when trying to assess risks to the NSR river source water. Without understanding all aspects of contaminants, including load calculations, entering the NSR from tributaries it is difficult to target land management practices to maintain high water quality. Mid-reach tributaries have the poorest water quality, but they also comprise a small amount of the annual flow of the NSR on an annual basis. We also know that during spring runoff, these tributaries can combine to contribute almost half the flow to the NSR.

Knowing that water quality is dependent on runoff conditions, it is important that the relationship between flow and water quality is well understood to calculate loads accurately. For streams that are driven by spring melt runoff and storm events, such as the ones in the mid-reaches of the NSR, it is estimated that 90% of the load is added during less than 10% of the year, emphasizing the need to capture these events. As mentioned above, water quality data for the upper tributaries is limited and for the mid-reach tributaries only a few tributaries have been sampled extensively enough to allow accurate annual and seasonal load calculations.

Table 12. Number of Water Quality Samples Collected Near Mouths of Tributaries to NSR (1975 - 2024).

Tributary	Fecal Coliforms	*E. coli*	Turbidity	*Giardia.*	*Cryptosporidium*	TSS	Total Phosphorus	TKN	Nitrate	Ammonia	Colour	DOC
Cline	41	41	43	1	1	43	43	43	43	43	41	33
Siffleur	51	51	63	1	1	63	63	63	63	63	61	62
Bighorn	60	62	87	4	4	88	87	87	88	88	79	78
Ram	84	85	115	4	4	116	115	115	115	116	105	113
Clearwater	74	79	108	5	5	109	107	107	108	109	98	103
Baptiste	95	98	135	24	24	130	128	128	129	130	119	116
Nordegg	103	112	139	45	45	135	131	130	132	132	133	99
Brazeau	89	91	128	18	17	122	121	120	122	122	112	113
Rose	317	320	82	12	12	393	393	392	392	388	142	78
Mishow	38	40	45	46	46	40	39	38	40	37	37	7
Modeste	77	76	103	32	32	99	98	97	99	103	92	82
Tomahawk	124	125	109	51	51	194	193	191	194	194	167	59
Wabamun	5	9	8	7	7	9	7	7	9	9	9	5
Washout	6	6	5	6	3	6	6	6	6	6	6	3
Strawberry	287	290	127	46	46	352	351	350	351	344	187	88
Weed	83	87	112	54	49	104	104	103	104	107	107	67
Conjuring	62	68	84	22	22	80	79	77	81	81	80	65
Whitemud	70	166	185	4	4	245	237	238	236	239	83	67

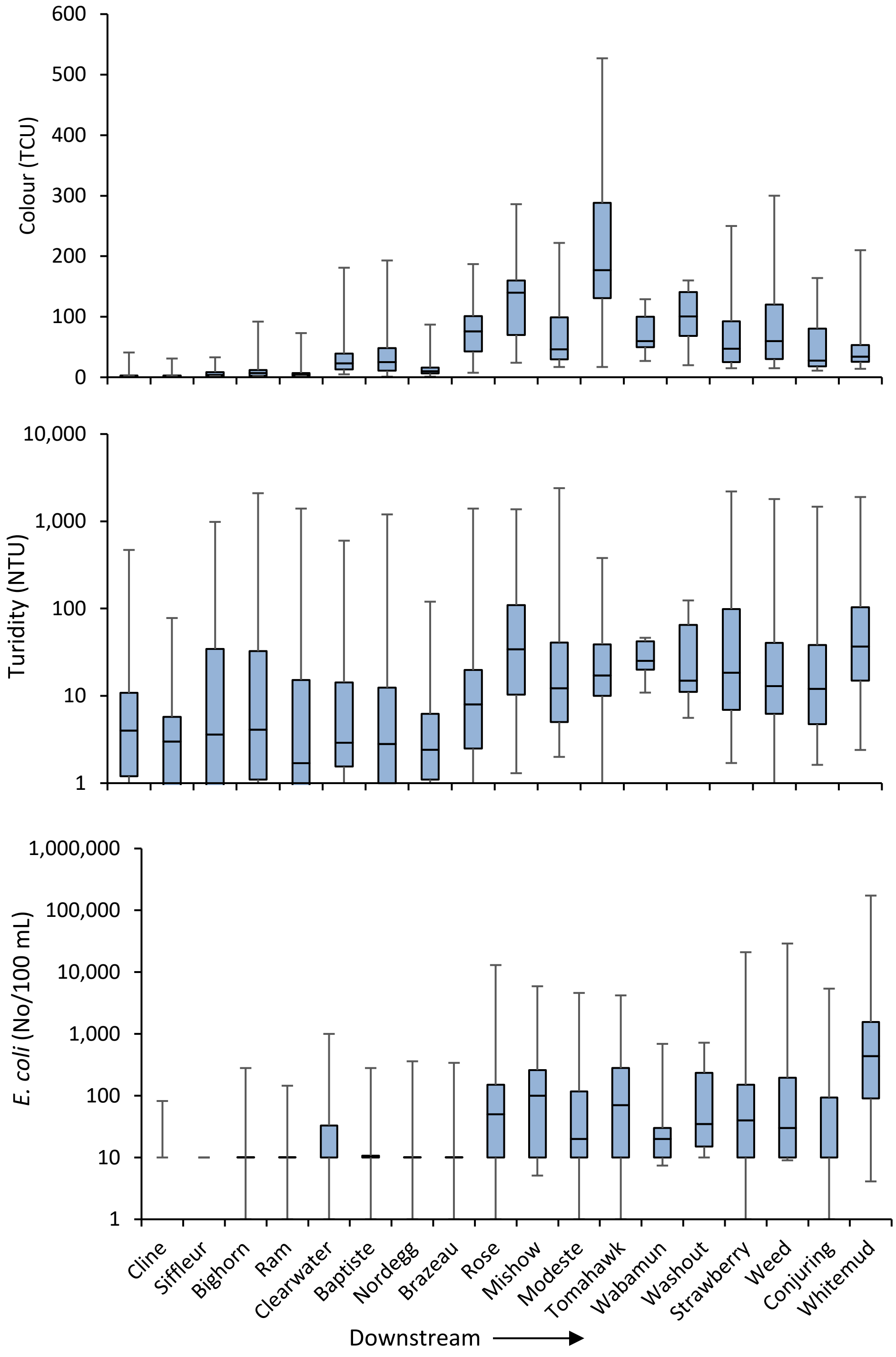


Figure 69. Colour, turbidity and *E. coli* in the major tributaries in the NSR watershed (1975 – 2024).

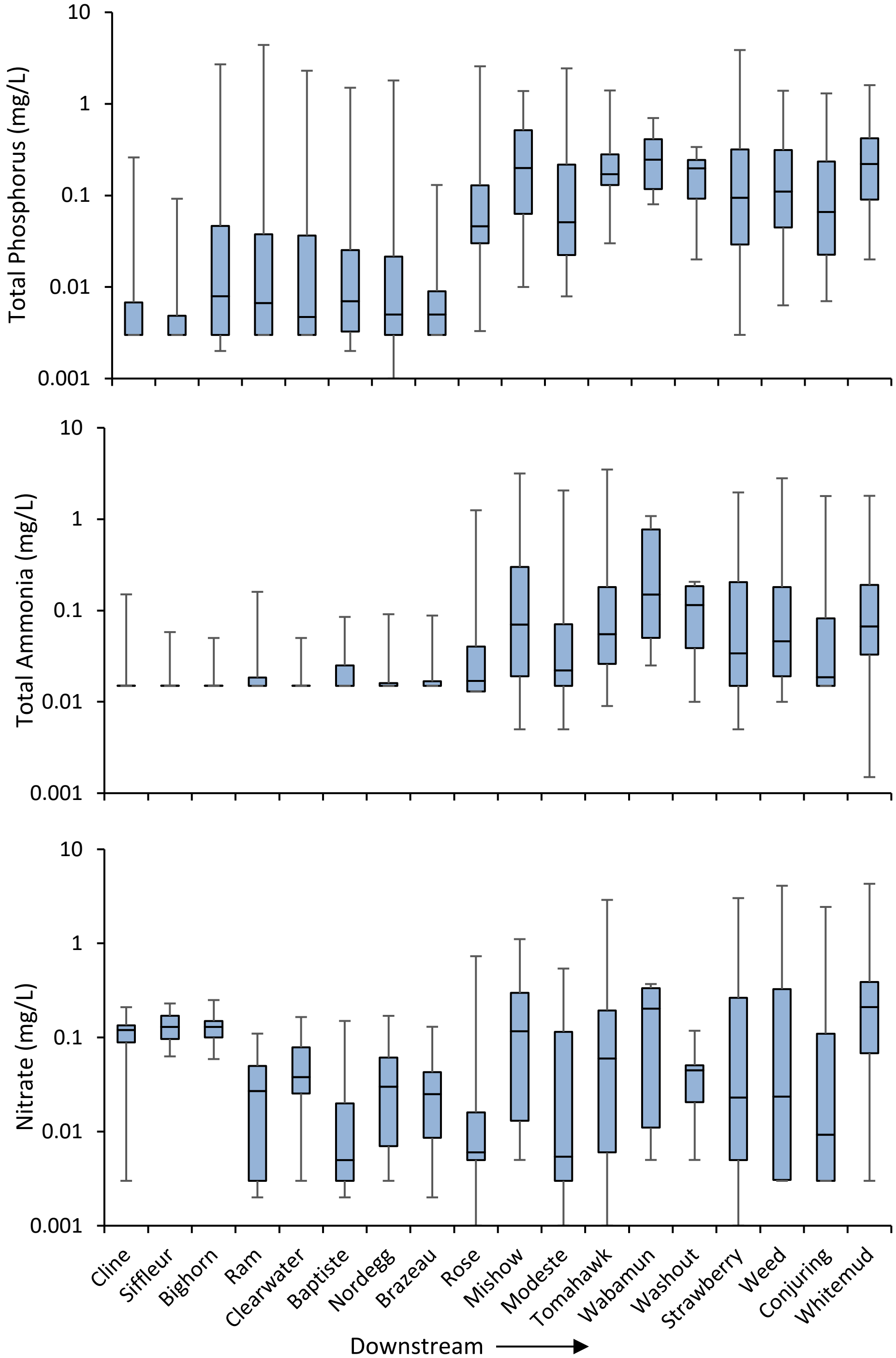


Figure 70. Total Phosphorus, ammonia and nitrate in the major tributaries in the NSR watershed (1975 – 2024).

3.4 Water Quantity

3.4.1 Where does the water come from?

On an annual basis, most of the water in the NSR originates in the headwater areas of the Rocky Mountains. Specifically, it has been estimated that of the mean annual natural discharge of the NSR at the Alberta/Saskatchewan boundary (7,510 Mm^3), the headwater hydrologic region contributes almost half (3,600 Mm^3) of the annual cumulative yield (Figure 71; Golder 2008a). Putting it another way, by the time the NSR reaches Drayton Valley, 87% of the annual flow at the border and 94% of the flow at Edmonton is accounted for. The headwater area yields a remarkable amount of water considering that it comprises only 4,110 km^2 compared to the gross drainage area of 56,860 km^2 to the border of Saskatchewan. This highlights the importance of protecting this source water area to ensure a sustainable supply of water for downstream reaches.

Most water in the NSR basin originates from the headwater areas with almost 90% of the water entering the river upstream of Drayton Valley. Groundwater contributions are estimated at ~25 m3/s and glaciers make up less than 3% of the flow. At certain times like spring runoff creeks draining agricultural watersheds upstream of Edmonton can contribute 50% of the flow. Similarly, stormwater runoff from the city can contribute up to 10% of the flow during spring runoff or local storms. Of the annual flow 70% moves through the two upstream reservoirs.

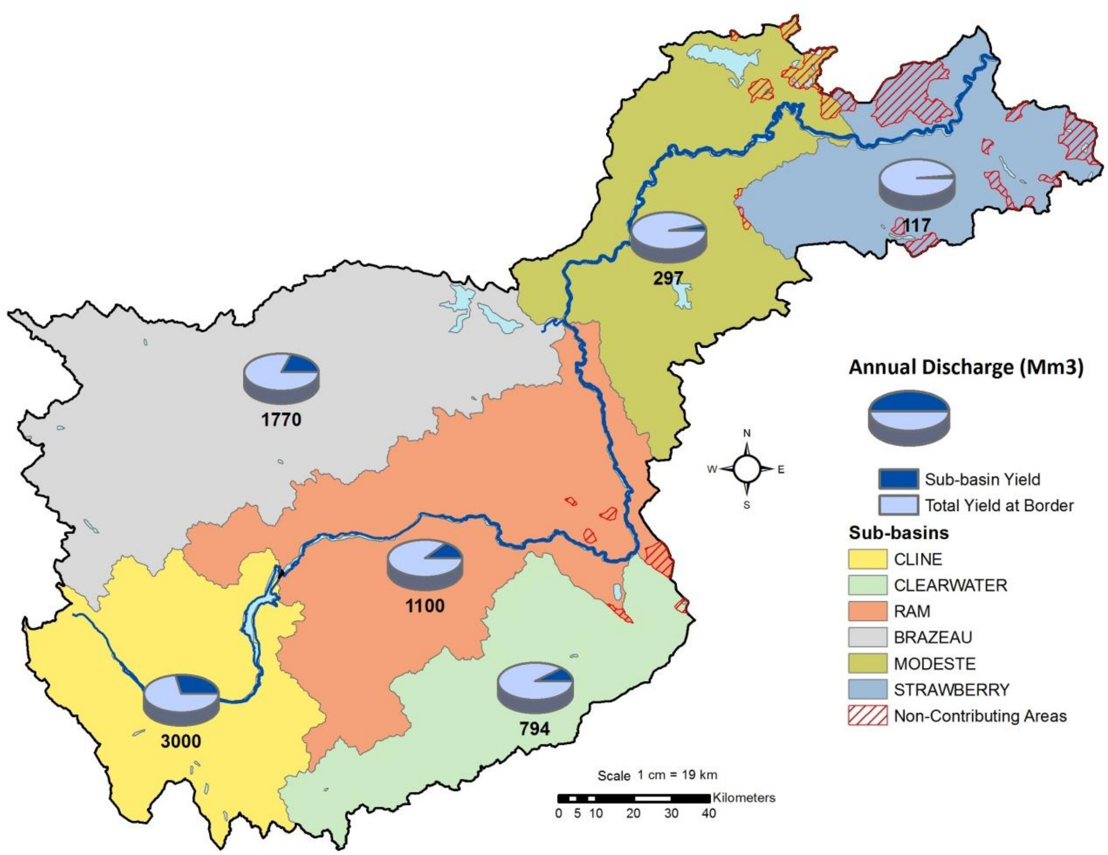


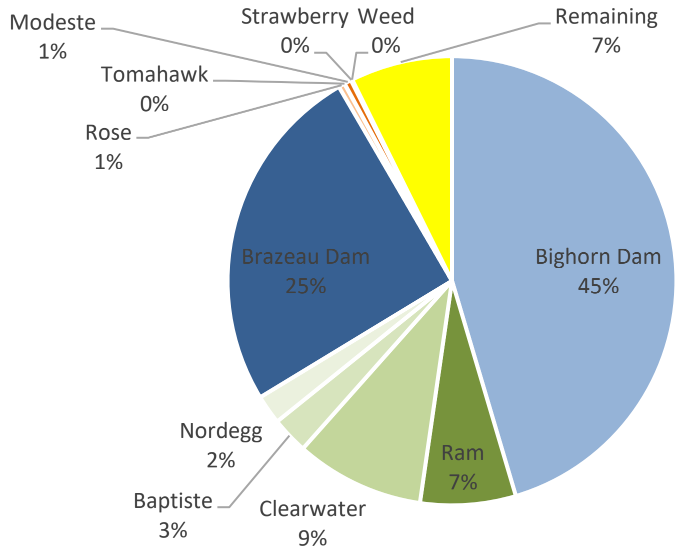
Figure 71. Water Yield Data for Sub-basins in the NSR watershed (Data Source: Golder 2008a)

Annual water yield paints only part of the picture when it comes to understanding water quantity in the NSR. Seasonal patterns reflect snow accumulation and melt, storm events, and early spring runoff in mid-stream reaches (Figure 72). Spring runoff typically occurs from mid-March to mid-April for the areas around and upstream of Edmonton. In contrast, the peak monthly yield from the headwater regions along the eastern slopes of the Rocky Mountains occur in July because of the gradual rise in temperature during spring and early summer at these high elevations. Peaks in flow occur during storm events and the effect on flow depends on the severity, geographic extent and duration of the storm. Variability in annual flow from year to year is driven by headwater snowpack volumes. Spring runoff peaks in the NSR are determined by local snowpack volume as well as by climate (for example, how rapidly temperatures rise) in the spring.

Data Source: Water Survey of Canada 2024

Figure 72. Daily Mean Hydrograph of the NSR Flow Based on 1972 to 2023 Water Survey of Canada Data at Edmonton (05DF001, Edmonton Low Level Bridge).

Long-term flow gauges exist on nine upstream tributaries. Summarizing median annual flow data from 2000 to 2023 (Figure 73), similar trends were observed as per the Golder (2008a) report. Contributions from monitored headwater areas above Rocky Mountain House (Bighorn dam, Ram and Clearwater rivers) comprise 61% of the annual flow at Edmonton and this is largely from snowmelt, though groundwater contributions occur as well (Figure 74). The Baptiste and Nordegg Rivers, whose watersheds remain forested, comprise 5% of the annual flow. Contributions from the Brazeau dam play on key role, comprising 25% of the flow. Mid-stream reaches, where land use is primarily agriculture, comprise a small amount of overall flow to the NSR. Specifically Rose, Weed, Modeste, Tomahawk, Strawberry and Weed creeks- comprise approximately 1% of the annual flow in the NSR above Edmonton. Approximately 7% of the annual flow measured at Edmonton is unaccounted for by these monitoring gauges; however, calculating this is challenging as discussed below. Additional flow gauges have been recently installed at Whitemud Creek, Conjuring Creek and Bighorn River; however, there is currently insufficient data available for a long-term analysis.



Data Source: Water Survey of Canada 2024

Figure 73. Annual flow contributions to the NSR at Edmonton (2000 to 2023).

The daily contribution of the various dams and tributaries provides a greater understanding of the seasonal trends of where flows in the NSR originate (Figure 74 and Figure 75). During the winter months when runoff from the landscape does not occur most of the flow originates from the two upstream dams (Bighorn and Brazeau) as well as a continuous supply of groundwater. Even during the summer months, most of the flow originates from the two upstream dams. Flows from agricultural tributaries typically peak in March and April but the median flows contribute little to the overall flow observed in Edmonton. There is some flow observed within the headwater tributaries throughout the year due to groundwater flows, but flows peak in June and July with the melting of snow in the upper headwaters and rainfall events. In Figure 74, it is important to note that the observed flows at Edmonton are notably higher than the sum of all gauged flows. These “missing flows” represent flows from ungauged tributaries and groundwater contributions. However, during the winter months, the sum of gauged flows exceeds those measured at Edmonton. The explanation for this trend is less clear. Some of the flows released by the dams would turn to ice before reaching Edmonton, but it is unclear if this is the entire explanation.

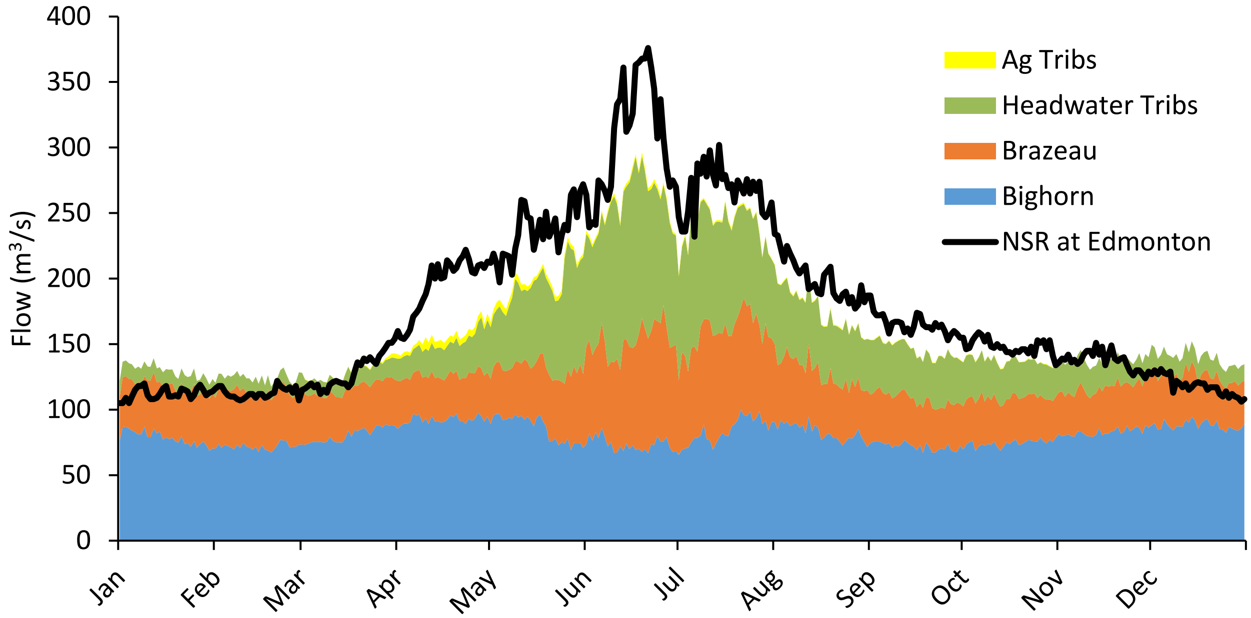


Figure 74. Median Daily Flows from Bighorn and Brazeau Dams, Headwater and Agricultural Tributaries and the NSR at Edmonton (2000 – 2023).

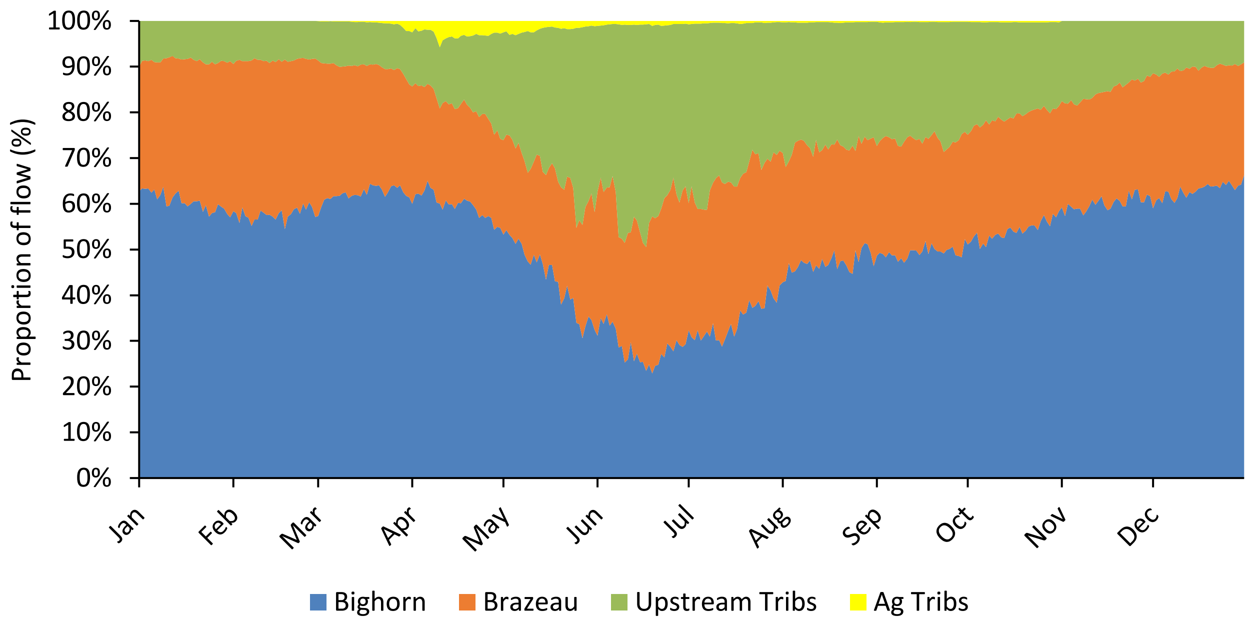


Figure 75. Relative Proportion of Median Daily Flows from the Bighorn and Brazeau Dams, and Headwater and Agricultural Tributaries (2000 – 2023).

Although agricultural mid-reach tributaries contribute less water overall than headwater streams, they can make up a large part of the North Saskatchewan River's flow during early spring runoff, before the headwaters start melting. For example, during the spring runoff periods in 2007 the agricultural tributaries contributed to over 50% of the flow the NSR at Edmonton (Figure 76). Because land use in these watersheds has been altered significantly in the last 100 years, during certain periods, these streams can have a significant impact on NSR water chemistry. During years with smaller or more gradual spring runoff, the contribution of the mid-reach streams remains small. Colour in the NSR at EPCOR's WTPs is closely related to the intensity of the spring runoff, and how much these mid-reach streams contribute to flows in the NSR.

Although mid-reach streams contribute less than 1% to the NSR flow on an annual basis, during spring runoff period they can contribute almost 50% the flow of the river and have a significant effect on source water quality.

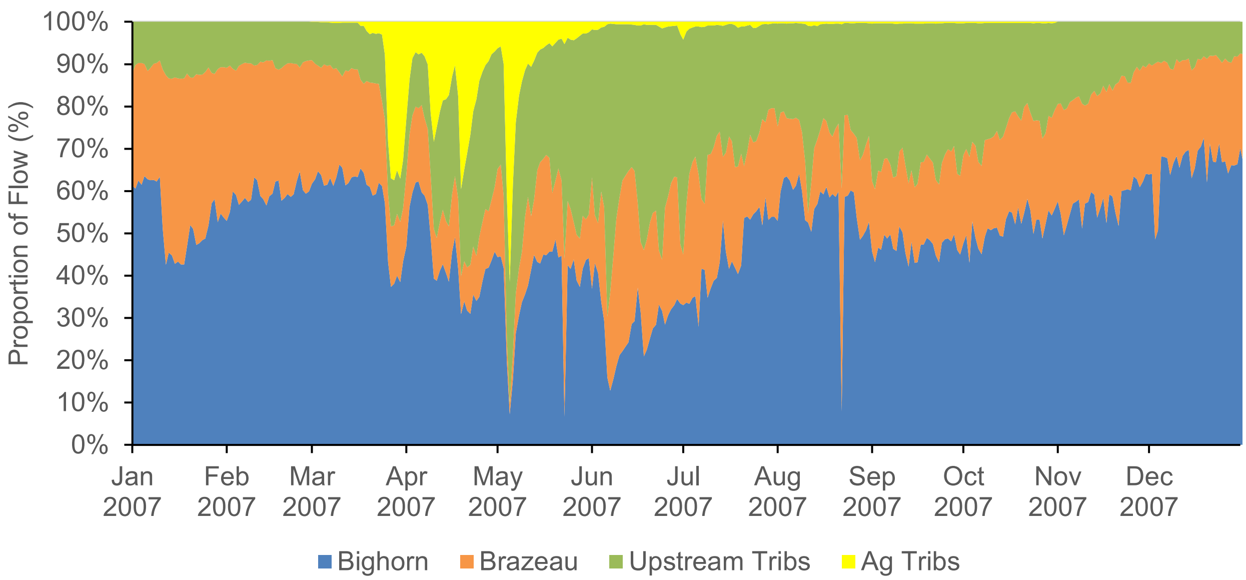


Figure 76. Relative Proportion of Median Daily Flows from the Bighorn and Brazeau Dams, and Headwater and Agricultural Tributaries (2007).

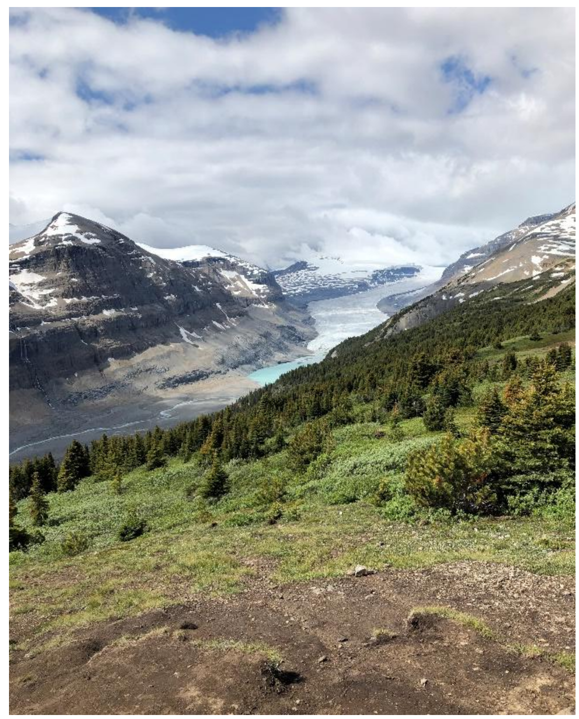
Glacial Contributions to Flow

The North Saskatchewan River originates at the base of the Saskatchewan Glacier in the Columbia Icefield in the Rocky Mountains. Multiple glaciers in the Rocky Mountains also contribute to NSR flows. Despite the presence of these large volumes of ice in the uppermost headwaters of the basin, the glaciers contribute less than 2 - 3 % of the annual flow of the NSR (Comeau et al. 2009, Marshall et al. 2011).

> Runoff from glaciers only contributes 2 – 3 % of the annual NSR flow at Edmonton (Comeau et al. 2009, Marshall et al. 2011).

White glaciers are an important source of flow for headwater streams, they contribute little to the overall flow of the river. The Bighorn dam, and to a lesser extent, the Brazeau dam capture nearly all glacial runoff from the headwaters.

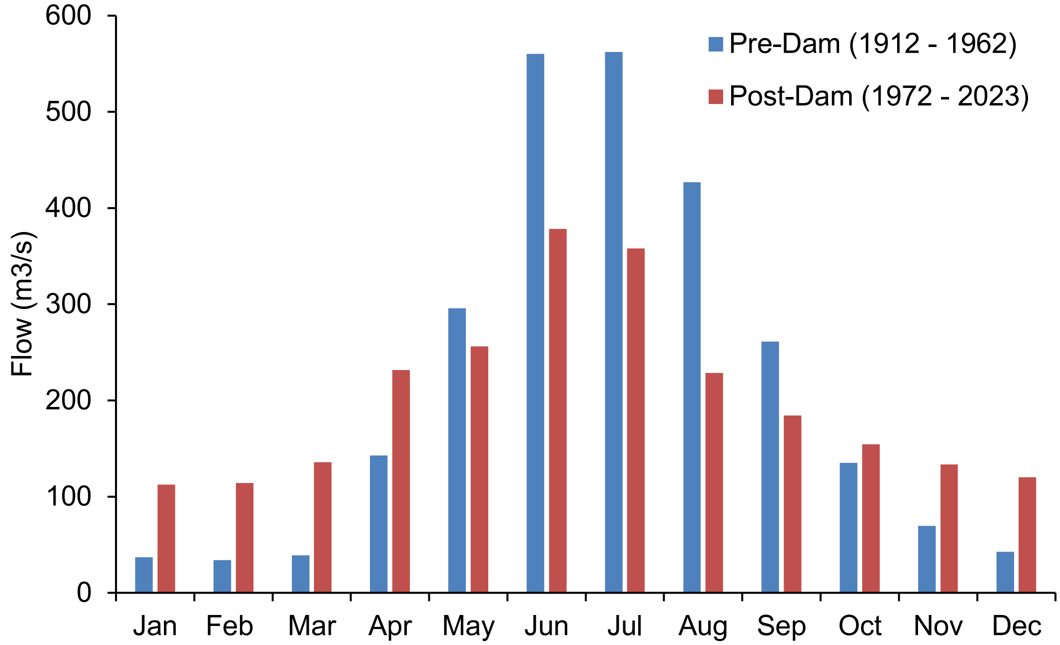
Glaciers in the Canadian Rocky Mountains have been in general decline since the neo-glacial maximum around 1850. However, a changing climate is exacerbating that loss. Research has shown that the icefields and glaciers that feed headwater streams and rivers are characterized by a negative mass balance, meaning they lose more water through melt each year than they gain through precipitation. By 2100, the volume of glacier ice in western Canada will shrink by 70 ± 10% relative to 2005 (Clarke et al. 2015). In streams where glacial melt is a significant source of water, climate change will have a disproportionate effect; however, the overall risk to Edmonton's source water from the reduction and eventual loss of glacial runoff is low. Shifts in the timing and magnitude of glacial runoff will affect operations of the Bighorn dam, and to a lesser extent the Brazeau dam; however, it is anticipated that TransAlta will be able to adjust their discharges to maintain water levels and continue to provide reliable flows to the NSR at Edmonton.



Saskatchewan Glacier Photo Credit: Mike Christensen

Upstream Dam Operations

The Bighorn and Brazeau dams located upstream of Edmonton have significantly altered the natural flow regime of the NSR, resulting in increased flows in the winter and decreased flows in the summer (Figure 77). This has resulted in a more consistent source of high-quality water in the NSR during the winter months, which also improved water quality downstream of Edmonton due to increased waste assimilation capacity (Neufeld 2010). The continued operation of the upstream dams plays an essential role in maintaining Edmonton's source water supply and quality.



Data Source: Water Survey of Canada 2024

Figure 77. Mean Monthly NSR Flows at Edmonton Before and After Dam Operation

The Bighorn and Brazeau dams are located upstream of Edmonton and are owned and operated by TransAlta. The Brazeau dam regulates the flow of the Brazeau River and first began operating in October 1961 (AENV 1990); however, the dam was not completed until 1965. The resulting reservoir has a capacity of 0.49 billion m^3 of live storage. The watershed area above the Brazeau dam is 5,660 km^2, which is 20% of the watershed area upstream of Edmonton. The Bighorn dam was built in 1972 and is located on the mainstem of the NSR. The resulting reservoir in named Abraham Lake and has 1.4 billion m^3 of storage and is the largest reservoir in Alberta (Alberta Environment 1990). The area upstream of the Bighorn dam is 3,800 km^2, which is 14% of the watershed area upstream of Edmonton. Therefore, 34% of the entire watershed upstream of Edmonton, and most of the headwater area, is regulated by these two dams.

The dams typically reach full capacity in late summer and early fall and are nearly emptied by the start of spring runoff each year (Figure 78 and Figure 79). As a result, the dams do not substantially alter the annual discharge of the NSR but significantly alter the timing of the flows. Water levels in the Brazeau Reservoir have fallen below the reported “zero level” in 2013, 2018 and 2020 due to late starts of spring runoff in the upper headwaters, but confirmation with TransAlta staff have clarified that water levels were still well above the “actual zero level” (Figure 79).

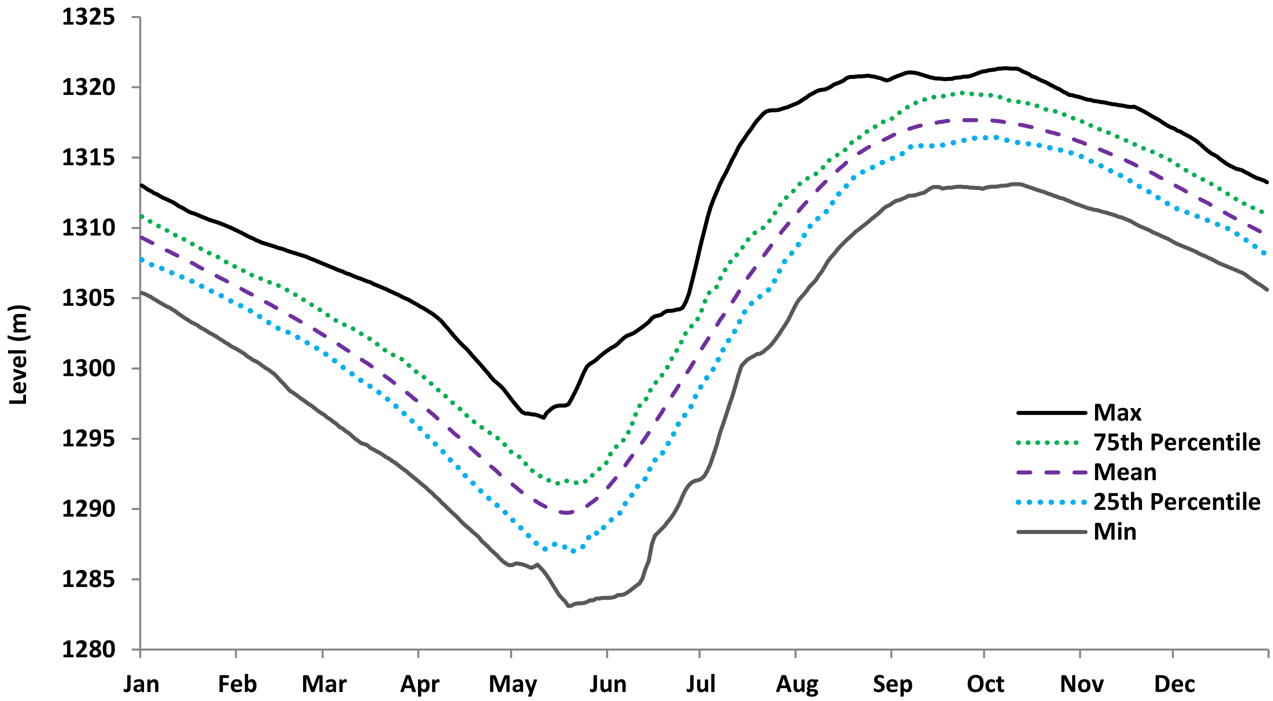


Figure 78. Water Levels at Abraham Lake (1972 – 2023).

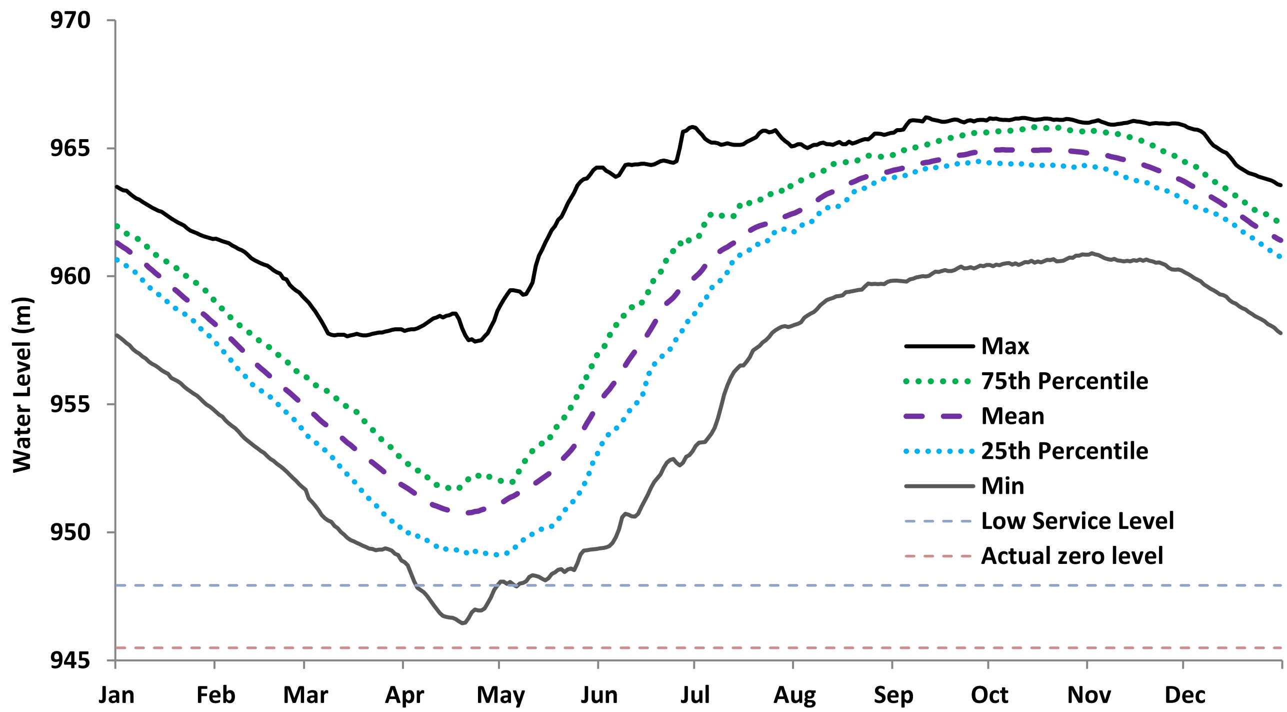


Figure 79. Water Levels at Brazeau Reservoir (1964 – 2023).

The Brazeau dam consists of three main components: the Reservoir, Canal (upper reservoir) and the gorge (lower reservoir). The gorge is the remains of the Brazeau River channel, which is largely dry due to the construction of the dam. Water is stored in the main reservoir and then flows into the canal, and the power plant is located at the downstream end of the canal. After passing through the power plant, water flows for approximately 16 km along the Brazeau River channel, before entering the NSR. TransAlta has proposed converting the Brazeau dam into a pumped hydro facility, where water will also be able to flow from the upper reservoir, through turbines to the lower reservoir. However, during periods of low power demand, water can be pumped from the lower reservoir back to the upper reservoir to function similar to a rechargeable battery.

The Brazeau dam typically runs 16 hours a day and is largely stopped during the night (TransAlta pers. comm. 2018). The size of the watershed is large in comparison to the size of the reservoir, and runoff and storms require the dam to release higher volumes throughout the entire day in order to maintain reservoir levels. The Brazeau dam has a discharge capacity of 311 m^3/s; however, the spillway can discharge an additional 1,840 m^3/s (AENV 1990). Based on EPCOR's understanding, the spillway drains the main reservoir through the gorge (i.e., the historical Brazeau River channel). The Brazeau dam can generate a lot of power on short notice, and based on EPCOR's observations, flows from the Brazeau dam are more "flashy" compared to the more consistent flows from the Bighorn dam.

The Bighorn dam is a peaking facility, which means that it discharges higher flows in the day and lower flows at night (TransAlta pers. comm. 2018). The Bighorn dam has two turbines and a discharge capacity of 164 m^3/s (AENV 1990), which is approximately half the capacity of the Brazeau dam. The Bighorn dam spillway has a capacity of 1,420 m^3/s. Due to the large capacity of the reservoir, flows through the Bighorn spillways are expected to infrequently occur, and are believed to have never occurred. The spillway drains through vegetated land before reaching the NSR. In the summer of 2021 and 2022, high reservoir levels required that TransAlta consider using the spillway, and AEPA predicted that up to 100 m^3/s could be discharged through the spillway, which was predicted to result in a large amount of debris and turbidity in the NSR. Dam leakage tests are conducted twice a year (spring and fall) where flows are stopped for 24 hours. During these tests, additional flows are typically discharged from the Brazeau dam to compensate; however, reduced flows are typically observed in Edmonton, but have not presented any concern to EPCOR's operations.

The daily peaking and reduction of flows of the two dams creates an observable daily fluctuation of water levels and flows downstream. In Edmonton, water levels can fluctuate between 30 and 50 cm, and flows can fluctuate by up to 100 m^3/s. These daily fluctuations have negligible impact on EPCOR's operations.

During the winter months, ice management is of high importance and TransAlta manages the operation of the two dams to help avoid ice jams and shifting/collapsing of the ice on the NSR (TransAlta pers. comm. 2018). TransAlta's normal practice is to maintain a daily average flow of 99 m^3/s from the two dams. During periods of ice formation, flow from one dam may be restricted, but compensated by the other. While flow is maintained in the NSR, EPCOR has observed changes in colour in the NSR when flows from the Bighorn dam are reduced and flows from the Brazeau dam are increased; which has resulted in challenges maintaining direct filtration. This is due to the Brazeau dam having higher colour than the Bighorn dam and is discussed in greater detail in Section 3.3.1.

The purpose of the two dams are for the generation of hydroelectric power, and reports have stated that the dams offer little protection against floods (AENV 1990). The watershed upstream of the Bighorn generally does not experience major rainfall events that produce large floods at Edmonton, therefore it has been assumed that the Bighorn dam provides negligible flow reduction during major flood events. In contrast, the Brazeau basin does experience major rainfall events that contribute to flood events in Edmonton; however, reports have stated that the amount of storage that is available in the Brazeau dam is limited, and negligible flow reduction should be assumed. However, based on EPCOR's analysis, the upstream dams, in particular the Brazeau dam, have some ability to attenuate the magnitude and severity of floods in Edmonton. This is discussed in greater detail in a subsequent subsection on floods.

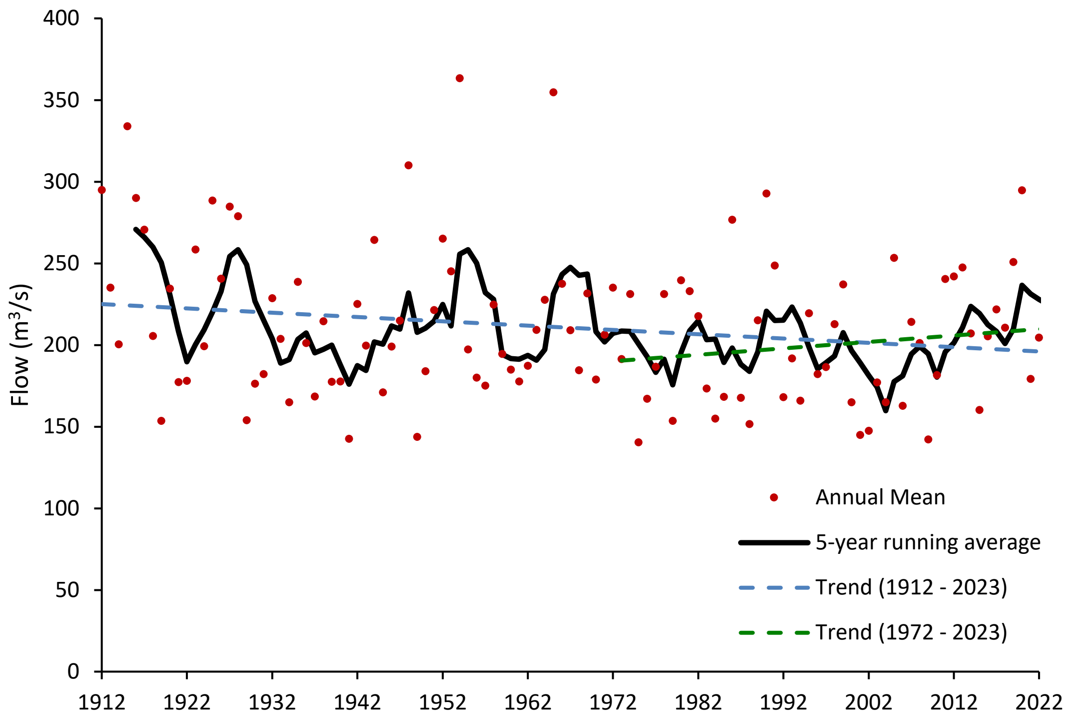
During winter months, up to 90% of flows observed in Edmonton originate from the two dams. Even during the summer months, the majority of the flows still originate from the upstream dams. During large precipitation events, the contribution from the upstream dams can be less than 20%.

3.4.2 Long-terms trends in flow

The NSR currently provides a secure and stable supply of raw water to the WTPs in Edmonton; however, it is important to understand the variability and changes in flows in the NSR over time to assess risks to supply in the future. Flow monitoring on the NSR at Edmonton began in 1911 and the average annual flow is 6,640,000,000 m^3 or 211 m^3/s. A simple linear trend of flows over the entire gauge record shows a long-term decrease in NSR flows; however, using flow data from the past 50 years (1973 – 2023), there is a slight increasing trend in annual flows (Figure 80). It is apparent that the NSR shows both interannual and decadal variability corresponding to wet and dry cycles; therefore, a simplistic linear trend is not appropriate to assess trends if the time scale is short.

The interannual and decadal trends in NSR flow are linked to ocean-atmospheric oscillations such as the El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) that alter the hydroclimate of western North America, and flow patterns in the NSR (Sauchyn et al. 2020). ENSO phases typically last less than a year, and reoccur every 3 to 7 years, whereas the PDO is a decadal cycle, which can remain in the same phase for 20 to 30 years. El Niño is associated with warmer temperatures and below average precipitation in western Canada, while La Niña is associated with cooler and wetter conditions. Likewise, the negative phase of PDO is linked to higher flows in western Canada, and the positive phase is linked with lower flows (St. Jacques et al. 2010). Floods in the NSR are more likely to occur during the positive phase of the PDO (Gurrapu et al. 2016), while droughts are more likely to occur during the negative phase (Sauchyn et al. 2020).

In summary, it is difficult to determine if the NSR is experiencing long-term changes in flows due to influence of decadal cycles; however, if flows in the NSR are decreasing over time, the decline is small relative to the observed variability.

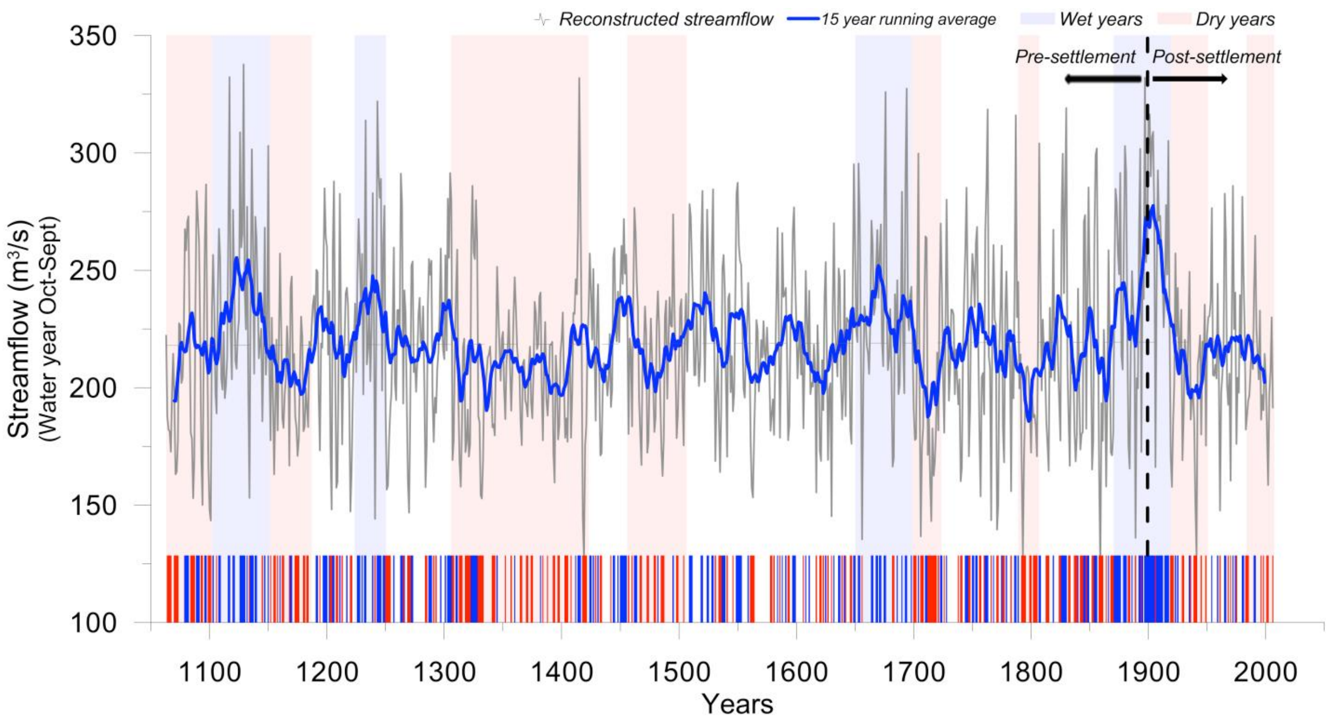


Data Source: Water Survey of Canada 2024

Figure 80. Mean Annual NSR Flows and Five Year Running Averages, 1912 to 2023.

The flow gauge record on the NSR provides 112 years of data and does not provide a complete picture of natural variability of flow in the river. EPCOR partnered with Prairie Adaptation Research Collaborative (PARC) to determine the natural hydroclimatic variability of the NSR beyond the recorded gauge record. PARC's collaborative team used an innovative method of tree ring growth correlated with the precipitation record to extend the gauge record for the NSR from the mid-11th century (1063) to the end of the 21st century (Sauchyn et al. 2011; Figure 81). The main findings of the report were:

- The 100-year gauge record does not capture the full range of natural variability in the flow of the NSR;
- The NSR basin was settled during one of the wettest periods on record;
- Drought periods similar to the 1930s are not uncommon, and have historically been longer and more intense;
- Storage behind the Bighorn and Brazeau dams can help mitigate against periods of low flows can be managed with the release of stored water. However, stored water will not be available to enhance summer flows if there is a dramatically reduced snowpack and/or drought in consecutive years. The worst-case scenario would be a prolonged drought, as shown in the reconstruction of the natural flows.



Note: Red bars and shading represent low flows in the 75th percentile, while blue bars and shading represent high flows in the 25th percentile. Reconstruction is smoothed with a 15-year running average (blue line).

Figure 81. Sustained Wet and Dry Intervals for Streamflow Reconstruction for the NSR, 1063 - 2006 (From Sauchyn et al. 2011).

The research conducted by PARC and Sauchyn et al. (2011) provides critical information about annual flows in the NSR over the past 900 years; however, annual flows are not necessarily helpful, as the risks to Edmonton's water supply are dependent on instantaneous flows in the NSR. Sauchyn and Ilich (2017) used the 900 years of tree-ring data to generate weekly flow estimates for this period. The flow data generated represent the naturalized flows at Edmonton, which assumes that there are no upstream dams on the NSR. EPCOR used the data provided by Sauchyn and Ilich (2017), and applied correction factors to the data to simulate the impacts of the upstream dams. To explore how drought may affect the water supply in the NSR, flows during a prolonged drought period from 1714-1718 (this drought is observable in Figure 81) were compared to EPCOR's current water withdrawals. These results show that during one of the largest droughts of the past 900 years, EPCOR's current withdrawals would take no more than 5% of the flow of the NSR assuming that flow is regulated by the upstream dams (Figure 82). However, if the flows in the NSR were naturalized (i.e., the upstream dams were removed), EPCOR's current withdrawals would take upwards of 18% of the NSR during the winter months.

To generate a worst-case scenario, the lowest flows of each week for the past 900 years were plotted against the EPCOR's highest weekly water use in the last five years. The results of this analysis show that there would be sufficient flow in the river to meet EPCOR's water withdrawals; however, upwards of 60% of the flow of the NSR would be withdrawn (Figure 83). Obviously this scenario is far from ideal, but it is important to note that even under an extreme scenario there is expected to be sufficient flow in the NSR for EPCOR to provide drinking water. It is also important to note that ~ 90% of the withdrawn water would be returned to the NSR via the wastewater treatment plants, as most use of water is not consumed, but is returned as treated wastewater.

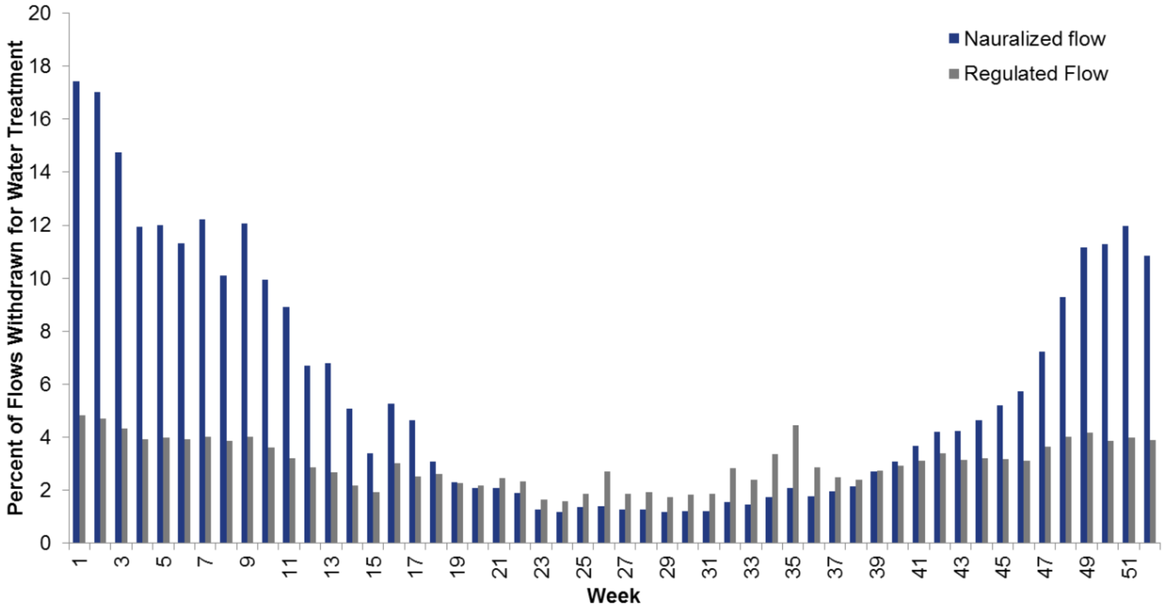


Figure 82. Mean Weekly Percent of the NSR Flow Withdrawn by the WTPs during a Historical Low Flow Period (1714-1718).

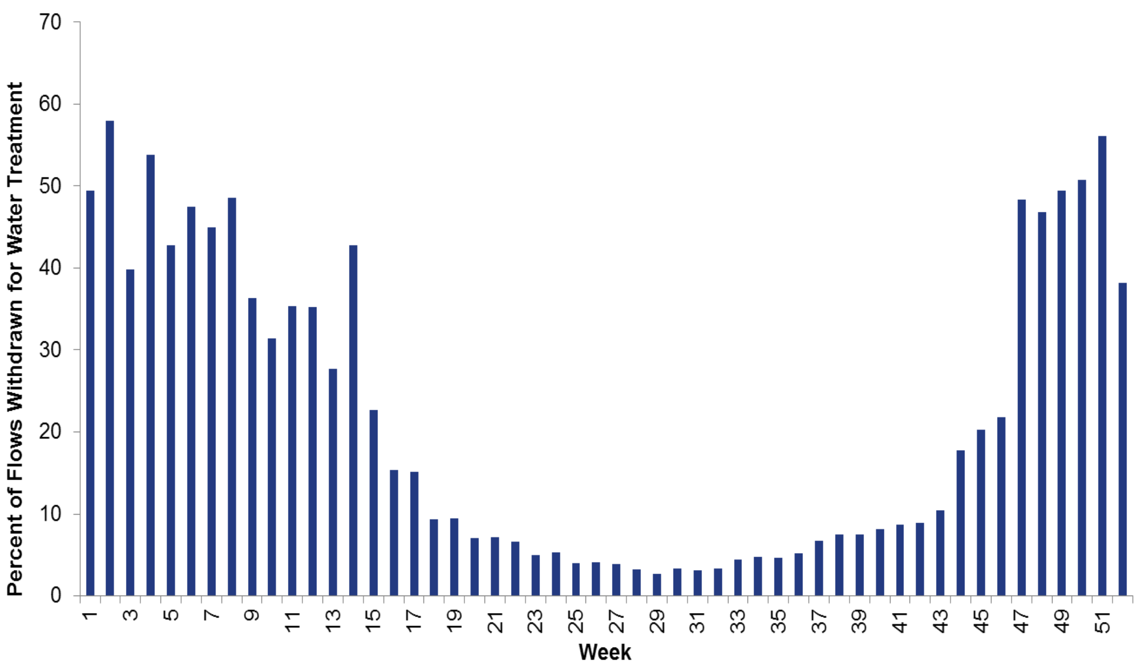


Figure 83. Highest Weekly WTP Withdrawal from 2012 – 2016 as a Percent of the Lowest Weekly Flows Each week for the 900 year NSR Flow Reconstruction.

3.4.3 Effect of Climate Change on Supply

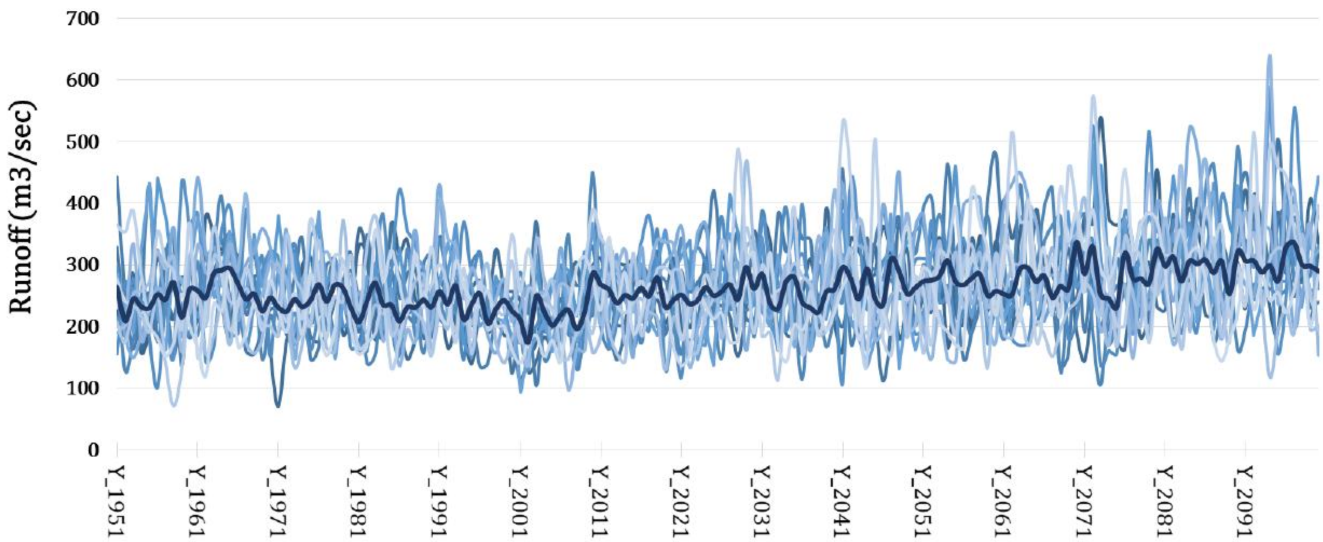
EPCOR understands that water resources are not stationary and that historical trends and patterns may not be applicable under a changing climate. Climate models run within the NSR basin by Golder (2008b), Kienzle et al. (2012) and Sauchyn et al. (2020) consistently predict increased temperatures and precipitation, earlier spring melts, increases in annual flow, warmer and wetter conditions in winter and spring and, on average, drier conditions in mid to late summer. Water management must be adjusted to a hydrological cycle which is increasingly sensitive to the timing and frequency of rainfall events and has less of a buffer from glacier ice and late snowmelt.

> Climate change is expected to lead to early spring melt and less snowpack contribution in summer but an overall increase to the annual NSR flow. Dam management will become an increasingly important tool in managing flows.

To improve future predictions of streamflow in the NSR EPCOR engaged and supported Dr. David Sauchyn and the researchers at PARC (Sauchyn et al. 2020). Model results predict an 8% increase in total annual flow by the year 2080, and increased interannual variability (Figure 84). The increased variability between years may be the more significant impact compared to a modest increase in flow. The overall increase in flow is driven by increased flow in the winter and spring that is offset by decreased flow during the summer month. This is driven by warmer temperatures, increased evaporation, and an earlier decline in snow pack (Figure 85).

> **Natural and Externally Forced Hydroclimatic Variability in the North Saskatchewan River Basin-** is a project that was initiated by EPCOR in 2018 and done in collaboration with the Prairie Adaptation Research Collaborative (PARC). The project sought to develop projections of future climate and flow in the NSR at Edmonton using the latest Regional Climate Models (RCMs). Projections of future climate and flows in the NSR in previous studies have been derived from Global Climate Models (GCMs). Flows for the NSR at Edmonton were derived using the MESH (Modélisation Environmentale-Surface et Hydrologie) land surface hydrology model, and 15 runs of the Canadian Regional Climlate Model (CanRCM4) under the RCP 8.5 emission scenario (i.e., business as usual). Projected flows are based on the naturalized flow in the NSR, which assume that the upstream dams are not in operation. Understanding how operation of the dams may change under future climate scenarios will be explored in further studies.

Modelled results show that the timing of spring runoff, peak summer flows and the decline in flows in the fall will each advance by a month for the period of 2041 – 2100. It is important to note that the flows depicted in Figure 85 are the naturalized flows of the NSR, which assume no operation of the Bighorn or Brazeau dams. However, as described in sections above, the operation of the two upstream hydroelectric dams have a profound effect on the timing of flows in the NSR. Thus, the resulting flows in the NSR will be affected not only by changes in climate, but how the upstream dams alter their operations due to changes in the timing and magnitude of flows into their reservoirs. EPCOR has been engaging with TransAlta regarding how climate change may affect the operations of both organizations.



Note: Simulated mean annual runoff from 15 model runs. Dark blue line represents the mean.

Figure 84. Mean Annual Runoff in the NSR at Edmonton from 1951 – 2100 (From Sauchyn 2020).

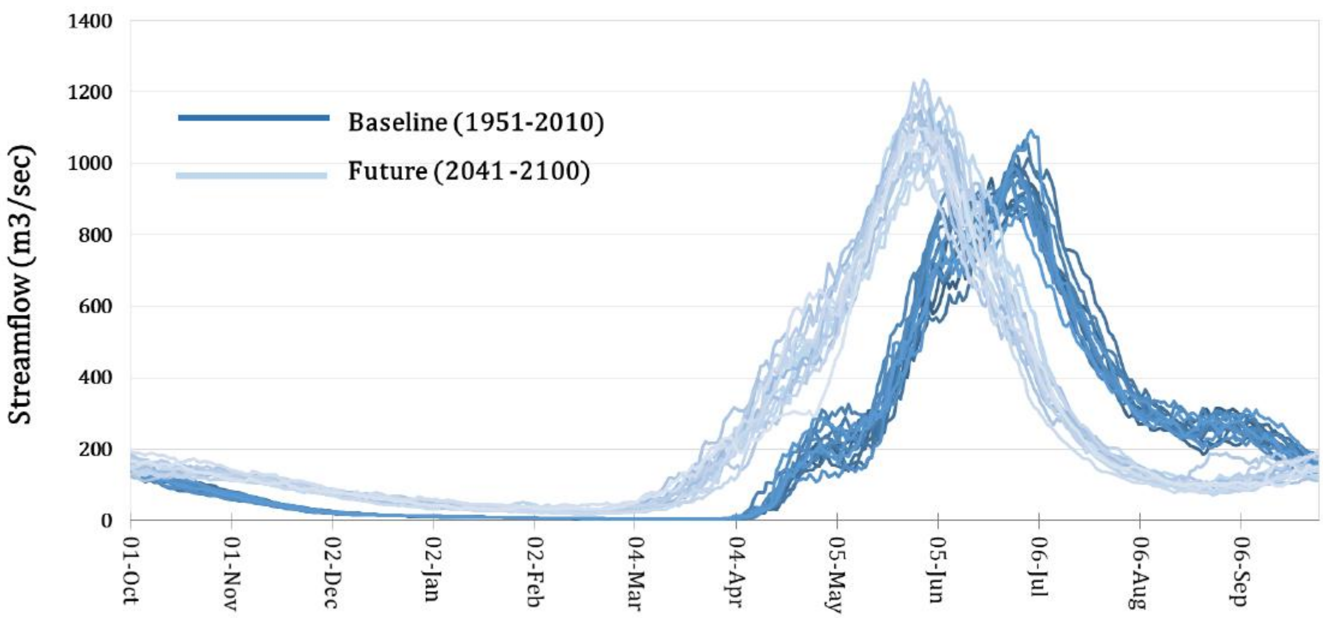


Figure 85. Naturalized Daily NSR Flow in the NSR at Edmonton under Baseline and Future Climate (From Sauchyn 2020).

3.4.4 Effect of Current and Future Water Use on Supply

Currently, the volume of water withdrawn by the WTPs for drinking water purposes is low compared to flows in the NSR. The WTPs withdraw between 4 and 7 m^3/s daily (annual average: 5 m^3/s) from the NSR. Of the withdrawn water 13 % is returned to the river by the WTPs as part of their residual wastestreams. The remaining water is treated and distributed to customers, where approximately 90% of the water is returned to the river through wastewater treatment plants. The amount of water (gross) withdrawn by the Rossdale and E.L. Smith WTPs typically ranges from 1 - 4 % of the daily flow of the NSR; however, during winter months when NSR flows are low, greater percentages can be withdrawn (Figure 868687). Seasonally, withdrawals make up a greater percentage during winter low flow periods (around 4%) compared to during open water periods (2% to 3%; Figure 8788).

EPCOR's WTPs typically only withdraw 1 - 4 % of the daily flow of the NSR, much of which is returned to the river by the WTPs and WWTPs

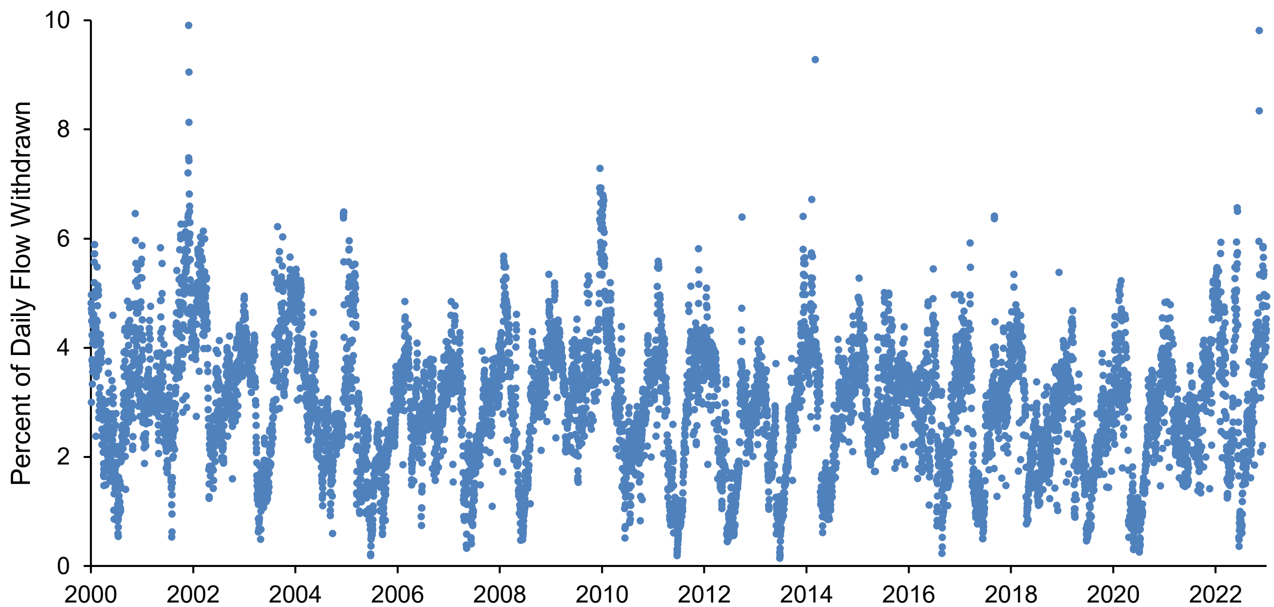


Figure 868687. E. L. Smith and Rossdale WTP Daily Intakes as a % of NSR Flow from 2000 – 2023

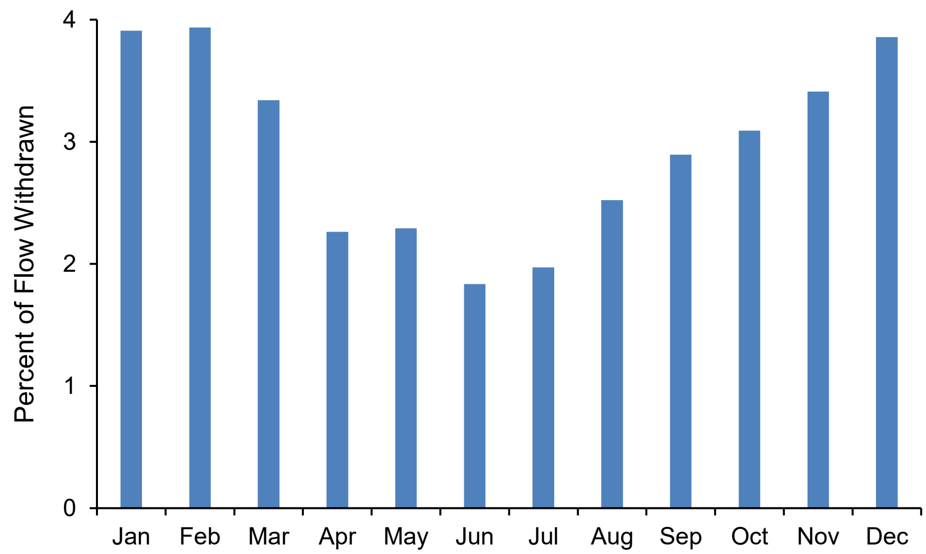


Figure 8788. Mean daily % of NSR flow withdrawn by E. L. Smith and Rossdale WTPs by month from 2000 to 2023.

Approximately 16% of the NSR flow at Pakan is allocated for use. Of that, 4% is consumptive use where it is not returned directly to the river after use.

Through the rest of the NSR basin, water use is low. To better understand emerging water quantity issues for the NSR, the NSWA commissioned a report on the current and future water use in the NSR basin (AMEC 2007). The NSWA presented an unpublished update to this report, and in general found the trends unchanged (NSWA 2017). Since that time, work as part of the NSWA's Roadmap project has shown that at Edmonton the total annual volume allocated is 1.11 billion m^3 of the 6.82 billion m^3 annual flow of the river, or 16% of the flow. Of the water that is allocated for use, only 37% (411 million m^3) is used, 40% of that (176 million m^3) is returned. This means of the total annual flow at Edmonton 4% is allowed to be consumed and not returned directly to the system. Upstream of Edmonton's WTPs use is even lower with 2% of the annual flow allocated and current use at 1%.

Water Licences and Annual Withdrawals

EPCOR's licences to withdraw water from the NSR allows for continued growth and increased water demand within the Capital region for multiple decades.

EPCOR has two licences (00070864-00-03 and 00023887-00-04) to withdraw up to 203,523,000 m^3/year water from the NSR. The Regional Water Customers Group Inc., who supplies water to regional customers outside of Edmonton have an additional two licences (00467643-00-00 and 00351924-00-00) to withdraw up to 60,600,000 m^3/year through EPCOR's WTPs. In total, EPCOR has licences to withdraw 264,123,000 m^3/year from the NSR. Between 2010 – 2023 EPCOR has withdrawn an average of 151,139,000 m^3/year (57% of total licences) with the highest annual withdrawal of 159,376,000 m3/year (60% of total licences) (Figure 8889). While residential water consumption per capita has dropped over time, the annual amount of water removed from the NSR has slowly increased over time, partially due to increased population within Edmonton, but also due to increased water demand from regional customers as regional networks have expanded. Projections of future growth scenarios and trends in water demand reveal that EPCOR has sufficient capacity in its existing licences to at least 2060, and possibly beyond.

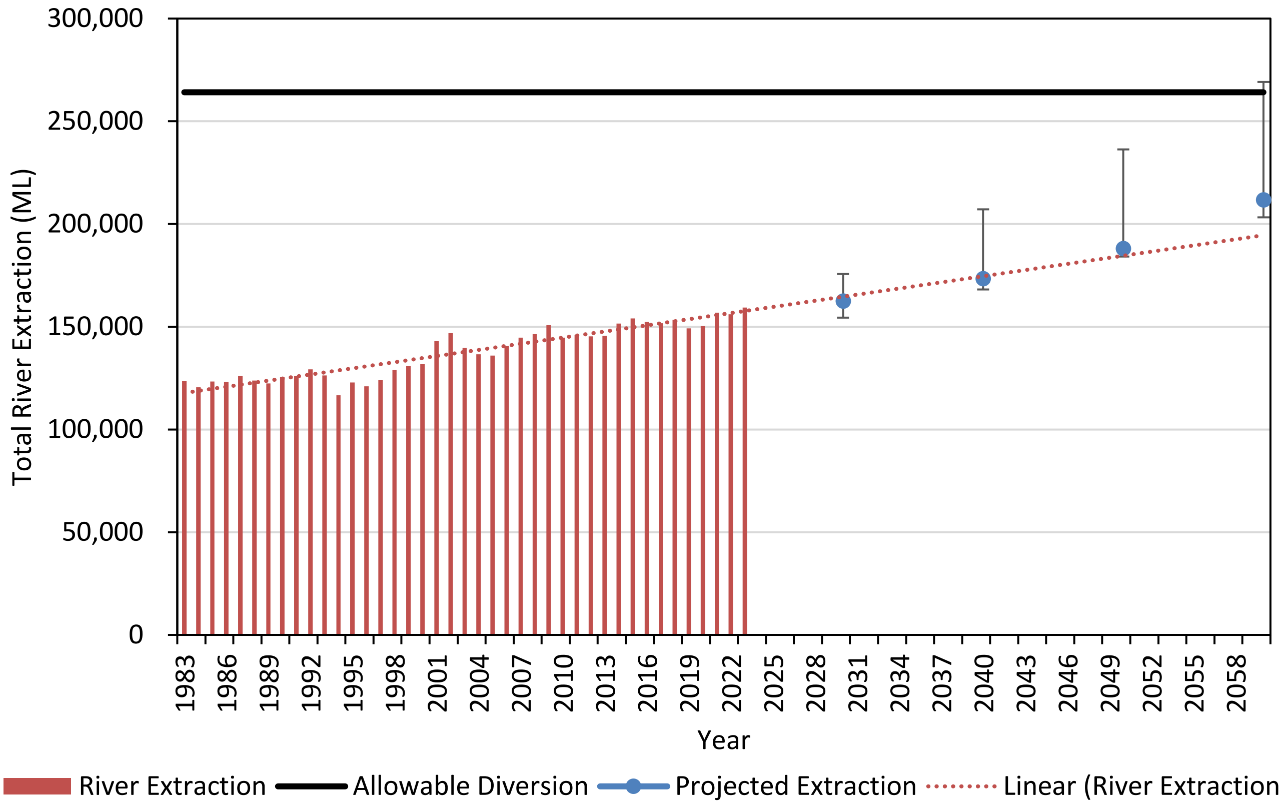


Figure 8889. Annual Water Extracted by the WTPs (1983 – 2023) and Projections to 2060.

3.4.5 Alternative Water Supplies and Groundwater

EPCOR engaged Stantec to evaluate various alternative water supplies to determine their feasibility in the event of a hydrocarbon spill and that the NSR was not usable as a source of raw water. Stantec (2017) evaluated six lakes (Wabamun, Lac Ste. Anne, Cooking, Beaverhill, Pigeon and Big lakes), three river locations (Athabasca, Red Deer and Sturgeon Rivers) and groundwater as alternative water sources for temporary and permanent requirements. Based on their review, Wabamun Lake and Lac Ste. Anne were considered as the primary options for use as a temporary alternative source of water. Costs of setting up a temporary water supply system with hoses and pump stations for a 30-day period from either of these sources would exceed $80 million. Additionally, neither of these lakes has sufficient water volume to be considered a permanent water source. Both the Athabasca and Red Deer rivers were considered for a permanent water source in the 2017 study, with the Athabasca River being preferable due to higher water quality and quantity. Costs of setting up a permanent water supply from the Athabasca River could approach $520 million, not including land costs.

Groundwater was evaluated by Stantec (2017) as an alternative source of water and it was concluded that a single well could not supply Edmonton's water demand, and that a well field, consisting of multiple wells would be required. Additionally, Stantec concluded that more detailed studies would be required to fully evaluate the potential for groundwater. Groundwater as an alternative water source may be an added source of resiliency, not only in terms of hydrocarbon spills (which was the focus of Stantec's report), but also in terms climate change, which may reduce the quantity and quality of other surface water sources evaluated by Stantec (2017).

Godfrey (1993) provides an overview of groundwater resources in the Edmonton Area and states that freshwater aquifers are found in cretaceous bedrock and surficial deposits. Bedrock aquifers in Edmonton are found in the Horseshoe Canyon Formation which was deposited 65 to 100 million years ago in a largely swampy, deltaic environment which was occasionally flooded by the sea. The lowermost depths of this formation contains multiple coal seams, and where these coal seams are fractured, they constitute important aquifers. These wells are generally capable of producing groundwater at rates ranging from 0.4 to 7.5 L/s, but coal seams beneath the Cooking Lake Moraine (a short distance east of Edmonton) may be more productive. Wells 45 m deep in this area can produce up to 8 L/s, and wells between 45 and 60 m deep can produce up to 2 L/s. Water from coal aquifers generally has high TDS, between 1,000 and 1,500 mg/L, and high iron and would requires treatment for iron and TDS reduction.

Alternatively, aquifers in surficial deposits are the result of more recent glacial activity. As described in Section 3.2.2, the ancestral flows of the North Saskatchewan River were stopped by glaciers and these river valleys were buried by deposits from the resulting Glacial Lake Edmonton. These ancient river channels are now buried-valley aquifers, and are the most important and productive aquifers in the Edmonton region. These larger valleys can produce water in rates in excess of 8 L/s in many places. Godfrey (1993) states that as much as 30 L/s has been pumped continuously by the town of Stoney Plain to lower the water table for more than 15 years. The chemistry of groundwater in these surficial deposits differs significantly from water in the underlying bedrock and the water is generally hard because of high calcium and magnesium concentrations. TDS concentrations can vary over short distances and range from 500 to 3,000 mg/L, and can be as high as 6,000 mg/L in some locations. Additionally, these waters often have high iron content and require iron removal for drinking water.

A more recent assessment of groundwater in the Edmonton area by Barker et al. (2011) suggests in the Edmonton area, the recommended groundwater extraction rates are between 0.5 and 0.75 L/m, but note that they do not represent the actual groundwater yield possible for each geological formation. Barker et al. (2011) also report that the hardness of groundwater in much of the Edmonton region ranged between 250 and 500 mg/L and that some areas to the east are above 500 mg/L. Similarly, total dissolved solids (TDS) is typically less than 1,000 mg/L but range between 1,000 and 1,500 mg/L in some areas. In a series of reports, Barker et al. (2013a, b, c, d and e) provide more detailed maps of groundwater chemistry (including calcium, magnesium, sodium, potassium, chloride, sulphate, alkalinity, iron, TDS and hardness) of bedrock and surficial aquifers in the Edmonton region. This series of reports would be an important resource when undertaking a more detailed evaluation of the feasibility of utilizing groundwater resources.

Despite the previously mentioned studies, relatively little information is known about groundwater resources in the basin. It is not known what fraction of the river flow at Edmonton is comprised of groundwater, or where the sources of groundwater in watershed are located. As described above, buried pre-glacial channels exist in/near Edmonton, but the volume of groundwater in the channels their recharge rates, and their ability to interact with the NSR is unknown. There is also limited understanding of how drought, climate change and future land use changes may impact surface water-groundwater interactions. EPCOR is providing financial support to a research project led by the University of Alberta and the Alberta Geological Society to provide a greater understanding of groundwater resources in the NSR.

In order to fully determine if groundwater is a feasible source of water supply for Edmonton, additional studies would be required. It is unclear if there is sufficient volume, and water quality would also need to be explored in greater detail. Additionally, EPCOR would need to determine if groundwater would feasible as presumably a large well field, with a large number of wells would need to be built to meet water demands.

3.4.5 Floods

As EPCOR's WTPs are both located in the NSR flood plain, flood events present a significant risk of damage to critical infrastructure. Even if direct damage does not occur, high water levels and high concentrations of organic material and suspended sediment can limit or completely prevent the ability of the WTPs to produce potable water for a period. Left unmitigated, 1:100 year return period floods or greater have the potential to cause significant damage to EPCOR's WTPs. Lower magnitude flood events, such as a 1:50 year return period flood, have the potential to cause shorter term disruptions to drinking water treatment due to an inability to drain the clarifiers at both WTPs. EPCOR has implemented several projects improve the resiliency of the WTPs to floods and are currently undertaking the construction of flood berms which are designed to protect the WTPs from a 1:500 year flood.

The five highest recorded flood events in gauge record are detailed in

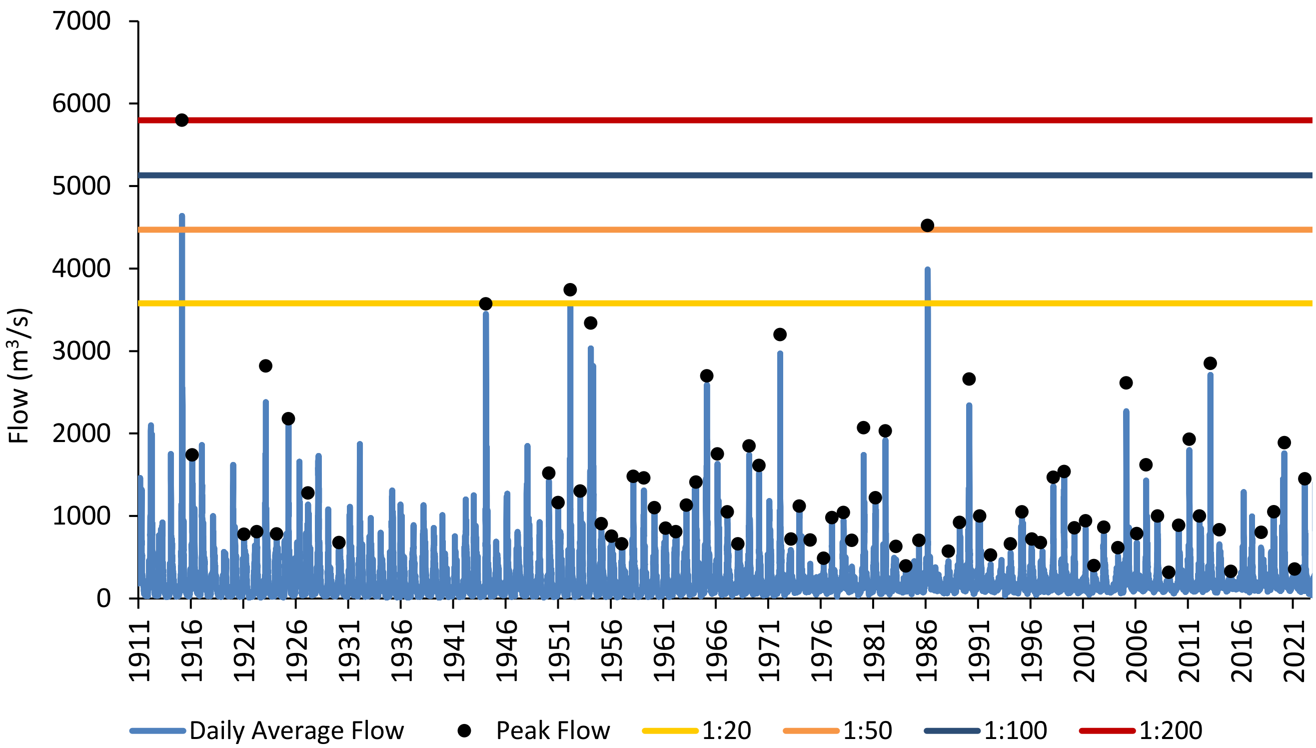
Table 13, along with the recent flood events of 2005 and 2013 (the 7th and 11th largest recorded flood events). Flows in the NSR along with the peak instantaneous flows and the flood return frequencies are presented in Figure 8990.

Table 13. Historical High Flow Events in Edmonton

Year	Date	Average Daily Flow (m³/s)	Maximum Daily Flow (m³/s)	Return Frequency
1915	June 29	4,640	5,800*	1:200
1986	July 19	3,990	4,520	1:50
1952	June 25	3,540	3,740	1:20
1944	June 16	3,450	3,570	1:20
1954	June 8	3,030	3,340	1:10
2013	June 23	2,710	2,850	1:5
2005	June 21	2,270	2,611*	1:5

* Estimated

Data Source: Water Survey of Canada 2024, AEP 2020



Data Source: Water Survey of Canada 2024, AEP 2020

Figure 8990. Daily mean flow and annual peak flows in Edmonton from 1911 to 2023.

Current flood predictions and return frequencies do not consider the potential impacts of climate change, or future changes to the land use within the watershed. Some predictions of climate change anticipate the increase both the frequency and severity of precipitation events (Kuo et al. 2015), which may result in more frequent and severe flooding in the NSR. A specific study done for the City of Edmonton by Dr. Dave Sauchyn showed that climate change increases flood magnitude by an average of 35% depending on the return flow.

The upstream Bighorn and Brazeau dams can provide ~15 percent attenuation of flood severity of the NSR in Edmonton, depending on the timing of the flood event and the capacities of the dams at the time. The watershed upstream of the Bighorn generally does not experience major rainfall events that produce large floods at Edmonton, therefore it has been assumed that the Bighorn dam provides negligible flow reduction during major flood events in Edmonton. In contrast, the Brazeau basin experiences major rainfall events that contribute to flood events in Edmonton; however, reports have stated that the amount of storage that is available in the Brazeau dam is limited, and negligible flow reduction should be assumed. The statements about the limited ability of the dams to attenuate floods were based on an assessment following the 1986 flood event where flows reached 4,520 m^3/s in Edmonton, and it was calculated that the Bighorn and Brazeau dam reduced flows by 40 and 10 m^3/s, respectively (AENV 1990). Based on EPCOR's assessment of the data, the Brazeau dam operated its spillway during the rainfall event, discharging up to 1,090 m^3/s compared to the estimated natural flow of 1,100 m^3/s. Given that the Brazeau dam has an outlet capacity of 311 m^3/s and a spillway capacity of 1,840 m^3/s, the discharge volumes could have only been achieved using the spillway. At the time of the rain event, the water levels of the Brazeau dam were near the median values for the time of year, and based on EPCOR's assessment, the reservoir had sufficient capacity to retain significantly more volume without requiring the use of the spillway. Could the use of the spillway been delayed even 24 or 48 hours, it is possible that peak flows in Edmonton could have been reduced by 700 – 1,000 m^3/s, reducing the flood severity from a 1:50 year event to a 1:20 year event. It is unclear why the Brazeau dam spillway was used during the 1986 flood event, and it is possible that there were multiple factors that lead to that decision that are not readily known today.

A recent example demonstrating the ability of the Brazeau dam to hold back flood flows from Edmonton was observed in June 2023. Between June 17 and June 20 between 50 mm and 170 mm of rain fell in the watershed upstream of Edmonton, with the largest precipitation totals being recorded upstream of the Brazeau dam. Flows in Edmonton reached 1,500 m^3/s, which was a 1:2 year flood event. However, based on how much volume was retained by the Brazeau reservoir, EPCOR estimates that the flows in Edmonton could have reached over 2,300 m^3/s, or a 1:5 year flood event, had the Brazeau dam not held back the flows.

Based on a draft report AEPA report (NHC 2020) flood frequency estimates for the NSR at Edmonton were generated using naturalized flows (i.e., assuming no dams are present) and regulated flows (i.e., assuming the dams are present). During flood events, regulated flows are 17 – 22 % lower than naturalized flows (

Table 14). For example, a 1:100 year flood event under regulated flows is approximately the same as a 1:35 year flood event under naturalized flows. In other words, the operation of the two upstream dams is anticipated to notably reduce the severity of flows that are observed in Edmonton during flood events. Climate change effects were added based on Belander et. al. 2024 who estimated an average increase in magnitude of ~30% depending on the return flow. This is contrary to the NHC report that stated there is insufficient information to be able to identify all the linkages between precipitation and runoff to make any forecasts about how climate change might affect flood peaks for NSR at Edmonton.

Table 14. Flood frequency estimates for the NSR at Edmonton (NHC 2020)

Return Period	Naturalized Flow (m^3/s)	Regulated Flow (m^3/s)	Estimated Climate Impacts on Regulated Flow (m^3/s)
2	1,300	1,070	1,264
5	2,220	1,750	2,170
10	2,910	2,260	2,868
20	3,580	2,790	3,604
35	4,130	3,240	4,225
50	4,470	3,540	4,659
75	4,860	3,890	5,149
100	5,130	4,140	5,512
200	5,800	4,790	6,440
350	6,340	5,340	7,220
500	6,670	5,710	7,763
750	7,060	6,140	8,378
1000	7,330	6,460	8,847

The ability of the dams to attenuate flood events is dependent upon their reservoirs having sufficient capacity to hold back incoming flows. Of the seven largest recorded flood events, six of them have occurred in June, and the one other flood event occurred in mid-July (

Table 13). As described above, the reservoirs are typically at their lowest in April or May, and full in August or September; and the dams typically have significant capacity during the periods when flood events occur (Figure 78 and Figure 79).

3.4.6 Ice Jams and Frazil Ice

High water levels on the NSR can also be caused by ice jams. On April 21, 2020 water levels at the Low Level Bridge rose 3.6 m over a period of four and a half hours due to an ice jam, and the E.L. Smith WTP experienced minor flooding. In November 2024, water levels at the E.L. Smith WTP rose 3.1 m in 3 hours but experienced no operational impacts. This ice jam was caused by a large increase in NSR flows released from the upstream dams to meet power demands during a cold snap when ice had just started to form on the NSR and was not strong enough to withstand the increased flows.

It is not known how frequently ice jams occur on the NSR, and many presumably go relatively unnoticed or unreported. The ice jam that occurred in November 2024 was only observed by the gauges at the E.L. Smith WTP and were not noticed by Water Survey of Canada gauges on the NSR. The Government of Alberta regularly monitors and provides regular updates on ice jams in the Peace and Athabasca rivers, but no regular monitoring of ice conditions occurs on the North Saskatchewan River. If an ice jam is observed at a gauge station, the government of Alberta will issue warning on the Alberta River Basins website. Ice jams that raise water levels enough to cause concern for EPCOR's WTPs occur infrequently; however, the potential consequences are significant.

Ice jams can occur during both winter freeze up and spring breakup; however, ice jams associated with spring breakup are typically more significant due to increased flows that occur during spring runoff (Turcotte et al. 2019). While the mechanisms of ice jams are well understood, the ability to predict the frequency, severity, timing, likelihood and location of ice jams is complicated by the large number of interacting variables that are need to occur to generate an ice jam (Kovachis et al. 2017, Madaeni et al. 2020). Even in rivers that are highly monitored for ice jam flooding, such as the Athabasca River near Ft. McMurray, it is challenging to predict when and where ice jams will occur (Turcotte et al. 2019).

Climate change will have uncertain impacts on the frequency and severity of ice jams in the NSR and other rivers (Turcotte et al. 2019). Warmer winter temperatures may contribute to thinner ice cover and therefore fewer ice jams. Warmer spring temperatures and increased precipitation during the winter and spring may also contribute to increase thermal breakups of ice, again reducing the likelihood and severity of ice jams. However, warmer spring temperatures and increased precipitation during the winter and spring could also result in more frequent and severe ice jams. Turcotte et al. (2019) concluded that future ice-jam flood risk under a warming climate in Canadian rivers may increase, decrease, or remain unchanged. Rokaya et al. (2019) looked at the frequency of ice jams in the Athabasca River under climate change scenarios and concluded that the probability of ice jam flooding would decrease, but extreme ice jam floods would still occur.

In summary, ice jams severe enough to impact EPCOR's operations occur infrequently, and there is no definitive research to suggest this will change in the future. EPCOR has been in collaboration with Dr. Yuntong She at the University of Alberta who is conducting research on ice dynamics in the NSR. Future research results may help inform future predictions on the frequency and severity of ice jams in Edmonton.

Frazil ice (i.e. slushy ice) has not previously been a concern for EPCOR; however, in December 2018, high concentrations of frazil ice in the NSR caused minor damage to traveling screens at the WTPs which are designed to remove debris. Frazil ice has the potential to completely block intakes; however, this has never occurred at EPCOR's WTPs. Frazil ice is formed during the late fall and early winter when the water is supercooled (i.e. drops below 0°C) before stable ice cover is achieved. This typically occurs when air temperatures rapidly drop; however, the precise conditions that generate high concentrations of frazil ice are complex and not fully understood. EPCOR now monitors air and water temperature to help anticipate when frazil ice conditions are possible; however, EPCOR's WTPs currently have few options to mitigate frazil ice; however, possible mitigation measures are being evaluated. EPCOR is currently engaging with the University of Alberta to better understand this phenomenon. Frazil ice in concentrations that can affect EPCOR's WTPs is an infrequent event, and there is no indication that the likelihood of these events is increasing or will increase under a warming climate.

SECTION 4 - RISK ASSESSMENT

4.1 Potential Hazards

By using a risk management approach, EPCOR has identified hazards to the water supply which could impair the operation of the components of the water system and result in threats to public health. This was informed by the detailed characterization of the watershed found in the previous sections. The risk assessment was done as part of EPCOR's Drinking Water Safety Plan (DWSP) (see Section 3.6.5) using an EPCOR methodology authorized by AEP.

A hazard refers to a source of (potential) harm to the functioning of any aspect of the drinking water system or to human health. Hazards can be the result of natural and/or human (anthropogenic) activities. A risk refers to the chance or possibility of a hazard causing this harm to the functioning of any aspect of the drinking water system or to human health (CCME 2004).

Refer to Table 15 for a list of all potential hazards. See Table 16 for a list of various contaminants associated with the identified hazards and Table 17 for a list of concerns related to potential contaminants in the NSR raw water source.

Table 15. Potential Hazards for Edmonton's Drinking Water System.

Source	Land-uses / Potential Contaminant Source/Activity
POINT	Small urban wastewater discharges
	Pipeline break
NON-POINT	Livestock waste excretion
	Livestock physical alteration of watershed
	Agricultural cropping activities
	Agricultural land cover and use
	Wildlife activity in watershed.
	Rural septic fields
	Small urban stormwater runoff
	Forest harvesting activities
	Pine beetle infestation
	Forest fires
	Waste disposal sites
	Alteration in climate (natural and anthropogenic)
	City of Edmonton stormwater runoff
	Contamination of pet fecal matter in urban areas
	Proximity to transportation corridor
	Spill on a bridge
	Recreational activities
	Ground water contamination
	Gravel extraction
	Coal surface mining
	Disposal of animal remains within watershed
	Dam operation and management
	Contamination of shallow aquifers
	Industrial land spillage
OTHER	Intentional contamination at critical source intakes
	Insufficient raw water quantity
	Catastrophic failure of dams
	Contamination of raw water due to intentional dumping or release of chemicals from industries
	Construction activities on the River – Upstream Bridges
	Lack of integration among watershed and other land and water planning initiatives

Table 16. Various Contaminants Associated with the Identified Hazards (Land-Use and Pollutant Analysis Matrix) (Water Research Foundation 1991).

Land-use/ Potential Source	Contaminant											
	Turbidity	pH	Nutrients	Algae	Viruses/ Parasites	Bacteria	THM Precursors	Pesticides	Other SOCs	VOCs	Heavy Metals	Iron/ Manganese
Hazardous Materials								X	X	X	X	X
Urbanisation	X	X	X	X	X	X	X	X	X	X	X	X
Municipal WWTP and Lagoons	X	X	X	X	X	X	X	X	X	X	X	X
Agricultural Grazing	X		X	X	X	X	X					
Industrial Discharges	X	X	X	X		X	X	X	X	X	X	X
Recreational Activities					X	X						
Roads	X		X	X			X					X
Mining	X	X	X								X	X
Cropland Runoff	X		X	X	X	X	X	X			X	X
Dairies / Feedlots	X		X	X	X	X	X					
Septic Systems		X	X	X	X	X	X	X				
Acid Rain		X										
Forest Management	X		X	X		X	X	X				X

Hazardous Materials: oil and gas pipelines, waste disposal sites, chemical and fuel storage sites, spills, grease and toxic chemicals. THM: Trihalomethane. SOCs: synthetic organic chemicals. VOCs: volatile organic compounds.

Table 17. Concerns Related to Potential Contaminants.

CONTAMINANT CATEGORIES		CONCERNS
Microbial Pathogens*	bacteria, protozoa, viruses, parasites (Giardia, Crypto, *E. coli* 0157:H7)	Most significant effect to public drinking water because the effects are acute.
		If ingested, pathogens can give people gastrointestinal illness within hours or days.
		Some cases, ingesting pathogens can result in permanent damage to internal organs or lead to chronic health problems.
		In the most severe cases, ingesting pathogens can be fatal.
Chemical and Radiological Contaminants	pesticides, inorganic chemicals (metals, total dissolved solids)	Health effects tend to be chronic, only appearing after people are exposed to high levels of the substance consistently over a period of years.
		Generally, only a small percentage of the population would see any effects.
		Health effects vary depending on the specific contaminant.
Physical Water Quality Parameters	turbidity, sediment, colour, taste and odour, temperature, pH	Physical characteristics do not pose a direct threat to human health.
		Can indicate presence of other chemical or biological concerns.
		Particulate matter (turbidity) can interfere with drinking water treatment processes, thereby increasing the risk of microbiological threats.
		WTPs have difficulty operating under these types of conditions
Interactions between Contaminant Categories		It is important to note, different types of hazards could interact with one another.
		Interaction may result in synergistic or antagonistic effects.

3.4.1 Point Source Contamination

Point source contamination is a source of pollution that can be traced back to a specific location (point of discharge and/or origin).

The following is a list (in no particular order) of possible point source contamination hazards that could affect the NSR raw water:

- Small urban communities waste water from continuous wastewater discharges (Rocky Mountain House, Drayton Valley and Devon) and other municipal sewage lagoons discharging pharmaceuticals, personal care products, contaminants of emerging concern, nutrients, pathogens and hazardous chemicals
- Industrial discharges or dam/tailing pond breaches releasing hazardous chemicals
- Pipeline breakage releasing hydrocarbons or other chemicals

3.4.2 Non-point Source Contamination

Physical, chemical, and biological characteristics and processes in a watershed affect the water quality of waterbodies that drain these areas. Changes to either the processes and/or physical characteristics of a watershed will ultimately lead to changes in water quality in downstream waterbodies. If these changes result in alteration of background water quality and/or quantity, it can be considered pollution. Without the ability to trace back to a single point of origin and/or discharge, it can be defined more specifically as non-point source pollution (NPSP). Examples of NPSP include: the addition of chemicals to the land base (e.g. nutrients, pesticides) which then run off into waterbodies and increase background levels and alteration of watershed functions and processes such as the removal of trees resulting in erosion and increased sediment concentrations in receiving waterbodies.

The following is a list (in no particular order) of possible non-point source contamination hazards that could affect NSR raw water:

- Agriculture – fertilizers and pesticides from cropping, bacteria, and nutrients from livestock waste excretion, increased erosion, and movement of contaminants from physical alteration of watershed
- Stormwater/urbanization – excess nutrients, metals, sediment, fertilizers, herbicides, insecticides and pet waste
- Mining – sediment, nutrients, dissolved solids, metals from leachate
- Forestry activities – sediment and nutrients from increases erosion, herbicides
- Roads – sediment and nutrients from increases erosion, metals, salt
- Construction sites – hydrocarbons, sediment
- Recreational activities – sediment and nutrients from increases erosion
- Septic systems – bacteria, nitrate, ammonia, pharmaceuticals, personal care products
- Atmospheric deposition – metals, contaminants of emerging concern
- Accidental spills / releases – hydrocarbons/petroleum products, heavy metals

4.2 Rank Hazards/Risk Statements and Identify Vulnerable Areas

Using the developed list of hazards/risk statements for Edmonton's water treatment operations, the level of risk associated with each has been identified through EPCOR's risk management approach (MS03-STD1-Risk Management Process: Risk Assessment, Risk Treatment and Risk Review Standard) and as part of EPCOR's Drinking Water Safety Plan (DWSP).

As part of this process, two types of risk were determined: inherent and residual risk. Inherent risk was defined as a risk without any controls applied, in this case the controls would be water treatment plants and watershed management (Table 18). Assuming normal plant operations and continued watershed management, the remaining risk was defined as residual risk. The difference between the inherent and the residual risk is a measure of the effectiveness of the controls and both are important in assessing risks to source waters. In most cases robust treatment renders a parameter with high inherent risk (upstream WWTP effluent) to low residual risk, particularly if those parameters are effectively treated at the WTPs, such as sediment or bacteria.

Risk was derived as a function of consequence and likelihood. The risk was determined by rating the consequence (impact) and the likelihood (probability) and then applying them to the EPCOR Risk Matrix. Consequence and likelihood ratings were based on historical evidence (quantitative assessment) as well as the best available knowledge of subject matter experts (qualitative assessment).

The steps to analyze the risk included:

1. **Rating the Consequences (Impacts/Effects)**
   Using the consequence categories in the EPCOR Risk Matrix, each risk/hazard was rated for the greatest potential consequence that could plausibly happen. This was done by scanning across all the consequence categories and determining which impact/effect is the greatest. The five categories were:
   - Health and safety (public and employees)
   - Reputation (credibility as a utility service provider)
   - Environmental consequences (including public health)
   - Regulatory compliance
   - Financial consequences (business/operating loss – financial/asset damage/reliability/business interruption)
2. **Rating the Likelihood (Frequency/Probability)**
   - Using the likelihood categories in the EPCOR Risk Matrix, the likelihood that the risk event would occur was determined.
3. **Estimating Risk (Calculating the Risk Level, Rank and Score)**
   The risk level was determined to be either:
   a. Level I "Green" with rank "Low"
   b. Level II "Yellow" with rank "Medium-Low",
   c. Level III "Orange" with rank "Medium-High" or
   d. Level IV "Red" with rank "High".

It should be noted the predictive nature of hazard identification and risk management dictate that substantial uncertainty will always be associated with these activities (CCME 2004).

Table 18. Edmonton Drinking Water System Risk / Risk Analysis Chart.

Source	Land-Uses / Potential Contaminant Source/Activity	Inherent Risk	Residual Risk
POINT	Small urban wastewater discharges	H	L
	Pipeline break	M-H	M-H
NON-POINT	Livestock waste excretion	H	L
	Livestock physical alteration of watershed	M-H	L
	Agricultural cropping activities	M-H	L
	Agricultural land cover and use	M-H	L
	Wildlife activity in watershed	M-H	L
	Rural septic fields	M-H	L
	Small urban stormwater runoff	M-H	L
	Forest harvesting activities	M-H	L
	Pine beetle infestation	M-H	L
	Forest fires	M-H	L
	Waste disposal sites	M-L	L
	Alteration in climate (natural and anthropogenic)	M-H	M-L
	City of Edmonton stormwater runoff	H	L
	Contamination of pet fecal matter in urban areas	M-H	L
	Proximity to transportation corridor	M-H	L
	Chemical spill on a bridge	M-H	M-L
	Recreational activities	M-L	L
	Ground water contamination from airport	M-L	L
	Gravel extraction activities	M-L	L
	Coal surface mining	L	L
	Disposal of animal remains within watershed	M-L	L
	Dam operation and management	M-L	L
	Contamination of shallow aquifers	M-H	M-L
	Industrial land spillage	M-H	M-L
OTHER	Intentional contamination at critical source intakes	M-H	M-L
	Insufficient raw water quantity- low flow	M-L	L
	Catastrophic failure of dams	M-H	L
	Contamination of raw water due to intentional dumping or release of chemicals from industries	M-H	M-L
	Construction activities on the river	M-H	L
	Poor integration of land and water planning	M-H	L
	Flood	H	M-H

Low = L, Medium-Low= M-L, Medium-High= M-H, High - H

4.3 Watershed Management and Compliance and Regulatory Requirements

4.3.1 United States

The United States (U.S.) has been more advanced when it comes to protecting their drinking water sources. Many Canadian drinking water utilities will and should refer to existing U.S. policy, regulations and literature for assistance in developing SWPPs.

***United States Environmental Protection Agency* (US EPA)**

The United States Environmental Protection Agency (US EPA) has released a number of documents, some of which include:

- "Consider the Source: A Pocket Guide to Protecting Your Drinking Water". June 2002. US EPA Office of Ground Water and Drinking Water.

As well, the US EPA maintains a comprehensive source water protection website which addresses all aspects of drinking water source protection and has links to current state, NGOs, and other organisation initiatives as they involve SWP: https://www.epa.gov/sourcewaterprotection

4.3.2 Government of Canada

In Canada, there are no current policies or legislation regarding source water protection specifically. However, the Federal Government has emphasized the importance of source water protection as the first step in a 'multi-barrier approach' to protect drinking water sources. The Government of Canada and the Canadian Council of Ministers of the Environment (CCME) have released a number of documents on source water protection that include:

- "From Source to Tap: The multi-barrier approach to safe drinking water". May 12, 2002. Federal-Provincial-Territorial Committee on Drinking Water and CCME Water Quality Task Group.
- "From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water". 2004. Federal-Provincial-Territorial Committee on Drinking Water and CCME Water Quality Task Group.
- "Guidance for Providing Safe Drinking Water in Areas of Federal Jurisdiction. Version 2. 2013. Health Canada.

Environment Canada released Wastewater Systems Effluent Regulations (WSER) in 2012 which, do not refer to source water protection directly; however, go a long way in ensuring point source effluent from wastewater treatment plants are managed effectively to protect water quality. The new regulations align with the CCME Canada-wide Strategy for the Management of Municipal Wastewater Effluent.

Indigenous and Northern Affairs Canada

Indigenous and Northern Affairs Canada (INAC) has developed a number of tools and documents regarding improving water and wastewaters services in First Nation communities. The following document is available on source water protection:

- "First Nations On-Reserve Source Water Protection Plan: Guide and Template". 2014. Aboriginal Affairs and Northern Development Canada

4.3.3 Other National Level Organizations

Governance for Source Water Protection in Canada is a collaborative research initiative supported by the Canadian Water Network. They have been since in existence since 2008 and are led by the Water Policy and Governance Group at the University of Waterloo. Researchers, academia, government, NGOs, First Nations and watershed groups work in collaboration to improve the knowledge around water governance will the ultimate goal of improved source water protection processes and outcomes throughout Canada. Two key reports are available:

- "Tools and Approaches for Source Water Protection in Canada". 2010. Simms, G., Lightman, D. and de Loë, R. Governance for Source Water Protection in Canada.
- "Governance for Source Water Protection in Canada Synthesis Report." 2012. de Loë, R.C. and D. Murray. Water Policy and Governance Group.

4.3.4 Province of Alberta

Although all levels of government in Canada have responsibility for drinking water, the legislative responsibility for providing safe drinking water to the public generally falls under provincial or territorial jurisdiction (CCME 2004).

Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems

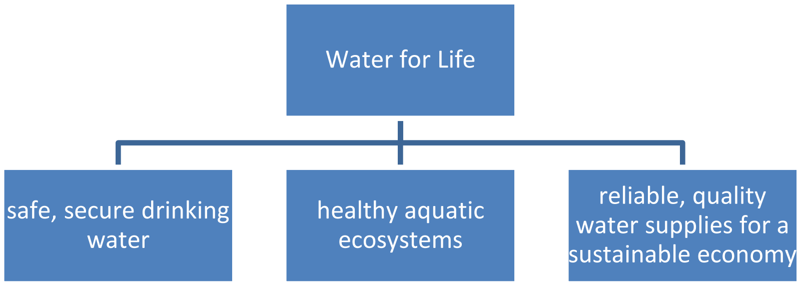
In 2012, Alberta Environment and Parks revised the "Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems". Part 2 of this revised document is titled "Guidelines for Municipal Waterworks" and includes a section on source water protection and highlighted the importance for municipalities to conduct source water protection planning.

Drinking Water Safety Plans

As part of the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, there is a requirement to complete Drinking Water Safety Plans (DWSP). These plants include a source to tap risk assessment. EPCOR completed its risk assessment in 2013, and the DWSP, including the action plan, was finalized in 2013. The risk assessment component for source waters has been incorporated the hazard and risk assessment in Section 3.5. EPCOR continues to re-evaluate and reassess its DWSP annually and update this SWPP.

Water for Life Strategy

AEP's Water for Life (WFL) Strategy was introduced in 2003 and guides watershed and water management in Alberta under the guidance of three main goals (see below) and through knowledge and research, partnerships, and water conservation.



Three main partnerships exist under WFL and they have a shared accountability to achieve Water for Life goals (Figure 91). The first partnership is a provincial partnership with the Alberta Water Council (AWC). The AWC is a consensus-based partnership that provides timely and strategic advice to governments, industry, and non-government organizations towards achieving WFL goals and outcomes. The second partnership is regional partnerships with Watershed Planning and Advisory Councils (WPACs), who are designated leaders in watershed assessment and planning. EPCOR is engaged primarily at this level and, for Edmonton operations, engagement occurs through participation on the NSWA. Thirdly, there are local partnerships which occur with watershed stewardship groups. Watershed stewardship groups take community-level, on the ground action to safeguard our water sources. This section of the report will focus on the role of watershed planning and source water protection within the broader WFL strategy.

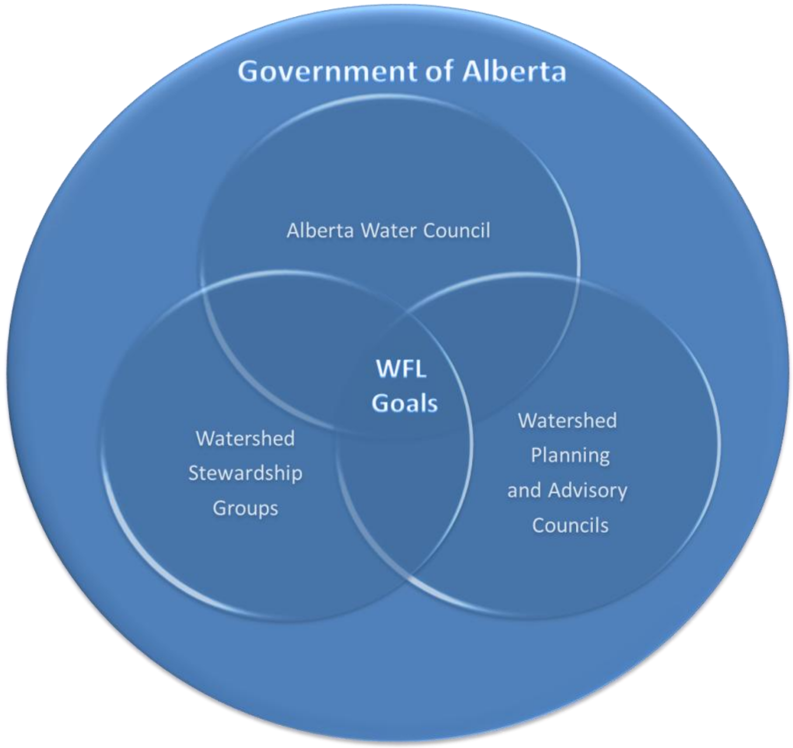


Figure 91. Water for Life Roles and Responsibilities (modified from AWC 2008).

In 2008, the Government of Alberta released a renewed Water for Life strategy and followed in 2009 with a *Water for Life Action Plan*, which supports the original goals and directions in the WFL strategy. The renewal emphasized partnerships and specifically highlighted working with the Alberta Water Council, Watershed Planning and Advisory Councils and watershed stewardship groups. The renewal was clear: Alberta's water resources must be managed within the capacity of individual watersheds and to ensure safe, secure drinking water we must recognize our dependence on aquatic ecosystems as source water.

The Action Plan outlines a comprehensive strategy to protect our drinking water as a specific outcome. The strategy involves ensuring Albertans have timely access to information about drinking water quality in their communities and that drinking water infrastructure strictly adheres to emerging standards. Key actions from the original strategy, as they pertain to source water protection, include:

- Development of a waterborne disease surveillance system and the undertaking of waterborne contaminant research. Progress to date is minimal.
- An update of water quality programs to support source protection information and planning. Progress to date includes enhanced tributary monitoring as part of the SaskWatch program.
- Working with WPACs to incorporate drinking water source protection into watershed planning. Progress to date: support of the Alberta Water Council Source Water Protection Projects.

Alberta Water Council

Incorporated as a not-for-profit society in 2007, the AWC is a multi-stakeholder partnership with twenty-four members from government, industry, and non-governmental organizations. Its primary task is to monitor and steward the implementation of Alberta's WFL strategy and to champion the achievement of its three goals. Recommendations on various aspects of water and watershed management are made to the provincial government, who then can choose to or not implement those recommendations into policy. Some key documents produced by the AWC which focus on watershed planning include: "Strengthening Partnerships: A Shared Governance Framework for Water for Life Collaborative Partnerships" and "Recommendations for a Watershed Management Planning Framework for Alberta". These documents were used to form current government policies in the WFL renewal and action plans and support sector-based approaches to watershed management.

In addition, projects teams have been developed in the areas of water conservation, efficiency and productivity, healthy aquatic ecosystems, Alberta's water allocation transfer system, non-point source pollution, and riparian management and conservation. EPCOR has been involved on project teams through participation with the NSWA or other stewardship groups. EPCOR was involved in the formation of the AWC's "Guide for Source Water Protection Planning" (AWC 2020) which provides an overview of how drinking water providers in Alberta can begin voluntarily undertake the creation of a SWPP. EPCOR is also working on an AWC project looking to scope how a web-based toolkit could be made available to assist communities in creating source water protection plans.

North Saskatchewan River Watershed Alliance (NSWA)

As the WPAC for the basin, the NSWA is mandated under WFL to complete State of Watershed reporting and to develop an Integrated Watershed Management Plan for the basin- which aligns with aforementioned WFL goals. Since its inception, an EPCOR staff member has been an active participant on the NSWA board and project teams.

The NSWA completed a "State of the North Saskatchewan River Watershed" in 2005, as well as a "Municipal Resource Guide" for communities in this watershed in 2006. In late 2005, the Alliance began work on developing an Integrated Watershed Management Plan (IWMP) for the basin, which was intended to set land use, water quantity, and water quality objectives for the basin. The plan was completed in 2012 (NSWA 2012b).

As a key part of the IWMP, a NSWA Technical Advisory Committee developed mainstem water quality objectives for the NSR. The final report: "Proposed Site-Specific Objectives for the Mainstem of the North Saskatchewan River" (NSWA 2010) set objectives for the NSR that helped guide watershed planning in the IWMP. The document promotes a "no further degradation in water quality" philosophy in the NSR. In areas, downstream of Edmonton, there is a call for improvement in water quality for some parameters.

Throughout the IWMP development and since then, knowledge and data gaps were identified. To fill those gaps and a series of reports have been completed:

North Saskatchewan River Water Management Roadmap Project	2025
North Saskatchewan River State of Watershed Experience Builder (in press)	2025
Canadian Heritage River System Designation (partner)	2024
Strategy to Improve Wetland Management in the North Saskatchewan River Watershed	2024
Riparian Web Portal	2022
Strawberry Watershed Riparian Area Assessment	2018
Modeste Watershed Riparian Area Assessments	2018
Preliminary Steps for the Assessment of Instream Flow Needs in the North Saskatchewan River Basin	2014
Vermilion River Watershed Management Plan	2012
Workbook Results: Integrated Watershed Management Plan for the North Saskatchewan River	2012
Discussion Paper for the Development of the IWMP for the North Saskatchewan River Watershed	2011
Economic Activity and Ecosystem Services in the North Saskatchewan River Basin	2010
North Saskatchewan River Basin Socio-Economic Profile	2010
Proposed Site-Specific Water Quality Objectives	2010
North Saskatchewan River Basin Overview of Groundwater Conditions, Issues, and Challenges	2009
Hydrodynamic and Water Quality Model of the North Saskatchewan River	2009
Cumulative Effects Assessment of the North Saskatchewan River Watershed using ALCES	2009
Cumulative Effects Assessment of the North Saskatchewan River Watershed Using ALCES	2009
Water Supply Assessment for the North Saskatchewan River Basin	2008
Climate Change Effects on Water Yield in the North Saskatchewan River Basin	2008
Current and Future Water Use in the North Saskatchewan River Basin	2007
Instream Needs Scoping Study	2007

Involvement with the NSWA will continue to provide an effective platform from which EPCOR can ensure effective and collaborative watershed management is achieved, with source water protection principles in mind.

Cumulative Effects Management and Land Use Framework

The Government of Alberta enabled cumulative effects management on a landscape level with the release of the Land-use Framework (LUF) in December 2008, followed by the *Alberta Land Stewardship Act* (ALSA) in early 2009. The Land Use Framework is the overarching planning mechanism for Alberta's natural resources and is enforced through the ALSA, which supersedes all other provincial legislation. Regional plans, which are developed under LUF, present one of the first opportunities for a cumulative effects management approach. LUF has committed the province to taking a cumulative effects approach to environment management in seven designated regions. Regional Advisory Councils (RACs) will be established to help guide/set landscape level outcomes which will be included in Regional Plans. Consultation of Phase 1 of the regional plan for the NSR Watershed is complete.

Cumulative effects management requires integration amongst spatial scales – provincial, regional, sub-regional, local and site-specific. At present, AEP is developing Management Frameworks that support regional plans under the LUF, including Water Quality Management Frameworks. Water quality management frameworks are place-based and likely to be developed for the mainstem rivers and other priority areas. The Industrial Heartland and Capital Region Water Management Framework is an example of an existing place-based framework that takes a cumulative effects approach to land and water management. EPCOR is engaged in planning through the Water Management Framework for the Industrial Heartland and Capital region.

Water Management Framework for the Industrial Heartland and Capital Region

The Water Management Framework (WMF) of the Industrial Heartland and Capital Region (AENV 2007) outlines specific environmental outcomes for the region and sets targets for sustainability and regional strategies for the tracking and management of air, water, and land. The WMF for the Industrial Heartland and Capital Region Report is the result of consultation, collaboration, and planning for growth by AEP, industry, municipalities, municipal water and wastewater treatment facilities, and the NSWA (Figure 92). The key strategic objective is to develop a world-class integrated water management system from the plan are to make Alberta a world leader is water and wastewater reclamation technology and to minimize the impact of "footprint" on the NSR by improve the quality of the water and ensuring water conservation practices are in effect. The WMF will be used to manage water quantity to ensure that sufficient water remains in the river to maintain aquatic life, support current and proposed industrial development, attain water quantity and quality targets, and move toward a minimal-loading discharge policy for return flows to the NSR. Updates on the Water Management Framework for the Industrial Heartland and Capital Region were completed in 2013, 2016 (GoA 2013b, 2016). In 2022, a 'North Saskatchewan Region surface water quality management framework for the North Saskatchewan and Battle rivers' was released which set water quality triggers and limits for the NSR for 21 parameters. The general principle was for a non-degradation approach to water chemistry on the NSR. As well there is a new Designated Industrial Zone for the region, however its downstream location means that its less relevant for this report.

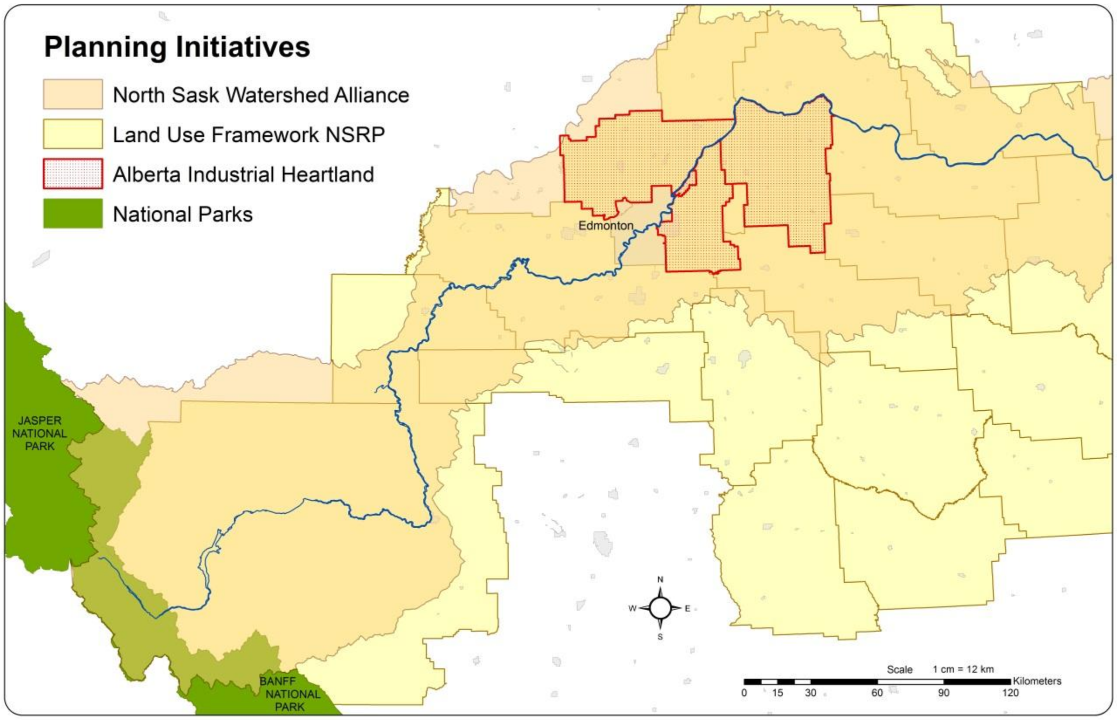


Figure 92. Planning Initiatives in the NSR Watershed (Data Source: GoA 2020)

As part of this work, AEP has completed a multitude of water quality modelling and assessment projects, reports, and frameworks as found below:

Status of surface water quality, North Saskatchewan Region, Alberta 2022	2025
North Saskatchewan Region surface water quality management framework for the North Saskatchewan and Battle rivers	2022
Industrial heartland designated industrial zone framework	2022
Effluent Characterization Program for the Industrial Heartland and Capital Region	2015
North Saskatchewan River: Water Quality and Related Studies (2007 – 2012)	2014
Pilot Water Quality Objectives and Allowable Contaminant Loads for the North Saskatchewan River.	2013
The Water Management Framework for the Industrial Heartland and Capital Region – Five Years of Implementation.	2013
Investigations of Trends in Select Water Quality Variables at Long-Term Monitoring Sites on the North Saskatchewan River	2012
Guidance For Deriving Site-Specific Water Quality Objectives for Alberta Rivers.	2012
Synthesis of Recent Knowledge on Water Quality, Sediment Quality, and Non-Fish Biota in the North Saskatchewan River with Special Emphasis on the Industrial Heartland – Capital Region Water Management Framework Reach.	2011
North Saskatchewan River Water Quality Model: Alberta Environment Technical Report - Version 1.1.	2009
Analysis of Water Quality Trends for the Long-term River Network: North Saskatchewan River, 1977-2002	2005

The WMF also completed an Effluent Characterization Program, which describes the monitoring and reporting requirements of point sources of industrial discharges entering the NSR in the Devon to Pakan reach. The goal is to have a better understanding of the relationship between effluent and surface water quality to better manage the cumulative effects to the NSR. The next step of the WMF is to refine and use the results from the Effluent Characterization Program to manage effluents and the cumulative effects to water quality in the NSR through load apportionment. This includes linking to established water quality triggers and limits.

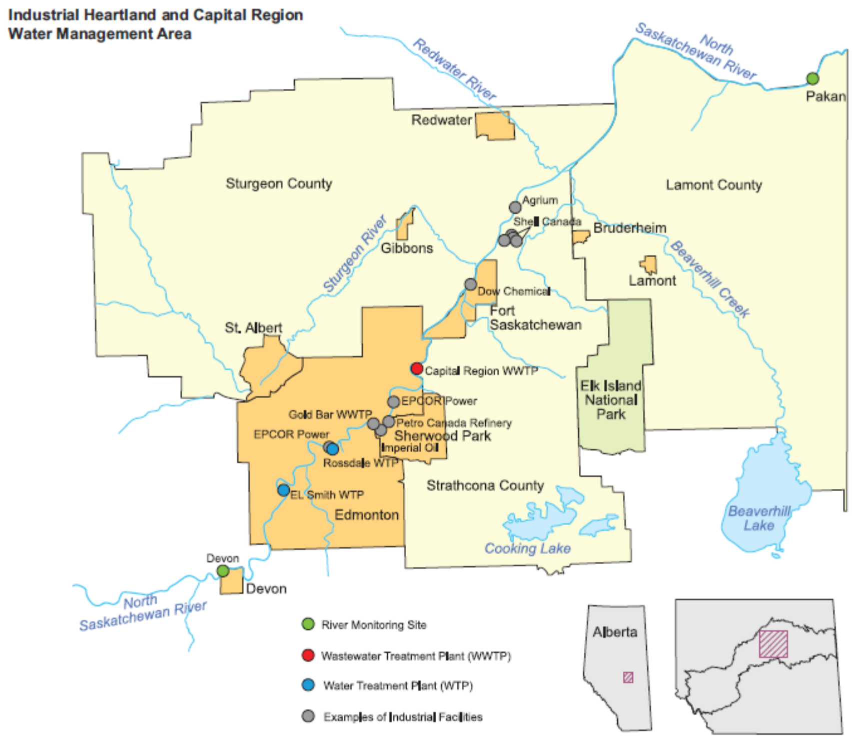


Figure 93. **Industrial Heartland and Capital Region Water Management Area (from NSWA 2012a).**

EPCOR's Watershed Protection Program

EPCOR's Watershed Protection Program (WPP) has two primary goals: to ensure a safe, secure drinking water supply through the application of source water protection principles and to ensure minimal effects from operations on water quality and aquatic ecosystem health in receiving water bodies. EPCOR recognizes that SWPP is a critical first step in a multi-barrier approach for water utilities to protect both quality and quantity of waters sources. Experience has shown the protection and proper management of the upstream watershed can improve or prevent deterioration of the quality of raw water entering treatment plants. Awareness of upstream activities also enables EPCOR to respond quickly to developing water quality issues within the watershed.

Watershed management is complex, particularly when multiple stakeholders affect land use and water quality in the upper reaches of the basin; as well when there are various landscape planning initiatives occurring at different levels of government. EPCOR's WPP works within the existing watershed management and source water frameworks, at both the federal and provincial level. The WPP has four main focus areas: watershed planning, implementation of watershed plans and programs, monitoring and research, and education and awareness. Although these focus areas are interrelated, in general, the core of EPCOR's WPP entails developing watershed planning documents, supporting the outcomes of those plans though implementation programs, developing and supporting monitoring and research programs to measure changes in selected metrics, and garnering support from watershed stakeholders.

EPCOR's Integrated Watershed Management Strategy (IWMS)

EPCOR is currently updating its Integrated Watershed Management Strategy (IWMS) as a public facing document. The intent of the IWMS is to 1) manage total loading effects on the health of the NSR and creeks and 2) to ensure source water protection for the Edmonton water supply in one unified watershed management program. The IWMS reviews the current state of planning, assessment, and implementation at multiple scales with the penultimate goal of a nested approach to watershed management. Integral to this approach is using established river outcomes to evaluate the impact of storm water, combined sewer, wastewater, and water treatment plant waste streams on the NSR and its tributaries. In this vein, once the relative influence of each source is understood the effectiveness of assessment programs and implementation and management decisions will also be evaluated. Where monitoring, modelling, or research is not adequate to determine relative contribution or effects on river or stream outcomes, recommendations will be made to fill those gaps. Although river outcomes provide the foundation from which to determine effects, we note that EPCOR is also grounded in a commitment to ensuring clean and abundant water supplies for EPCOR's WTPs and to also reduce the impact of discharges released to the NSR.

The IWMS guided the update to EPCOR's Total Loading Plan which was submitted in 2022. It replaced the previous 2009 City of Edmonton Total Loading Plan. In this plan is a commitment to protect the regional watershed, comply with regulatory requirements and surface water quality frameworks, and sustain the surface water quality by managing and limiting loadings from storm water and wastewaters collection systems.

EPCOR's Stormwater Integrated Resource Plan

To reduce flooding risks within the City of Edmonton, EPCOR developed the Stormwater Integrated Resource Plan (SIRP). SIRP is intended to reduce urban and riverine flooding events through capital and operational changes applying a risk ranking assessment based on hazards/risks related to: Health and Safety, Environment, Financial and Economic Impact and Social or Service Level impact. EPCOR developed the investment recommendations considering a mix of grey and green infrastructure components. On commercial or industrial land green infrastructure funding is targeting to highly impervious lots that are major contributors to storm collection system. The approximately $1.6 billion capital program proposed through the SIRP can be classified into five themes of investment: slow, move, secure, predict and respond. Although flooding risk is the main driver of SIRP, it is expected that water quality improvements will be made through the implementation of green infrastructure and managing surface runoff at the source. Peak flow reduction and overall stormwater volume reduction will reduce impact on urban creeks, specifically reducing bank erosion and destruction of natural drainage ways as result of land development.

The SIRP approach is to capture the stormwater volumes in dry ponds prior to reaching the storm trunk network to provide additional capacity in the pipes in the immediate path of the storm. The addition of Low Impact Development (LID) throughout the catchment area will reduce peak flow and further retain these volumes at the source and reduce the impact on the entire pipe network as storms travel across the community as well as impact on urban creeks and all natural drainage ways. The plan also includes tunnels, trunks and sewer separation in locations where, due to configuration of the community, there is limited space to install additional ponds or LID components to fully capture the expected water volumes during a major storm event. Need for additional trunks/tunnels will be re-evaluated as we progress with SIRP implementation but currently the focus is to control and reduce the inflow and utilize existing collection system to maximum through monitoring and control.

City of Edmonton

In 2012 the City of Edmonton published their River for Life Strategy (City of Edmonton 2012). The strategy committed to a number of policy objectives aimed at long-term protection of water quality of the North Saskatchewan River under its environmental strategic plan, The Way We Green (City of Edmonton 2011). At the time, the City of Edmonton's Drainage Services contributed to these objectives by developing a framework and 30 year strategic plan to reduce pollutant discharge within the watershed, with the goal of achieving net zero impact from human activities. The idea was that River for Life would consider three discharge pathways: urban runoff from storm events, combined sewer overflows, and municipal wastewater and was intended to guide the City's efforts to reduce contaminants in each pathway in the short, medium and long term. The drivers to achieve net zero impact relied on watershed planning, municipal leadership, responding to regulations, ensuring infrastructure is resilient, investing in high value resources to reduce contaminant discharges, and being proactive and innovative. Since Drainage Services joined EPCOR in 2018, River for Life has come under EPCOR's umbrella and was reviewed as part of EPCOR's Integrated Management Strategy. EPCOR has incorporated the general intent of this strategy into its Integrated Watershed Management Strategy, which is currently in development, and River for Life is now a legacy initiative.

The importance of the NSR is highlighted in the City of Edmonton's Climate Resilient Edmonton: Adaptation Strategy and Action Plan (City of Edmonton 2018), and ConnectEdmonton Strategic Plan (City of Edmonton 2019), in terms of water quality and quantity for drinking water, as well the risk of potential river flooding.

Blackmud/Whitemud Creek Surface Water Management Group

The pace of development in the Edmonton-Leduc corridor has been increasing recently and the 1200 km^2 area is expected to be developed over the next 50 years. This development will place additional stresses on Blackmud and Whitemud Creeks, which have already been impacted by previous development. In order to determine the cumulative effects of additional stormwater discharges to these creeks, the Blackmud/Whitemud Surface Water Management Group was formed. Stakeholders participating included the Leduc County, the City of Edmonton, the City of Leduc, the Town of Beaumont, Strathcona County, and the North Saskatchewan Watershed Alliance. More recently EPCOR has been involved in this group.

The group completed the Blackmud/Whitemud Creek Surface Water Management Study which involved hydrologic, hydraulic and environmental analyses of the Blackmud and Whitemud Creek basins to develop a stormwater management strategy to accommodate future development in the basin (Associated Engineering 2017). As development continues in the Blackmud and Whitemud basins, the runoff rates and volumes will increase and it is expected that flooding, erosion, and declining water quality will result unless stormwater releases are managed. Historical release rates vary across the municipalities and range from 2 to 9 L/s/ha. The key objective of this project was to prepare a Surface Water Management Plan (SWMP) in accordance with the Stormwater Management Guidelines for the Province of Alberta and the Alberta Wetland Policy, to ensure that cumulative effects on the watershed are understood and will be appropriately mitigated and managed. A final release rate of 3.0 L/s/ha was agreed upon by the group which will be achieved through a series of grey and green infrastructure projects through SIRP.

4.3.5 Industry Best Practice

Pollution Probe

Pollution Probe is a non-profit charitable organization that promotes clean air and clean water. Pollution Probe published the following document on SWP:

- "The Source Water Protection Primer". May 2004. Pollution Probe.

American Water Works Association

The American Water Works Association (AWWA) has developed numerous documents, but the most relevant and recent one for SWPP is:

- “Operational Guide to Source Water Protection”. 2016. American Water Works Association.

Water Research Foundation

The Water Research Foundation (WRF) is research organization that focuses on advancing research in water quality, water treatment, stormwater and wastewater. WRF has published over 200 studies on various aspects of source water protection, including climate change, contaminants of emerging concern, pathogens, cyanotoxins, stormwater, watershed management and risk assessment.

EPCOR

SECTION 5 – EPCOR'S EDMONTON SWPP GOALS

The goals of this Source Water Protection Plan are as follows:

1. Protect public health by ensuring the safety and reliability of the drinking water supply.
2. Establish a risk-based approach in setting priorities when creating action plans and determining the focus of watershed management plans.
3. Support and participate in aquatic health, water quality, and water quantity monitoring initiatives in the watershed and research opportunities.
4. Encourage stricter effluent discharge criteria of municipal sewage effluent through support of monitoring and load apportionment frameworks.
5. Support and encourage implementation of agricultural Best Management Practices focusing on industrial, agricultural, and urban land use.
6. Promote and participate in technical studies and influencing regulators with respect to best management practices and policy development (agriculture, forestry, and oil and gas development sites).
7. Ensure there is excellent communication between AEP, AER, the City of Edmonton Fire Departments, and EPCOR Drainage on notification of spills and releases that may influence the operation of the WTPs.
8. Support and participate in understanding and mitigating risks from pipelines in the watershed and the possible purposeful contamination of intakes.
9. Participate in technical studies to determine the effects of climate change on the watershed and the water supply, terms of both quantity and quality.
10. Promote environmental stewardship through educational programs and collaborative initiatives.
11. Support watershed planning and policy through participation on Watershed Planning and Advisory Councils (NSWA), Alberta Water Council, Regional Planning, Water Management Frameworks, stewardship groups, and other water and watershed planning initiatives.

SECTION 6 – EPCOR'S EDMONTON SWPP ACTION PLAN AND PROGRAM RESULTS

EPCOR's Source Water Protection Plan has identified the following actions needed to mitigate existing and future threats to the quality of the NSR. As well, program results or initiatives are included along with some identified barriers and challenges. In general, the watershed planning component of Source Water Protection Planning leverages already established frameworks in Alberta. These frameworks and initiatives have their unique challenges, but EPCOR understands that working within existing water and watershed planning frameworks is beneficial in the long-term and will likely result in better source water protection outcomes.

<table>
<tr><th></th><th>Actions</th><th>Program Results</th></tr>
<tr><td rowspan="8">Planning</td><td>Alberta Water Council: Work with the Alberta Water Council on the development of water policy that aligns with SWPP goals.</td><td>Co-chaired the Protecting Sources of Drinking Water in Alberta: Guide to Source Water Protection Planning project team.

Co-chairing the Source Water Protection Risk Assessment Tools and Data Working Group

Past: On Non-Point Source Pollution, Lake Management, Riparian Health Project Teams</td></tr>
<tr><td colspan="2">Challenges and Barriers: Recommendations from Project Team reports are often not implemented by GoA</td></tr>
<tr><td>Watershed Planning Groups: Continue leadership on watershed and water management through support of existing watershed planning initiatives.</td><td>NSWA Board member, Strategic Planning and Priority Committee member, Headwater Alliance TAC member, and Urban Creeks Collaborative member.

Co-chairing the Industrial Heartland and Capital Region Water Management Framework Advisory Committee and Member of the Technical Committee</td></tr>
<tr><td colspan="2">Challenges and Barriers: NSWA lacks the authority to implement aspects of the plan and land and water planning continues to be disjointed provincially. Data is not sufficient to allow for site specific water quality objectives. Pilot water quality objectives and load apportionment work is lagging.</td></tr>
<tr><td>Spill Management: Develop a spill management and communication plan with regular internal and external drills to ensure communication lines are operational.</td><td>Training and drills occur within EPCOR and regular meetings with GoA take place to ensure lines of communication remain open

Maintenance of a ‘time of travel’ calculation tool in case of spill that will allow operations to determine how soon the spill will reach Edmonton. Has been incorporated into the THREATs tool.

Worked with the City of Edmonton, AEP and their Alberta Environment Support and Emergency Response Team, AER and the Environmental Hotline.</td></tr>
<tr><td colspan="2">Challenges and Barriers: Pipeline GIS data are difficult to obtain, and raw data files are time consuming to remove overlapping layers.</td></tr>
<tr><td>Climate Change Planning: Continue to fund and support research on how climate change will impact source water quality and quantity</td><td>Continued implementation of EPCOR’s Climate Change Adaptation Strategy and 2025 update to include the water cycle.

Financially supported research conducted by the Prairie Adaptation Research Collaborative to better understand the historical variability of the NSR and future runoff scenarios and U of A Groundwater Research understanding climate effects</td></tr>
<tr><td colspan="2">Challenges and Barriers: Data needs to be integrated into future scenarios and communication across stakeholders on effects of climate change</td></tr>
</table>

Monitoring and Modelling	**Monitoring and Modelling**: Support water quality monitoring and modelling on the NSR to quantify and understand non-point source and point source pollution (with a focus on pathogens, organic matter, and sediment). Modelling would be basin wide and investigate changing land cover and land use impacts on tributary and river water quality and quantity. Continue to work with the EPCOR Drainage on quantifying and managing storm water inputs on the NSR and the Integrated Watershed Management Strategy and Storm Water Integrated Resource Plan.	SaskWatch Monitoring Program: A tributary and mainstem monitoring program for the watershed lead by EPCOR in partnership with the City of Edmonton, NSWA, CreekWatch and AEP. Supported the development of a hydrological model for the basin with WaterSMART which was led by the NSWA. Continued implementation and refinement of Modelling Strategy for the NSR with AEP, City of Edmonton, and NSWA. Developing an urban watershed model to predict future storm water loads using PCSWMM. Complete the Edmonton Monitoring Program that measures water quality and flow at storm outfalls and WWTPs and estimates loads for the whole system.
	Challenges and Barriers: Modelling work is underfunded and priority is based on current pressures not long-term planning. Internal resourcing for a designated watershed modeller	
Research	**Research:** Continued support of research that enhances watershed science and knowledge.	*for*Water Project: financial support for the understanding of how forest management practices and events such as forest fires will impact the quality and treatability of source water for drinking water. Groundwater Research: financial support for University of Alberta led work on contribution of groundwater to the NSR including a groundwater model for the City of Edmonton. Ice Core Study: financial support for University of Alberta led work on ice-core analysis of PFAS and other deposited organic contaminants in upstream glaciers Integrated Modelling for Watershed Evaluations of BMPs: financial and technical support for University of Guelph led work to develop imWEBs model to assess the impacts of BMPs to water quality and quantity in Modeste and Strawberry Creek PARC: financial support for University of Regina work on projections of future flows in the NSR under future climate scenarios and historical variability
	Challenges and Barriers: Linking research to planning at the urban and watershed scale is difficult because of the complexity of these systems.	

Implementation	**Implementation**: Continue to promote agricultural and urban BMPs to mitigate movement of contaminants to the NSR, for example through the Strawberry Creek Pilot Project or IMWEBs work.	Continued to promote agricultural and urban BMPs to mitigate movement of contaminants to the NSR through work on through financial contributions to Clearwater Landcare and other stewardship groups that target the preservation of natural assets.
	Challenges and Barriers: There is a lack of a landscape level model that measures beneficial management effectiveness at the basin scale and links to source water quality. As well there is not a market for green infrastructure because they are not considered assets in the typical way.	
Education	**Education and Awareness**: Continue to foster and support educational programs focused on watershed stewardship and expanding water quality knowledge.	Financial support of RiverWatch/CreekWatch Support EPCOR's Glass of the Sask Program Developed an NSR River documentary
	Challenges and Barriers: Need to improve consistent communication to stakeholders within EPCOR	

SECTION 7 - PERIODIC EVALUATION AND REVISION

A review and evaluation of this SWPP will be conducted in an evergreen fashion and will be updated as the Drinking Water Safety Plan is updated annually. The purpose of the review will be to ensure changes which may affect the SWPP are recognized and captured. Those factors which should be considered in the evaluation are listed below:

- Source water delineation
- Risks (frequency and consequences)
- New regulatory initiatives
- Research, data and new results
- Implementation of study recommendations
- New watershed planning documents
- Significant incidents
- Performance of programs and initiatives

The evaluation of the SWPP and associated action plans will be based on the suitability, effectiveness and adequacy with respect to the following:

- Source Water Protection Vision
- Characterization of Watershed
- Implementation of Action Plan

The review and evaluation process should be used as the basis to continually improve the Plan while ensuring it remains current.

SECTION 7 - VERIFICATION

EPCOR will maintain adequate records and documents of its SWPP. These records shall include the following:

- Summaries and minutes of stakeholder meetings
- Minutes of any relevant public hearings with respect to the SWPP
- Technical studies
- Monitoring data
- Any other documents that support or are related to the SWPP

SECTION 8 – REFERENCES

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