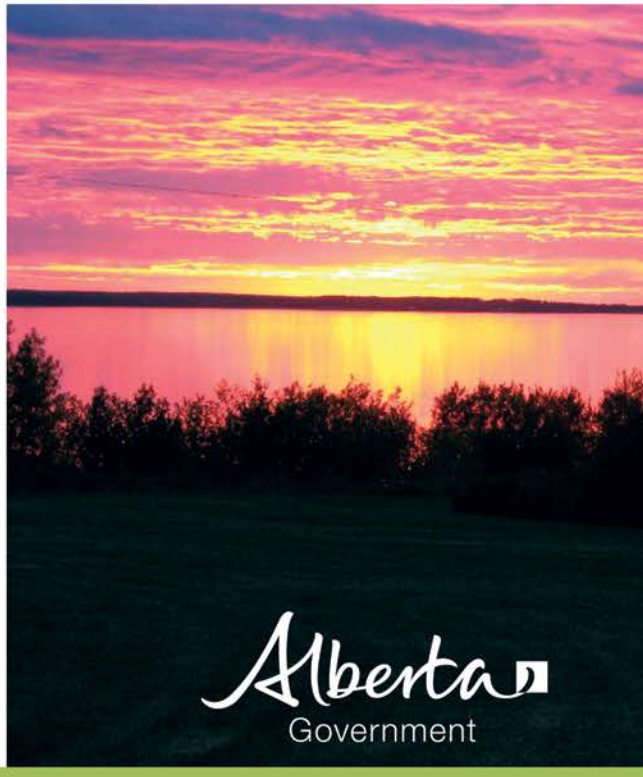
Lower Athabasca Region

Status of Management Response for Environmental Management Frameworks

As of October 2017

- Air Quality Management Framework
- Surface Water Quality Management Framework



Any comments or questions on the content of this report may be directed to:

Alberta Environment and Parks
Lower Athabasca Region, Operations Division
Box 450, 2nd Floor, Provincial Building
9503 Beaverhill Road
Lac La Biche, Alberta
T0A 2C0

General inquiries on management framework development and implementation can be directed to:

Alberta Environment and Parks
Planning Branch, Policy and Planning Division
3rd floor, South Petroleum Plaza
9915-108 Street, Edmonton, Alberta
T5K 2G8

For copies of this report, please contact:

Information Centre
Alberta Environment and Parks
Phone: Toll Free Alberta 310-3773
Email: AEP.Info-Centre@gov.ab.ca
Website: www.aep.alberta.ca

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Executive Summary

As part of the Integrated Resource Management System, this report communicates Alberta's management response to air and surface water quality triggers since 2012 in the Lower Athabasca Region. This fulfills commitments made to Albertans in the Lower Athabasca Region Air Quality Management Framework for Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) and the Lower Athabasca Region Surface Water Quality Management Framework for the Lower Athabasca River.

Since 2012, there were no limits exceeded for air and surface water quality indicators. This means that the state of the environmental health remains with the range of acceptable conditions, and that air and surface water quality objectives identified in the Lower Athabasca Regional Plan are being met.

However, some proactive triggers were exceeded. As a result, the Ministry of Environment and Parks is leading the required management response. This report communicates the status of the response to 2015 trigger exceedances, and includes an update on the management response to 2012, 2013 and 2014 trigger exceedances.

The following is a summary of the management response to date and some key findings:

Air Quality

In 2016, 15 air monitoring stations that measured nitrogen dioxide (NO_2) and 19 stations that measured sulphur dioxide (SO_2) were considered, including two new stations at Stony Mountain and Brion McKay. Conklin station did not have enough data to be included in 2016 air quality assessment.

- No limits were exceeded for air quality indicators.
- The trigger for Level 4 was exceeded at Lower Camp station for upper range of ambient concentrations of SO_2.
- Mildred Lake and Mannix stations exceeded the Level 3 trigger for upper range of ambient concentrations of SO_2.
- Upper range of ambient concentrations of SO_2 was above the trigger for level 2 at Fort McKay – Bertha Ganter, Buffalo Viewpoint, Fort McKay South and Shell Muskeg River stations
- Both upper range and annual average concentrations of NO_2 were above the trigger for level 2 at Shell Muskeg River station.

As a response to exceedances in previous years, a number of management activities have been undertaken:

- Actions initiated by Syncrude as part of their emissions reduction program have effectively lowered total SO_2 emission scenarios of Syncrude operations.
- Improved trend assessment methodology is being developed; with the creation of a tool that will allow for flexible application of this methodology in a user-friendly environment.
- Non-point source emissions in the Lower Athabasca Region have been reported on by the Clean Air Strategic Alliance.
- Improvements to the monitoring network program were assessed by a third party reviewer. The report submitted by third party is now under review by AEP.

In 2016, increase of the upper range of SO_2 values at Lower Camp station was preliminarily investigated. These elevated values may be the result of industrial operations from neighbouring industrial operations or other sources and further investigations are required to confirm contributions to these emissions. The following detailed investigations were first recommended in response to the 2015 report and will need to be completed as part of the management response to the 2016 report.

- Compile a detailed emission inventory of SO_2 emissions in the oil sands region for 2012-2016;
- Complete episode analysis of hourly SO_2 at Lower Camp station;
- Complete wind and dispersion modelling of SO_2 emissions within LAR;
- Complete trajectory analysis to determine any influence of transboundary flows and exceptional events on the SO_2 peak at Lower Camp station
- Gap/uncertainty analysis of source determination to identify any missing $S0_2$ sources.

Surface Water Quality

Water quality has never exceeded a limit in any year since implementation of the Surface Water Quality Framework (2012). However, management response activities undertaken in 2017 consisted of trend analysis to complete the preliminary assessment for parameters that exceeded a trigger in 2016 and were not already under investigation (dissolved lithium and dissolved cobalt), and updated trend analyses for parameters already under investigation (total nitrogen, dissolved uranium, sulphate, dissolved iron, and potassium). Based on the trend analysis, a determination was made for each parameter to initiate/continue the investigation phase or to close the management response.

- In 2016, four water quality parameters exceeded a trigger. These included: sulphate (peak), dissolved lithium (mean/peak), dissolved uranium (mean and peak), and dissolved cobalt (peak).
- No statistical temporal trends were observed for dissolved cobalt. Management response was closed following preliminary assessment.
- The management response for dissolved lithium was closed in 2014, but reanalysis with recent data have revealed significant upward trends in concentration. An investigation into dissolved lithium will be opened.
- Total nitrogen remains under investigation. Increasing trends over time seem to be weakening in terms of statistical significance. Trends in unadjusted concentrations are no longer statistically significant but trends in flow-adjusted concentrations remain significant.
- Dissolved uranium, sulphate, dissolved iron, and potassium remain under investigation. For each, both unadjusted and flow-adjusted concentrations exhibit increasing trends over time.

Next steps in the investigation include analysis of seasonal trends with updated (2017) data and analyses at upstream locations

Alberta Environment and Parks (AEP) will post updates to the status of the management response and supporting documents on the Ministry website.

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1.0 Introduction

Under the Lower Athabasca Regional Plan (GoA 2012), a management response must be initiated when the Minister of Environment and Parks determines that an air quality trigger or limit has been exceeded. Triggers and limits are identified in the Lower Athabasca Air Quality Management Framework, (AESRD 2012). As each annual report on condition becomes available, the ongoing management response is reviewed and updated.

Environment and Parks (AEP) leads the management response and will work with other branches of government, regulators (e.g. Alberta Energy Regulator) and external parties to implement the identified management actions.

A full description of the management system is found in the Lower Athabasca Region Air Quality Management Framework. The management response process incorporates steps that must be undertaken when an ambient air quality trigger or limit is exceeded, depending on the air quality issue and level of exceedance, some or all of the steps may be undertaken.

In order to ensure the most appropriate actions are initiated, the management response for air quality concerns will consider a variety of factors including but not limited to the type and location of the monitoring station, averaging time (hourly or annual) and the ambient air quality trigger or limit that was exceeded.

2.0
Summary of Ambient Levels Assigned

The Minister's Determination confirmed that no limits have been exceeded in the Lower Athabasca Region since the implementation of the management framework. However, air quality triggers have been exceeded at several monitoring stations, resulting in the assignment of ambient air quality levels described in the 2012 - 2016 Status of Ambient Environmental Condition Reports (AESRD 2014, AEP 2016a, 2017a, 2017b, AEMERA 2014) (Table 1).

In 2016,

- No limits were exceeded for air quality indicators.
- The trigger for Level 4 was exceeded at Lower Camp monitoring station, which was at Level 3 in 2015 and Level 2 in 2014, for upper range of SO_2 concentrations.
- Mildred Lake and Mannix monitoring stations exceeded the Level 3 trigger for upper range of SO_2 concentrations. Both of these stations were at Level 3 for the last several years.
- Bertha Ganter-Fort McKay, Buffalo Viewpoint, Fort McKay South and Shell Muskeg River monitoring stations had SO_2 upper range ambient concentrations above the trigger for Level 2.
- Shell Muskeg River had NO_2 ambient concentrations above the trigger for Level 2 for both annual average and upper range measurements.

Table 1.
Ambient NO_2 and SO_2 levels assigned to air quality stations in the Lower Athabasca Region 2012-2016 based on triggers established in the Air Quality Management Framework

Station Name (listed North to South)	Nitrogen Dioxide (NO_2)										Sulphur Dioxide (SO_2)									
	Annual Average					Upper Range					Annual Average					Upper Range				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Anzac	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bertha Ganter - Fort McKay	1	1	1	1	1	2	2	2	1	*1*	1	1	1	1	2	2	2	2	2	2
Brion McKay River					1					1					1					1
Buffalo Viewpoint											1	1	1	1	1	2	2	1	1	2
CNRL Horizon	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	2	2	2	1	1
Cold Lake South	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Conklin[1]					-					-					-					-
Firebag				1	1				1	1				1	1				1	1
Fort Chipewyan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fort McKay South	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Fort McMurray – Athabasca Valley	2	2	2	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Fort McMurray Patricia McInnes	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	2	1	1
Lower Camp											1	1	1	1	1	2	2	2	3	4
Mannix											1	1	1	1	1	3	3	3	3	3
Maskwa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mildred Lake											1	1	1	1	1	3	2	3	3	3
Shell Muskeg River	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2
Stony Mountain					1					1					1					1
Wapasu			1	1	1			1	1	1			1	1	1			1	1	1

[1] Conklin station was operational starting April 2016. It did not meet the criteria of 75 per cent data completeness in order to be included in reporting and analysis.

3.0

Status of Management Response

The management response is a set of steps that must be taken when ambient air quality triggers or limits are exceeded; some or all steps may be undertaken depending on the trigger exceeded and issue being addressed. Initial steps include verification, preliminary assessment and an investigation to determine the need for management actions, followed by delivery of management actions, evaluation and communication. A full description of the management system can be found in the Lower Athabasca Region Air Quality Management Framework. Status of management response is reported on a yearly basis (AEP 2014, 2016b, 2017c) along with supporting technical reports (Yan et.al. 2015).

3.1 Verification and Preliminary Assessment

Verification and preliminary assessment are reported in the 2016 Status of Air Quality report (AEP 2017a). In some cases, additional work may be completed in order to determine if rare events or natural circumstances contributed to trigger or limit exceedances. In this reporting cycle, verification and preliminary assessment were completed for the 2016 air quality data and no rare events or natural circumstances were identified as contributors to trigger exceedances in 2016.

In particular, the potential for forest fires (e.g. the Fort McMurray fire) to influence the outcome of monitoring was examined during the analysis. Time series of NO_2 and SO_2 concentrations for each station were examined for unusually high levels during the summer months. Two stations had anomalously high NO_2, however these anomalies did not affect the management levels for the stations. No abnormally high SO_2 concentrations were observed, so metrics were recalculated after discarding any data points with elevated $PM_{2.5}$ or SO_2 concentrations. Removal of these data points had no impact on the management levels for any station.

The Conklin station was not in operation until March 2016 and therefore did not fulfill the completeness criteria (75 per cent of data availability) for the NO_2 and SO_2 metrics in 2016 and is not included in the 2016 Status of Air Quality report, or in this report.

Investigation of the 2015 and 2016 results has started but, to date, clear explanations for the exceedances and increases in upper range SO_2 concentrations at Lower Camp in particular, have not been determined. Environment and Parks has started discussions with the Alberta Energy Regulator and other stakeholders as part of the investigation into the 2015 and 2016 trigger exceedances.

3.2 Investigation

The investigation stage focuses on determining likely causes for the performance of an indicator and is expected to influence decisions on management action. Investigations vary in complexity and effort required to get at root causes but often start by looking at trends and air quality history at specific stations reporting exceedances. Table 2 provides a summary of the investigation to date.

Table 2. Status of Investigations into Ambient Air Quality (2012-2016)

Year	Status	Notes
2012	Complete	Technical Report for 2012 Lower Athabasca Region Air Quality Management Framework Management Response was released March 2016 by Environment and Parks (Yan et.al. 2015)
2013	Complete	Technical Addendum: Technical Supporting Document for the 2013 Air Quality Management Framework (AQMF) Management Response (unpublished)
2014	Complete	Results of the 2014 investigation were summarized in the Status of Management Response report (AEP 2016b).
2015	Initiated	A series of activities have been identified based on 2015/16 air quality results and preliminary investigation. Outstanding activities will be addressed in 2017-2018.
2016	Initiated	

2016 Investigation - Nitrogen Dioxide (NO_2)

The 2012 Technical Report for Lower Athabasca Air Quality Management Framework Management Response (Yan et.al. 2015) reported that more than 90 per cent of total NO_2 emissions in the LAR are from a combination of point source emissions (e.g. stacks) and non-point source emissions (e.g. mine fleets). Elevated levels of NO_2 at stations that were recorded at Level 2 occurred during colder months under stable meteorological conditions when releases did not have an opportunity to disperse. Based on the 2016 results for NO_2, with Shell Muskeg River station stable at Level 2 and no other station exceeding Level 1, there is no need to investigate the results further.

Annual Average of NO_2 Concentrations

In 2016, the annual average concentrations of NO_2 within the Lower Athabasca Region were placed at Level 1, except at Shell Muskeg River station. Shell Muskeg River was above the trigger for Level 2, where it has consistently been since 2012, though values have been lower in 2015 and 2016 (Figure 1).

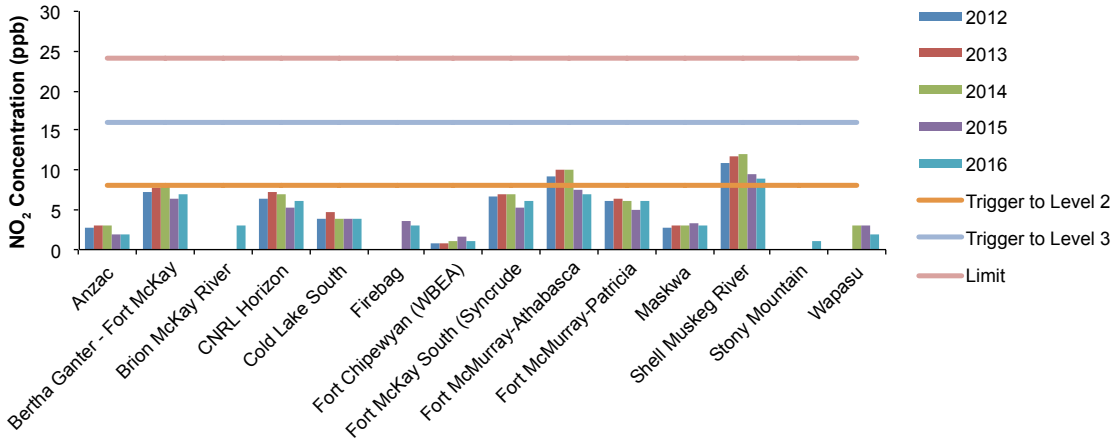

Figure 1.
Annual Average of the Hourly Data for Nitrogen Dioxide for 2012 to 2016 from Air Monitoring Stations in the Lower Athabasca Region.

The Upper Range of Hourly NO_2 Concentrations

The upper range concentrations of NO_2 at Shell Muskeg River station remained at Level 2 in 2016 as it has every year since 2012. Upper range concentrations of NO_2 at CNRL station dropped below the level 2 trigger in 2016. The upper range NO_2 concentrations remained at Level 1 at all other stations in 2016 (Figure 2).

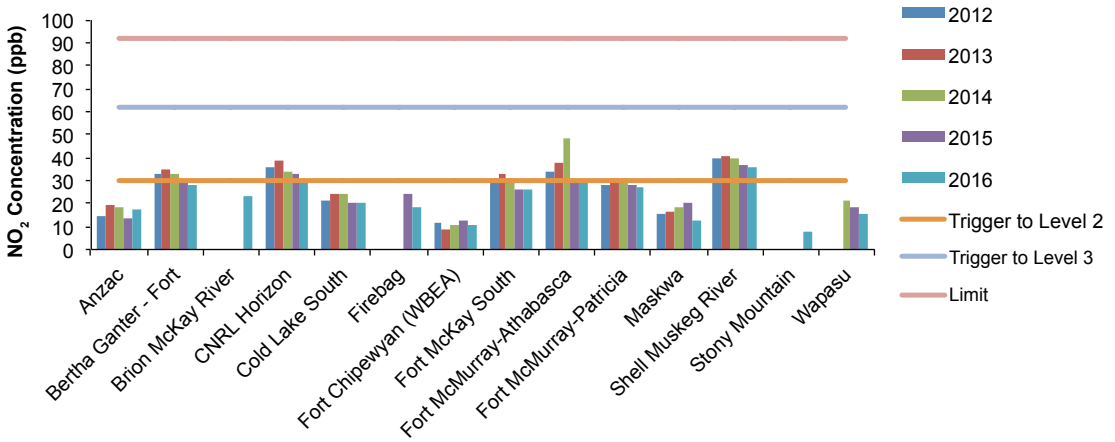

Figure 2.
Upper Range of the Hourly Data for Nitrogen Dioxide for 2012 to 2016 from Air Monitoring Stations in the Lower Athabasca Region

2016 Investigation - Sulphur Dioxide (SO_2)

Emissions inventories have shown that industrial point sources were the major contributors to SO_2 emissions in the LAR and that the largest industry emissions contributions were from the Syncrude and Suncor upgraders 3 (Figure 5). The investigation into the 2012 SO_2 levels indicated that Level 3 station exceedances were attributable to plume downwash from upgrader stacks, whereas Level 2 station exceedances were driven by SO_2 emissions from the adjacent upgraders. However, based on the preliminary investigation, the attributions from the 2012 investigation cannot be determined, with great certainty, to be the cause of the SO_2 exceedances for 2016.

Annual Average of SO_2 Concentrations

In 2016, preliminary investigation showed that, though there was a Ground Level Concentration (GLC) exceedance of 1-hr Alberta Ambient Air Quality Objective (AAAQO) for SO_2 concentrations (172 ppb) at Mannix (1st October, 2016), the total SO_2 emissions in Lower Athabasca Region decreased. This decrease can mainly be attributed to reductions in SO_2 emissions as a result of the implementation of Flue Gas Desulfurization (FGD) at Syncrude. The annual average of hourly SO_2 concentrations at all stations remained at Level 1 (Figure 3).

This year, investigation was focused on Lower Camp station where SO2 concentrations increased year over year from 2012-2016.

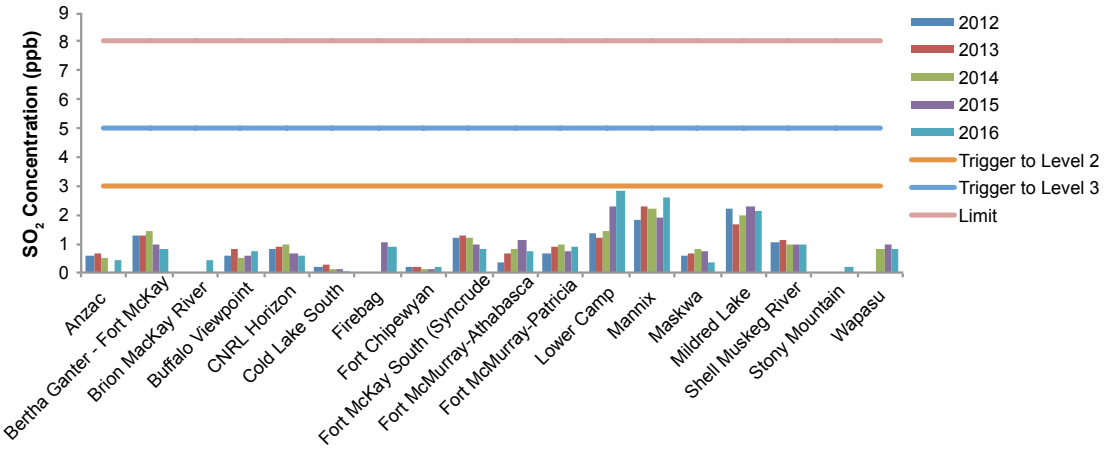

Figure 3. Annual Average of the Hourly Data for Sulphur Dioxide for 2012 to 2016 from Air Monitoring Stations in the Lower Athabasca Region.

Upper Range of Hourly SO_2 Concentrations

In 2016, the 99th percentile of Upper Range of Hourly SO_2 concentrations increased at Buffalo Viewpoint, Fort Chipewyan, Lower Camp, and Mannix stations relative to 2015. Anzac, Cold Lake South and Maskwa stations had decreases in upper range concentrations of SO_2 from 2015 to 2016. Remaining stations had smaller increases or stayed stable over that time period. SO_2 at Lower Camp station reached 43 ppb (Level 4) an increase from 27 ppb in 2015 (Level 3) (Figure 4).

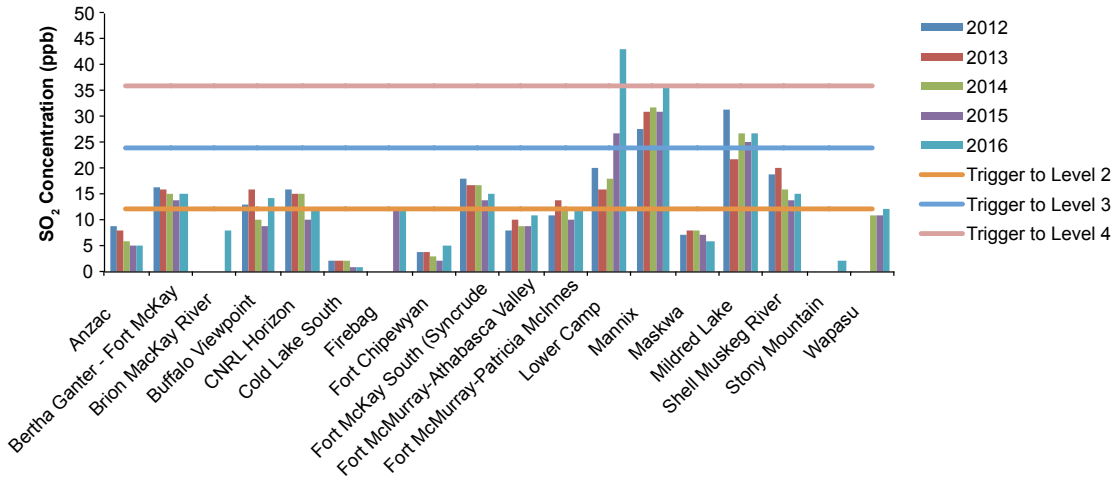

Figure 4.
Upper Range of 99th percentile Hourly Sulphur Dioxide for 2012 to 2016 from Air Monitoring Stations in the Lower Athabasca Region.

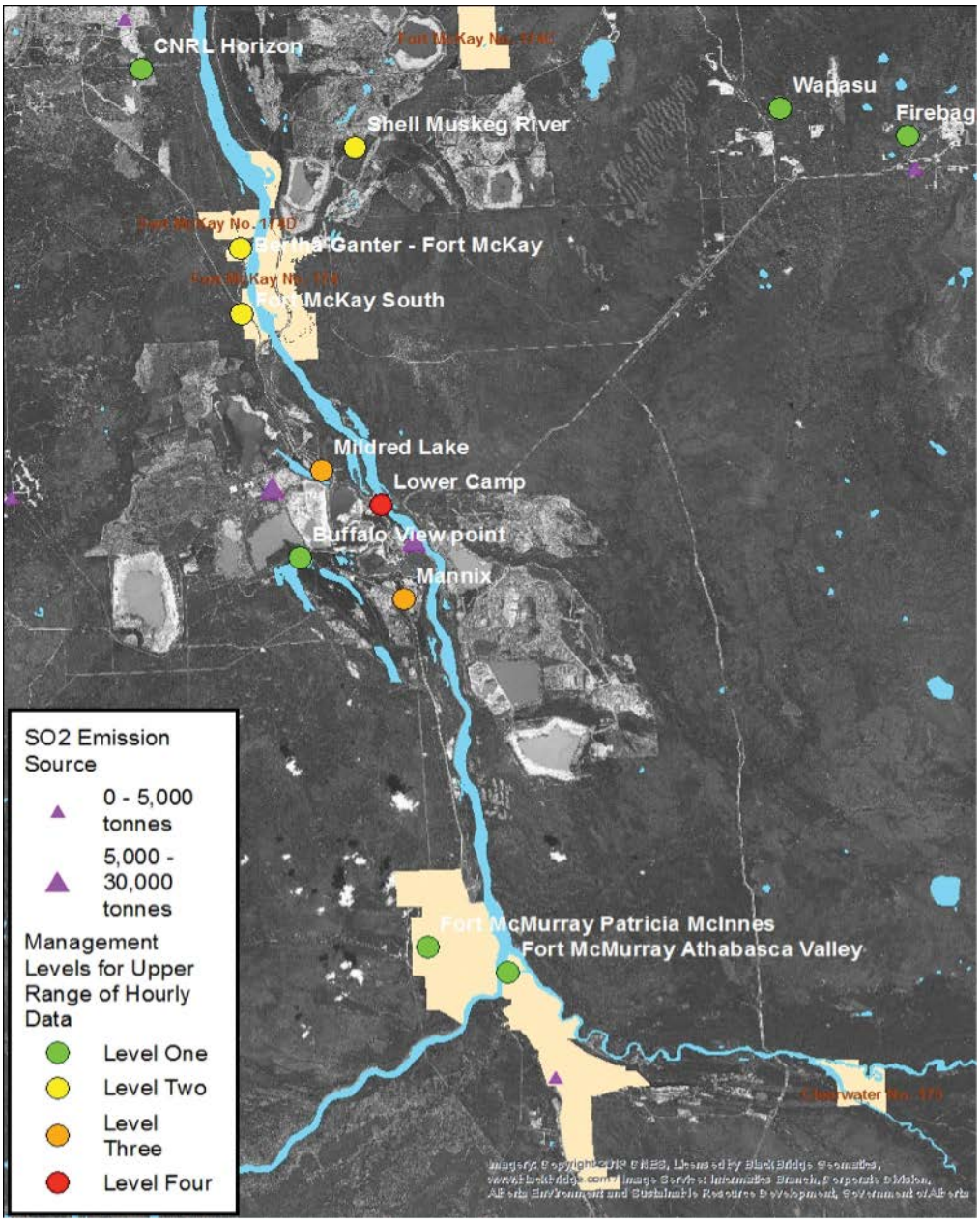

Figure 5.
Map of major SO_2 emission sources in the LAR relative to the management levels for upper range of hourly SO_2 concentrations at air monitoring stations in 2015.

Pollution Roses

Pollution roses are used to graphically indicate the relative frequency of the wind direction at a particular place over a period of time. They can be helpful in identifying the direction of the source of pollutants at a given air monitoring station. Pollution roses were completed for all stations that had upper range of SO_2 concentrations in Level 2 or higher and which were in the vicinity of Lower Camp in order to better understand the impact of wind direction on the Lower Camp exceedances (Figures 6a, 6b, 6c, 6d). They were completed to identify both wind direction over the course of the year and direction during periods when SO_2 exceedances were recorded (SO_2>12 ppb).

Buffalo Viewpoint (Upper Range Level 2) and Mannix (Upper Range Level 3) stations showed higher concentrations of SO_2 when winds were northerly (NW, N, NE) suggesting both Syncrude and Suncor upgraders, which are located N, NE of these stations, may be driving those exceedances. Mildred Lake and Lower Camp had higher SO_2 concentrations when winds were from SE, S and SW. This suggests that the Suncor upgrader, which is in S, SE of these stations, is a potential source of SO_2; the origin of SO_2 from the SW wind vector is uncertain. The 2016 audit for the Lower Camp wind sensors and SO_2 analyzer confirmed that the equipment was functioning within acceptable parameters. Field inspectors were deployed to conduct ground-truthing in areas SW of Lower Camp; no SO_2 sources were observed.

Firebag (Level 1) and Wapasu (Level 1) stations, which are located to the NE of both Syncrude and Suncor, had lower SO_2 concentrations than the other stations during 2016, but experienced higher concentrations of SO_2 when wind was from the S, SW (Figure 6c).

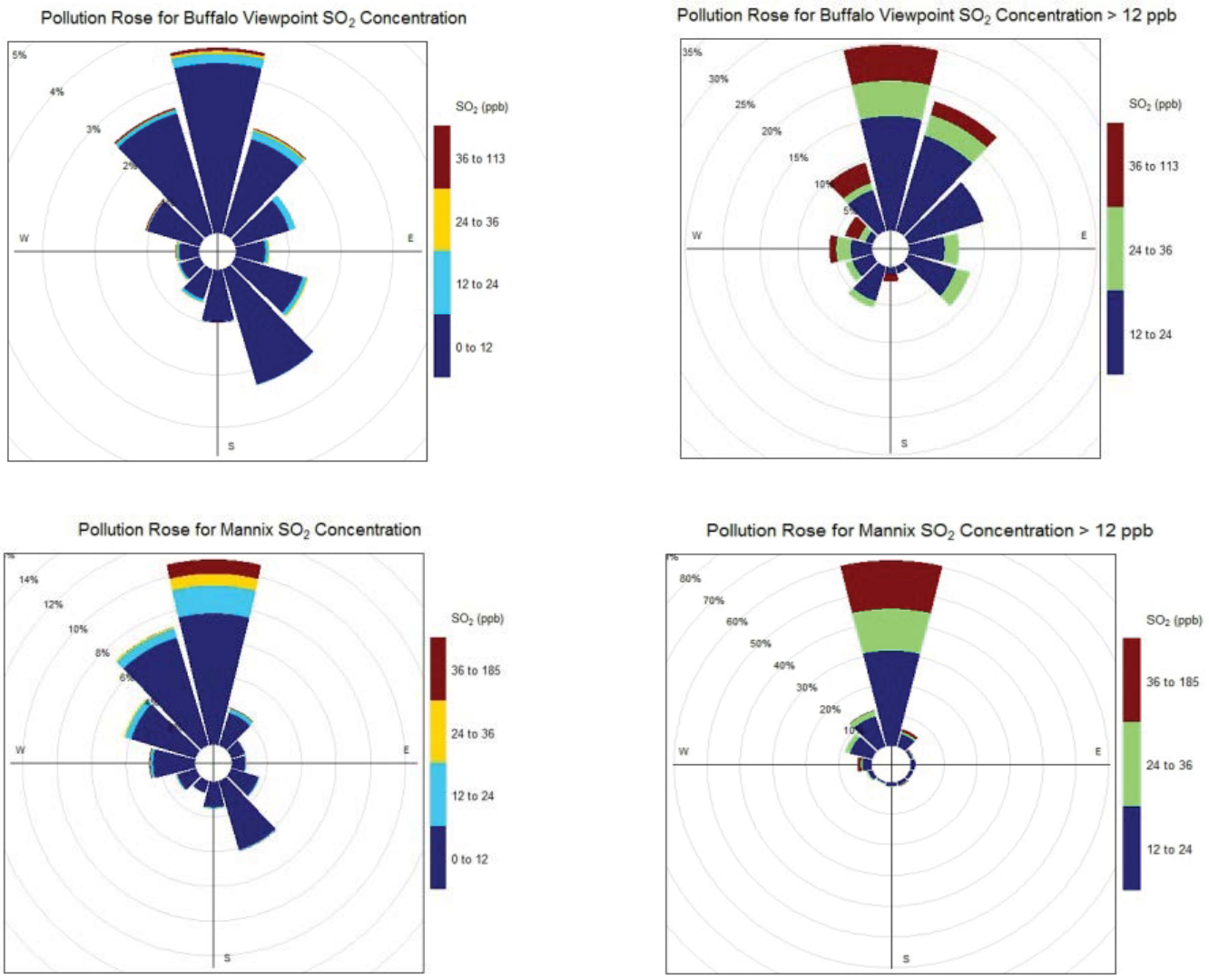

Figure 6a. Pollution Rose for Buffalo Viewpoint and Mannix (2016).

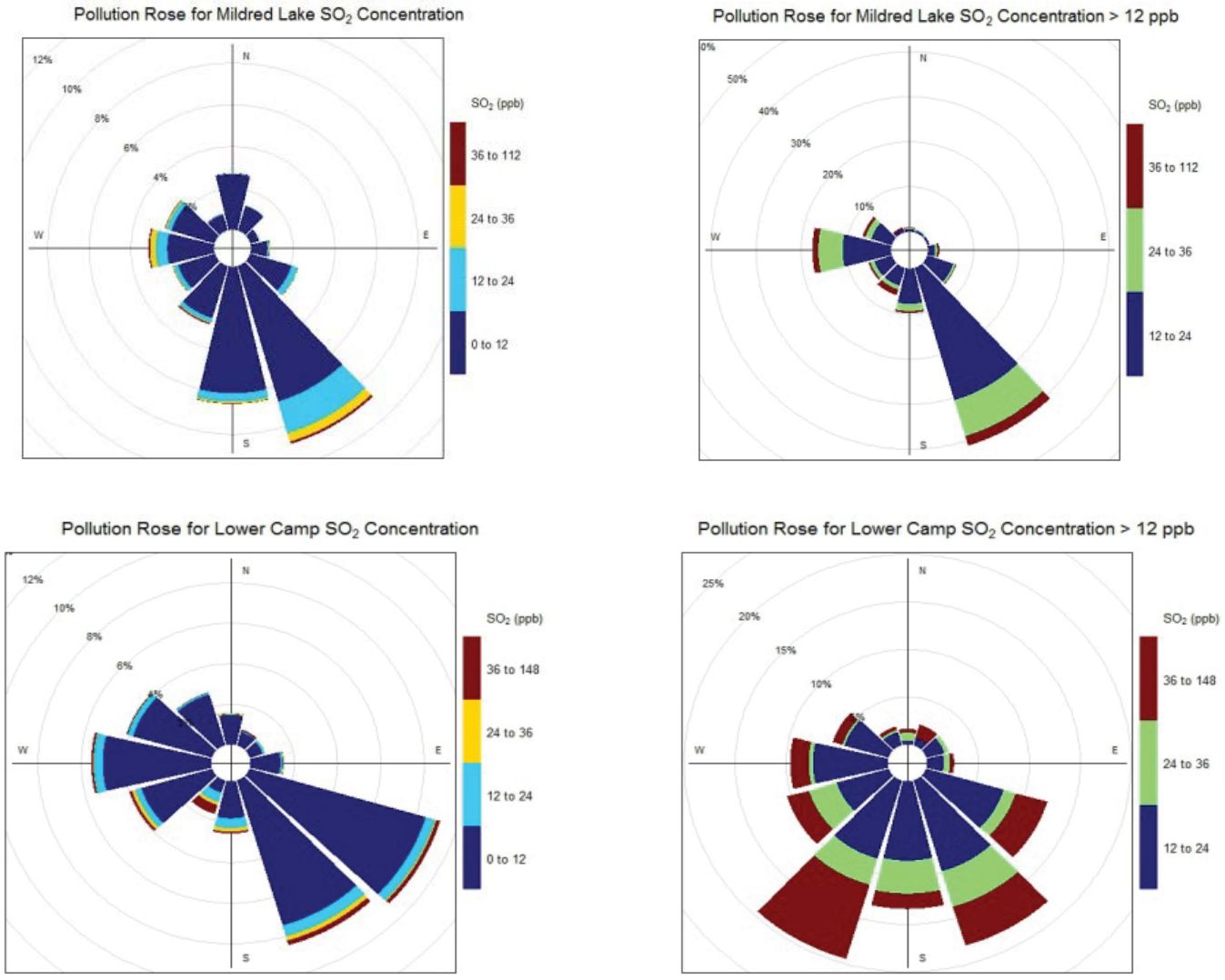

Figure 6b.
Pollution roses for Mildred Lake and Lower Camp (2016).

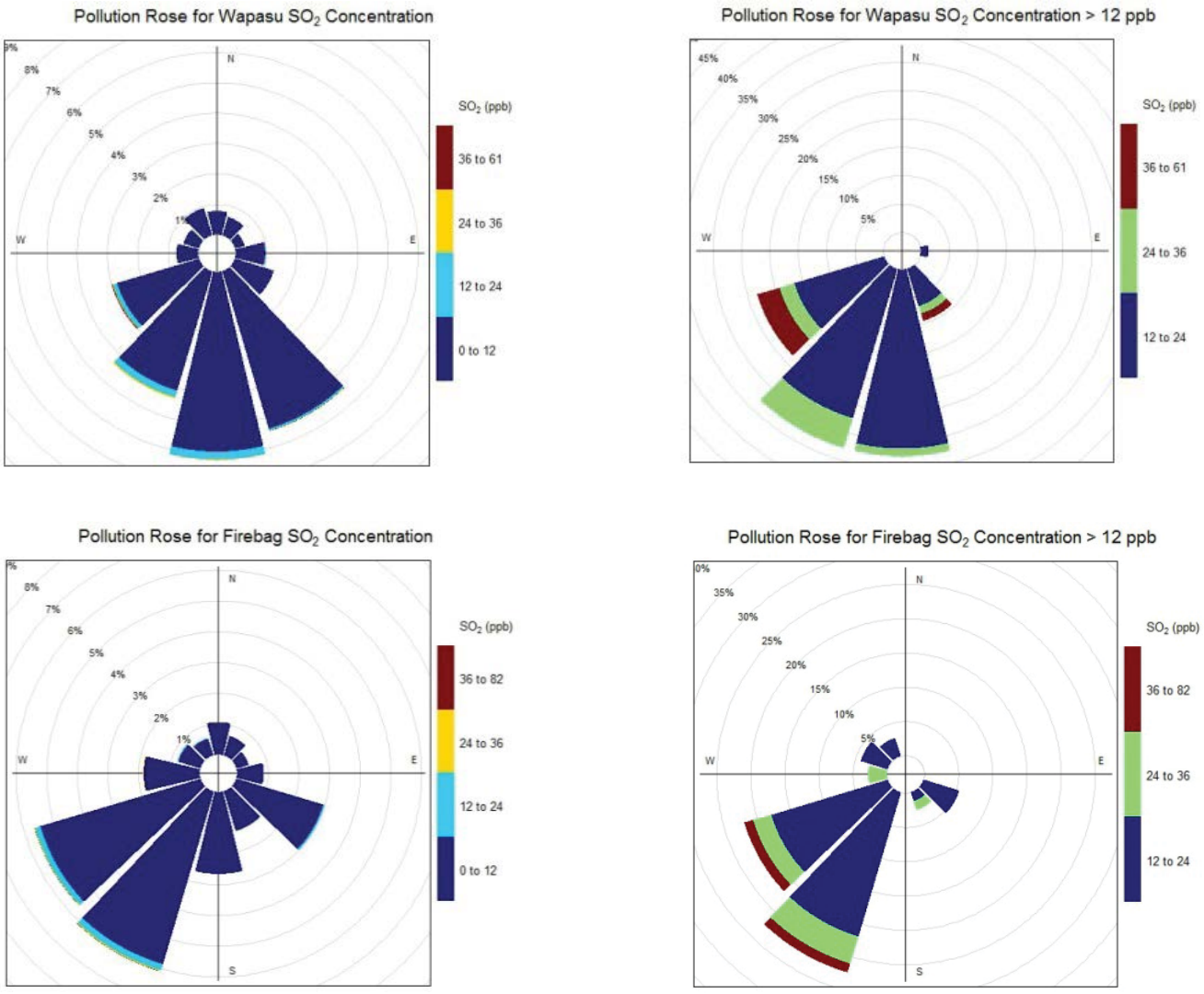

Figure 6c.
Pollution roses for Wapasu and Firebag (2016).

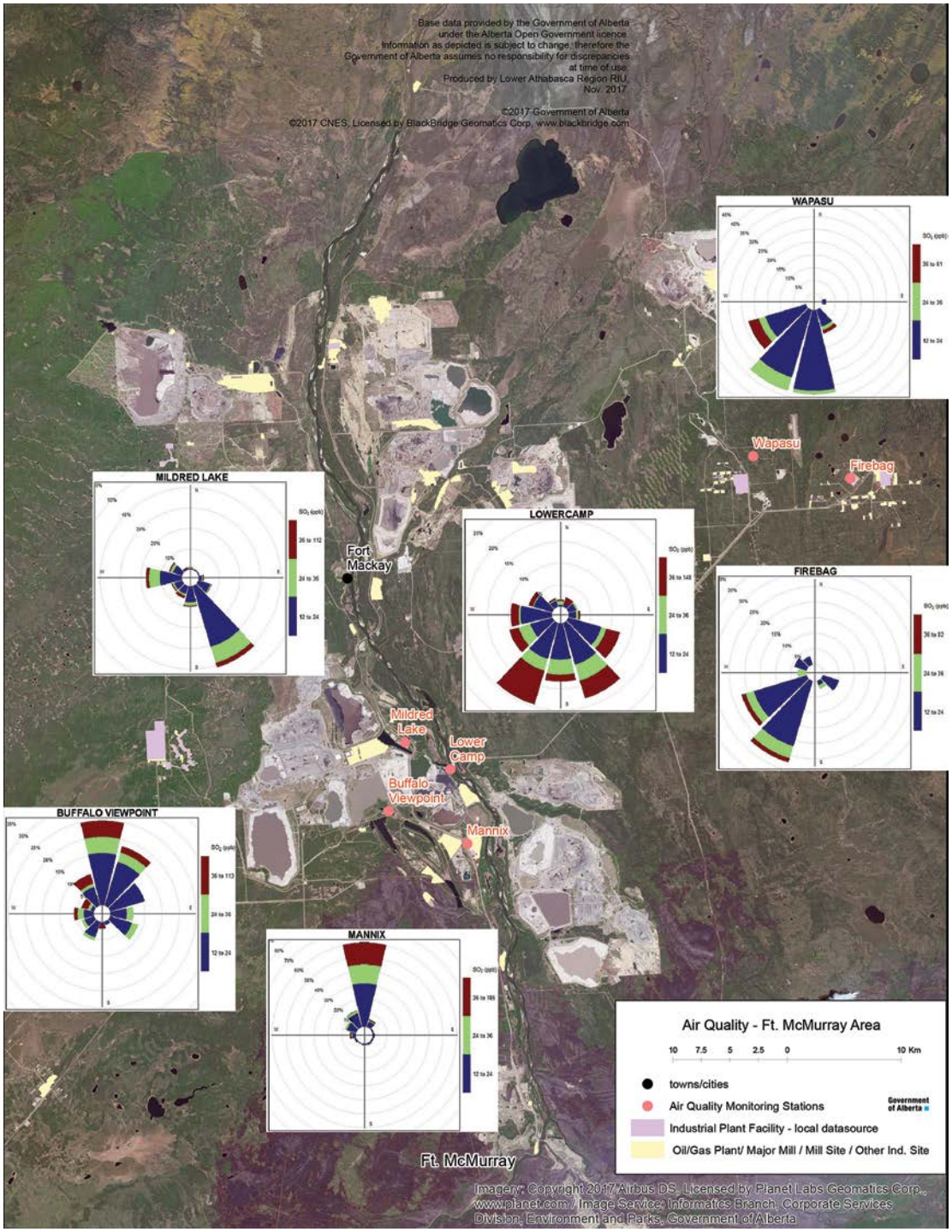

Figure 6d.
Pollution roses for Lower Camp and nearby air monitoring stations indicating wind direction during SO_2 exceedances.

SO_2 emissions in the oil sands

Total industrial SO_2 emissions were lower in 2016 compared to 2015 in the Lower Athabasca Region (Figure 7).

Suncor had a slight increase in SO_2 emissions, from 12, 634 tonnes in 2015 to 12, 948 tonnes in 2016, which is attributable to unplanned flaring. Suncor's daily average of SO_2 emissions from flaring (5.52 tons/day) was above their threshold limit of 5.0 tonnes/day. Exceedance of the daily threshold limit was attributed to 9 contraventions where more than 20 tonnes of SO_2 were flared in a given unplanned event. The shutdown and start-up required as a result of the Fort McMurray fire and unplanned outages from the upgraders drove those contraventions. Without these events, Suncor's daily average would have been 2.64 tonnes of SO_2 per day.

Canadian Natural Resources Limited saw a decreased from 3968 tonnes SO_2 in 2015 to 1495 tonnes SO_2 in 2016. Syncrude also saw a decreased in SO_2 emissions from 27927 tonnes SO_2 in 2015 to 22457 tonnes SO_2 in 2016.

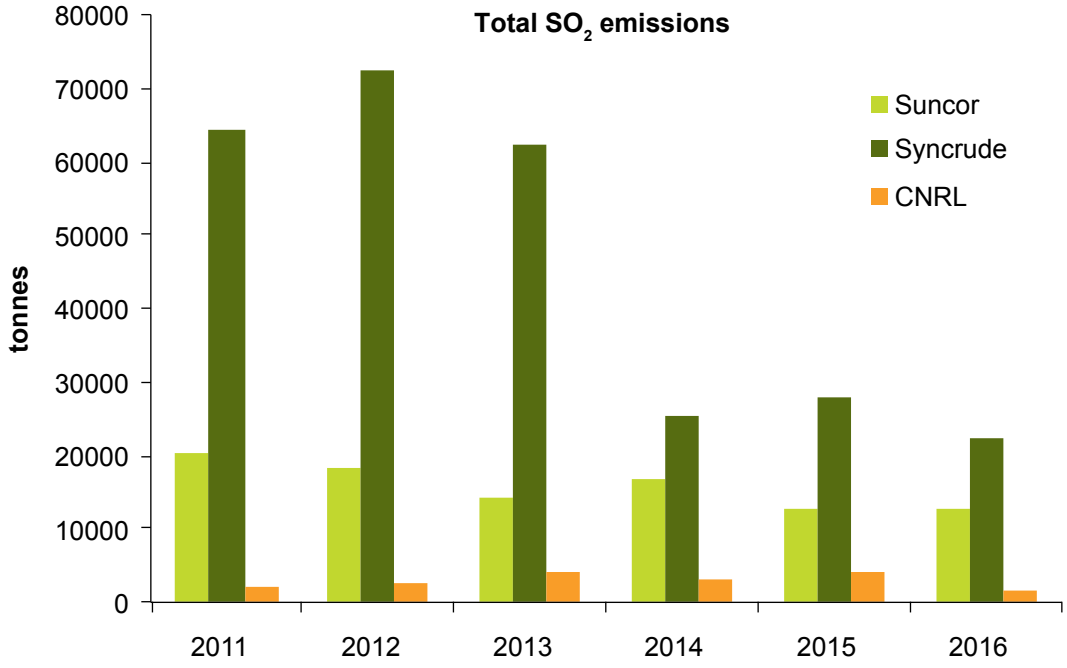

Figure 7.
Total yearly SO_2 emissions from major oil operations in the Lower Athabasca Region (2011-2016).

Next steps of the investigation:

Preliminary investigation of the SO_2 monitoring results for 2016 has not resulted in a clear understanding of the drivers of level increases; meaning that additional investigation is required. Table 3 identifies four additional investigation tasks that will allow for a more fulsome understanding of the SO_2 exceedances in the region for 2015 and 2016.

Table 3. Status of Identified Investigation Tasks

Investigation Task	Status
Compile a detailed SO_2 emissions inventory in the oil sands region for 2012-2016.	Proposed
Episode analysis of hourly SO_2 at Lower Camp and neighbouring stations.	Proposed
Complete wind and dispersion modelling.	Proposed
Trajectory analysis of SO_2 hourly concentrations at Lower Camp station.	Proposed

The oversight and delivery of these tasks are detailed below.

Compile a detailed SO_2 emissions inventory in the oil sands region for 2012-2016

A detailed SO_2 emission inventory from 2012 -2016 from Suncor and Syncrude based on CEMS data and reported flaring and diverter stack emissions organized in a time series will help identify the largest SO_2 sources in this region, the SO_2 sources near Lower Camp, and the typical upwind SO_2 sources. This analysis will also allow for the identification of any gaps in knowledge about SO_2 sources to be addressed through further work. The largest known sources of SO_2 emissions sources near Lower Camp station are tall stacks whose emissions typically disperse greatly before reaching the height of monitoring stations. Analysis from 2012 data indicated that plume downwash may be driving exceedances under specific meteorological conditions, but the driver of exceedances in 2016 may be different. Thus, it is important to examine all SO_2 sources that have the potential to influence Lower Camp concentrations.

While total SO_2 emissions in Lower Athabasca Region have decreased since 2013 (Figure 7), particularly as a result of the Syncrude implementation of flue gas desulfurization, an inventory of other sources of SO_2 emissions in the region will help identify if there may be areas where emissions have increased as a result of operational expansion or other changes.

Complete an episode analysis

Complete a detailed episode analysis for SO_2 exceedance occurrences. This will involve looking for similarities in conditions and results among stations neighbouring Lower Camp in order to understand as fully as possible the potential drivers of Lower Camp SO_2 exceedances.

Complete wind and dispersion modelling

Due to the potential complex terrain in the area, wind analysis at 167 m above ground level at the Lower Camp meteorological tower would help resolve the wind field in the area around Lower Camp station. Wind behaviour may be an influential factor in SO_2 exceedances at Lower Camp station.

While total SO_2 emissions in the Lower Athabasca Region have decreased over the last few years (mainly due to SO_2 reductions from initiatives at Syncrude), analysis of the other patterns and changes in SO_2 emissions in the region is needed. Through this analysis, it will become clear if SO_2 emissions from other sources have also decreased or whether they have increased with the addition of new facilities and existing facilities expanding.

Complete trajectory analysis of SO_2 hourly concentrations at Lower Camp station

Back trajectory analysis will help find any influence of transboundary flows and/or exceptional events on SO_2 concentrations at Lower Camp station.

3.3 Identification of Management Actions

No new management actions have been identified to respond to SO_2 exceedances in the 2016 data because additional investigation is required as indicated in Section 3.2 in order to understand where SO_2 emissions can be targeted to influence air quality results. Ongoing initiatives that are being developed or are in place to reduce emissions in the region are detailed in sectioin 3.4 based on responses to exceedances prior to 2016.

As part of the commitment to stakeholder engagement under the Lower Athabasca Regional Plan, AEP is currently developing a process to solicit input on the air quality management response on a recurring basis. The initiative started in 2017 with an exploration of options for engagement with stakeholders and Indigenous peoples. In 2017-18, the process will identify and take steps to implement the preferred engagement option starting with a workshop in December 2017.

3.4 Oversight/Delivery of Management Actions

Table 4 Status of Delivery of Management Actions

Action	Lead Agency	Status	Notes
Level 3 Stations – Sulphur Dioxide (Upper Range) Management Intent: Proactively maintain air quality below Level 4 trigger			
Emissions Management – Sulphur Emissions Reduction	AER/ Environment and Parks	Complete	Evaluation of management action will continue through 2018.
Level 2 Stations – Sulphur Dioxide (Upper Range) and Nitrogen Dioxide (Annual Average and Upper Range) Management Intent: Improve knowledge and understanding and plan			
Develop improved trend assessment methodology	Environment and Parks	Underway	The report for this work is being finalized and the tool has been trialled.
Assess and improve monitoring network	Environment and Parks	Ongoing	Report submitted by third party contractor and is under consideration by Environment and Parks.
Compile information on non-point source emissions	Clean Air Strategy Alliance (CASA)	Underway	The report is at the final stage of review and will be publicly available January 2018.

Sulphur Emissions Reduction

The Syncrude Sulphur Emission Reduction Program has changed the emissions scenario of Syncrude operations. In 2016, the total SO_2 emission was lowered to 22.5K tonnes from 25.4K tonnes in 2015. Emissions from flaring stacks also decreased to 1.3 tonnes in 2016 from 7.0 tonnes in 2015.

Environment and Parks will continue to work with the Alberta Energy Regulator to monitor the progress of this program and evaluate its effectiveness in reducing regional SO_2 concentrations into 2018.

Develop Improved Trend Assessment Methodology

The development of a tool suitable for calculating both short-term and long-term trends in SO_2 and NO_2 concentrations in the Lower Athabasca Region was identified as something that needed to be addressed in order to fully understand changes in air quality over time. The Environmental Monitoring and Science Division of Environment and Parks has recently developed a statistical tool for analysing trends in air quality data, which also provide information on trends of the quantiles of hourly SO_2 data. This tool was used to analyse SO_2 concentrations at Buffalo Viewpoint, Lower Camp,

Mannix, and Mildred Lake stations from 2012 to 2016. Lower Camp was the only station to show a positive trend in SO_2 upper range concentrations over that time period; no trends were identified for any of the other analysed stations.

Assess and Improve Monitoring Network

The Oil Sands Monitoring (OSM) network assessment was initiated to provide recommendations on adjustments to the monitoring network to improve characterization and understanding of ambient air quality in the Lower Athabasca Region. A third-party report with recommendations has been submitted to Environment and Parks and is under review by EMSD.

Compile Information on Non-point Source Emissions

Non-point source emissions in the Lower Athabasca Region have been reported on by the Clean Air Strategic Alliance. Based on the report, 99 per cent of SO_2 emissions are from point sources and only 1 per cent is from non-point sources. The report is in the final stages of review and is expected to be publicly released in January 2018.

4.0
Next Steps

Management actions to reduce SO_2 will ultimately depend on the main contributors to the elevated SO_2 concentration episodes identified. Reducing emissions from the main contributing sources will be the priority, as reducing overall regional annual SO_2 emissions may not address the specific elevated SO_2 episodes that are occurring.

Environment and Parks will continue to oversee the delivery of the identified management actions while also initiating investigation into 2015-2016 trigger exceedances in collaboration with other government organizations (e.g. Alberta Energy Regulator) and external parties as required.

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Status of Surface Water Quality Management Response

Figures

Tables

1.0 Introduction

Under the Lower Athabasca Regional Plan (GoA 2012), a management response must be initiated when a surface water quality trigger or limit has been exceeded, as determined by the Minister of Environment and Parks. Triggers and limits are identified in the Lower Athabasca Region Surface Water Quality Management Framework (AESRD 2012). Part of the management response is determining the need for management action(s).

The first management response was initiated when triggers were exceeded based on the 2012 surface water quality data. As each annual report on condition becomes available, the management response is re-evaluated and updated based on new information. New management responses are initiated for new exceedances.

This report is intended to provide an update on current management responses to trigger exceedances since the last status report, as of December 2016 (AEP 2017b) and describe any new management response to exceedances identified in the 2016 Status of Ambient Environmental Condition Report (AEP 2018). The report also identifies next steps for the overall management response.

Environment and Parks is the lead coordinator in undertaking the management response and will work with other government organizations (e.g. Alberta Energy Regulator) and external parties as required to undertake investigation and implement identified management actions.

A full description of the management system is found in the Lower Athabasca Region Surface Water Quality Management Framework (AESRD 2012). The management response is a set of six steps that must be undertaken (in full or in part) when an ambient surface water quality trigger or limit is exceeded. Initial steps include verification, preliminary assessment and an investigation to determine the need for management actions.

1.1 Monitoring of the regulatory site

Triggers and limits identified in the framework apply to the regulatory site referred to as ‘Old Fort’. It is located on the Athabasca River within the Peace-Athabasca Delta; upstream of Lake Athabasca and downstream of all oil sands development (Figure 1). ‘Old Fort’ refers to the combined historical data from two monitoring sites. Due to accessibility constraints, surface water samples are typically collected at the Old Fort monitoring station during the open water season and from the Devil’s Elbow monitoring station in winter. The Devil’s Elbow site is approximately 20 km downstream, past the confluence of the Richardson River.

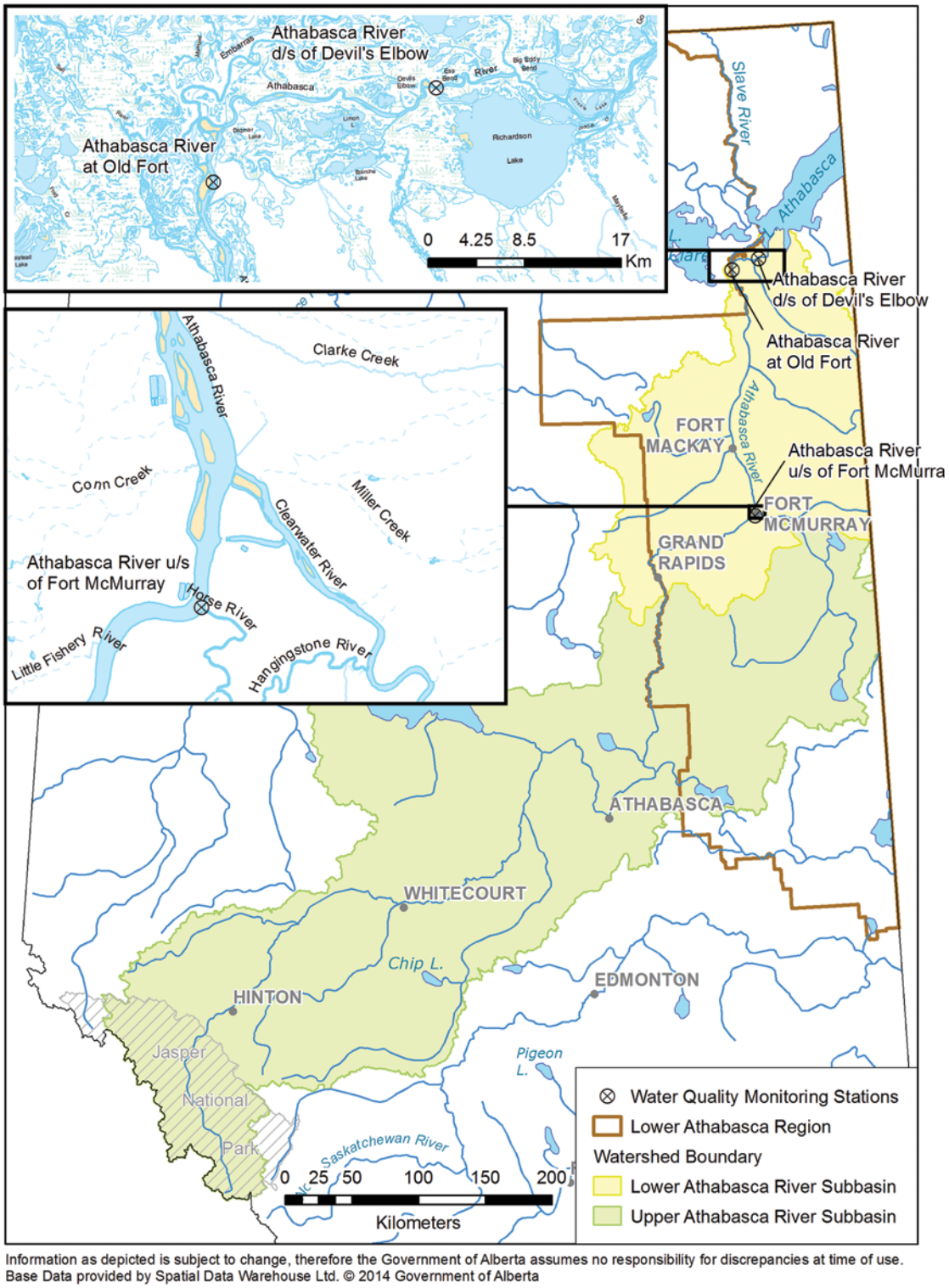

Figure 1
Map of the Athabasca River Basin and Lower Athabasca Region surface water quality monitoring stations.

2.0

Summary of Trigger Exceedances and Status of Management Response

To date, surface water quality parameters in the lower Athabasca River have not exceeded any limits. Trigger exceedances; however, have been observed each year since the framework was first implemented in 2012. Historical exceedances are reported in AESRD 2014, AEP 2016a, 2017a, 2018, AEMERA 2014, white the status of management response is provided each year in AEP 2014, 2016b, 2017b.

Table 1 identifies trigger exceedances since 2012 subject to a current management response as well as exceedances from 2016.

Table 1.
Trigger exceedances from 2012 to 2016 and status of management response.

Indicator	2012	2013	2014	2015	2016	Status of management response as of December 2017
Potassium			Mean			Investigation
Sulphate			Mean	Mean	Peak	Investigation
Iron (dissolved)		Mean				Investigation
Nitrogen (total)	Mean	Mean				Investigation
Uranium (dissolved)	Mean/ Peak	Mean/ Peak	Peak	Mean/ Peak	Mean/ Peak	Investigation
Lithium (dissolved)	Peak				Mean/ Peak	Investigation
Cobalt (dissolved)			Peak		Peak	Closed
Aluminum (dissolved)		Peak				Closed
Lithium (total)		Peak				Closed
Strontium (dissolved)				Mean		Closed

Of the 2016 exceedances, dissolved uranium has exceeded triggers each year since 2012. Sulphate exceeded triggers in the last three consecutive years. Dissolved lithium exceeded a trigger for the first time since 2012, and dissolved cobalt exceeded a trigger previously in 2014.

At time of the last management response report (AEP 2017b), the next steps identified for the management response were to assess trends and seasonality of trends at several locations upstream of ‘Old Fort’ for parameters under investigation. Due to the accelerated timelines for preparation of the 2016 Status of the Management Response Report, these results will be presented in the Status of the Management Response report for 2017. Herein we present updated trend analyses for parameters currently under investigation, and preliminary assessments for parameters that exceeded triggers in 2016. Preliminary assessments consist of trend analysis of flow-adjusted and unadjusted data.

3.0
Status of Management Response

This report is the fourth Status of Management Response Report for the Lower Athabasca Region. A summary of all activities undertaken and reported on in the previous Status of Management Response Reports was provided in the December 2016 management response report (AEP 2017b).

The following section provides a description of the activities undertaken to advance the management response for parameters that either exceeded a trigger in 2016, or are currently subject to a management response. 2016 trigger exceedances were identified by AEP (2018) and are shown in Table 1.

The management response since the last Status of Management Response Report has focused on completing statistical trend analysis on both flow-adjusted and unadjusted data from 'Old Fort', using surface water quality data and flow data up to and including 2016. These trend analyses support the preliminary assessment for dissolved lithium and dissolved cobalt, and reaffirm the rationale for investigating sulphate, dissolved iron, potassium, total nitrogen, and dissolved uranium.

3.1 Verification

Verification of data occurs each year as new annual datasets are available and includes the calculation of mean and peak metrics to compare to trigger values established in the framework. This work was completed by Alberta Environment and Parks for the 2016 data from 'Old Fort' (AEP 2018). Parameters with 2016 trigger exceedances are shown in Table 1. Management response proceeded to preliminary assessment for these parameters.

3.2 Preliminary Assessment

The purpose of the Preliminary Assessment is to determine if an investigation is required or if the management response may be closed. A key component of this assessment is analyzing for emerging trends in water quality over time. If a positive trend is detected (i.e. has a p-value below 0.05), the parameter is moved into the investigation phase of a management response. If a trend is not detected, the management response is closed. Appendix A provides further explanation of trend analysis, including how the influence of flow is accounted for.

The preliminary assessment conducted in 2017 consisted of a statistical trend analysis for parameters first exceeding triggers in 2016. A re-evaluation of preliminary assessments for all parameters currently subject to management responses was also performed using updated datasets.

3.2.1 Dissolved lithium

Dissolved lithium exceeded peak triggers in both 2012 and 2016 (Table 1). Preliminary assessment of the 2012 trigger exceedance did not reveal a significant trend (AEP 2016). The current trend analysis - which includes more recent data - contrasts with this earlier finding.

The current trend analysis for dissolved lithium showed increasing concentrations at 'Old Fort' (Figure 2). The trends in concentrations were also significant when adjusted for flow. Thus, an investigation into dissolved lithium was opened.

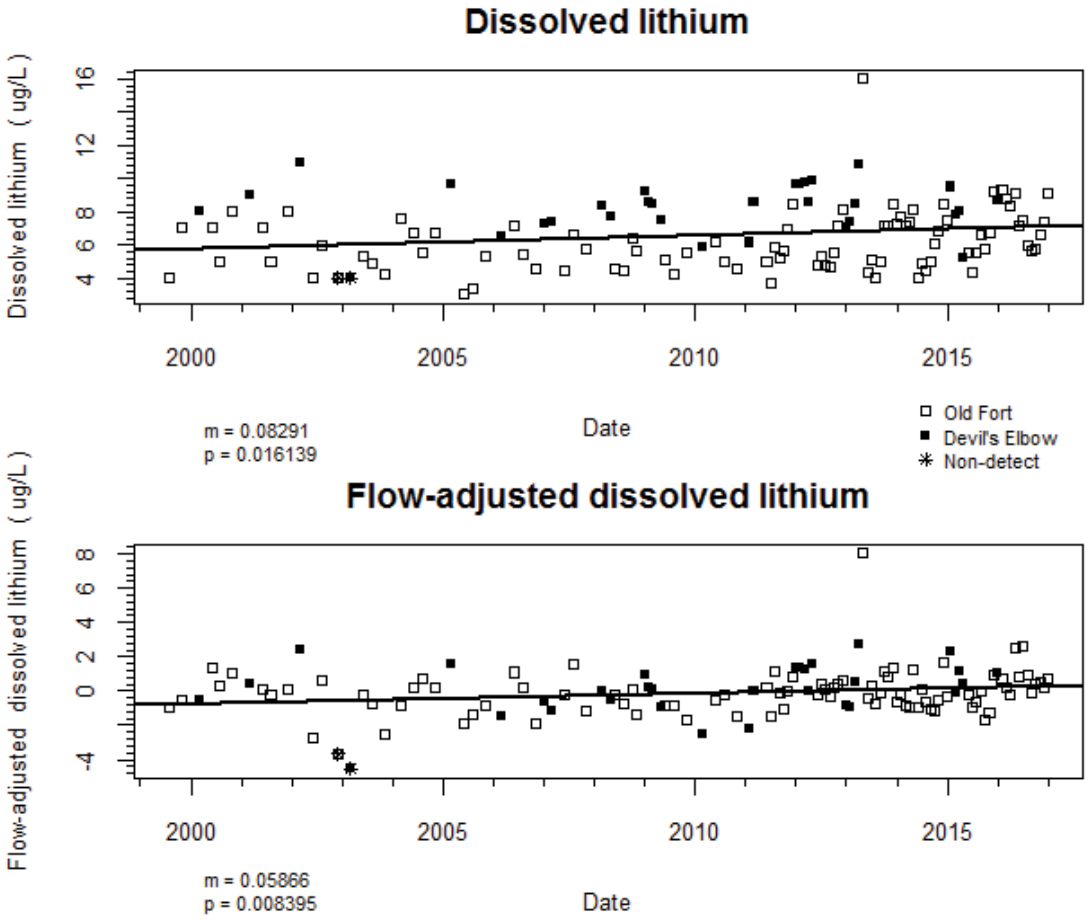

Figure 2
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at 'Old Fort'. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.2.2 Dissolved cobalt

Dissolved cobalt has exceeded triggers in 2014 and 2016 (Table 1). Preliminary analysis of the 2014 trigger exceedance did not reveal a significant trend (AEP 2017b). The current trend analysis were consistent with findings in the previous report, showing no significant trend over time in the concentration of dissolved cobalt at 'Old Fort' (Figure 3). Therefore, the management response for dissolved cobalt was closed.

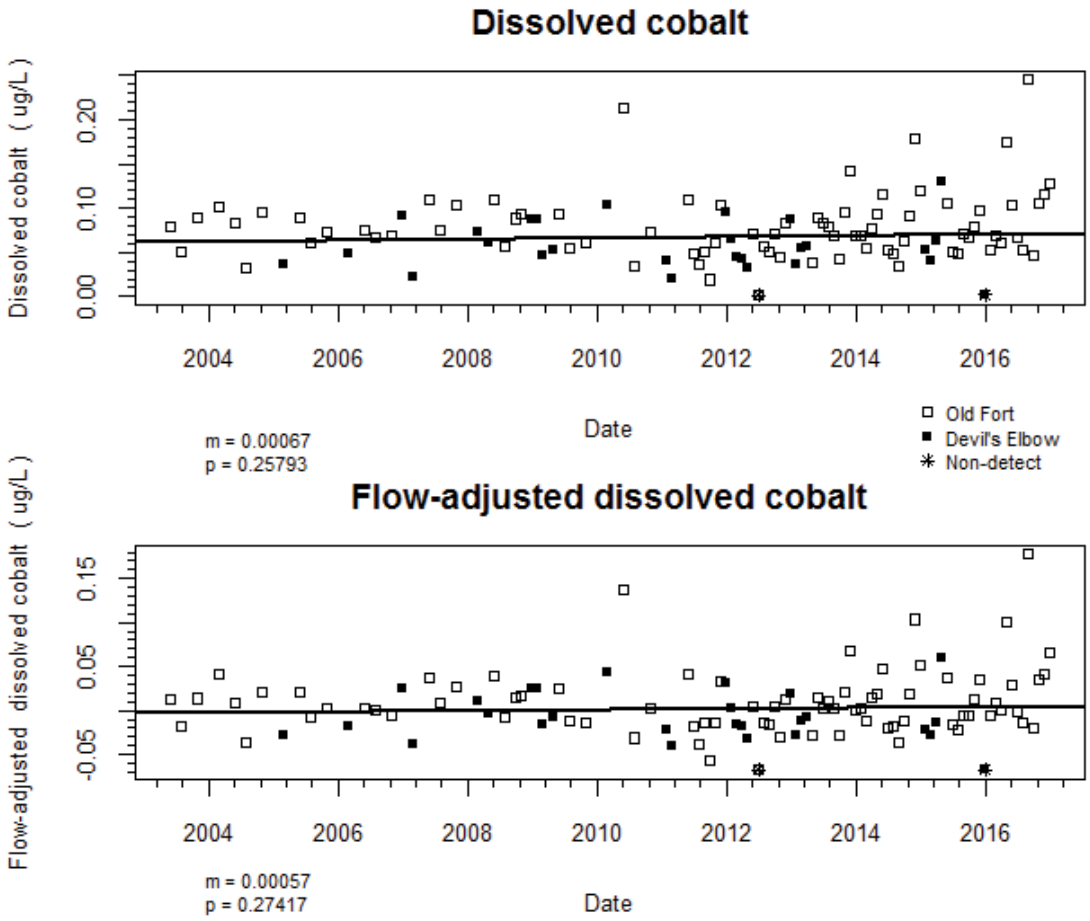

Figure 3
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at 'Old Fort'. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.3 Investigation

The purpose of an investigation is to identify sources and/or processes that contribute to trends in surface water quality. Determining the temporal and spatial scope of observed changes in surface water quality is a key milestone in an investigation. This includes seasonal trends and analyses at upstream locations. Narrowing down the coarse location and timing of contributing sources is referred to herein as scoping.

In 2016, investigations consisted of an update to the trend analyses presented in the 2015 report. Progress in the spatial and temporal scoping of observed changes in surface water quality will be reported in the Status of the Management Response report for 2017. The 2017 report will include a reassessment of seasonal trends with updated data and analyses at upstream locations.

3.3.1 Total nitrogen

Total nitrogen exceeded triggers in 2012 and 2013 (Table 1). Trend analyses performed in previous years have identified significant increasing trends in concentration, largely driven during the open water period (AEP 2017b). In contrast, the 2016 analysis suggested that increasing trends in concentration of total nitrogen have weakened and are no longer significant at a 95% confidence level (Figure 4). However, the trends remained significant when concentrations were adjusted for flow. Since flow-adjusted trends remained significant, investigation into trends in total nitrogen was continued.

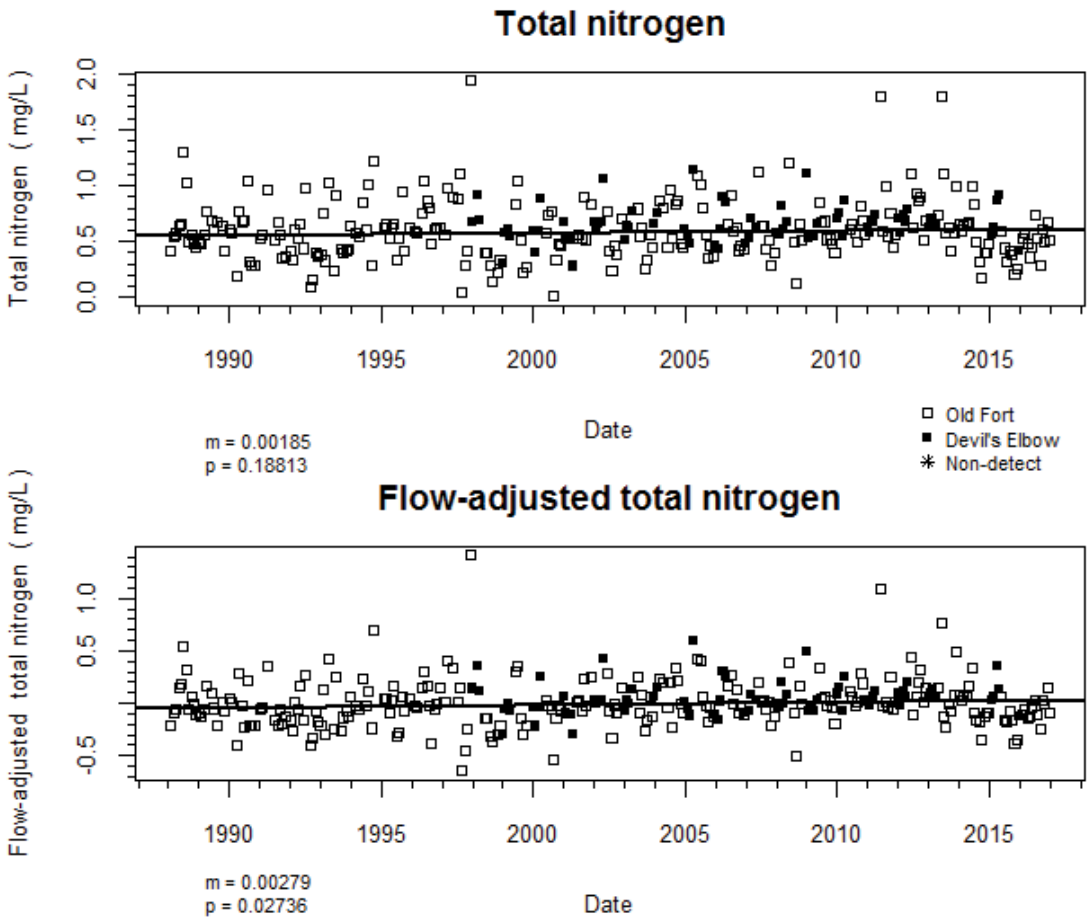

Figure 4.
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at 'Old Fort'. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.3.2 Dissolved uranium

Dissolved uranium has exceeded triggers in each year since 2012 (Table 1). The most recent trend analysis confirms increasing concentrations over time of dissolved uranium (Figure 5). Trends are also significant and observable in flow-adjusted concentrations. Since flow-adjusted trends remained significant, investigation into trends in dissolved uranium was continued.

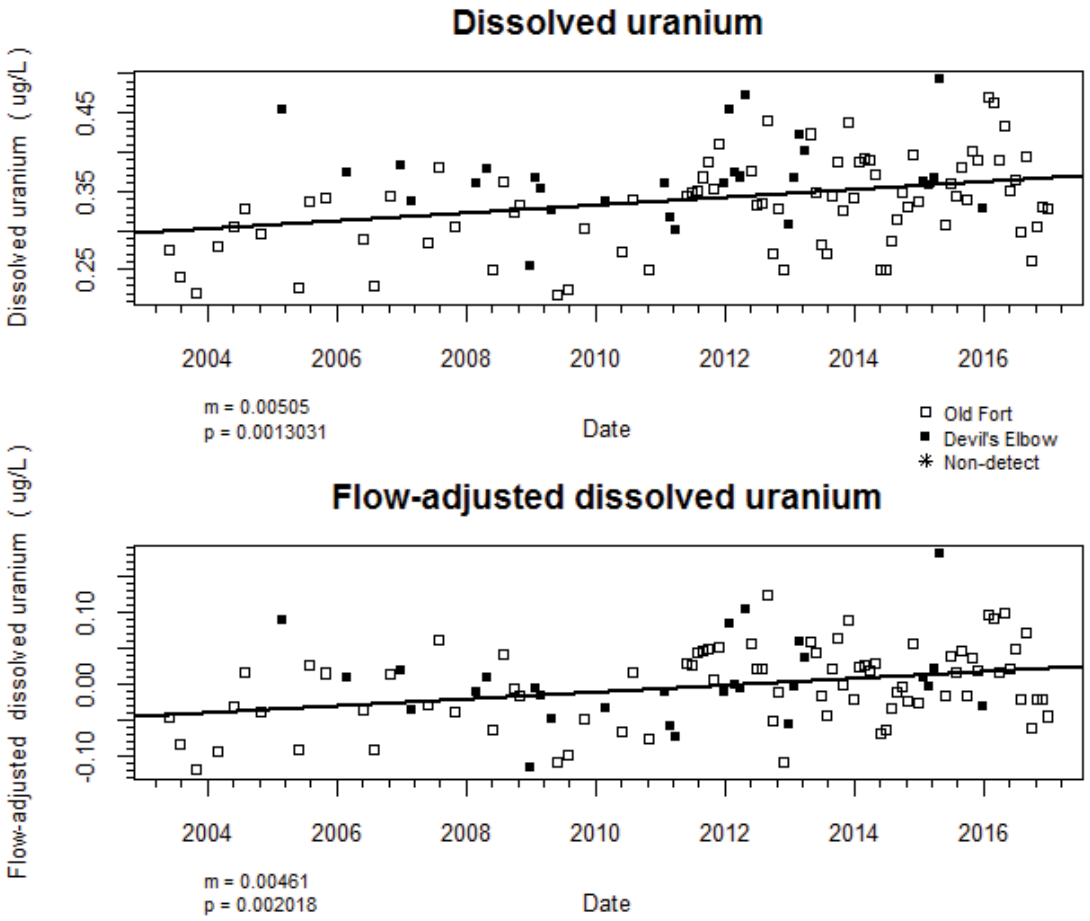

Figure 5.
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at ‘Old Fort’. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.3.3 Potassium

Potassium exceeded a mean trigger in 2014 (Table 1). An investigation into potassium was opened in 2017 following preliminary assessment documented in the previous Status of the Management Response report (AEP 2017b). A trend analysis that included 2016 data also showed increasing trends in concentration for potassium (Figure 6). Trends were also significant when adjusted for flow. Since flow-adjusted trends remained significant, investigation into trends in potassium was continued.

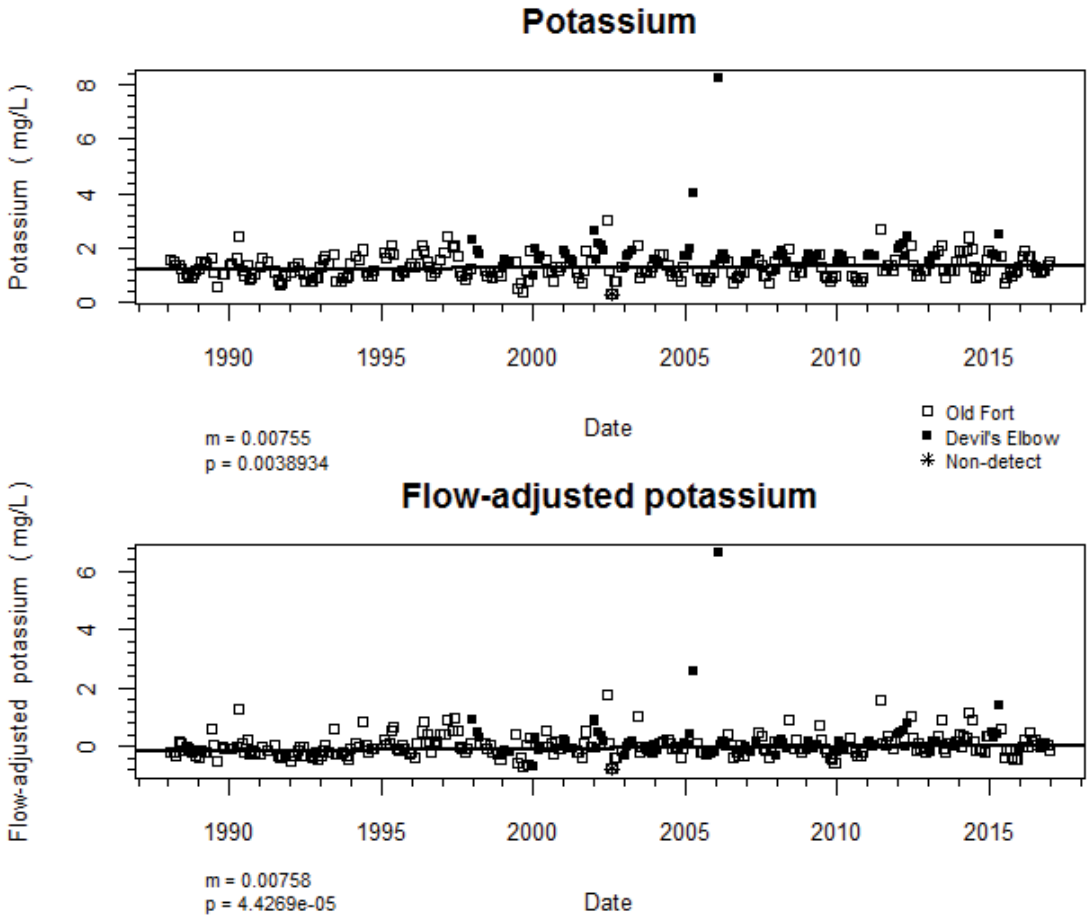

Figure 6.
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at ‘Old Fort’. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.3.4 Sulphate

Sulphate has exceeded triggers in each year since 2014 (Table 1). An investigation into sulphate was opened in 2017 following preliminary assessment documented in the previous Status of the Management Response report (AEP 2017b). A trend analysis that included 2016 data also showed increasing trends in concentration for sulphate (Figure 7). Trends were also significant when adjusted for flow. Since flow-adjusted trends remained significant, investigation into trends in sulphate was continued.

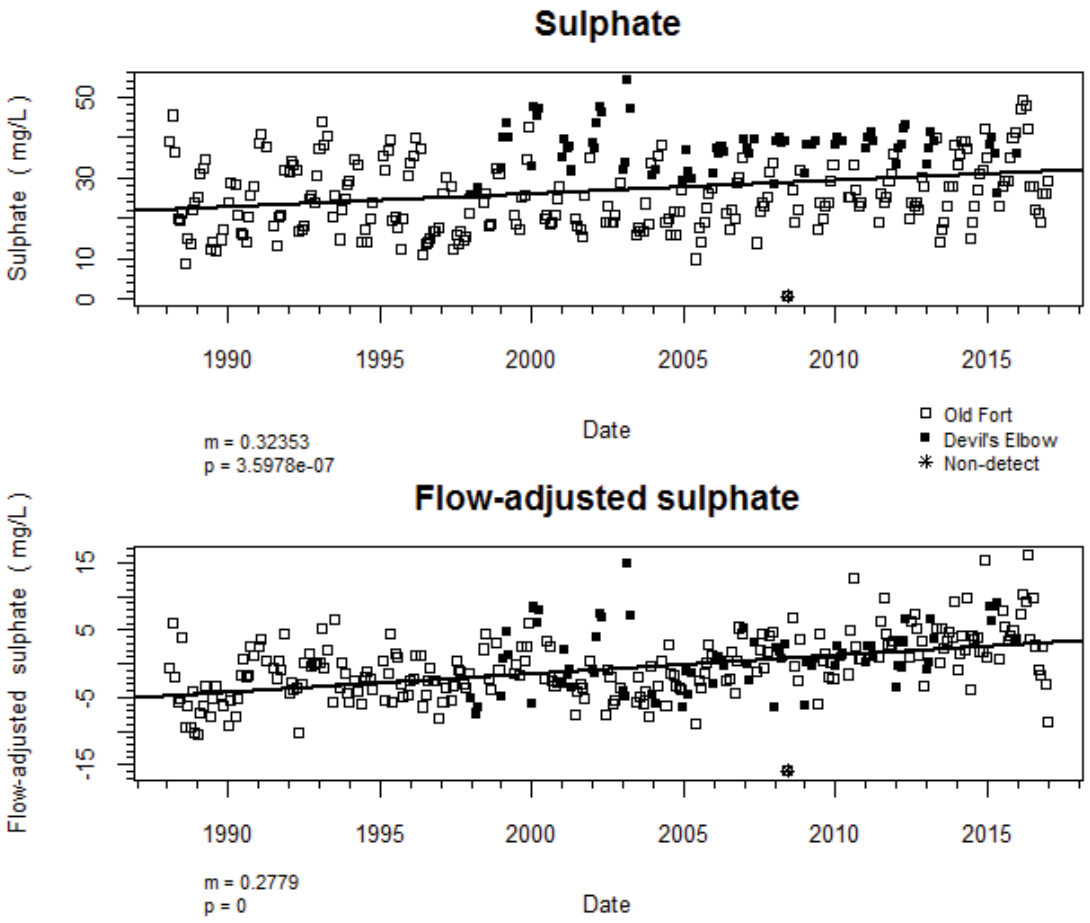

Figure 7.
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at 'Old Fort'. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.3.5 Dissolved iron

Dissolved iron exceeded a trigger in 2013 (Table 1). It is noteworthy that 2013 was a flood year. Regardless, an investigation into dissolved iron was opened in 2017 following preliminary analysis documented in the previous Status of the Management Response report (AEP 2017b). A trend analysis that included 2016 data also showed increasing trends in concentration for dissolved iron (Figure 8). Trends were also significant when adjusted for flow. Since flow-adjusted trends remained significant, investigation into trends in dissolved iron was continued.

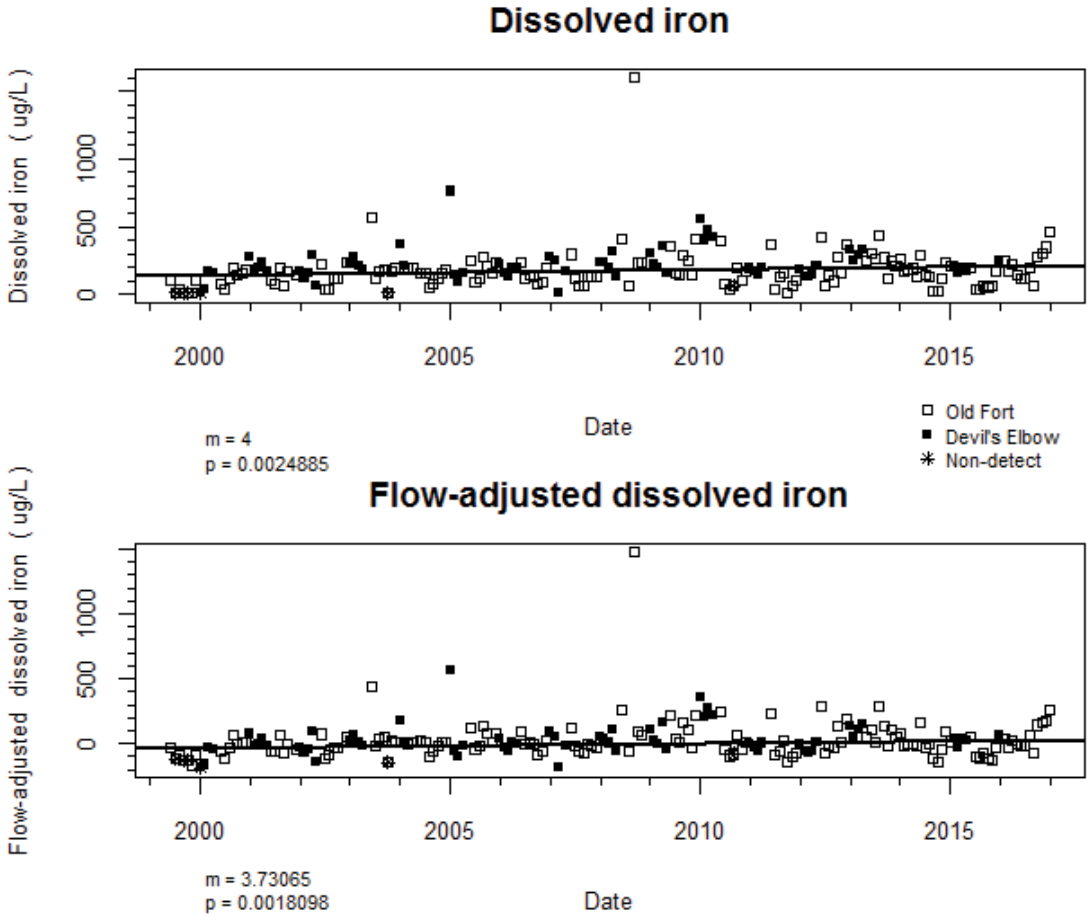

Figure 8.
Time series plots of unadjusted concentrations (top) and flow-adjusted concentrations (bottom) from the Athabasca River at 'Old Fort'. Trend lines represent Akritas-Theil-Sen line and Turnbull intercept.

3.4 Management Actions

The need for management actions and the selection of appropriate management actions will be determined based on the results of the investigation phase of the management response.

4.0
Next Steps

As of June, 2107 the status of management response is as follows:

- Total nitrogen, dissolved uranium, sulphate, potassium, and dissolved iron remain under investigation.
- Dissolved lithium has been moved into the investigation phase.
- Management response for dissolved cobalt has been closed after the preliminary assessment.

4.1 Parametres under Investigation

Total nitrogen, dissolved uranium, potassium, sulphate, dissolved iron, and dissolved lithium are under investigation. The next step in the investigation will focus on scoping. Scoping consists of determining the upstream extent of the observed trends by conducting statistical trend analysis on flow-adjusted and unadjusted data from monitoring stations both upstream of 'Old Fort'. The seasonality of observed trends at 'Old Fort' and other stations will also be assessed to better understand the temporal patterns of the concentration of each parameter and support the identification of potential sources. Future steps include identification of potential sources. Reporting of results for these scoping activities is expected for 2018.

Understanding the influence of hydrology on water quality regime requires an understanding of the various flow contributions from the tributaries. Archived data from the Regional Aquatics Monitoring and Oil Sands Monitoring programs provides extensive, subregional dataset at higher spatial resolution and could be leveraged during the investigation phase of the management response. Analyses of historical discharge within some tributaries are possible. The GOA also has data from past winter synoptic surveys along the Athabasca River. Alberta Environment and Parks also launched a tributary monitoring program in 2017 which will contribute to these efforts. Investigations will use data from these and other available sources where relevant.

4.2 Parametres whose Management Response is Closed

Trend assessment determined that the trigger exceedance for dissolved cobalt do not represent a significant long term change in the surface water quality condition at this time. No investigation will be conducted and the management response for dissolved cobalt is closed.

4.3 Stakeholder engagement

AEP is currently developing a process to solicit input on the water quality management response on a recurring basis. The initiative started in 2017 with an exploration of options for engagement with stakeholders and Indigenous peoples. In 2017-18, the process will identify and take steps to implement the preferred engagement option. This effort is being led by the Resource Management Branch within the Operations Division of AEP. For more information on this initiative, contact Lower Athabasca Region Resource Management within the Operations Division of the Ministry of Environment and Parks.

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6.0 Appendices

Appendix A: Description of trend analysis and flow-adjustment

Trend Analysis

Trend analysis, with respect to the Framework, is a test performed using linear regression on a time series of water quality observations. In the trend analysis, the date of sample collection is the independent variable, and the concentration (of flow-adjusted concentration) is the dependent variable. The analysis determines if a trend is stable, increasing, or decreasing by calculating the slope and significance of the regression line.

Water quality measurements from rivers capture (some portion of) both suspended solids and dissolved ions. Flow provides the energy that suspends solids in water. Therefore, changes in flow often influence water quality measurements from rivers. This influence is accounted for by undertaking flow-adjustment of the sampled water quality concentrations. Flow adjustment simply means that the effects of flow on the changes in water quality over the period of analysis are accounted for.

Flow Adjustment

In flow-adjustment of the sampled water quality concentrations, residuals are calculated by subtracting concentrations typically observed over a range of flow rates. These residuals, known as flow-adjusted concentrations, exclude the influence of flow. In doing so flow-adjusted concentrations highlight chemical changes caused by other factors such as effluent and land use changes within the watershed or regional boundary under assessment.

If a trend in the sampled water quality concentration does not also occur in FACs, the trend likely reflects the natural effect of flow. However, if trends detected in the sampled water quality concentrations are also observed in FACs, then the seasonal or monthly changes in streamflow flow cannot account for the observed trend. This eliminates changes in the streamflow regime as a potential cause of change in surface water quality and necessitates further investigation under the framework.