2021 Status of surface water quantity, Lower Athabasca Region, Alberta

Reporting on the Lower Athabasca Region Surface Water Quantity Management Framework for January 2021– December 2021

Alberta

2021 Status of Surface Water Quantity, Lower Athabasca Region, Alberta

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Alberta's Environmental Science Program

The Chief Scientist has a legislated responsibility for developing and implementing Alberta's environmental science program for monitoring, evaluation and reporting on the condition of the environment in Alberta. The program seeks to meet the environmental information needs of multiple users in order to inform policy and decision-making processes. Two independent advisory panels, the Science Advisory Panel and the Indigenous Wisdom Advisory Panel, periodically review the integrity of the program and provide strategic advice on the respectful braiding of Indigenous Knowledge with conventional scientific knowledge.

Alberta's environmental science program is grounded in the principles of:

- Openness and Transparency. Appropriate standards, procedures, and methodologies are employed and findings are reported in an open, honest and accountable manner.
- Credibility. Quality in the data and information are upheld through a comprehensive Quality Assurance and Quality Control program that invokes peer review processes when needed.
- Scientific Integrity. Standards, professional values, and practices of the scientific community are adopted to produce objective and reproducible investigations.
- Accessible Monitoring Data and Science. Scientifically-informed decision making is enabled through the public reporting of monitoring data and scientific findings in a timely, accessible, unaltered and unfettered manner.
- Respect. A multiple evidence-based approach is valued to generate an improved understanding of the condition of the environment, achieved through the braiding of multiple knowledge systems, including Indigenous Knowledge, together with science.

Learn more about the condition of Alberta's environment at: environmentalmonitoring.alberta.ca.

Acknowledgements

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Reviewer 1 holds a Ph.D. in Water Resources Engineering, is a registered Professional Engineer in Alberta (P.Eng.) and has over 20 years of combined experience in water resources engineering practice (hydrology, hydraulics, and municipal engineering studies), management, research, and instrument set-up.

Reviewer 2 holds a MSc. in Environmental Engineering and is a registered Professional Engineer in Alberta (P.Eng). The reviewer has over 10 years of experience working in cumulative effects management and the development and implementation of environmental management frameworks with the Government of Alberta. She is currently leading a team of Government of Alberta scientists responsible for the monitoring, evaluation and reporting on the condition of Alberta's water resources.

Reviewer 3 holds a M.A. in Geography and has more than 15 years of experience working in water resources and environmental policy, planning, and management. The reviewer is currently in a leadership role in the development and implementation of environmental management frameworks.

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

EPA	Alberta Environment and Protected Areas
AER	Alberta Energy Regulator
ANI	Preliminary Aboriginal Navigation Index
LARP	Lower Athabasca Regional Plan
RSD	Resource Stewardship Division
The Framework	Lower Athabasca Region Surface Water Quantity Management Framework for the Lower Athabasca River
TDL	Temporary Diversion Licence
WSC	Water Survey of Canada
WURS	Alberta's Water Use Reporting System

Executive Summary

Background

The Lower Athabasca Region Surface Water Quantity Management Framework for the Lower Athabasca River (the Framework) came into effect on October 29, 2015. The Framework establishes weekly management triggers and water withdrawal limits to enable proactive management of mineable oil sands water use from the Lower Athabasca River. The Framework also includes a series of adaptive management triggers that will signal when river flow and water use conditions are close to, or outside of, the range of predicted future conditions used in modelling and development of the weekly management triggers and water withdrawal limits.

This report presents a summary of 2021 streamflow on the Lower Athabasca River and water use by the mineable oil sands sector and other licenced users, relative to weekly management limits, and provides analyses of six of the seven adaptive management triggers. This evaluation fulfills commitments for public reporting outlined in the Framework.

2021 Results Summary

- Water withdrawal for mineable oil sands in 2021 were below limits established by the Framework
- River flow and water use were within the range of future conditions used in development of the Framework
- Water withdrawals for mineable oil sands in 2021 were below the trigger for the preliminary Aboriginal Navigation Index

Introduction

The Lower Athabasca Region Surface Water Quantity Management Framework for the Lower Athabasca River (the Framework) came into effect on October 29, 2015, after the Government of Alberta committed to completing the Framework in the Lower Athabasca Regional Plan. The objective is to manage cumulative water withdrawals to support both human and ecosystem needs, while balancing social, environmental, and economic interests. The Framework is the second step of a two-phased approach replacing Phase 1 *Water Management Framework: Instream Flows Needs and Water Management System for the Lower Athabasca River* (Alberta Environment and Fisheries and Oceans Canada 2007). The Framework augments and complements existing policies and legislation and is consistent with other provincial policies, strategies, and frameworks, and with the stated desired outcomes for the region.

The Framework relies on two types of tools in establishing the need for and nature of a management response – weekly management triggers and associated water withdrawal limits, and indicators with associated adaptive management triggers. Weekly management triggers and water withdrawal limits only pertain to the mineable oil sands sector. They are implemented by the Alberta Energy Regulator (AER) to enable proactive management of mineable oil sands water use from the Athabasca River. The Framework establishes weekly limits to water withdrawals and how these limits decrease with streamflow according to the weekly management triggers. Indicators and adaptive management triggers pertain to all licenced water users. Indicators provide information and track changes over time on streamflow, overall licenced water use, Aboriginal navigation or ecosystem status. These indicators inform adaptive management triggers that if crossed prompt a management response (see Figure 8 in the Framework). Adaptive management triggers indicate when streamflow and/or water use are outside predicted future conditions used when developing the weekly management triggers and water withdrawal limits. Adaptive management triggers also assess whether impacts to Aboriginal navigation or ecosystem status exceed changes predicted to occur from the Framework.

Evaluation of the management triggers and water withdrawal limits is completed for every calendar year. This report presents flow conditions in the Athabasca River and water use by the mineable oil sands sector, relative to weekly management triggers and water withdrawal limits, and analyses of six of the Framework's seven adaptive management triggers. The seventh adaptive management trigger, which aims to relate ecological function and status to surface water quantity, is still under development.

There is ongoing work to address ecological knowledge gaps that were identified throughout the development of the Lower Athabasca Region Surface Water Quantity Management Framework for the Lower Athabasca River. The objectives for the knowledge gaps are to address uncertainties with the Framework that could not be answered due to limited data and evaluate how withdrawal limits from the surface water affect the ecosystem health and sustainable development of the region. A summary report outlining the current status of ecological knowledge gaps is in progress.

The evaluation covers January 1 to December 31, 2021 and fulfills commitments for public reporting outlined in the Framework.

Lower Athabasca Region

The Lower Athabasca Regional Plan (LARP) was developed by the Government of Alberta in 2012, under the Land Use Framework (Government of Alberta, 2008). The Lower Athabasca Region covers approximately 93,212 km^2 in northeastern Alberta (Figure 1). The LARP identifies strategic directions aligned with a long-term vision for the region that includes economic, environmental, and social goals, and establishes monitoring, evaluation, and reporting commitments. The plan is given legislative authority under the *Alberta Land Stewardship Act* (Government of Alberta, 2009), and aligns with key pieces of provincial legislation and strategies.

The Resource Stewardship Division (RSD) of Alberta Environment and Protected Areas (EPA) is responsible for the monitoring, evaluation and reporting on the condition of the environment, and developing management actions in the Lower Athabasca Region, while other divisions of the Government of Alberta and regulators are responsible for management of activities and resources in response to environmental conditions.

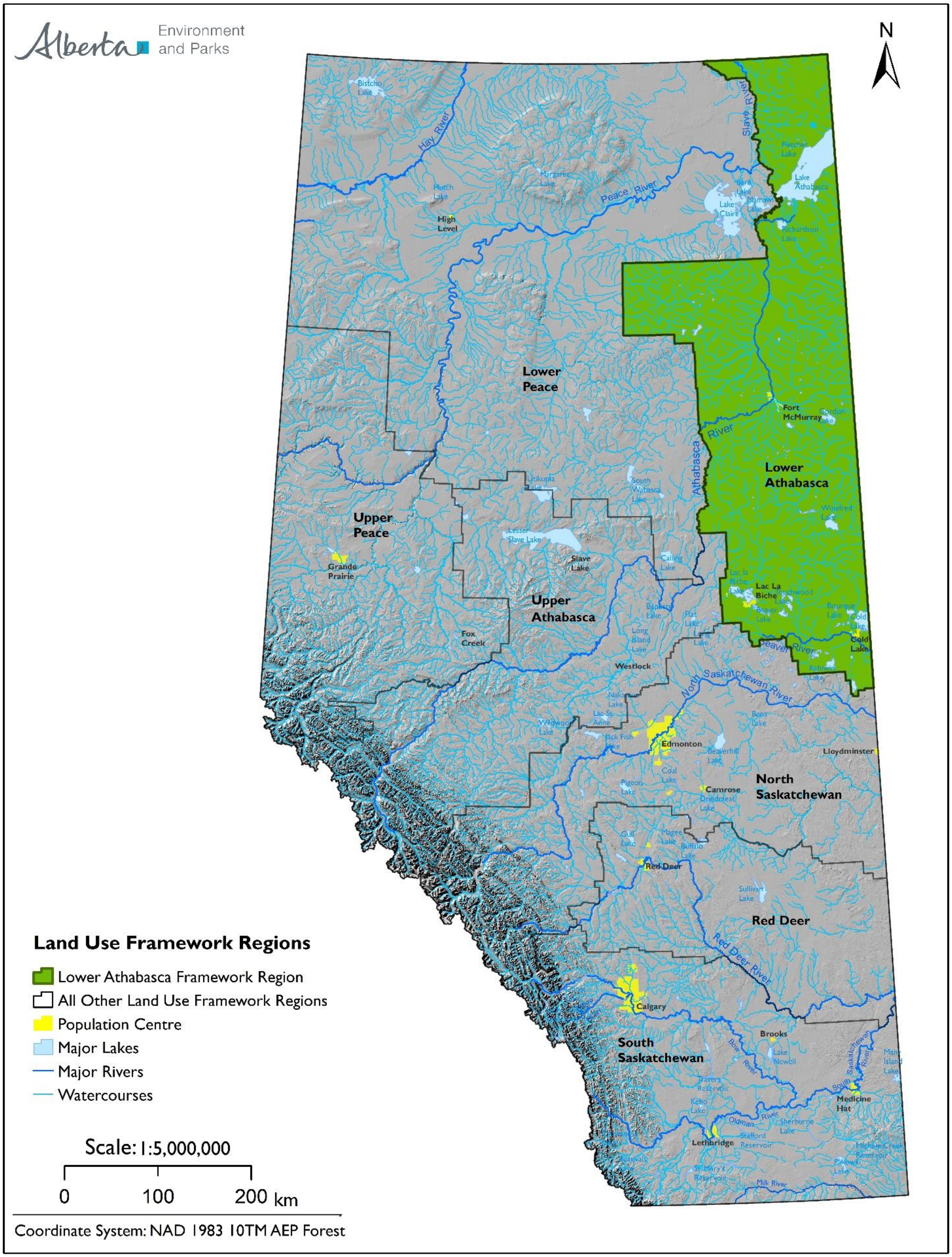

Figure 1: Location of the seven Land Use Framework Regions in Alberta. The Lower Athabasca Region is the area shaded in green on the map.

Data Sources

Implementation of and reporting on the Framework requires a variety of data, including both reported and modelled streamflow, water allocation and use data from the mineable oil sands sector and other licenced users.

Official verified mean daily flow rates for the Athabasca River reported at the Water Survey of Canada (WSC) Fort McMurray station (historic hydrometric data for 07DA001 "Athabasca River below Fort McMurray") are used to evaluate adaptive management triggers. This hydrometric station has been monitored continuously since 1957 and is located below Fort McMurray, downstream of the confluence with the Clearwater River and upstream of all water withdrawals by the oil sands sector (Figure 2). Streamflow on the Athabasca River at Fort McMurray represents the integration of upstream hydroclimatic conditions, including rainfall, snowmelt, and glacier melt, as well as groundwater fluxes (Marshall *et al.* 2011; Peters *et al.* 2013; Bawden *et al.* 2014; Gibson *et al*. 2016), and upstream withdrawals and returns.

Official verified flows from the WSC at the Fort McMurray station are not available in real time to determine water withdrawal limits. Therefore, weekly management triggers and cumulative withdrawal limits are evaluated using weekly flow estimates calculated by EPA. Weekly flow estimates are provided by EPA to mineable oil sands operators, the AER, and the public, through the Athabasca River Conditions and Use website at the start of each week. These weekly flow estimates are based on the best information available at the time and are used to determine the applicable cumulative water withdrawal limit for a given week. They do not necessarily represent a weekly average flow estimate for the week or flow forecast for the following week, i.e. the flow estimate available as close as possible to the beginning of the week is used as the weekly flow. The Operational policy: lower Athabasca River weekly flows provides additional information on the process for the determination, communication, and application of weekly flows that is used in the implementation of the Framework's weekly management triggers and water withdrawal limits.

Surface water allocations from the Athabasca River Basin are specified in *Water Act* licences, which are required by all significant water users. The licence data is contained in the Alberta Environment and Protected Areas Environmental Management System (EMS). Actual water use data is reported by oil sands operators and other major water users (e.g. forestry, water management) to Alberta's Water Use Reporting System (WURS) according to the condition specified in their licences. Annual water use for all reporting licences upstream of the Fort McMurray station is extracted from WURS and used to calculate the upstream water use adaptive management trigger. Daily water use by mineable oil sands operators is extracted from WURS and used to calculate weekly average values, and the range of minimum and maximum daily withdrawal rates each week, and evaluate weekly management triggers and cumulative withdrawal limits. Some licence-holders are not required to report their use.

Under the *Water Act*, two types of water licences can be issued: multiyear term licences and Temporary Diversion Licences (TDLs). TDLs provide authority for diverting and using water for a maximum of one year. Typically, TDLs are issued when there is a need for a short-term water diversion and use for emergency water supply, dust control and bridge washing, drilling oil and gas wells, and possibly other short term uses. Efforts are currently being made to consider the contributions of TDLs for annual reporting, and estimations of TDL water use for oil sands water use related metrics are provided in

It should be noted that at the time the Framework was developed, term licences represented the vast majority of water withdrawals compared to TDLs (similar to current situation). Estimation of usage by TDLs was challenging due to differences in reporting intervals, and the presence of non-reporting TDLs.

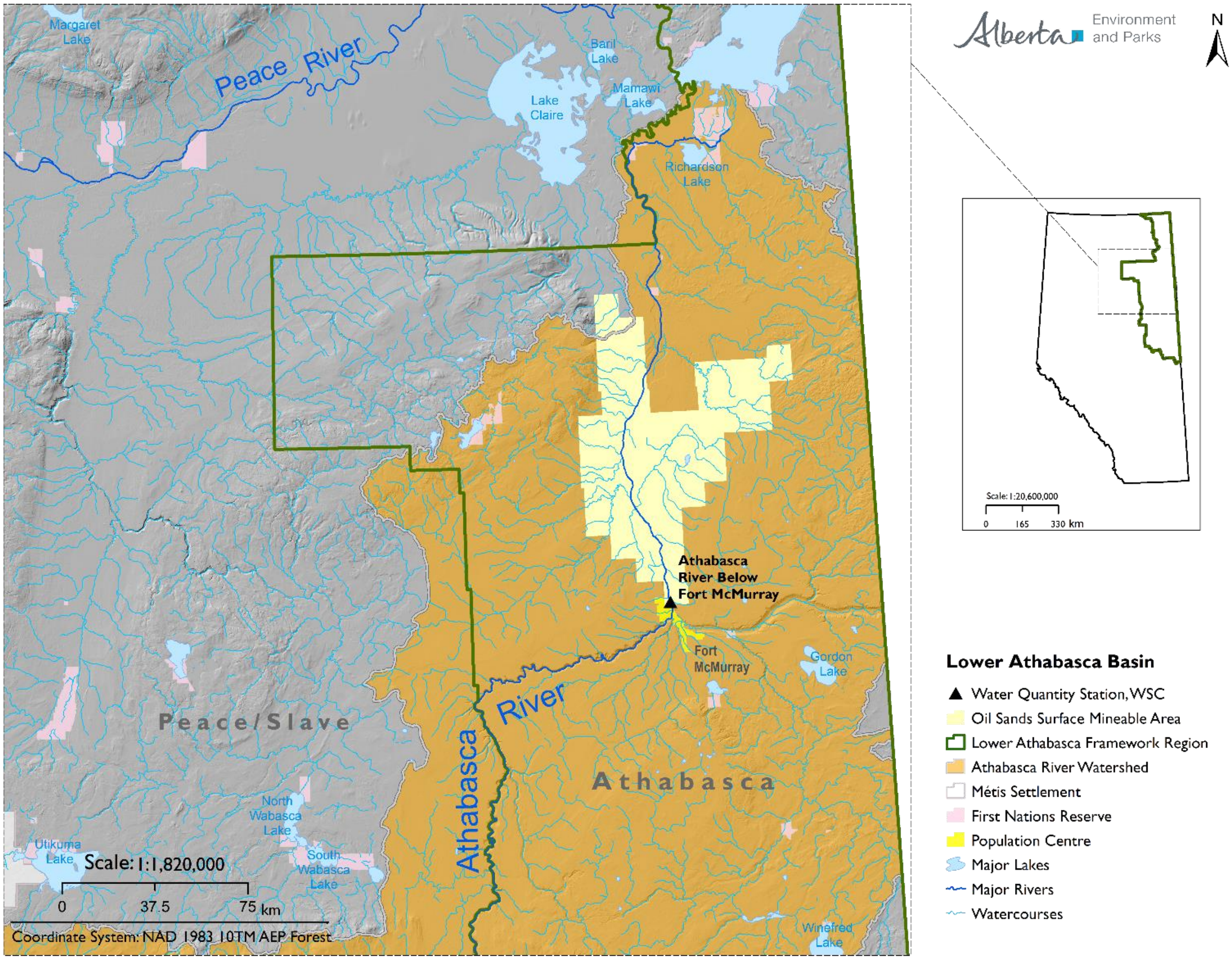

Figure 2: Location of Water Survey of Canada Fort McMurray station (WSC gauge 07DA001 "Athabasca River below Fort McMurray") in the Lower Athabasca Region of Alberta

2021 Hydroclimatic Conditions

The following hydroclimatic summary, for the Athabasca River basin, of 2021 conditions provides context to flows reported under the Framework. The 2021 reporting period was characterized by below average streamflow for most of the year except for spring freshet and early winter flows (Figure 3). Streamflow largely fell within the range of the 25th and 75th percentiles except for a short period during the spring in which flows exceeded the 75th percentile and late summer in which flows were lower than the 25th percentile. Spring snowpack in the mountain headwater region was above average, while the plains was below average (https://rivers.alberta.ca). Water year precipitation (November 1, 2020 to November 1, 2021) was below average at 20 stations in the Athabasca River basin, ranging from 60-100% of normal, and above average at one station in the upper Athabasca, at 109% of normal (Figure 4).

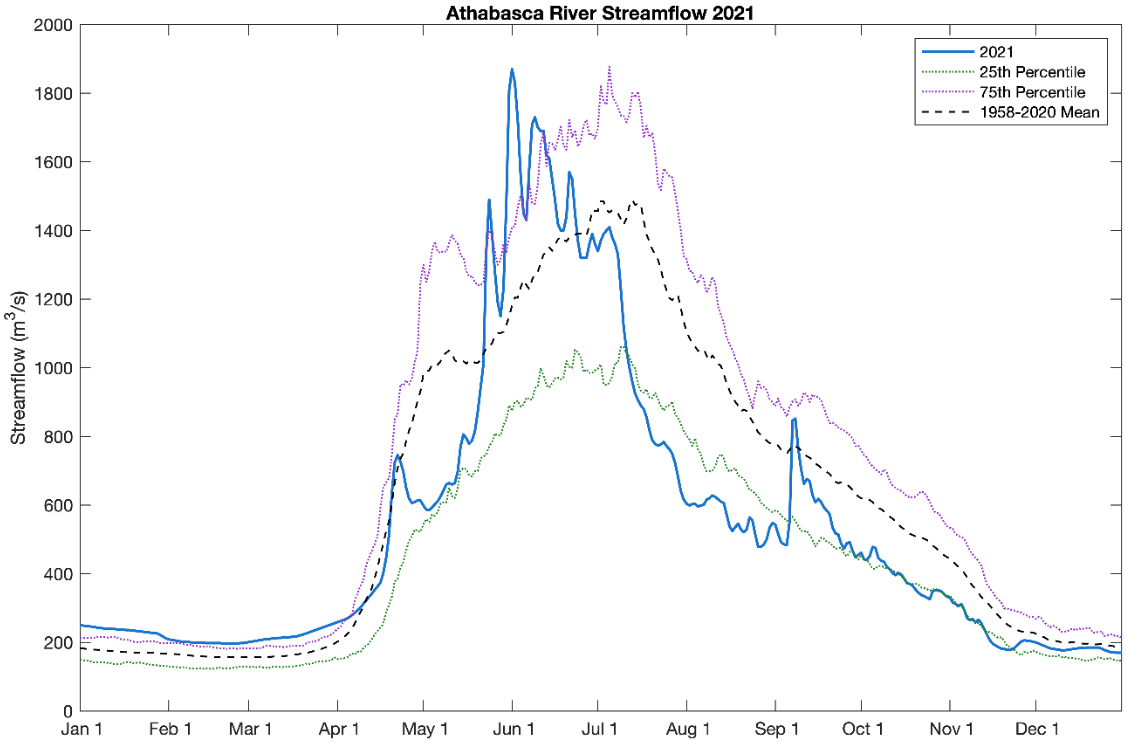

Figure 3: Daily streamflow on the Athabasca River below Fort McMurray for Jan 1 to Dec 31, 2021, referenced against long-term mean, 25th, and 75th percentiles

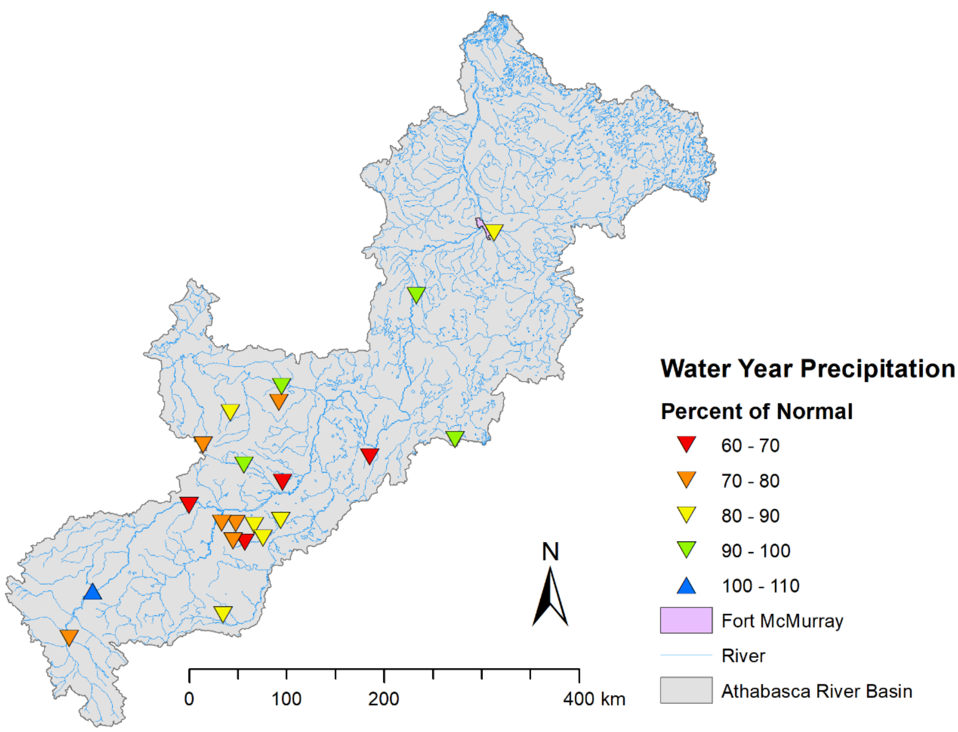

Figure 4: Water year (Nov 1, 2020 to Nov 1, 2021) precipitation as a percent of 30-year normal at climate stations in the Athabasca River Basin. Twenty of 21 stations reported below average precipitation.

Weekly and Adaptive Management Triggers Overview

The weekly management triggers and withdrawal limits established in the Framework set the maximum cumulative water withdrawals permitted by mineable oil sands operators from the Athabasca River. The weekly management triggers and water withdrawal limits are divided into five seasons: Mid-Winter, Early Spring, Late Spring, Summer/Fall, and Early Winter. Each of these seasons has distinct weekly flow triggers and corresponding cumulative water withdrawal limits. The weekly triggers and limits are implemented and tracked by the AER.

Adaptive management triggers signal when river flow and water use conditions are close to the bounds of, or outside of, the range of predicted future conditions derived from modelling and used in the development of the weekly management triggers and water withdrawal limits.

Seven adaptive management triggers are included in the Framework, the first six of which are included in this report:

1. Upstream water use
2. Changes to long-term seasonal flow in the Athabasca River
3. Changes to oil sands water use
4. Cumulative oil sands water use, relative to weekly flow
5. High oil sands water use during low summer/fall flows
6. Preliminary Aboriginal Navigation Index (ANI)
7. Ecological indicators and triggers (under development)

Adaptive management triggers 1 and 2 indicate a change in background conditions relevant to the Framework. Adaptive management triggers 3-5 assess increased demand on water use for mineable oil sands either annually or seasonally from that projected during Framework development. Adaptive management triggers 6 and 7 indicate whether social or environmental impacts from the Framework are greater than expected.

Weekly Management Triggers and Cumulative Withdrawal Limits

The AER tracks and reports annually on the performance of mineable oil sands operators relative to the weekly water withdrawal limits identified in the Framework. These limits are cumulative in that they represent the total permitted withdrawal by oil sands operators, combined, each week, based on flow estimates provided by EPA (Table 1). Water withdrawals remained below these limits for the reporting period, January 1 to December 31, 2021, and have not exceeded weekly withdrawal limits since the implementation of the management framework in October 2015.

Weekly flows and associated water withdrawal limits are given in Figure 5. Streamflow and withdrawal limits are lowest during the winter period when precipitation is falling as snow and the river is ice-covered, and are highest during the spring and summer. Weekly withdrawal limits compared to actual water use are shown in Figure 6 and provided in tabular form in Appendix A. The range between maximum and minimum combined daily withdrawals within each week are shown in grey shading in Figure 6. While streamflow and withdrawal limits fluctuate seasonally, actual water withdrawals remain within a limited range of variability throughout the year (2.4 to 4.6 m^3/s). At most, the maximum cumulative daily withdrawal rate is 5.3 m3/s, or 33% of the associated limit for that week.

Oil sands operators using water from the Lower Athabasca River develop and submit annual Oil Sands Mining Water Management Agreements by November 1 of each year as identified in the Framework. Two water management agreements covering 2021 were delivered by the mineable oil sands operators (agreements for the 2020-2021 and 2021-2022 periods). These agreements specify the share of the available water for each of the individual mine operators during different seasons and under different streamflow conditions for the upcoming year to ensure that the weekly cumulative water withdrawal limits under the Framework are not exceeded.

Inclusion of mineable oil sands related TDLs is not included in these calculations, but are considered and reported in separately, under Appendix B: Inclusion of Temporary Diversion Licences.

TABLE 1: WEEKLY FLOW TRIGGERS AND CUMULATIVE WATER USE LIMITS ON THE LOWER ATHABASCA RIVER FOR MINEABLE OIL SANDS OPERATIONS

Mid-Winter (January 1 to April 15) Weeks 1-15	
Weekly Flow Triggers (m^3/s)	Cumulative Water Withdrawal Limits
more than 270 m^3/s	16 m^3/s
150 to 270 m^3/s	6% of Weekly Flow
91.6 to 150 m^3/s	9 m^3/s
87 to 91.6 m^3/s	Weekly Flow minus 82.6 m^3/s
less than 87 m^3/s	4.4. m^3/s

Early Spring (April 16 to May 6) Weeks 16-18	
Weekly Flow Triggers (m^3/s)	Cumulative Water Withdrawal Limits
more than 98.6 m^3/s	16 m^3/s
87 to 98.6 m^3/s	Weekly Flow minus 82.6 m^3/s
less than 87 m^3/s	4.4. m^3/s

Late Spring (May 7 to June 10) Weeks 19-23	
Weekly Flow Triggers (m^3/s)	Cumulative Water Withdrawal Limits
more than 102.6 m^3/s	20 m^3/s
87 to 102.6 m^3/s	Weekly Flow minus 82.6 m^3/s
less than 87 m^3/s	4.4. m^3/s

Summer/Fall (June 11 to October 28) Weeks 24-43	
Weekly Flow Triggers (m^3/s)	Cumulative Water Withdrawal Limits
more than 111.6 m^3/s	29 m^3/s
87 to 111.6 m^3/s	Weekly Flow minus 82.6 m^3/s
less than 87 m^3/s	4.4. m^3/s

Early Winter (October 29 to December 31) Weeks 44-52	
Weekly Flow Triggers (m^3/s)	Cumulative Water Withdrawal Limits
more than 200 m^3/s	16 m^3/s
150 to 200 m^3/s	8% of Weekly Flow
94.6 to 150 m^3/s	12 m^3/s
87 to 94.6 m^3/s	Weekly Flow minus 82.6 m^3/s
less than 87 m^3/s	4.4. m^3/s

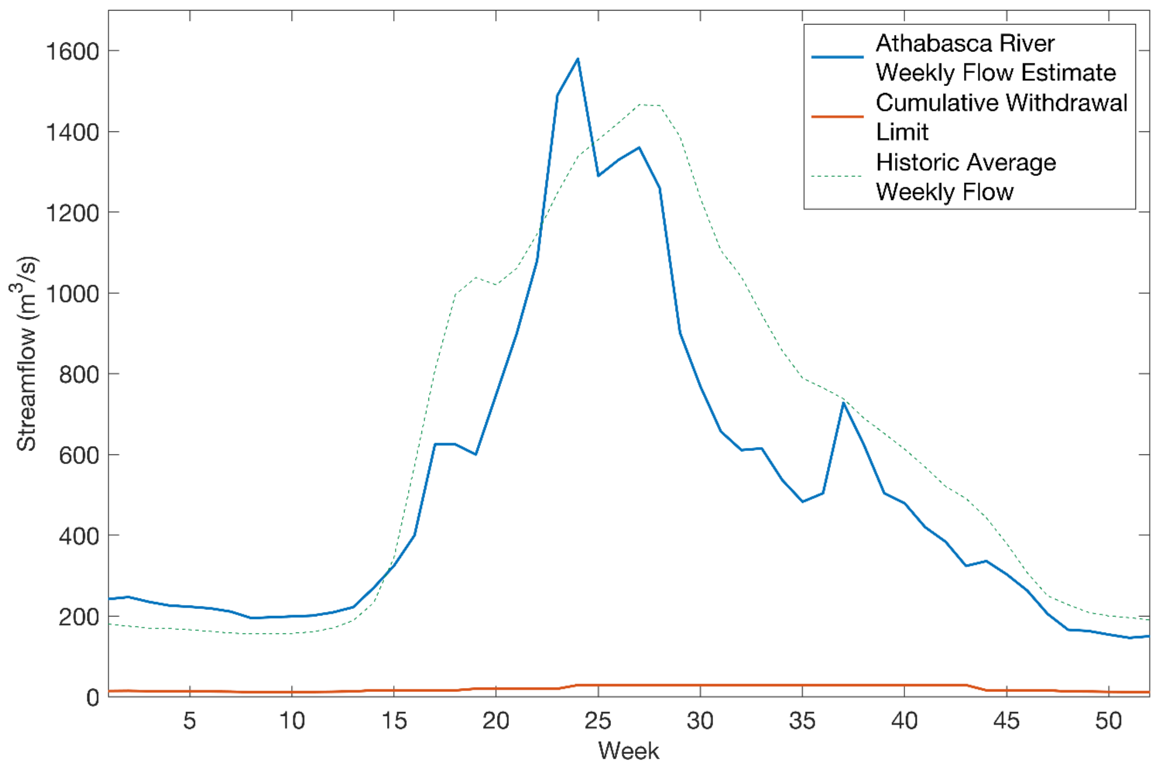

Figure 5: Mean weekly streamflow, weekly withdrawal limits from January 1 to December 31, 2021, and long-term historic (1957-2020) average weekly streamflow. Cumulative withdrawal limits represent the combined total permitted water withdrawal by oil sands operators each week, and are determined by weekly streamflow estimates provided by EPA. In 2021, cumulative withdrawal limits ranged from 11.7 m^3/s in late February to 29 m^3/s during summer and fall.

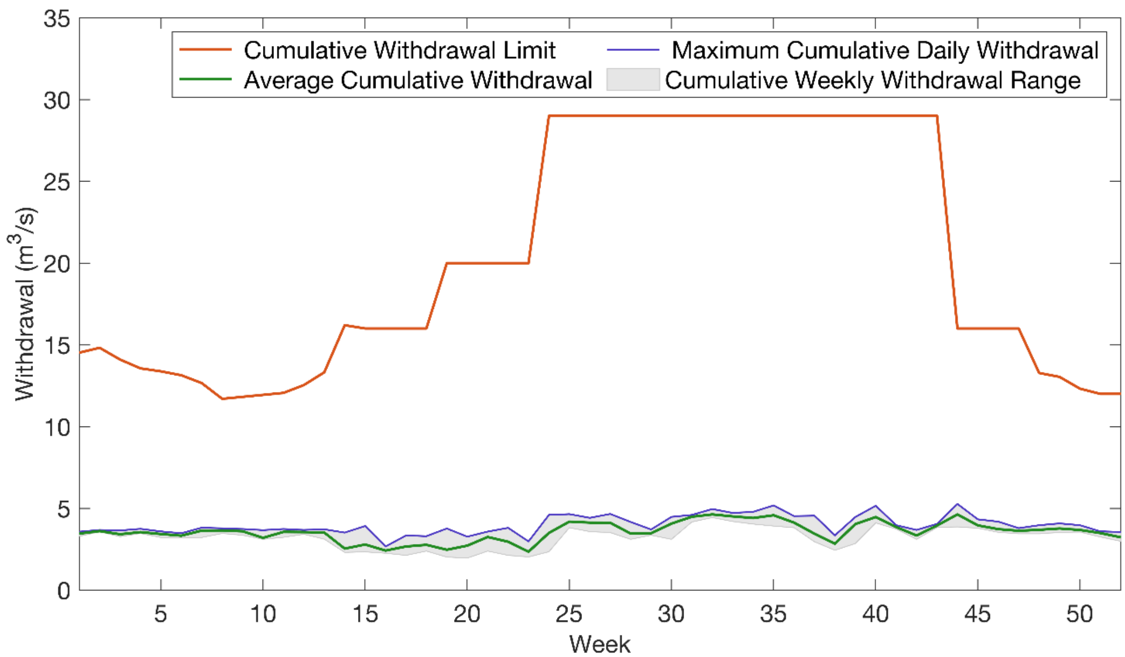

Figure 6: Cumulative withdrawal rates from January 1 to December 31, 2021. The green line represents the average cumulative withdrawal for the week, the grey shaded region represents the range between the lowest and highest daily withdrawals for that week, and the purple line indicates the maximum daily withdrawal within that week.

Adaptive Management Triggers

Adaptive management triggers are designed to indicate when river flow or water use conditions are close to the bounds of or outside of the modelled predictions used to develop the Framework. Results of six of the seven adaptive management triggers for 2021 are summarized below. The seventh trigger, relating ecological function to surface water quantity, is under development.

Upstream Water Use

Trigger exceedance occurs when:

- Net water allocation[1] upstream of Fort McMurray reaches or exceeds 160 million m^3/year (approximately 5 m^3/s).
- Actual reported net water use upstream of Fort McMurray reaches or exceeds 60 million m^3/year (approximately 2 m^3/s).

The upstream water use trigger is intended to indicate if upstream water use begins to affect the degree to which flow measurements in the Athabasca River below Fort McMurray approximate natural flows. Water licences in the region exist for a variety of purposes, including recreation (e.g. parks and golf courses), agriculture, forestry, urban or municipal, and water or environmental management (e.g. flood control, lake stabilization, and wetlands). At present, all water allocation users are considered in the calculation of the upstream water use trigger. Licences for wetlands and lake level stabilizations represent water loss by evaporation rather than water diversions. Total water allocations and usage with and without the inclusion of these licence categories is given in Appendix C.

In 2021, the gross water allocation upstream of Fort McMurray was 263 million m^3, with 162 million m^3 of this volume required to be returned to the river after use. This equates to a net water allocation of 101 million m^3 which is less than the 160 million m^3 allocation trigger. This is the same value as the 2020 net water allocation, and is similar to previous years.

Licence holders representing approximately 87% of the total allocated volume upstream of Fort McMurray in 2021 are required to report water use under the terms of their licences. Actual water use information is not available for the remaining 13% of the total allocation volume. The non-reporting users represent a significant water allocation volume and it is critical to account for this water use to best estimate actual net water use. The calculation of actual reported net water use, and consequently, the evaluation of this trigger exceedance, relies on estimations regarding the non-reporting users. The most consistent approach (as used in all previous reporting periods) bases actual reported net water use calculations on the assumption that non-reporting users utilized and returned water at the same ratios as the reporting users.

In 2021, the gross allocation for licence holders reporting water use was 228 million m^3 and return volume was 153 million m^3, whereas non-reporting licence represented 35 million m^3 allocation and 9 million m^3 return volume. Licence holders reporting water use utilized 48% of their total allocated diversion volume and returned 61% of their allocated return volume. Applying these utilization and return ratios to the non-reporting licence holders results in an estimated gross upstream diversion of 126 million m^3, an estimated actual return flow of 100 million m^3, and the estimated net upstream water use is 26 million m^3, which is below the 60 million m^3 water use trigger. This is similar to 2020 in which net water use was 28 million m^3. There is uncertainty associated with non-reporting users, and as such, the net upstream water use may be higher or lower than the calculated estimate. As an example, a range of 25% higher or lower than the ratio reporting users utilized and returned water was calculated. This estimates a net upstream water use range of 20 to 33 million m^3, which still remain below the 60 million m^3 trigger threshold. It is recognized that the methodology used to calculate net water use of non-reporting licence holders requires refinement and a scientific review of calculation methods is ongoing.

Based on the above calculations, the Upstream Water Use trigger was not exceeded in 2021.

[1] Water allocations do not directly reflect actual water use. Rather, an allocation volume represents the maximum amount of water granted for use on an annual basis. Licences consists of three components: consumption, losses, and return flow.

Temporary Diversion Licences (TDLs)

The calculation of upstream water use does not include TDLs. However, efforts are being made to consider these temporary diversions in calculations. TDLs provide authority for short-term diversions and usage of water. In 2021, the total TDL allocation volume for the Athabasca River Basin upstream of Fort McMurray was 5.13 million m^3. Adding the TDL volume to the total net upstream allocation of 101 million m^3 gives a total net allocation of 106 million m^3, which is still well below the trigger value of 160 million m^3/year.

Assuming a conservative estimate that full TDL allocation is used with no return volume, the estimated net upstream water use including TDL volumes is 26 + 5.13 = 31 million m^3, which is below the 60 million m^3 water use trigger.

Changes to Long-term Seasonal Low Flow in the Athabasca River

Trigger exceedance occurs when:

- Median seasonal flow for a given season drops below the specified Long-Term Seasonal Low Flow Threshold values (Table 2) three or more times within any 10 consecutive year period.

From 2012 to 2021, median seasonal flow remained above the respective Low Flow Threshold each year (Figure 7). There was no exceedance of the Long-term Seasonal Flow trigger in the 10 year period from 2012 to 2021. Median seasonal flow for summer 2015 was close to, but remained above the threshold value.

TABLE 2. LONG-TERM SEASONAL LOW FLOW ADAPTIVE MANAGEMENT THRESHOLDS AND 2021 SEASONAL FLOWS.

Weeks	Season	Low Flow Threshold (m^3/s)	2021 Seasonal Flow (m^3/s)
1 to 15 (January 1 – April 15)	Mid-Winter	91.3	229
16 to 18 (April 16 – May 6)	Early Spring	173	599
19 to 23 (May 7 – June 10)	Late Spring	442	1234
24 to 33 (June 11 – August 19)	Summer	636	927
34 to 43 (August 20 – October 28)	Fall	298	494
44 to 52 (October 29 – December 31)	Early Winter	105	185

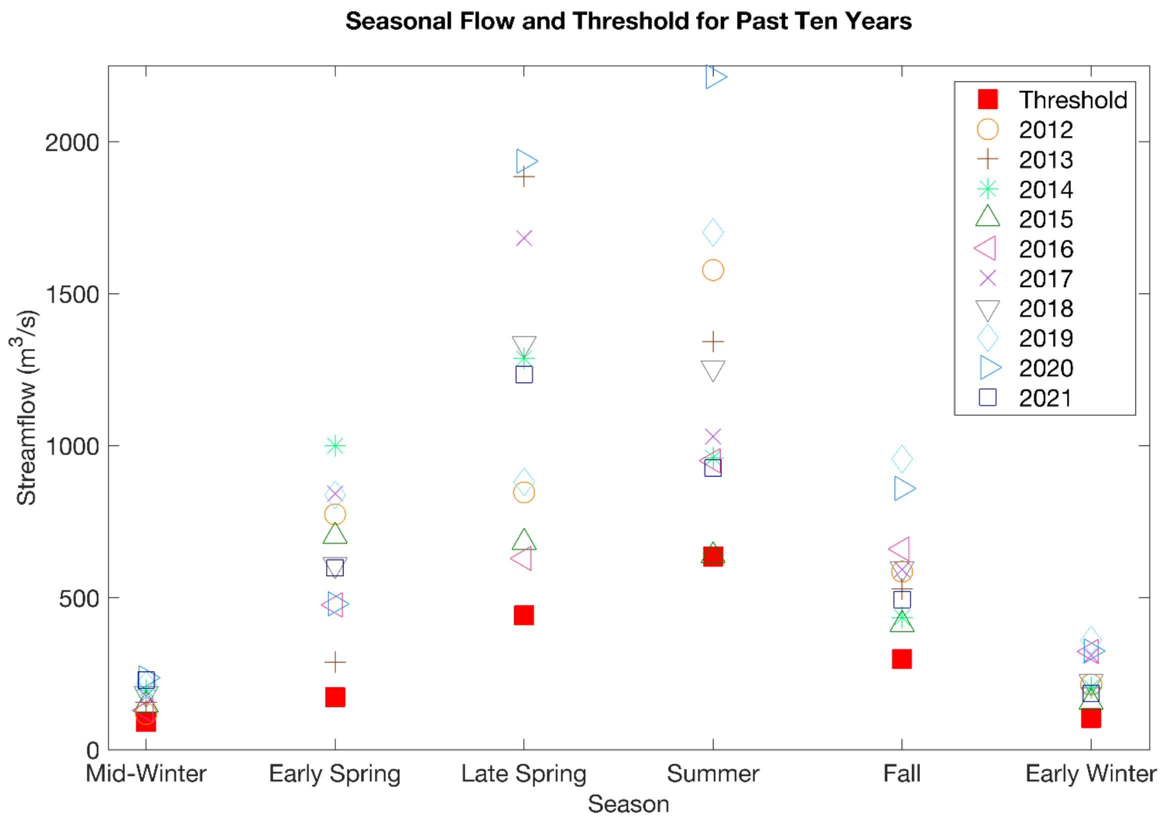

Figure 7: Comparison of seasonal low flow threshold and median flow for 2012-2021. Seasonal flow for summer 2015 was close to, but remained above the threshold value.

Long-Term Seasonal Flow Exceedance Indicator (supporting indicators)

The Framework identifies Long-Term Seasonal Flow Exceedance Indicators (Table 3), derived by determining the number of times over ten consecutive years that modelled weekly average flows would drop below a series of key flows, given a moderate climate change scenario. Weeks are divided into the winter (ice covered) and open water seasons. These indicators were designed to identify changes to river flows that might be occurring over a wider range of flows than just the very low flows utilized in the 'Changes to Long-term Seasonal Low Flows in the Athabasca River' adaptive management trigger. However, given the ten-year period of analysis, flow variability may be influenced by periods of natural variability and low-frequency and/or persistent modes of climate variability, such as the Pacific Decadal Oscillation (PDO) or El Niño-Southern Oscillation (ENSO).

The PDO oscillates between positive and negative phases with periodicities of multiple decades (Mantua and Hare 2002). Positive (La Niña) and negative (El Niño) phases of ENSO persist for approximately 9-12 months and occur every 3-5 years. Negative phases of the PDO and positive phases of ENSO are associated with higher than average streamflow, where positive PDO and negative ENSO phases are associated with lower than average streamflow in Alberta (St, Jacques *et al.* 2014; Rood *et al.* 2015). The most recent El Niño phase occurred between the last half of 2018 and first half of 2019, while La Niña conditions developed during autumn 2020 and persisted through 2021 (NOAA 2022). Given the duration of the PDO and ENSO phases, ten-year flow may be anomalously high or low and may not be indicative of longer-term changes.

The Long-Term Seasonal Flow Exceedance Indicators are intended to inform an understanding of potential changes to river flow and support investigation and development of management actions when there are exceedances of adaptive management triggers (see Figure 8 in the Framework).

Between 2012 and 2021, the number of winter weeks when the flow was below the thresholds was lower than the number predicted by the climate change scenarios (Table 3) for key flow rates below 1600 m^3/s, and equal to the predicted frequency for 1600 m^3/s (Figure 8). During the open water period the number of weeks when the flow was below the given thresholds

(Table 3) was lower than the frequency predicted in the Framework (Figure 9). Based on the results of this indicator, there is no indication of change in the flow regime over this ten-year time period.

TABLE 3. LONG-TERM SEASONAL FLOW EXCEEDANCE INDICATORS. THE PREDICTED NUMBER OF WEEKS (OVER A CONSECUTIVE 10-YEAR PERIOD) BELOW KEY FLOWS, BASED ON A MODERATE CLIMATE CHANGE SCENARIO, AS COMPARED TO THE ACTUAL NUMBER OF WEEKS BELOW KEY FLOWS FROM 2012 TO 2021.

Weekly Mean Flow Rate (m^3/s)	# of Weeks Below Flow, Over 10-Year Period (2012-2021)			
	Winter (weeks 44-15)		Open Water (weeks 16-43)	
	Threshold	2021 Reporting	Threshold	2021 Reporting
87	9	0	0	0
100	37	0	1	0
125	96	18	1	0
150	131	41	1	0
200	184	119	4	0
270	221	189	13	3
400	237	222	60	13
600	240	236	133	73
1000	240	239	241	167
1600	240	240	275	241

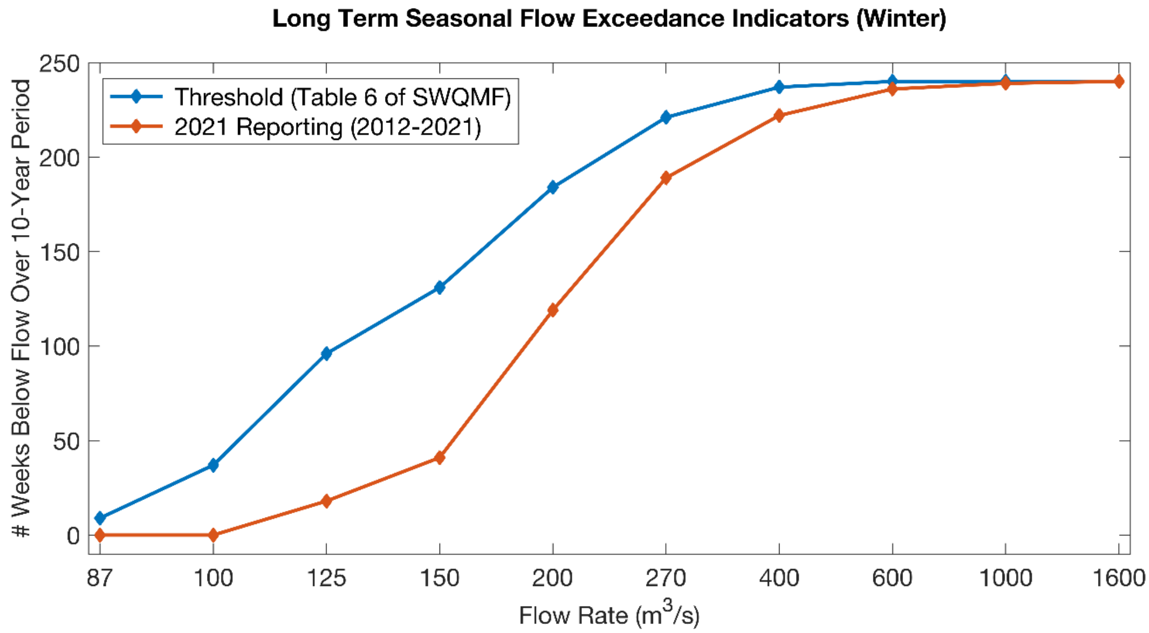

Figure 8: Evaluation of Long-term Seasonal Flow Exceedance Indicators from 2012 to 2021 for the winter season. Actual number of weeks below key flows is lower than or equal to the predicted number of weeks for all key flows.

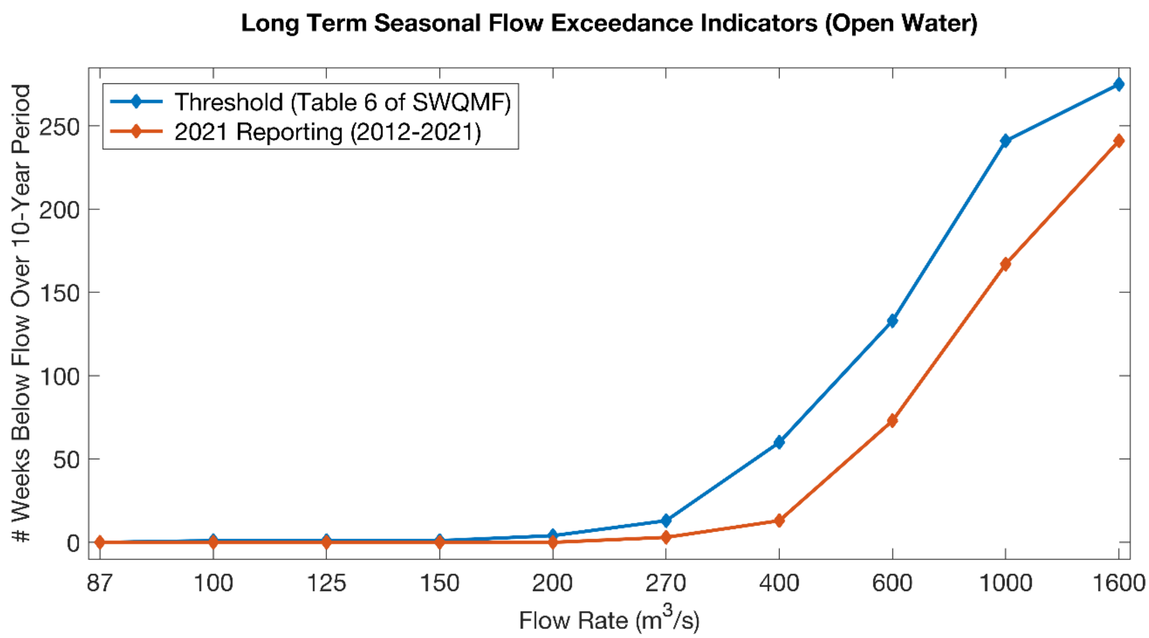

Figure 9: Evaluation of Long-Term Seasonal Flow Exceedance Indicators from 2012 to 2021 for the open water season. Actual number of weeks below key flows is lower than or equal to the predicted number of weeks for all key flows.

Changes to Oil Sands Water Use

Trigger exceedance occurs when:

- Cumulative annual water withdrawals by the oil sands sector exceed 441 million m^3/year (14 m^3/s).

In 2021, the cumulative water withdrawal (gross) by the oil sands mining sector was 113 million m^3/year (3.6 m^3/s); therefore, the Oil Sands Water Use trigger was not exceeded. Temporary Diversion Licences (TDLs) related to Oil Sands usage were calculated for 2021 at 8,084 m^3, and have negligible impact on the total withdrawal volume (Appendix B).

Cumulative Oil Sands Water Use, Relative to Weekly Flow

Trigger exceedance occurs when:

- Cumulative (mineable and in situ) oil sands water use is equal to or greater than 10 per cent of the flow reported at the Fort McMurray station for six or more weeks during the winter period of any given year (weeks 1 to 15 and 44 to 52); or
- Cumulative (mineable and in situ) oil sands water use is equal to or greater than 6 per cent of the flow reported at the Fort McMurray station for six or more weeks during the open water period of any given year (weeks 16 to 43); or
- Cumulative (mineable and in situ) oil sands water use is equal to or greater than 15 per cent of the flow reported at the Fort McMurray station for a single week at any time of the year.

There are two winter (ice covered) periods in the 2021 calendar year - the winter beginning on week 44 of 2020 and extending to week 15 of 2021, and weeks 44-52 of 2021. For the purposes of trigger exceedance calculation, this report is concerned with the cumulative number of weeks over the two separate winter periods in 2021 (weeks 1-15 and 44-52); however, for illustrative purposes only, the winter period beginning on week 44 of 2020 is also included in Figure 10. In 2021, average weekly water withdrawal by mineable and in situ oil sands producers from the Athabasca River ranged from 0.8% to 1.9% of the reported flow during the early 2021 winter period (weeks 1-15) and from 1.4% to 2.0% of the reported flow during the late 2021 winter period (weeks 44-52). During the open water period (weeks 16-43), average weekly water withdrawals ranged from 0.1% to 1.2% of reported flow. Considering maximum weekly water withdrawals, the range is 1.2% to 1.9% during weeks 1-15, 0.2% to 1.2% for weeks 16-43, and 1.6% to 2.2% for weeks 44-52. Therefore, the Cumulative Oil Sands Water Use, Relative to Weekly Flow trigger was not exceeded.

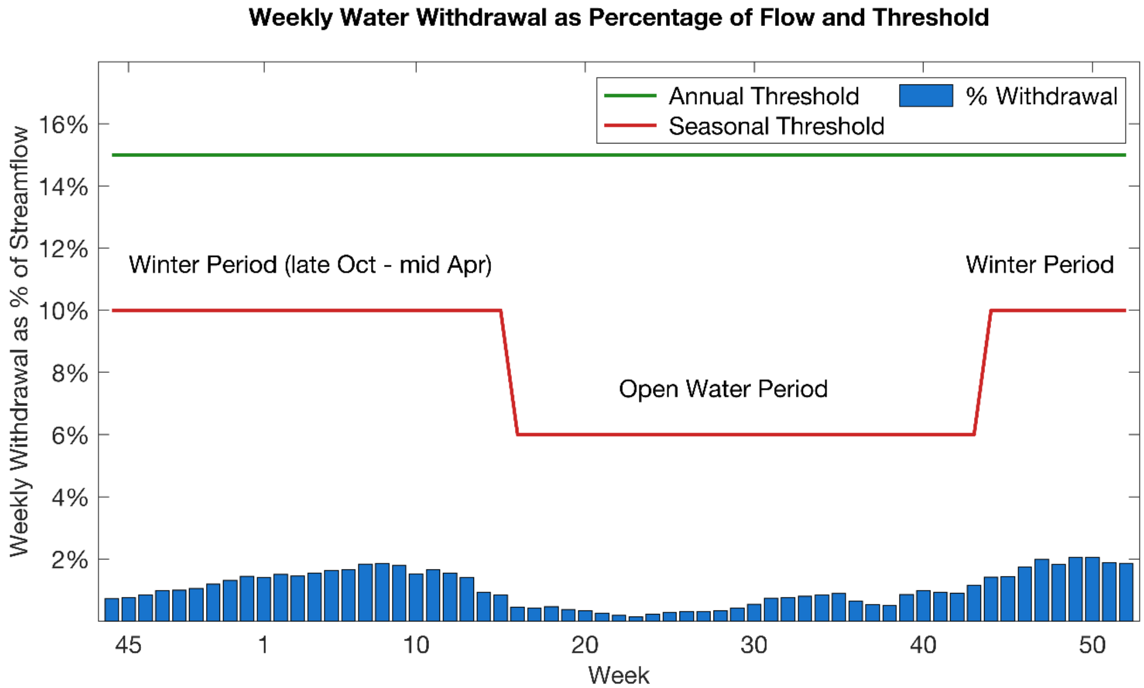

Figure 10: Weekly water withdrawal during winter (late October 2020 - mid-April 2021), open water (mid-April – late October 2021), and winter (late October – end December 2021) as percentage of flow, compared to single week and seasonal thresholds.

High Oil Sands Water Use During Low Summer and Fall Flows

Trigger exceedance occurs when:

- Cumulative oil sands water use exceeds the predicted full build-out scenario (16 m^3/s) during any week in the Summer/Fall season (weeks 24 to 43) in which the average weekly flow is less than 400 m^3/s.

In 2021, average weekly flow remained above 400 m^3/s for weeks 24-41 and dropped below 400 m^3/s for weeks 42-43 (Figure 11). The weekly flow in weeks 42 and 43 was 370 m^3/s and 340 m^3/s, respectively. Average weekly water withdrawals for weeks 24-41 ranged from 2.8 m^3/s and 4.6 m^3/s, and for weeks 42 and 43 were 3.3 m^3/s and 4.0 m^3/s, well below 16 m^3/s (Figure 12). Therefore, the High Oil Sands Water Use During Low Summer/Fall Flows was not exceeded in 2021.

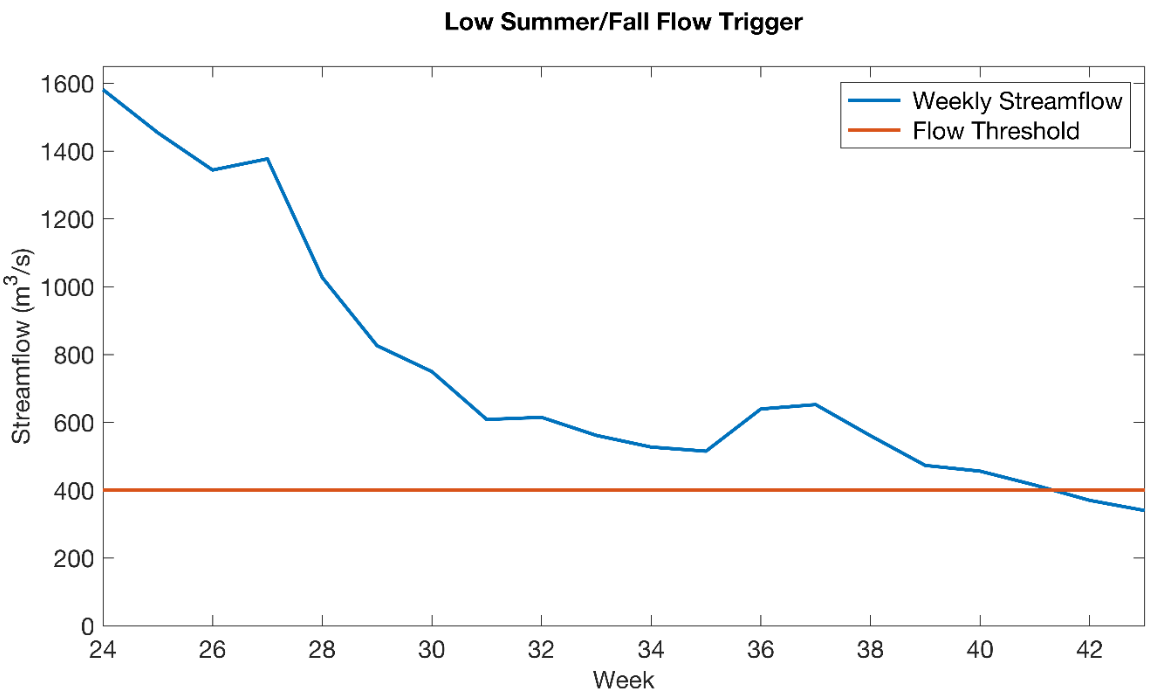

Figure 11: Streamflow for summer and fall (weeks 24-43), 2021, compared to the weekly low flow threshold. Weeks 42 and 43 were below the flow threshold of 400 m^3/s.

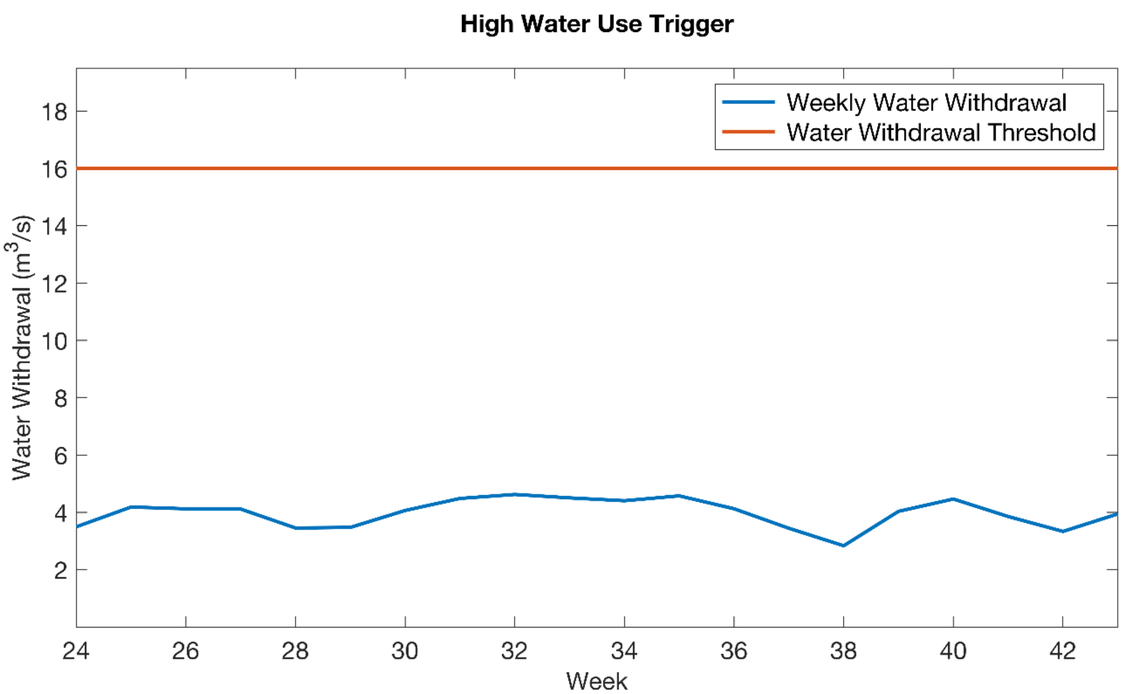

Figure 12: Weekly water withdrawal for summer and fall (weeks 24-43), 2021, compared to the water withdrawal threshold. Streamflow for weeks 42 and 43 were below the flow threshold, however, water withdrawals remained below the withdrawal threshold.

Preliminary Aboriginal Navigation Index (ANI)

Trigger exceedance occurs when:

- The fall season (weeks 34 to 43) ANI decreases by 10% after accounting for withdrawals.

The Athabasca River is an important navigational route that provides access to traditional activities for First Nations and Métis communities. Navigation can be challenging during periods of low flow, including fall when low flows can persist for weeks or months before winter freeze up. Calculation of the ANI is based on a range of streamflow navigability and is intended to provide advanced notice of potential change in river navigability. Exceedance of the trigger represents a change in water depth of less than 3 cm at a specific point in the river where navigation is particularly challenging.

ANI calculations incorporate concepts of Aboriginal Base Flow (ABF; 1600 m^3/s) and Aboriginal Extreme Flow (AXF; 400 m^3/s). The ANI indicator is preliminary and subject to continuous improvement, as more knowledge around navigation becomes available. Weekly fall season streamflow from 2016-2021 along with streamflow values are given in Appendix D.

During Fall 2021 (weeks 34 to 43), the average ANI decreased by 1.85%, with weekly decreases ranging from 0.84% to 8.73% from water withdrawals by the oil sands sector from the Athabasca River (Figure 13). The highest change in ANI occurred during weeks 42 (4.33%) and 43 (8.73%) when streamflow dropped below 400 m^3/s. A summary of the weekly and seasonal ANI before and after withdrawals is provided in Figure 14. The Preliminary Aboriginal Navigation Index trigger was not exceeded in 2021.

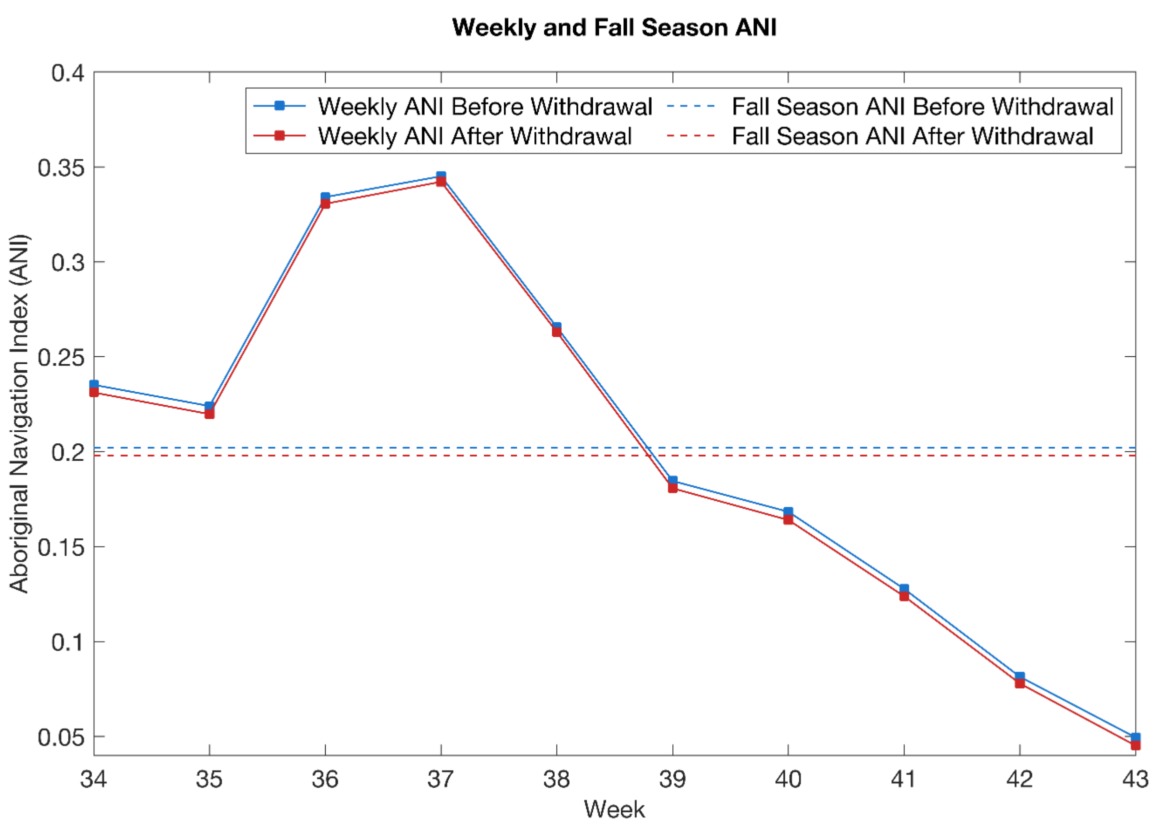

Figure 13: Fall (weeks 34-43) 2021 weekly and average seasonal Aboriginal Navigation Index, before and after accounting for withdrawals.

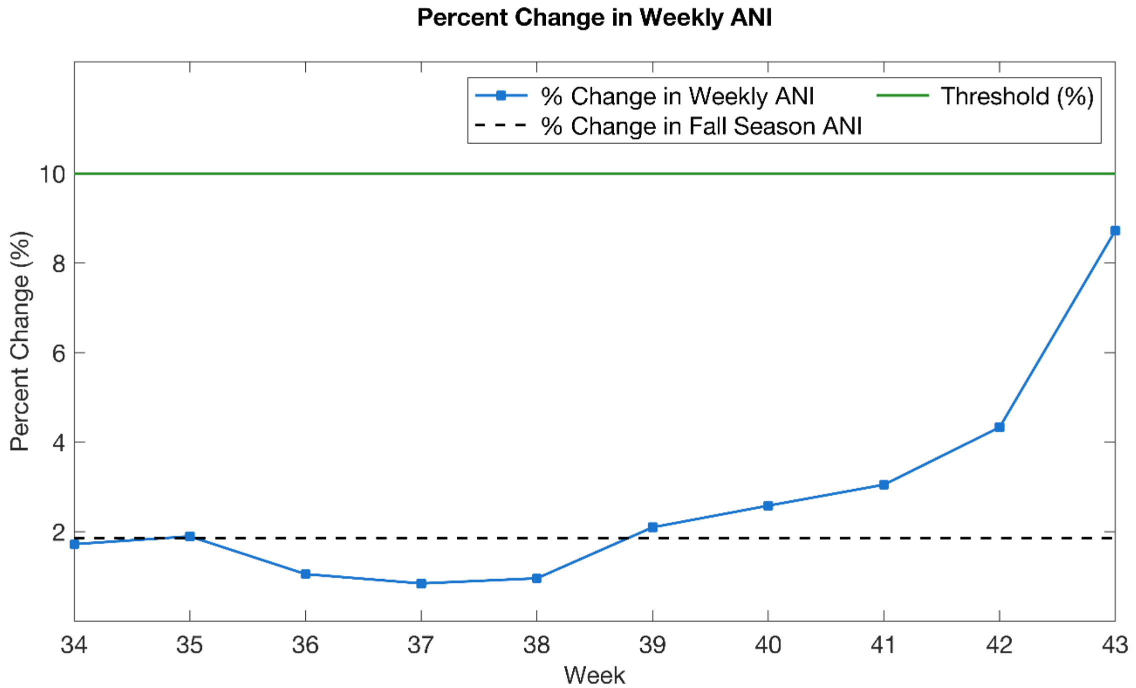

Figure 14: Fall (weeks 34 to 43) 2021 weekly and seasonal percent changes in the Aboriginal Navigation Index compared with the threshold

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Appendix A: Summary of the weekly management triggers and cumulative withdrawal limit

TABLE 4: SUMMARY OF THE WEEKLY MANAGEMENT TRIGGERS AND CUMULATIVE WITHDRAWAL LIMITS FOR THE 2021 REPORTING PERIOD

Year	Week	Weekly Flow Estimates (m^3/s)	Cumulative Withdrawal Limit (m^3/s)	Average Cumulative Withdrawal (m^3/s)	Maximum Daily Withdrawal within the week (m^3/s)
2021	1	242	14.52	3.46	3.57
2021	2	247	14.82	3.61	3.68
2021	3	235	14.1	3.42	3.65
2021	4	226	13.56	3.55	3.75
2021	5	223	13.38	3.43	3.59
2021	6	219	13.14	3.33	3.48
2021	7	211	12.66	3.64	3.82
2021	8	195	11.7	3.65	3.78
2021	9	197	11.82	3.60	3.74
2021	10	199	11.94	3.20	3.67
2021	11	201	12.06	3.56	3.74
2021	12	209	12.54	3.55	3.68
2021	13	222	13.32	3.52	3.72
2021	14	270	16.2	2.54	3.52
2021	15	325	16	2.79	3.92
2021	16	400	16	2.42	2.67
2021	17	625	16	2.67	3.34
2021	18	625	16	2.77	3.30
2021	19	600	20	2.47	3.77
2021	20	749	20	2.72	3.27
2021	21	899	20	3.25	3.58
2021	22	1080	20	2.96	3.81
2021	23	1490	20	2.35	2.98
2021	24	1580	29	3.50	4.60
2021	25	1290	29	4.19	4.65
2021	26	1330	29	4.13	4.42
2021	27	1360	29	4.12	4.66
2021	28	1260	29	3.46	4.17
2021	29	901	29	3.48	3.71
2021	30	768	29	4.07	4.48
2021	31	657	29	4.49	4.60
2021	32	611	29	4.63	4.96
2021	33	615	29	4.51	4.72
2021	34	537	29	4.41	4.79
2021	35	483	29	4.58	5.18
2021	36	504	29	4.13	4.53
2021	37	728	29	3.45	4.55
2021	38	624	29	2.84	3.35
2021	39	504	29	4.04	4.47

2021	40	479	29	4.47	5.16
2021	41	420	29	3.86	3.97
2021	42	384	29	3.34	3.68
2021	43	324	29	3.95	4.05
2021	44	336	16	4.63	5.27
2021	45	303	16	3.96	4.33
2021	46	263	16	3.73	4.19
2021	47	205	16	3.63	3.79
2021	48	166	13.28	3.69	3.97
2021	49	163	13.04	3.77	4.08
2021	50	154	12.32	3.68	3.97
2021	51	146	12	3.49	3.59
2021	52	150	12	3.23	3.56

*The flow estimate for week 20 was not posted to the Athabasca River Conditions and use website and was added later

Appendix B: Inclusion of Temporary Diversion Licences

Under the province's Water Act, a licence must be obtained before diverting surface water. A Temporary Diversion Licence (TDL) provides authority for this diversion for a maximum of one year. TDLs may be regulated through either the Alberta Energy Regulator (AER) or Alberta Environment and Protected Areas (EPA). Those regulated by AER are required to report usage, while those regulated by EPA are not. Due to this partial usage reporting, and the fact that the reporting interval for AER TDLs is normally different than term licences (i.e. monthly vs. daily), it can be difficult to calculate the exact contribution of TDLs to water withdrawals and returns. However, efforts are being made to consider their contributions for annual reporting metrics.

Oil Sands Water Usage

Oil sands water usage is reported for both the Weekly Management Trigger (Cumulative Withdrawal Limits) and Adaptive Management Triggers (Changes to Oil Sands Water Use, Cumulative Oil Sands Use Relative to Weekly Flow, and High Oil Sands Water Use During Low Summer and Fall Flows). It considers water usage directly from the main stem of the Athabasca River downstream of the Water Survey of Canada Station 07DA001. It should be noted, however, that most TDL Oil Sands users do not withdraw directly from the main stem of the Athabasca River, but from lakes and tributaries.

For 2021, reporting shows that the total water usage for TDLs related to Oil Sands Usage was 8,084 m^3, which represents 0.007% of the 113 million m^3 Oil Sands water use in 2021. Oil Sands TDL usage had a minimal effect on Oil Sands related triggers in the framework. For 2017, 2018, and 2019 reporting shows there was no usage for AER-regulated or EPA-regulated TDLs related to "Oil Sands Usage" as defined in the framework. In 2020, Oil Sands TDL usage was 15,400 m^3/s, which was 0.013% of the Oil Sands water use for that year.

Appendix C: Wetlands and Lake Level Stabilization

Each year upstream water allocations for wetlands and lake level stabilizations comprise 7-8% of total allocations by volume. In 2021, wetlands and lake level stabilization allocations accounted for 7.4% by volume. While most water use allocations are licenced for active, consumptive withdrawals, licenced water allocations for wetlands and lake level stabilizations aim to account for the loss of water by evaporation. These are non-reporting licences, meaning that the actual withdrawals and returns are not reported and assumptions are made with respect to how much of the usage and return allocations are used. For example, in 2021, licence holders that are required to report use utilized 48% of their allocated diversion volume and returned 61% of their allocated return volume. The total diversion allocation for all wetlands and lake level stabilizations licences was 19.5 million m^3 and the assumption is made that 48%, or 9.4 million m^3 of this allocation was utilized. Wetlands and lake level stabilization licences have minimal impact on the proximity to triggers for net water allocation (Figure 15) and net water usage (Figure 16) upstream of Fort McMurray. Efforts are being made to better understand water consumption under these water licences and improve the accuracy of these calculations.

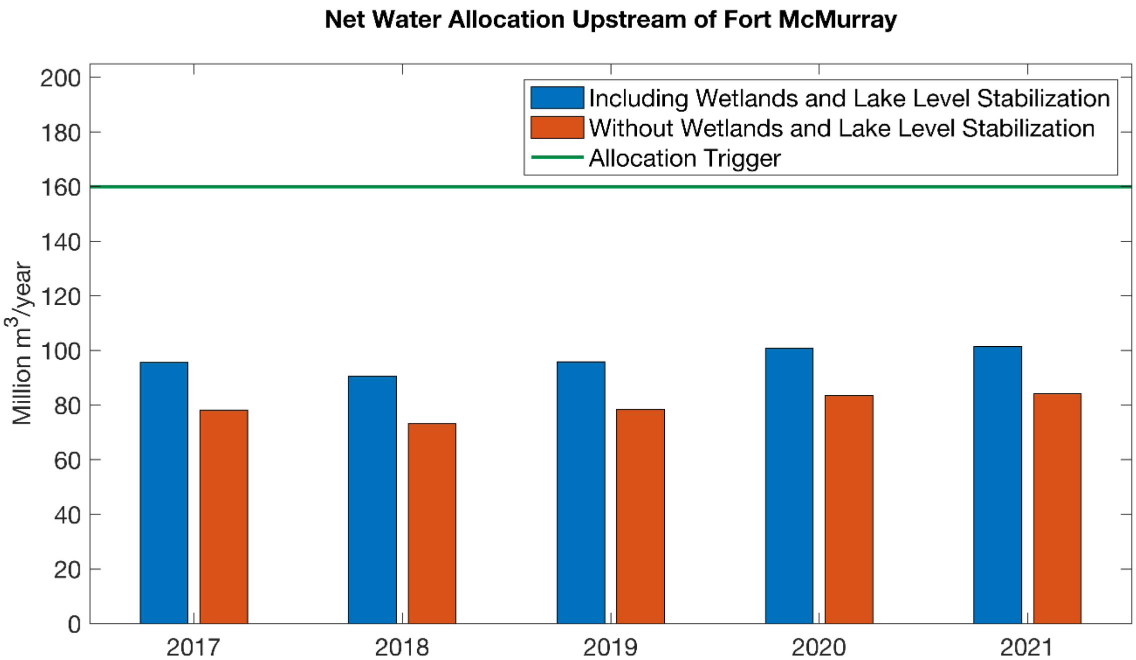

Figure 15: Net water allocation upstream of Fort McMurray including (blue) and excluding (red) wetlands and lake level stabilization licences, relative to the net allocation trigger value (green)

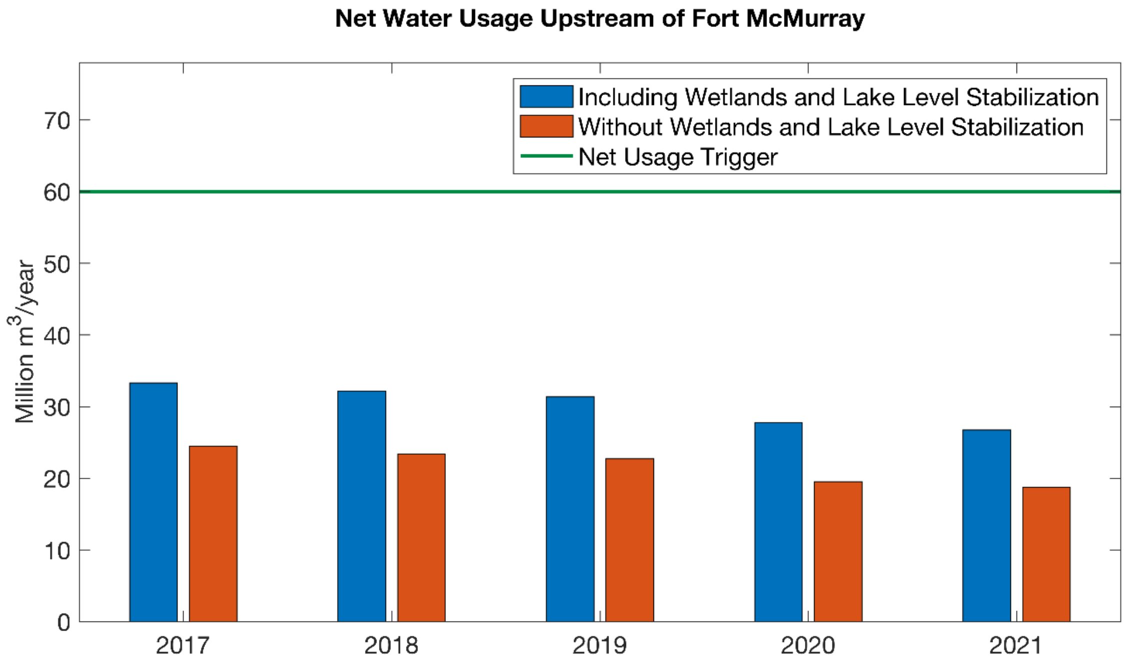

Figure 16: Net water usage upstream of Fort McMurray including (blue) and excluding (red) wetlands and lake level stabilization licences, relative to the net usage trigger value (green)

Appendix D: Weekly Fall Flows Related to ANI Concepts

ANI calculations incorporate concepts of Aboriginal Base Flow (ABF; 1600 m^3/s) and Aboriginal Extreme Flow (AXF; 400 m^3/s). Calculations are done such that the ANI = 1 for flows at 1600 m^3/s, 0.1 when flows are 400 m^3/s, and 0 when water depth is one metre or less at a critical navigation point, or approximately 300 m^3/s (see Appendix G in the Framework).

As indicated earlier, the ANI indicator is preliminary and subject to continuous improvement as more knowledge around navigation becomes available. Consideration may be given to adjust flow values and other components of the ANI calculation in the future. Figures 17 to 23 illustrate actual streamflows relative to flow values of 300, 400 and 500 m^3/s.

Weekly fall season streamflow (weeks 34-43) with referenced key streamflow values for 2016-2021 is shown in Figure 17. Also shown in Figure 17 is the average flow for Weeks 34-43 over the period of record (1958-2021) at WSC gauge 07DA001 "Athabasca River below Fort McMurray". The shading of streamflow values of 500 m^3/s, 400 m^3/s, and 300 m^3/s facilitate the identification of weeks when streamflow is below these amounts. Weekly fall season streamflow before and after withdrawals, with referenced key streamflow concepts, are shown for individual years between 2016 and 2021 (Figures 18-23).

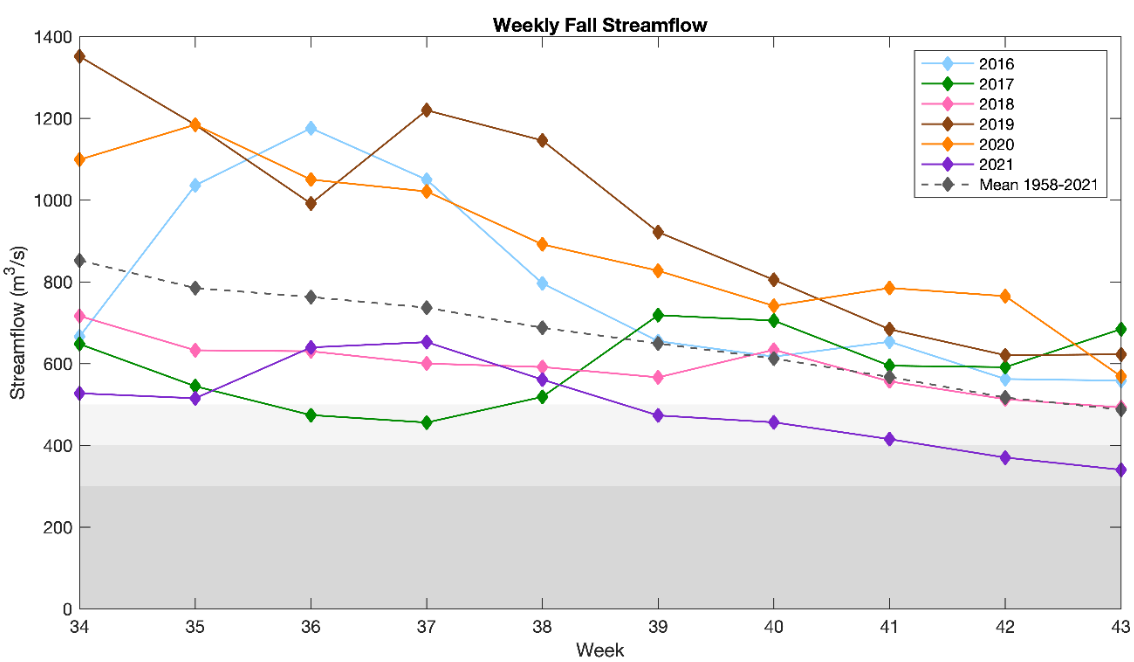

Figure 17: Weekly fall season streamflow for 2016-2021 shown with reference key streamflow concepts of 500 m^3/s, 400 m^3/s and 300 m^3/s shown as grey and dark grey shading

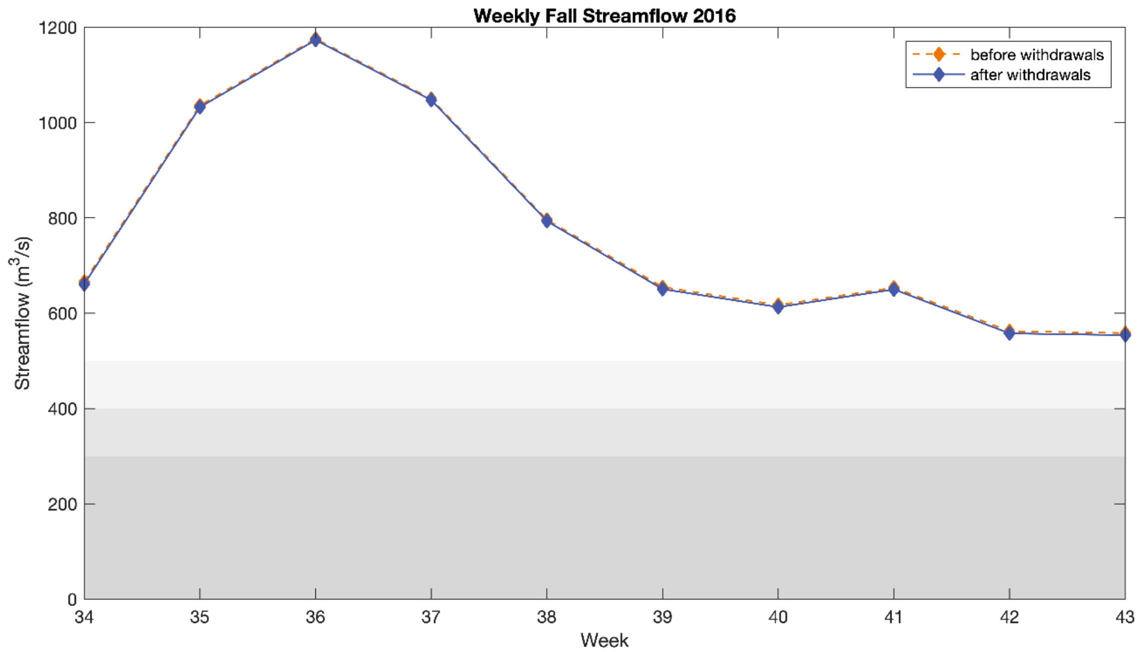

Figure 18: Weekly fall season streamflow for 2016 before and after withdrawals shown with reference key streamflow concepts of 500 m^3/s, 400 m^3/s and 300 m^3/s shown as grey and dark grey shading

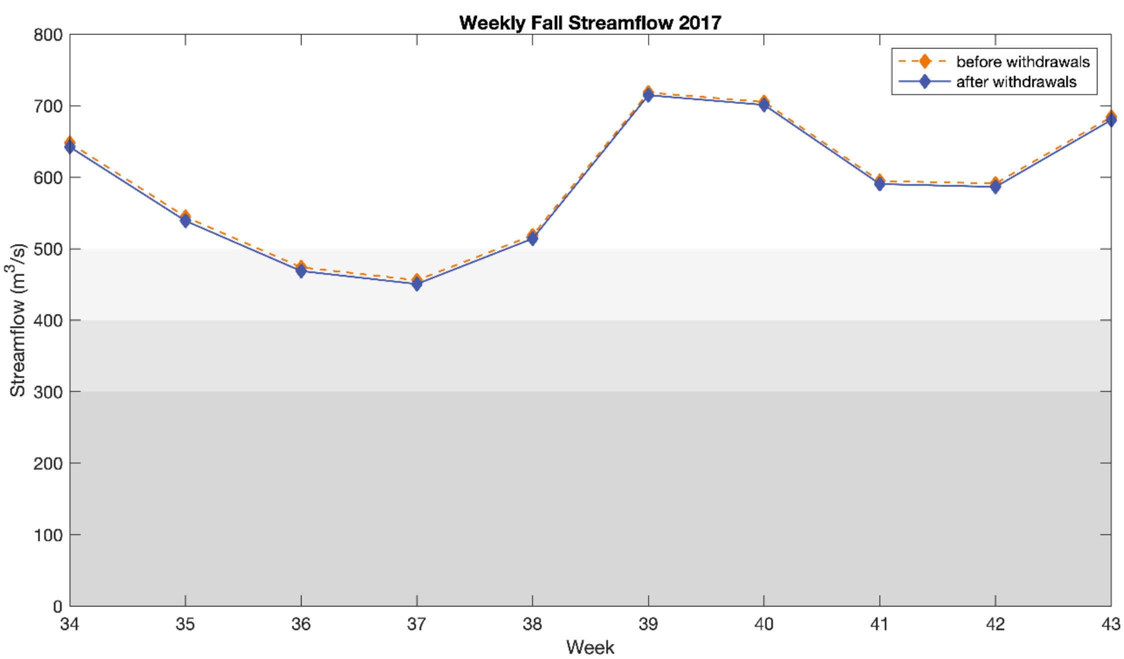

Figure 19: Weekly fall season streamflow for 2017 before and after withdrawals shown with reference key streamflow concepts of 500 m^3/s, 400 m^3/s and 300 m^3/s shown as grey and dark grey shading

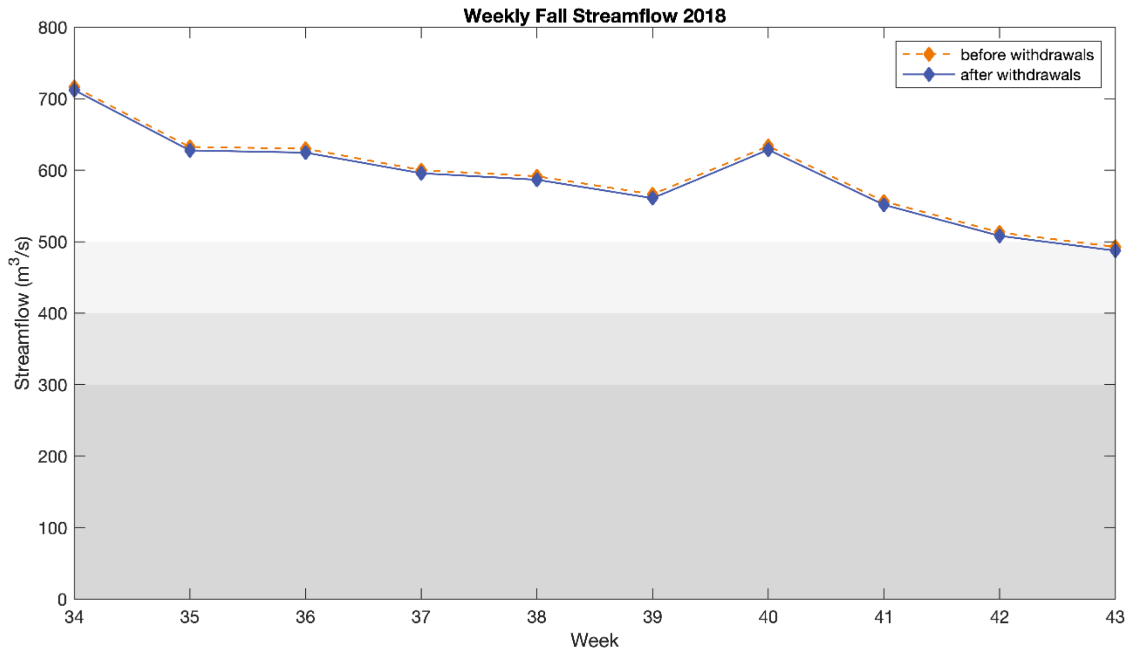

Figure 20: Weekly fall season streamflow for 2018 before and after withdrawals shown with reference key streamflow concepts of 500 m³/s, 400 m³/s and 300 m³/s shown as grey and dark grey shading

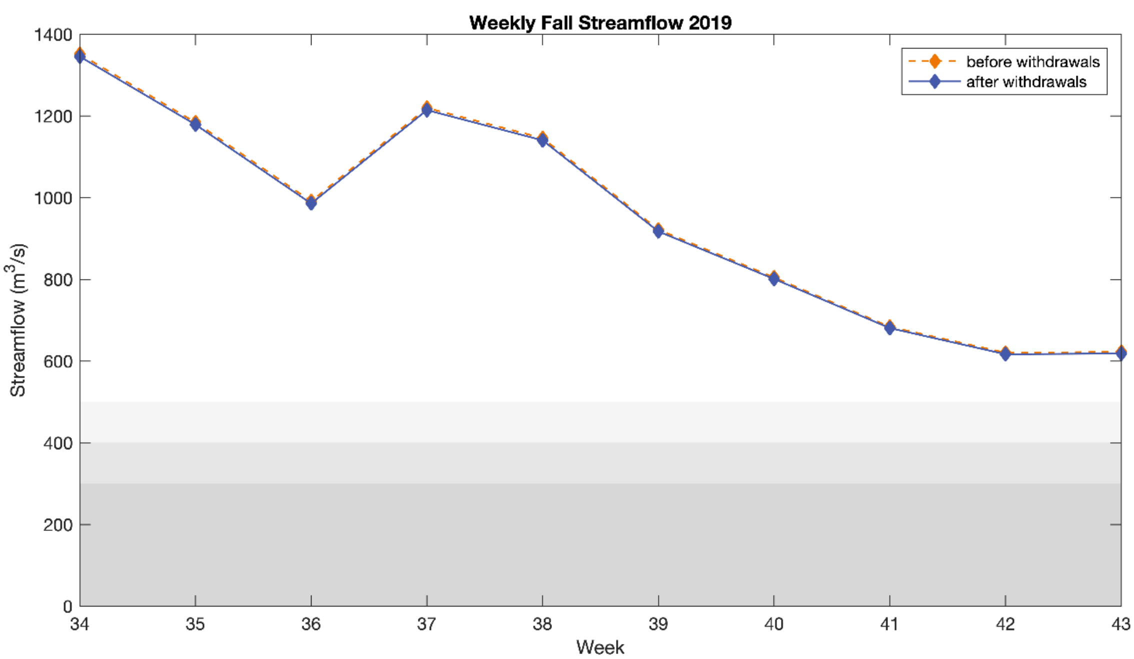

Figure 21: Weekly fall season streamflow for 2019 before and after withdrawals shown with reference key streamflow concepts of 500 m³/s, 400 m³/s and 300 m³/s shown as grey and dark grey shading

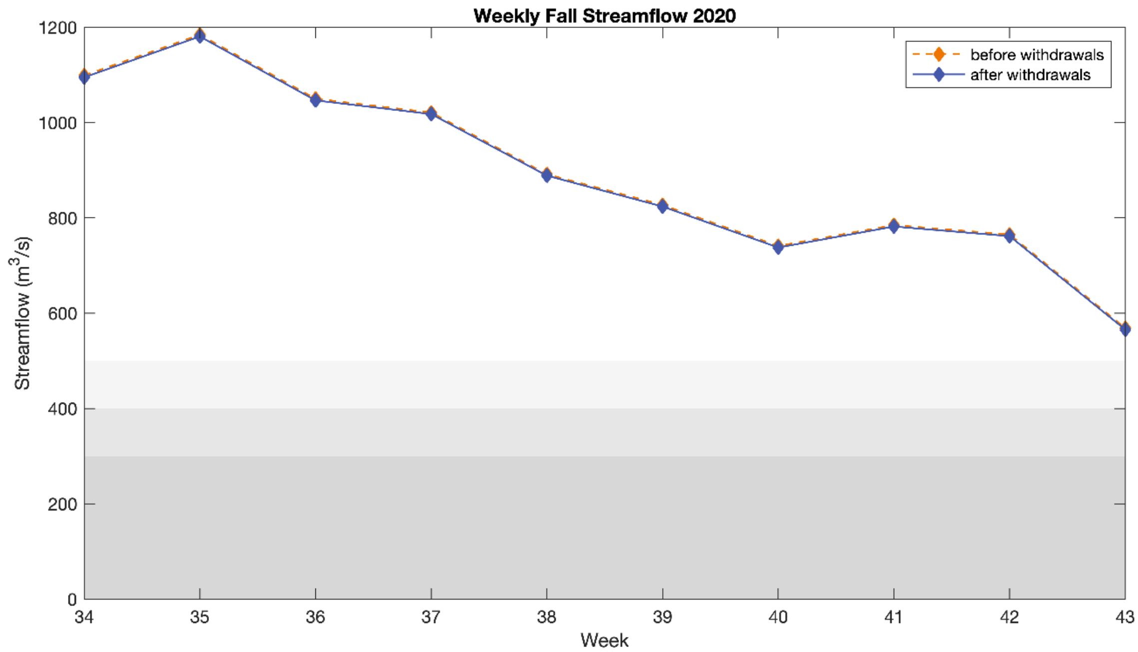

Figure 22: Weekly fall season streamflow for 2020 before and after withdrawals shown with reference key streamflow concepts of 500 m³/s, 400 m³/s and 300 m³/s shown as grey and dark grey shading

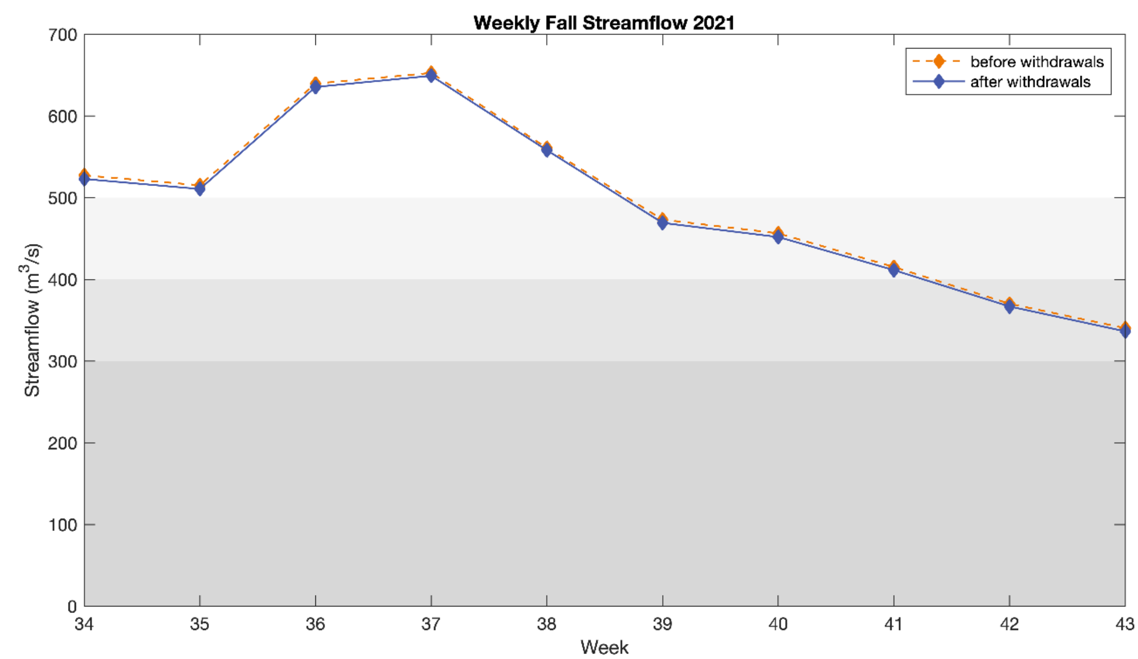

Figure 23: Weekly fall season streamflow for 2021 before and after withdrawals shown with reference key streamflow concepts of 500 m³/s, 400 m³/s and 300 m³/s shown as grey and dark grey shading