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REGIONAL AQUATICS MONITORING

in support of the

JOINT OIL SANDS MONITORING PLAN

Final 2015 Program Report

April 2016

Prepared for:

Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA)
Edmonton, Alberta

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Prepared for:

ALBERTA ENVIRONMENTAL MONITORING, EVALUATION AND REPORTING AGENCY

Prepared by:

HATFIELD CONSULTANTS

KILGOUR AND ASSOCIATES LTD.

and **WESTERN RESOURCE SOLUTIONS**

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

The 2015 aquatics monitoring program was conducted in support of the Joint Oil Sands Monitoring Plan by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) and the Hatfield Implementation Team under the direction of AEMERA, consisting of Hatfield Consultants (Hatfield), Kilgour and Associates Ltd. (Benthic Invertebrate Communities component) and Western Resource Solutions (Acid-Sensitive Lakes component).

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EXECUTIVE SUMMARY

OVERVIEW

In 2012, the governments of Canada and Alberta developed a "Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring" (Canada and Government of Alberta 2012) specific to the Athabasca oil sands region of northeastern Alberta. The implementation plan was to build and expand on existing environmental monitoring programs for the Athabasca oil sands region, including the Regional Aquatics Monitoring Program (RAMP, www.ramp-alberta.org). RAMP was implemented in 1997 as a multi-stakeholder aquatics monitoring program to assess the health of rivers and lakes within the Athabasca oil sands region and to assess potential cumulative effects of oil sands development. The intent of the new joint implementation plan was to enhance these monitoring activities and work to integrate environmental monitoring across all environmental components (i.e., air, water, land, and biodiversity), which were historically monitored independently through separate organizations or programs.

As part of the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring, the Joint Oil Sands Monitoring Plan (JOSMP, www.jointoilsandsmonitoring.ca) was initiated and executed from 2012 to 2015 to characterize the state of the environment in the Athabasca oil sands region, understand the cumulative effects of and changes to that environment, and develop recommendations for an integrated environmental monitoring program with an adaptive management framework for implementation. The RAMP Committees worked with the governments of Canada and Alberta to align aquatics monitoring activities historically undertaken by RAMP into the JOSMP, completing this process by April 1, 2014.

The Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA, www.aemera.org) was established in 2014 and given the responsibility for the integration of all environmental monitoring in the province of Alberta, specifically to collect credible scientific data and other relevant information on the condition of Alberta's environment and to provide the public with open and transparent reporting and access to the data and information. The intent of AEMERA is to provide timely collection and objective reporting of scientific data and information on air, land, water, and biodiversity, including information necessary to understand cumulative effects, in order to better inform the public, policy makers, regulators, planners, researchers, communities, and industries.

With the expiry in March 2015 of the "Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring", AEMERA assumed responsibility for the coordination and implementation of the JOSMP in the Athabasca oil sands region. The transition of the JOSMP to AEMERA in 2015 included an expansion of aquatics monitoring previously conducted under the JOSMP to provide an increased coverage of the Athabasca oil sands region, a greater sampling frequency, and an increase in potential contaminants examined.

This document reports on the results of aquatics monitoring conducted under the JOSMP by AEMERA and Hatfield Consultants (Hatfield) under the direction of AEMERA in the 2015 Water Year (WY: 1 November 2014 to 31 October 2015); this monitoring was implemented on the basis of monitoring study designs developed by AEMERA. In this report, the aquatics monitoring conducted under the JOSMP by AEMERA and Hatfield in the 2015 Water Year, and the analysis and reporting of the results of this monitoring, are collectively termed the 2015 Program.

The study area for the 2015 Program was defined as the major watersheds in the Athabasca oil sands region within which oil sands developments have been approved. Monitoring for the 2015 Program occurred as far south as the town of Athabasca and extended north to the Athabasca River Delta. The watersheds in which monitoring occurred in the 2015 Program included:

- lower Athabasca River;
- major tributary watersheds/basins of the lower Athabasca River including the Clearwater River, Christina River, Hangingstone River, High Hills River, Horse River, Gregoire River, Steepbank River, Muskeg River, MacKay River, Ells River, Tar River, Calumet River, and Firebag River;
- select minor tributaries of the lower Athabasca River (McLean Creek, Mills Creek, Beaver River, Poplar Creek, Fort Creek, Pierre River, Eymundson Creek, Redclay Creek, and Big Creek);
- select minor tributaries to Christina Lake (Sunday Creek, Birch Creek, Jackfish River, Sawbones Creek, and two unnamed creeks);
- a minor tributary of the lower Peace River catchment (Alice Creek), which flows into Lake Claire of the Athabasca River Delta;
- specific wetlands and shallow lakes in the vicinity of current or planned oil sands and related developments; and
- a selected group of 50 regional acid-sensitive lakes.

The study area also included the Athabasca River Delta as the aquatic receiving environment for any oil sands developments occurring in the Athabasca oil sands region.

The monitoring approach for the 2015 Program incorporated a combination of both stressor- and effects-based monitoring approaches. Using impact predictions from the various oil sands environmental impact assessments (EIAs), specific potential stressors were identified and monitored to document *baseline* conditions, as well as potential changes related to oil sands development. Examples include specific water quality variables and changes in water quantity. In addition, there was a strong emphasis in the 2015 Program on monitoring sensitive biological indicators that reflect and integrate the overall condition of the aquatic environment such as benthic invertebrate communities and fish populations. Combining both monitoring approaches enabled a more holistic understanding of potential effects on the aquatic environment related to the development of oil sands projects to be achieved.

The scope of the 2015 Program focuses on the following key components of boreal aquatic ecosystems:

1. Climate and hydrology, monitored to provide a description of changing climatic conditions in the Athabasca oil sands region, as well as changes in the water level of selected lakes and in the quantity of water flowing through rivers and creeks.
2. Water quality in rivers and lakes, monitored to identify anthropogenic and natural factors affecting the quality of streams and lakes in the Athabasca oil sands region and to assess the potential exposure of fish and invertebrates to organic and inorganic chemicals.

3. Benthic invertebrate communities and sediment quality in rivers, lakes, and the Athabasca River Delta, monitored because they reflect habitat quality, serve as biological indicators, and are important components of fish habitat.

4. Fish populations in rivers and select lakes, monitored as they are biological indicators of ecosystem integrity and are a highly valued resource in the region.

5. Water quality in regional lakes, monitored to assess potential changes in water quality as a result of acidification.

A weight-of-evidence approach was used for the analyses of monitoring data obtained in the field component of the 2015 Program by applying multiple analytical methods to interpret results and determine whether any changes have occurred due to oil sands developments. The analyses:

- were conducted at the watershed/river basin level, with an emphasis on watersheds in which development has already occurred, as well as the lower Athabasca River at the regional level;
- used a set of measurement endpoints representing the health and integrity of valued environmental resources within each component; and
- used specific criteria (criteria used in oil sands project EIAs, provincial and federal water quality and sediment quality guidelines, and environmental effects monitoring criteria) for determining whether or not a change in values and levels of measurement endpoints had occurred and the extent of the significance of any change with respect to the health and integrity of valued environmental resources. The magnitude of change in the values of measurement endpoints was described as **Negligible-Low**, **Moderate**, or **High** relative to *baseline* conditions (see the tabular summary following the Executive Summary for details regarding these criteria).

The 2015 Program Report uses the following definitions for monitoring status:

- ***Test*** is the term used in this report to describe aquatic resources and physical locations (i.e., stations, reaches) downstream of oil sands developments; data collected from these locations are designated as *test* for the purposes of data analysis, assessment, and reporting. The use of this term does not imply or presume that effects are occurring or have occurred, but simply that data collected from these locations are being tested against *baseline* conditions to assess potential changes; and

- ***Baseline*** is the term used in this report to describe aquatic resources and physical locations (i.e., stations, reaches, data) that are (in 2015) or were (prior to 2015) upstream of all oil sands developments; data collected from these locations are designated as *baseline* for the purposes of data analysis, assessment, and reporting.

Land change due to oil sands development activities that had occurred in the study area up to and including 2015 was estimated with satellite imagery in conjunction with more detailed maps provided by a number of oil sands companies. Land change in the study area as of 2015 was estimated to be approximately 128,486 ha, which was an increase of 4,496 ha from 2014. The total area of land change represented approximately 3.49% of the total area of the watersheds in which these oil sands development activities are occurring, compared to 3.47% in 2014. The percentage of the area of watersheds with land change as of 2015 varied from less than 1% for many watersheds (MacKay, Horse, Pierre River, and Upper

Beaver watersheds), to 1% to 5% for the Steepbank, Calumet, Firebag, Ells, Christina, and Hangingstone watersheds, to more than 10% for the Muskeg River, Fort Creek, Mills Creek, Tar River, Shipyard Lake, Poplar Creek, and McLean Creek watersheds, as well as for the smaller Athabasca River tributaries between Fort McMurray and the confluence of the Firebag River.

ASSESSMENT OF 2015 WY MONITORING RESULTS

A tabular summary of the 2015 WY results by watershed and component is presented at the end of this Executive Summary.

Lower Athabasca River and Athabasca River Delta

Hydrology Hydrometric monitoring for the Athabasca River was conducted at three *test* stations. The mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge in the 2015 WY were 1.1%, 1.8%, 0.7%, and 1.4% lower, respectively, in the Athabasca River observed (*test*) hydrograph than in the estimated (*baseline*) hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Water quality was monitored in the 2015 WY in the Athabasca River at ten *test* stations and one *baseline* station, and in the Athabasca River Delta at four *test* stations. Monthly data from 2015 indicate variations across months at all stations for most water quality measurement endpoints, with concentrations of TSS and associated nutrients and metals highest during freshet and concentrations of TDS and associated dissolved constituents highest during lower flows in the fall. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Differences in water quality in fall 2015 for all stations monitored in the Athabasca River and Athabasca River Delta and regional *baseline* fall conditions were classified as **Negligible-Low**.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities and sediment quality were monitored in the Athabasca River Delta in fall 2015 at four depositional *test* stations. Variations in benthic invertebrate community measurement endpoints compared to historical *baseline* conditions were classified as:

- **Negligible-Low** at Big Point Channel, Fletcher Channel, and Embarras River; and
- **Moderate** at Goose Island Channel on the basis of high abundances (greater than 120,000 individuals per m^2) and the dominance of tubificids.

Concentrations of sediment quality measurement endpoints were below guideline concentrations in fall 2015, with the exception of:

- total arsenic at *test* stations on the Embarras River and on the Athabasca River at Northlands and above the Muskeg River;
- Fraction 3 hydrocarbons at *test* stations on Goose Island Channel and the Embarras River; and
- predicted PAH toxicity at *test* stations on Big Point Channel, Embarras River, and on the Athabasca River at Northlands and above and below the Muskeg River, and at a *baseline* station on the Athabasca River at Poachers Landing.

Fall sediment quality results for stations monitored in 2015 on the Athabasca River mainstem and in the Athabasca River Delta were not classified. A Sediment Quality Index could not be calculated for these stations because there are no regional *baseline* concentrations for sediment quality for either the Athabasca River mainstem or the Athabasca River Delta against which the 2015 conditions could be assessed.

Fish Populations (Wild Fish Health) Wild fish health monitoring was conducted in the Athabasca River in fall 2015 at five *test* reaches and four *baseline* reaches using trout perch as the target species. There was a concentration of changes in values of wild fish health measurement endpoints starting at the *test* reach below the Muskeg River confluence, becoming more prominent at the *test* reach above the Ells River confluence, and then dissipating at the *test* reach near the Athabasca River Delta. A similar spatial trend was found in liver enzyme activity (i.e., Ethoxyresorufin-O-deethylase [EROD] induction) of trout perch, measured to evaluate the potential exposure of fish to contaminants such as PAHs. When each monitoring reach was compared to the reach located immediately upstream (i.e., considered a "*baseline*" reach for comparison purposes in an effort to test for specific influences of interest), the classification of results for wild fish health was assessed as:

- **High** at *test* reaches below the Firebag River and above the Ells River;
- **Moderate** at *baseline* reaches at Poachers Landing, above Fort McMurray, and below Fort McMurray at Northlands, and at *test* reaches below the Muskeg River and near the Athabasca River Delta; and
- **Negligible-Low** at the *test* reach above the Muskeg River.

Muskeg River Watershed

Hydrology Hydrometric monitoring of the Muskeg River watershed in the 2015 WY was conducted at 11 *test* stations and two *baseline* stations. The 2015 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were +2.1%, +11.1%, -3.8%, and +4.6%, respectively, in the observed *test* hydrograph compared to the estimated *baseline* hydrograph. The differences in mean open-water discharge, annual maximum daily discharge, and open-water minimum daily discharge were classified as **Negligible-Low** and the difference in mean winter discharge was classified as **Moderate.** The results of a quantitative longitudinal assessment of the Muskeg River suggest that the magnitude of hydrologic impacts was generally **Moderate** to **High** in the mid reaches of the Muskeg River between Jackpine and Stanley creeks and generally **Negligible-Low** to **Moderate** above Stanley Creek.

In the 2015 WY, the water level of Kearl Lake generally decreased for most of the water year, and stabilized from July to October, 2015. Lake levels were typically between the historical lower quartile levels and historic minimum levels, with occasional periods in summer that were below historic minimum levels.

Water Quality Water quality was monitored in the Muskeg River watershed in the 2015 WY at nine *test* stations on the Muskeg River, two *test* and two *baseline* stations on Jackpine Creek, one *test* station on Wapasu Creek, one *test* station on Stanley Creek, and one *test* station in Kearl Lake. At long-term monitoring stations in the Muskeg River mainstem and its tributaries, water quality was similar to previous years, and concentrations of most water quality measurement endpoints were within the range of *baseline* conditions. Monthly trends in water quality for 2015 at monitoring stations established in 2015 were similar to monthly trends in water quality at the long-term stations. Continuous monitoring data indicated higher concentrations of dissolved oxygen in lower-river stations than at stations located in slower-flowing, lentic stations further upstream on the mainstem. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Differences in water quality conditions at all stations in fall 2015 compared to regional *baseline* water quality conditions were classified as **Negligible-Low**.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in the Muskeg River in fall 2015 at one erosional *test* station and two depositional *test* stations, in Jackpine Creek at one depositional *test* station and one depositional *baseline* station, and in Kearl Lake at one depositional *test* station. Variations in the values of measurement endpoints for benthic invertebrate communities were classified as:

- **Negligible-Low** at all *test* reaches of the Muskeg River: (i) the benthic invertebrate communities at these reaches in fall 2015 contained fauna typically associated with good environmental conditions; (ii) there were no significant differences in values of benthic invertebrate community measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance that also implied degrading conditions for benthic invertebrate communities; and (iii) none of the excursions in values of benthic invertebrate community measurement endpoints in fall 2015 outside of normal ranges implied degrading conditions for benthic invertebrate communities.

- **Negligible-Low** at the lower *test* reach in Jackpine Creek: (i) the benthic invertebrate community in fall 2015 contained a rich and diverse fauna, including several taxa that are typically associated with relatively good environmental conditions; (ii) none of the significant differences in values of benthic invertebrate community measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means implied degrading conditions for benthic invertebrate communities; and (iii) while the value of one of the six measurement endpoints in fall 2015 (equitability) was beyond the inner tolerance limit of the 95^{th} percentile of the normal range of values of prior years, the excursion did not imply degrading conditions for benthic invertebrate communities.

- **Negligible-Low** at the *test* station in Kearl Lake: (i) the benthic invertebrate community in fall 2015 contained a diverse fauna and included several taxa that are typically associated with relatively good environmental conditions; (ii) none of the significant differences in values of measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means implied degrading conditions for benthic invertebrate communities; and (iii) while values of three of the six measurement endpoints in fall 2015 were beyond the inner tolerance limit of the 95^{th} percentile of the normal range of values of prior years, none of these excursions outside of normal ranges implied degrading conditions for benthic invertebrate communities.

Values of sediment quality measurement endpoints were within the range of regional *baseline* conditions at all stations within the Muskeg River watershed, with the exception of total metals and carbon-normalized total PAHs at the middle *test* station on the Muskeg River, carbon-normalized total PAHs at the *baseline* station on Jackpine Creek, and total metals (when normalized to percent fine sediments) at the *test* station on Jackpine Creek. Sediment quality at all river stations within the Muskeg River watershed indicated **Negligible-Low** differences from regional *baseline* conditions. Sediment quality index values were not calculated for Kearl Lake because lakes were not included in the regional *baseline* calculations of sediment quality.

Fish Populations (Fish Communities) Fish communities were assessed in the Muskeg River watershed in fall 2015 at one *test* reach in the Muskeg River, and at one *test* and one *baseline* reach in Jackpine Creek. Differences in measurement endpoints for fish communities were classified as:

- **Negligible-Low** for the *test* reach in the Muskeg River compared to regional *baseline* reaches: (i) there were no significant differences in values of fish community measurement endpoints that implied a negative change in the fish community, and (ii) the mean values of all measurement endpoints for fish community monitoring at the *test* reach in fall 2015 were within the ranges of regional *baseline* values.

- **Negligible-Low** at the lower *test* reach in Jackpine Creek: (i) there were no significant changes in values of fish community measurement endpoints that explained greater than 20% of the variance in annual means, and (ii) although there have been decreases in abundance at the *test* reach since 2010, abundance, CPUE, richness, and diversity were higher in 2015 compared to 2014, which may indicate improving conditions for fish communities.

Fish Populations (Wild Fish Health) Wild fish health was assessed in fall 2015 at one *test* reach in the Muskeg River using lake chub as the target species. Because an upstream *baseline* reach on the Muskeg River was not sampled in 2015, quantitative comparisons for assessing potential effects could not be conducted; qualitative comparisons of values of wild fish health measurement endpoints were therefore made against regional *baseline* reaches in other watersheds where lake chub was monitored in 2015. Values of wild fish health measurement endpoints of female lake chub at the *test* reach in the Muskeg River were relatively similar to measurement endpoints of female lake chub at regional *baseline* reaches with the exception of relative liver size, which were smaller in fish at the *test* reach in the Muskeg River. Temporal comparisons were not possible because 2015 was the first year of fish health monitoring at this *test* reach.

Steepbank River Watershed

Hydrology Hydrometric monitoring for the Steepbank River watershed in the 2015 WY was conducted at two *test* stations. The 2015 WY, mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were all 0.44% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low.**

Water Quality Water quality monitoring was conducted in the 2015 WY at five *test* stations on the Steepbank River. There were clear temporal variations in water quality measurement endpoints at individual stations across months in the 2015 WY. Concentrations of nutrients and metals had within-year temporal trends similar to the levels of particulates (i.e., total suspended solids), while concentrations of major ions had within-year temporal trends similar to trends in concentration of total dissolved solids.

Generally, water quality measurement endpoints in the 2015 WY fell within historical monthly ranges of available historical data. Continuous water quality data indicated consistently high dissolved oxygen and typically low turbidity at all monitoring stations. There were **Negligible-Low** differences in water quality conditions for all stations in fall 2015 compared to regional *baseline* water quality conditions. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years.

Fish Populations (Fish Communities) Fish communities were assessed in the Steepbank River in fall 2015 at one lower *test* reach and one upper *baseline* reach. Differences between values of fish community measurement endpoints at the lower *test* reach compared to *baseline* conditions were classified as **High** as three of the five measurement endpoints (abundance, richness, and CPUE) have significantly decreased over time; these significant trends explained more than 20% of the variation in annual means.

Tar River Watershed

Hydrology Hydrometric monitoring for the Tar River watershed in the 2015 WY was conducted at one *test* station and one *baseline* station. The 2015 WY mean open-water discharge, maximum daily discharge, and minimum daily discharge were all 29.06% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph for the Tar River near the mouth. These differences were classified as **High**. Differences in the values of the three hydrologic measurement endpoints between *test* and *baseline* cases were assessed as **High** from the mouth of the Tar River to approximately 6 km upstream, **Moderate** for the next 7 km upstream, and **Negligible-Low** for the next 7 km to the upper *baseline* station.

Water Quality Water quality was monitored in the 2015 WY at one *test* station and one *baseline* station on the Tar River. There were no obvious monthly trends in values of most of the water quality measurement endpoints at either station from May to October 2015. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. The ionic composition of water at both stations was consistent with historical observations and most water quality measurement endpoints were within the range of previously-measured concentrations and consistent with regional *baseline* concentrations. Water quality index values calculated for fall 2015 indicated **Negligible-Low** differences in water quality for fall 2015 at both stations compared to regional *baseline* ranges.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in the Tar River in fall 2015 at one depositional *test* reach and one erosional *baseline* reach. Variations in the values of measurement endpoints for benthic invertebrate communities of the Tar River were classified as **Moderate** at the lower *test* reach: (i) the benthic invertebrate community at the *test* reach in fall 2015 did not contain taxa typically associated with good environmental conditions, (ii) Ephemeroptera were missing from the benthic invertebrate community in fall 2015 and have not been present at the *test* reach since 2012, indicating a compromised community and degraded conditions; and (iii) two benthic invertebrate community measurement endpoints had significant differences in values between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means and which implied degrading conditions for benthic invertebrate communities.

Sediment quality was monitored in fall 2015 at the lower *test* station on the Tar River. Differences in sediment quality conditions in 2015 between the *test* station and regional *baseline* conditions were classified as **Negligible-Low** as all sediment quality measurement endpoints at the *test* station in fall 2015 were within regional *baseline* concentrations. Concentrations of naphthalene, retene, and total parent PAH values in fall 2015 were below previously-measured minimums, while concentrations of the heavier hydrocarbon fractions (Fraction 3 and 4) exceeded previously-measured maxima. Concentrations of measurement endpoints of sediment quality were below guideline concentrations in fall 2015, with the exception of predicted PAH toxicity and the PAH hazard index. There have been significant increases in concentrations of Fraction 1, 2, 3, and 4 hydrocarbons at this *test* station over the period of the monitoring record.

Fish Populations (Fish Communities) Fish communities were assessed in fall 2015 at one *baseline* reach in the Tar River. Mean values of all measurement endpoints were higher at the *baseline* reach in fall 2015 compared to fall 2014. Differences between values of fish community measurement endpoints at the lower *baseline* reach compared to the normal range of variability for *baseline* conditions were classified as **Negligible-Low** because there were no significant changes in measurement endpoints that explained more than 20% of the variance in annual means.

MacKay River Watershed

Hydrology Hydrometric monitoring for the MacKay River watershed in the 2015 WY was conducted at one *test* station and three *baseline* stations. The 2015 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.009%, 0.021%, 0.016%, 0.021% higher, respectively, in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Water quality was monitored in the MacKay River watershed in the 2015 WY at three *test* stations and two *baseline* stations on the MacKay River and at three *baseline* stations on the Dover River. There was generally low monthly variation in concentrations of water quality measurement endpoints between May and October in the 2015 WY. Concentrations of all water quality measurement endpoints in fall 2015 at long-term monitoring stations on the MacKay River were within previously-measured concentrations with the exception of total parent PAHs at the *baseline* station, with a measured concentration in fall 2015 that exceeded the previously-measured maximum concentration. The only significant trends in fall concentrations of water quality measurement endpoints were decreases in arsenic and sulphate at the *test* station near the MacKay River mouth. Concentrations of all water quality measurement endpoints in fall 2015 were within the range of historical fall concentrations and regional fall *baseline* concentrations with the exception of a number of major ions at the Dover River stations with concentrations that exceeded the 95th percentile of regional *baseline* concentrations and total suspended solids at several stations with concentrations that were below the 5th percentile of regional *baseline* concentrations. Water quality index values calculated for fall 2015 indicated **Negligible-Low** differences in water quality for fall 2015 at all stations in the Mackay River watershed compared to regional *baseline* ranges.

Sediment Quality Sediment quality was monitored in the MacKay River watershed in fall 2015 at two *test* stations and one *baseline* station on the MacKay River, and at three *baseline* stations on the Dover River. Values of all sediment quality measurement endpoints were below guideline concentrations at all stations of the Dover River and the upper stations of the MacKay River and, with the exception of total PAHs (absolute and carbon-normalized) and the PAH hazard index level at the lower *test* station on the MacKay River, all sediment quality measurement endpoints were within the ranges of regional *baseline* conditions for stations within the MacKay River watershed. Sediment quality index values calculated for fall 2015 indicated **Negligible-Low** differences in sediment quality for fall 2015 at all stations in the Mackay River watershed compared to regional *baseline* ranges.

Fish Populations (Fish Communities) Fish communities were monitored in fall 2015 at one *test* reach in the lower MacKay River. Differences in measurement endpoints of the fish community at the *test* reach were classified as **Negligible-Low**. There were no significant changes in measurement endpoints over time and mean values of most measurement endpoints for fish community monitoring at the *test* reach in fall 2015 were within the ranges of regional *baseline* values for these measurement endpoints. Species richness was above the regional *baseline* range, indicating a positive change.

Fish Populations (Wild Fish Health) Wild fish health was assessed at two *test* reaches and one *baseline* reach in the MacKay River using longnose dace as the target species, and at three *baseline* reaches in the Dover River using lake chub as the target species. The classification of effects for reaches of the MacKay River was assessed as:

- **Moderate** for the lower *test* reach because an exceedance of the effects criteria associated with significant differences was measured in one of five measurement endpoints (relative liver size of male longnose dace) compared to the upper *baseline* reach in the MacKay River; and

- **Negligible-Low** for the middle *test* reach because no significant differences were measured in any of the measurement endpoints compared to the upper *baseline* reach in the MacKay River.

Reaches of the Dover River consisted solely of *baseline* reaches in fall 2015; therefore, no classification of results could be assessed.

Calumet River Watershed

Hydrology Hydrometric monitoring for the Calumet River watershed in the 2015 WY was conducted at one *test* station. The 2015 WY mean open-water discharge, maximum daily discharge, and minimum daily discharge were 4.24% higher, 0.25% lower, and 0.25% lower, respectively, in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

Water Quality Water quality was monitored in the Calumet River in the 2015 WY at one *test* station and one *baseline* station. There were inconsistent within-year trends in the concentrations and levels of most of the water quality measurement endpoints at the lower *test* station from May to September 2015. Temporal trends in the concentrations of all major ions except potassium and sulphate were similar to temporal trends in the concentration of total dissolved solids, but temporal trends in concentration of particulate-associated metals were not similar to temporal trends in the concentration of total suspended solids. Concentrations of most water quality measurement endpoints were within previously-measured ranges for both stations. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Concentrations of all water quality variables were within the regional baseline concentrations in fall 2015, with the exception of total suspended solids. Water quality index values calculated for fall 2015 indicated **Negligible-Low** differences in water quality for fall 2015 at both stations compared to regional *baseline* ranges.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in fall 2015 at one depositional *test* reach and one depositional *baseline* reach in the Calumet River. Variations in measurement endpoints for benthic invertebrate communities at the lower *test* reach were classified as **Negligible-Low.** Although values of benthic invertebrate community measurement endpoints at the lower *test* reach differed from upper *baseline* reach, none of the differences indicated degrading conditions for benthic invertebrate communities at lower *test* reach. The lower *test* reach contained a rich and diverse benthic invertebrate community, with various genera of mayflies, stoneflies and caddisflies, which indicate good habitat quality.

Values of sediment quality measurement endpoints were within the range of regional *baseline* conditions with the exception of total PAHs (absolute and carbon-normalized) and total hydrocarbons at the lower *test* station and total metals at the *baseline* station, all of which exceeded the 95th percentile of regional *baseline* concentrations. Concentrations of Fraction 2 and 3 hydrocarbons, chrysene, and dibenz(a,h)anthracene in sediment exceeded the guidelines at the *test* station in fall 2015 while concentrations of Fraction 3 hydrocarbons and total arsenic exceeded the guidelines at the *baseline* station. Temporal trend analyses for sediment quality measurement endpoints were not possible for either station due to the limited years of historical data available. Sediment quality index values calculated for fall 2015 indicated **Moderate** and **Negligible-Low** differences in sediment quality for fall 2015 at the lower *test* station and the upper *baseline* station, respectively, compared to regional *baseline* ranges.

Firebag River Watershed

Hydrology Hydrometric monitoring in the Firebag River watershed in the 2015 WY was conducted at two *test* stations and one *baseline* station, and the McClelland Lake levels were recorded at one *test* station. The 2015 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.50%, 0.52%, 0.22%, and 0.56% lower in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences were classified as **Negligible-Low**.

The water level at McClelland Lake in winter of the 2015 WY was generally above historic maxima from November 2014 to mid-May 2015, when the annual peak lake level was recorded. Water levels then generally fell for the remainder of the water year. Water levels were above the median historic level until early August, and were between the mean and the lower historic quartile for the remainder of the water year.

Water Quality Water quality was monitored in the Firebag River watershed in the 2015 WY at two *test* stations and one *baseline* station on the Firebag River, as well as at one *test* lake (McClelland Lake) and one *baseline* lake (Johnson Lake). Water quality of the Firebag River and McClelland and Johnson lakes were similar to measurements in previous years, with similar water quality at upper and lower Firebag River stations and generally consistent monthly trends at all riverine and lacustrine stations. Concentrations of most water quality measurement endpoints and ion balance at all were within the previously-measured historical ranges. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Water quality index values calculated for fall 2015 indicated **Negligible-Low** differences in water quality for fall 2015 at all stations on the Firebag River compared to regional *baseline* ranges. Concentrations of water quality measurement endpoints for lake stations were not compared to regional *baseline* conditions given the ecological differences between lakes and rivers.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in fall 2015 at one depositional *test* reach in the Firebag River, one *test* lake, and one *baseline* lake. Variations in measurement endpoints of benthic invertebrate communities were classified as:

- **Moderate** at the lower *test* reach in the Firebag River: richness in lower *test* reach was significantly lower in fall 2015 than the mean of all prior years; this difference accounted for more than 20% of the variation in annual means and was indicative of degrading conditions for benthic invertebrate communities.

- **Negligible-Low** at McClelland Lake: (i) while there were statistically-significant temporal differences in values of benthic invertebrate community key measurement endpoints that accounted for more than 20% of the variation in annual means, none were indicative of degrading conditions for benthic invertebrate communities; (ii) values of all benthic invertebrate community measurement endpoints in fall 2015 were within the inner tolerance limits for the normal range of variation of previous years; and (iii) the general composition of the community in terms of relative abundances of benthic taxa, presence of fully aquatic forms and presence of generally sensitive taxa, such as the mayfly *Caenis* and two types of caddisflies, suggested that the community of McClelland Lake was in good condition and generally consistent with *baseline* conditions.

The benthic invertebrate community of Johnson Lake in fall 2015 showed some variation in composition from 2014, with an increase in richness and the presence of EPT taxa, which were not observed in 2013. In addition, the presence of permanent aquatic forms such as amphipods, gastropods and bivalves indicated that Johnson Lake was in good condition for benthic invertebrate communities in fall 2015.

Sediment quality index values calculated at the lower *test* station on the Firebag River for fall 2015 indicated **Negligible-Low** differences in sediment quality compared to regional *baseline* ranges. Values of sediment quality measurement endpoints were not compared to regional *baseline* concentrations for McClelland Lake or Johnson Lake because lakes were not included in the calculation of *baseline* concentrations.

Ells River Watershed

Hydrology Hydrometric monitoring for the Ells River watershed in the 2015 WY was conducted at one *test* station and one *baseline* station. The 2015 WY mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were 0.15% higher in the observed *test* hydrograph than in the estimated *baseline* hydrograph. These differences are classified as **Negligible-Low**.

Water Quality Water quality was monitored in the Ells River watershed in 2015 WY at four *test* stations and *two* baseline stations on the Ells River, and in two *baseline* lakes: Gardiner Lake; and Namur Lake. Concentrations of a number of water quality measurement endpoints showed intra-year variation at both *test* and *baseline* stations, with concentrations of total suspended solids and associated nutrients and metals being highest in May and concentrations of total dissolved solids and associated ionic constituents being highest in July and August. Concentrations of most water quality variables were higher at Gardiner Lake than at Namur Lake. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Water quality index values calculated for fall 2015 indicated **Negligible-Low** differences in water quality for fall 2015 at all stations on the Ells River compared to regional *baseline* ranges. Concentrations of water quality measurement endpoints for Gardiner and Namur lakes were not compared to regional *baseline* conditions given the ecological differences between lakes and rivers.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in fall 2015 at one depositional *test* reach in the Ells River, and at depositional *baseline* stations in two lakes. Differences in measurement endpoints for the benthic invertebrate community at the *test* reach in the lower Ells River were classified as **Negligible-Low**: (i) significant increases in Correspondence Analysis (CA) Axis 1 scores over time were not indicative of degrading conditions, and (ii) all measurement endpoints were within the inner tolerance limits of the normal range of variation for previous years of sampling, with the exception of %EPT, which was not significantly different in fall 2015 than in previous years, signifying no change in conditions.

The benthic invertebrate communities of both Namur and Gardiner lakes in fall 2015 were consistent with relatively high quality benthic habitats, with the presence of Ephemeroptera and Trichoptera taxa and permanent aquatic forms (e.g., bivalves, gastropods).

Sediment quality was assessed in fall 2015 at three *test* stations and one *baseline* station on the Ells River, and two *baseline* lakes.

Differences in sediment quality index values calculated for stations on the Ells River for fall 2015, compared to regional *baseline* conditions were:

- **High** at the lower *test* station due to high concentrations of petroleum hydrocarbons and PAHs;
- **Moderate** at the *test* station near the mouth due to high concentrations of petroleum hydrocarbons and PAHs; and
- **Negligible-Low** at the middle *test* station and upper *baseline* station.

Sediment quality index values were not calculated for *baseline* stations in Namur Lake and Gardiner Lake because lakes were not included in the regional *baseline* calculations. No sediment guidelines or threshold values were exceeded at either lake station in 2015.

Fish Populations (Fish Communities) Fish communities were monitored at one *test* reach in the Ells River. Differences in measurement endpoints for the fish community at the *test* reach were classified as **Negligible-Low**: (i) mean values of all measurement endpoints for fish community monitoring at the *test* reach in fall 2015 were within the ranges of regional *baseline* values for these measurement endpoints, (ii) while the statistically-significant decreases in abundance and the Assemblage Tolerance Index (ATI) over time from 2010 to 2015 are consistent with a potential negative change in the fish community at the *test* reach, less than 20% of the variance in annual means is explained by these decreasing trends.

Fish Populations (Wild Fish Health) Wild fish health was assessed in fall 2015 at two *test* reaches and one *baseline* reach in the Ells River using lake chub as the target species. The classification of effects for reaches of the Ells River was assessed as:

- **Moderate** for the lower *test* reach because female lake chub were significantly younger than female lake chub at the middle *test* reach, and male lake chub were significantly younger than both the middle *test* and upper *baseline* reaches and magnitude of these significant differences exceeded the Environment Canada effects criteria; and

- **Negligible-Low** for the middle *test* reach because there were no significant differences in values of measurement endpoints for wild fish health at middle *test* reach compared to the upper *baseline* reach.

Clearwater River Watershed

Hydrology Hydrometric monitoring for the Clearwater River watershed in the 2015 WY was conducted at one *test* station and two *baseline* stations. The assessed hydrologic change classification for the Clearwater River was **Negligible-Low**, which was based on the calculated hydrologic change from the Christina River and then proportionally scaled to the increased watershed size in the Clearwater River.

Water Quality Water quality was monitored in the Clearwater River watershed in the 2015 WY at two *test* stations and one *baseline* station on the Clearwater River, and at one *baseline* station on the High Hills River. The ionic composition of water at all stations in the Clearwater River watershed in fall 2015 was similar to previous years. Concentrations of most water quality measurement endpoints measured in fall 2015 were within the ranges of regional *baseline* conditions. Differences in water quality conditions in fall 2015 compared to regional *baseline* conditions were:

- **Moderate** at the *baseline* station in the upper Clearwater River; and
- **Negligible-Low** at the lower *test* station on the Clearwater River and at the *baseline* station on the High Hills River.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in the Clearwater River watershed fall 2015 at one depositional *test* reach and one depositional *baseline* reach in the Clearwater River, and at one erosional *baseline* reach in the High Hills River. Variations in measurement endpoints of benthic invertebrate communities were classified as **Negligible-Low** at the *test* reach in the Clearwater River: (i) variations in CA Axis 1 scores at the *test* reach were unlikely to be related to oil sands development given similar trends were observed at both the *test* and *baseline* reaches, and (ii) the percentage of sensitive EPT taxa was higher at the *test* reach than at the *baseline* reach, indicating that conditions are not degrading in the lower Clearwater River. The benthic invertebrate community of the *baseline* reach in the High Hills River reflected good water and sediment quality, with a high diversity of typical riffle fauna including mayflies, stoneflies, and caddisflies.

Differences in sediment quality conditions in fall 2015 at both *test* and *baseline* stations in the Clearwater River watershed compared to regional *baseline* sediment quality conditions were **Negligible-Low**.

Christina River Watershed

Hydrology Hydrometric monitoring for the Christina River watershed in the 2015 WY was conducted at nine *test* stations and three *baseline* stations. The water balance analysis was conducted for the *test* station near the mouth. Water balance analysis showed that differences in mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge between the observed *test* and estimated *baseline* hydrographs were +0.05%, +0.06%, +0.06%, and +0.05%, respectively. These differences were classified as **Negligible-Low**.

Water Quality Water quality was monitoring in the Christina River watershed in the 2015 WY at four *test* stations and one *baseline* station on the Christina River, four *test* stations, and two *baseline* stations on tributaries to Christina Lake, two *test* stations on tributaries to the Christina River, and two *test* lakes.

Concentrations of most water quality measurement endpoints in the Christina River and its tributaries exhibited relatively consistent seasonal changes, with total dissolved solids and dissolved ions lowest in May during freshet, and higher in months with lower flows. Concentrations of some water quality measurement endpoints (e.g., total dissolved solids, boron, sodium, chloride, and sulphate) were generally higher in each month at the lower *test* station on the Christina River and on Gregoire River than at other *test* and *baseline* stations. Concentrations of most water quality measurement endpoints were within the historical monthly ranges.

Concentrations of water quality measurement endpoints in fall 2015 were within regional *baseline* concentrations with few exceptions, including total dissolved phosphorus, sodium, calcium, chloride, and total boron, which exceeded the 95th percentile of regional *baseline* concentrations the lower *test* station on the Christina River and on Gregoire River and *baseline* stations on the upper Christina River and Birch Creek. In contrast, concentrations of total suspended solids, total dissolved solids, total boron, total mercury, magnesium, and potassium were lower than the 5th percentile of regional *baseline* concentrations at *test* stations in Jackfish River, Gregoire River, Sawbones Creek and two unnamed creeks flowing into Christina Lake and at *baseline* stations in Birch Creek and Sunday Creek. The ionic composition of water at all stations in the Christina River watershed in fall 2015 was similar to previous years. Differences in water quality in fall 2015 at all stations in the Christina River and its tributaries compared to regional *baseline* conditions were classified as **Negligible-Low**. Classifications were not generated for *test* stations in Christina Lake and Gregoire Lake because lakes were not included in the regional *baseline* conditions given the ecological differences between lakes and rivers.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in the Christina River watershed in the 2015 WY at three depositional *test* reaches, one erosional *test* reach, and one depositional *baseline* reach on the Christina River, four depositional *test* stations and two depositional *baseline* stations on tributaries to Christina Lake, two erosional *test* stations on tributaries to the Christina River, and two depositional *test* lakes.

Variations in measurement endpoints for benthic invertebrate communities in the Christina River were classified as:

- **Moderate** at the lower depositional *test* reach because while the benthic invertebrate community at the *test* reach in fall 2015 included several taxa that are typically associated with relatively good environmental conditions, values of all measurement endpoints for fall 2015 were outside the inner tolerance limits of the normal range of variation from previous years of sampling, including a lower %EPT than previous years.
- **Negligible-Low** at the middle depositional *test* reach because the significant difference in CA 1 Axis scores over time that accounted for more than 20% of the variance in annual means did not imply degrading conditions for benthic invertebrate communities, and values of all measurement endpoints in fall 2015 were within the inner tolerance limits of the normal range of variation from previous years of monitoring.

- **Negligible-Low** at the upper depositional *test* reach because no significant changes in values of measurement endpoints at the *test* reach were measured between 2015 and 2014 and values of all measurement endpoints in fall 2015 were within the inner tolerance limits of the normal range of variation for regional *baseline* depositional reaches.

Variations in values of measurement endpoints for benthic invertebrate communities at the erosional *test* reach in the Christina River in fall 2015 were not classified because there are only two years of data for this station, which were collected eight years apart; during this time the reach changed from *baseline* to *test*.

Differences in values of measurement endpoints for benthic invertebrate communities at reaches monitored in fall 2015 in Sunday Creek were classified as **High** because the results of temporal and spatial comparisons contain significant differences in values for three measurement endpoints – richness, equitability, and %EPT – for the *test* reach that explain more than 20% of the variation in annual means.

Variations in values of measurement endpoints of benthic invertebrate communities monitored in fall 2015 in Sawbones Creek were classified as **Moderate** because there were significant differences in values of two measurement endpoints (abundance and %EPT) in the temporal comparisons that accounted for more than 20% of the variance in annual means.

Variations in values of measurement endpoints of benthic invertebrate communities at the two unnamed creeks that flow into Christina Lake were classified as **Negligible-Low** because there were no significant variations over time at the monitored reaches and values of all measurement endpoints in fall 2015 for the monitored reaches were within normal ranges for *baseline* reaches.

Variations in the values of measurement endpoints for benthic invertebrate communities of the Jackfish River in fall 2015 were classified as **Moderate**. While the benthic invertebrate community in fall 2015 contained a benthic fauna that reflected good water and sediment quality, two of the three significant differences in values of measurement endpoints (taxa richness and %EPT) between 2015 and the mean of the prior years that accounted for more than 20% of the variance in annual means implied degrading conditions for benthic invertebrate communities. It should be emphasized that values of measurement endpoints for benthic invertebrate communities for 2015 were adjusted to account for the change in sampling gear and this classification should be interpreted with caution.

Variations in the values of measurement endpoints for benthic invertebrate communities of Gregoire River for fall 2015 were classified as **Negligible-Low**. The benthic invertebrate community monitored on the Gregoire River in fall 2015 contained a benthic fauna representative of a healthy erosional river and none of the significant differences in values of measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means implied degrading conditions for benthic invertebrate communities.

Variations in values of the measurement endpoints of the benthic invertebrate community in Christina Lake in fall 2015 were classified as **High** because there were significant differences in values of all measurement endpoints in the temporal comparisons that accounted for more than 20% of the variance in annual means; it is worth noting that the lake in 2015 contained a diverse benthic fauna that included several permanently aquatic forms (e.g., clams, snails, amphipods), as well as several large aquatic insects (mayflies and caddisflies).

Differences in measurement endpoints of the benthic invertebrate community in Gregoire Lake in fall 2015 were classified as **Negligible-Low** given none of temporal comparisons for benthic invertebrate communities of Gregoire Lake accounted for significant variation.

In fall 2015, concentrations of sediment quality measurement endpoints were generally similar to previous years (where applicable) and were typically within regional *baseline* concentrations at all stations. Differences in sediment quality conditions in fall 2015 at all sediment quality stations in the Christina River watershed were **Negligible-Low** compared to regional *baseline* conditions. Sediment quality measurement endpoints were not compared to regional *baseline* concentrations for Christina Lake or Gregoire Lake because lakes were not included in the calculation of *baseline* concentrations.

Fish Populations (Fish Communities) Fish communities were monitoring in fall 2015 at one *test* reach of the Christina River, four *test* reaches and two *baseline* reaches in tributaries to Christina Lake, and one *test* reach in Jackfish River. Differences in values of fish community measurement endpoints for the *test* reaches in the Christina River, Jackfish River and Sunday Creek were classified as **Negligible-Low** because: (i) there were no significant changes in values of measurement endpoints for these *test* reaches in either spatial comparisons to *baseline* reaches or in changes over time that implied a negative change in the fish communities at those reaches; and (ii) mean values of all measurement endpoints at these *test* reaches were within the ranges of regional *baseline* values for these measurement endpoints.

No spatial or temporal comparisons were conducted for Sawbones Creek or the two unnamed creeks flowing into Christina Lake; reliable statistical analysis was not possible for these reaches because too few fish have been captured at these reaches during the entire monitoring period. Similarly, comparisons of values of fish community measurement endpoints to regional *baseline* values were not made for these reaches.

Fish Populations (Wild Fish Health) Wild fish health was assessed at one *test* reach in the Jackfish River, one *test* reach in Sawbones Creek, and one *test* reach on Sunday Creek using slimy sculpin as the target species. Classification of results for wild fish health monitoring in the Christina River watershed in 2015 was not possible because no *baseline* reaches were sampled in the Christina River watershed for the wild fish health component in 2015 and the target fish species, slimy sculpin, was not sampled at any regional *baseline* reach during the 2015 Program.

Hangingstone River Watershed

Hydrology Hydrometric monitoring for the Hangingstone River watershed in the 2015 WY was conducted at two *test* stations. For the 2015 WY, the differences in mean open-water discharge, mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge between the observed *test* and estimated *baseline* hydrograph for the Hangingstone River were all 0.30%. These differences were classified as **Negligible-Low**.

Water Quality Water quality monitoring was conducted at two *test* stations on the Hangingstone River in the 2015 WY. Monthly variation in water quality showed similar trends at both *test* stations, with concentrations of suspended solids and several associated nutrients and metals highest during freshet and lowest in September and October at open-water low flows, and concentrations of total dissolved solids and most dissolved ions and metals showing an inverse relationship with flow. Generally, concentrations of most water quality measurement endpoints were higher at the lower *test* station than at the upper *test* station. Monthly water quality measurement endpoints at both stations were generally within historical monthly ranges. Concentrations of all water quality measurement endpoints in fall 2015 were lower than or within the previously-measured ranges except chloride at both stations (higher than previously-measured maximum concentrations), and naphthenic acids, oilsands extractable acids, and total alkylated PAHs at the upper *test* station (lower than previously-measured minimum concentrations). Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Differences in water quality in fall 2015 between *test* stations and the regional *baseline* fall conditions were classified as **Moderate** for the lower *test* station and **Negligible-Low** for the upper *test* station.

Benthic Invertebrate Communities Benthic invertebrate communities were monitored at one erosional *test* reach in the Hangingstone River. Variations in the values of measurement endpoints for benthic invertebrate communities of the Hangingstone River were classified as **Negligible-Low** because values of all six benthic invertebrate community measurement endpoints in fall 2015 were within the inner tolerance limits of the normal range of *baseline* values for erosional habitats. In addition, the benthic invertebrate community in fall 2015 contained numerous taxa associated with good environmental conditions including a diverse and rich fauna.

Fish Populations (Wild Fish Health) Wild fish health was assessed at the upper *test* reach of the Hangingstone River in fall 2015 using longnose dace as the target species. Because an upstream *baseline* reach on the Hangingstone River was not sampled in 2015, quantitative comparisons for assessing potential effects could not be conducted. To provide context to the results for the *test* reach on the Hangingstone River, qualitative comparisons of measurement endpoints were made with a *baseline* reach on the MacKay River that also used longnose dace as the target species. These comparisons indicated that longnose dace in the Hangingstone River were relatively younger with smaller relative gonad and liver sizes than longnose dace in the MacKay River. Temporal comparisons were not possible because 2015 was the first year of fish health monitoring at the upper *test* reach in the Hangingstone River.

Pierre River Area

Hydrology Hydrometric data were collected in the 2015 WY from four *baseline* stations in the Pierre River area to develop hydrographs for each watershed but water balances were not completed given that there had been no oil sands development in the Pierre River area as of 2015.

Water Quality Water quality was monitored in the 2015 WY at four *baseline* stations in the Pierre River area. Monthly water quality samples collected between May and September in Big Creek exhibited higher concentrations of total suspended solids, associated metals, and PAHs in May and June during high flows, and higher concentrations of dissolved constituents, total dissolved solids and associated major ions in fall during low flows. Concentrations and levels of water quality measurement endpoints at all four *baseline* stations in fall 2015 were generally within the range of available previously-measured concentrations and regional *baseline* conditions. Ion balance was similar to historical observations at all stations except the station in Big Creek, because a historically-low concentration of sulphate was measured at that station in fall 2015. Water quality guideline exceedances in the 2015 WY were consistent with water quality guideline exceedances identified by the RAMP and JOSMP in previous monitoring years. Differences in water quality in fall 2015 between *baseline* stations in Big Creek, Pierre River, and Redclay Creek and regional *baseline* fall conditions were classified as **Negligible-Low**, while differences in water quality in fall 2015 between the *baseline* station in Eymundson Creek and regional *baseline* fall conditions was classified as **Moderate**.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in fall 2015 at three depositional *baseline* reaches and one erosional *baseline* reach in the Pierre River area. The benthic invertebrate communities in Big Creek, Eymundson Creek, and Pierre River were typical of sandy-bottomed rivers with a high abundance of chironomids and worms, which are indicative of poor water quality conditions. EPT taxa were present, as were permanent aquatic forms. Overall, a decrease in the abundance of worms and an increasing proportion of EPT taxa indicated stable conditions. The benthic invertebrate communities in Redclay Creek had a lower proportion of tolerant worms and chironomids in 2015, indicating good habitat quality.

Sediment quality measurement endpoints were within the range of regional *baseline* conditions at all sediment quality stations in the Pierre River area, with the exception of total metals, carbon-normalized total PAHs, and normalized total metals at Eymundson Creek, normalized total metals at Pierre River, and carbon-normalized total PAHs at Big Creek. Differences between sediment quality in fall 2015 at all sediment quality stations in the Pierre River area and regional *baseline* conditions were classified as **Negligible-Low**.

Miscellaneous Aquatic Systems

Fort Creek, McLean Creek, and Horse River

Water Quality Water quality was monitored in the 2015 WY at one *test* station on Fort Creek, one *test* station on McLean Creek, and one *test* station on the Horse River. Differences in water quality in fall 2015 between these *test* stations and regional *baseline* fall conditions were classified as:

- **Negligible-Low** at Fort Creek as concentrations of most water quality variables in fall 2015 were within regional *baseline* concentrations. Concentrations of a number of water quality measurement endpoints have increased over time in Fort Creek, particularly dissolved ions. Guideline exceedances occurred most frequently between July and September and included total phenols and sulphides, which have commonly exceeded guidelines in previous sampling years;

- **Negligible-Low** at McLean Creek: concentrations and levels of all water quality measurement endpoints in fall 2015 were within the ranges of regional *baseline* concentrations, with the exception of total dissolved solids and several associated ions, including calcium, sodium, chloride, and sulphate, all of which were higher than their respective 95^{th} percentile of regional *baseline* concentrations;

- **Negligible-Low** at Horse River: although there were seasonal fluctuations, concentrations of water quality measurement endpoints in fall 2015 were within the ranges of regional *baseline* concentrations.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were monitored in fall 2015 at one depositional *test* reach in Fort Creek. Variations in measurement endpoints for benthic invertebrate communities were classified as **High** because while the presence of clams, snails, and particularly of stoneflies in fall 2015 suggested that the quality of benthic habitat at the *test* reach is good, there were significant differences in values of three of the benthic invertebrate community measurement endpoints (abundance, richness, and equitability) between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means and which suggested degrading conditions for benthic invertebrate communities.

Differences in sediment quality conditions in fall 2015 between the *test* station on Fort Creek and regional *baseline* conditions were classified as **Negligible-Low**. Values of measurement endpoints of sediment quality at the *test* station on Fort Creek were below guideline concentrations in fall 2015, with the exception of Fraction 3 hydrocarbons and chrysene, and concentrations of all sediment quality measurement endpoints in fall 2015. Concentrations of measurement endpoints were within the ranges of regional *baseline* concentrations with the exception of total hydrocarbons, with a concentration that was above the 95th percentile of regional *baseline* concentrations.

Poplar Creek and Beaver River

Climate and Hydrology Hydrometric monitoring for the Poplar Creek watershed in the 2015 WY was conducted at one *test* station and one *baseline* station. The 2015 WY mean winter discharge, annual maximum daily discharge, and open-water minimum daily discharge were all -0.25% less in the observed *test* hydrograph than in the estimated *baseline* hydrograph. The mean open-water discharge was 43.12% higher in the *test* hydrograph than in the estimated *baseline* hydrograph and this difference was classified as **High**. The results of a longitudinal assessment suggested that the effects on mean open water flow that were classified as **High** occurred in the lowest 3.5 km of Poplar Creek. (i.e., the portion downstream of the Poplar Creek spillway).

Water Quality Water quality was monitored in the 2015 WY at one *test* station on the Poplar River and at one *test* and one *baseline* station on the Beaver River. In general, the highest concentrations of metals and ions occurred in December 2014 and August 2015 at the *test* station on the Poplar River while particulates and total metals at the *test* station on the Beaver River were highest in June 2015. Guideline exceedances occurred most frequently in September in the Poplar River while guideline exceedances occurred equally frequently in June, August, and September in the Beaver River. Concentrations of total phenols, sulphides, and dissolved iron exceeded guideline concentrations at all stations, while concentrations of total silver in January and total zinc in November exceeded water quality guidelines on the Poplar River. There were **Negligible-Low** differences between water quality conditions at all stations in fall 2015 compared to regional *baseline* conditions, with most water quality measurement endpoints within the ranges of regional *baseline* concentrations.

Benthic Invertebrate Communities and Sediment Quality Benthic invertebrate communities were sampled in fall 2015 at one depositional *test* reach in Poplar Creek and one depositional *baseline* reach in the Beaver River. Variations in values of measurement endpoints of benthic invertebrate communities at the *test* reach in Poplar Creek were classified as **Moderate**. While the benthic invertebrate community in Poplar Creek in fall 2015 was in generally good health, as evidenced by trends and levels of %EPT and had a range of fauna typical for a sandy-bottomed river, significant differences in values of equitability between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means implied degrading conditions for benthic invertebrate communities.

Differences in fall 2015 sediment quality conditions between the *test* station in Poplar Creek and the *baseline* station in Beaver River and regional *baseline* conditions were classified as **Negligible-Low**.

Sediment quality measurement endpoints were within the ranges of regional *baseline* conditions for both stations with the exception of total PAHs in sediments of the Beaver River. Concentrations of all sediment quality measurement endpoints were below guideline concentrations at the *baseline* station in the Beaver River in fall 2015 and concentrations of Fraction 3 hydrocarbons and chrysene exceeded published guidelines at the *test* station in Poplar Creek.

Alice Creek

Water Quality Water quality monitoring was initiated in reaches of Alice Creek in fall 2015 at two *baseline* stations. Differences in water quality in fall 2015 between *baseline* stations in Alice Creek and regional *baseline* fall conditions were classified as **Negligible-Low**, with most water quality measurement endpoints within regional *baseline* concentrations.

Sediment Quality Sediment quality monitoring was initiated in reaches of Alice Creek in fall 2015 at two *baseline* stations. Differences in fall 2015 sediment quality conditions between these stations and regional *baseline* conditions were classified as **Negligible-Low**. Concentrations of all sediment quality measurement endpoints were within regional *baseline* concentrations at both *baseline* stations in Alice Creek. Concentrations of all sediment quality measurement endpoints were below published guidelines at the lower *baseline* station, while predicted PAH toxicity and total arsenic concentrations exceeded guideline values at the upper *baseline* station.

Fish Populations (Wild Fish Health) Wild fish health monitoring was conducted at two *baseline* reaches in Alice Creek in fall 2015, using lake chub as the target species. Results from the lower *baseline* reach indicated that lake chub exhibited lower relative gonad size in females and a lower mean age and relative liver size in both males and females compared to the upper *baseline* reach.

Isadore's Lake

Water Quality Concentrations of most water quality measurement endpoints in fall 2015 at the *test* station in Isadore's Lake were within the range of previously-measured concentrations and concentrations and levels of water quality measurement endpoints were below water quality guidelines in fall 2015 with the exception of sulphide. Shifts in ion balance and significant increasing trends in concentrations of many dissolved ions suggest a gradual and ongoing change in water quality in Isadore's Lake over time.

Benthic Invertebrate Communities and Sediment Quality Variations in values of measurement endpoint of the benthic invertebrate community in Isadore's Lake at the *test* station were classified as **Negligible-Low**. While there were a number of significant differences in values of measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means, none of these implied degrading conditions for benthic invertebrate communities.

Sediment Quality The following significant temporal trends in fall concentrations of sediment quality measurement endpoints were measured at the *test* station in Isadore's Lake: (i) increasing concentrations of Fraction 2, 3, and 4 hydrocarbons, total alkylated PAHs and total PAHs; and (ii) decreasing concentrations of total metals. Concentrations of all sediment quality measurement endpoints in fall 2015 were within the ranges of regional *baseline* concentrations with the exception of Fraction 3 hydrocarbons and total arsenic.

Shipyard Lake

Water Quality Concentrations of most water quality measurement endpoints in fall 2015 at the *test* station in Shipyard Lake were within previously-measured concentrations with the exception of sulphide. The ionic composition of water in Shipyard Lake has occasionally shifted toward influences of sodium and chloride, particularly in 2010, and also from 2013 to 2015. This observation is consistent with significant temporal trends of increasing concentrations of sodium, potassium, and chloride and a decreasing trend in calcium concentration.

Benthic Invertebrate Communities and Sediment Quality Variations in values of measurement endpoints of benthic invertebrate communities for the *test* station in Shipyard Lake in fall 2015 were classified as **Negligible-Low**. While there were a number of significant differences in values of measurement endpoints between *test* and *baseline* conditions that accounted for more than 20% of the variance in annual means, none of these implied degrading conditions for benthic invertebrate communities.

Significant temporal trends in concentrations of total hydrocarbons (Fractions 1, 2, 3, and 4) and total alkylated PAHs were measured in sediments in fall 2015 at Shipyard Lake. Concentrations of sediment quality measurement endpoints were below guideline concentrations, with the exception of Fraction 3 hydrocarbons; total arsenic, benz[a]anthracene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and phenanthrene.

Acid-Sensitive Lakes

Results of the analysis of the acid-sensitive lakes in 2015 compared to the historical data suggested that there have been no significant changes in the water chemistry of the 50 lakes across the years of monitoring that could be attributed directly to acidification. These results were consistent with the revised estimates of potential acid input suggesting that only 19 of the 50 ASL lakes (all remote from the industrial developments) were actually exposed to acidifying deposition.

In 2015, there were no exceedances of the ASL effects criterion for any of the measurement endpoints in the Canadian Shield, West of Fort McMurray and Northeast of Fort McMurray subregions. These three subregions were classified as having a **Negligible-Low** indication of incipient acidification. The Stony Mountains, the Birch Mountains and the Caribou Mountains were classified as having a **Moderate** indication of incipient acidification largely because of increases in the sum of base cations; these increases in the sum of base cations were not attributed to catchment acidification but increases in alkalinity loadings to these lakes.

SPECIAL STUDIES

Three studies were also conducted in 2015 in support of the JOSMP that are not part of the regular monitoring program:

1. Study to explore relationships between turbidity, total suspended solids (TSS), and discharge in tributaries to the Athabasca River: The objectives of the preliminary study were to: (i) calibrate levels of turbidity obtained from the data sondes to concentrations of TSS; and (ii) assess the value of collecting total TSS samples specifically along with discharge measurements, which has been conducted historically as part of the Climate and Hydrology component for the RAMP/JOSMP. The results suggested that site-specific relationships exist between turbidity and

TSS in the study area and that further turbidity-TSS calibrations for data sonde stations in the JOSMP network would be useful to characterize the *baseline* or current conditions, identify disturbances, and calculate sediment budgets between monitoring stations. Uncertainties associated with the derivation of continuous TSS data from a discharge record were deemed to be greater than the increase in uncertainty using computed discharge values with TSS samples collected during routine water quality sampling. Therefore, discontinuing TSS sampling along with manual discharge measurements would only marginally increase the uncertainty in any TSS-discharge relationship that is developed.

2. Expanded fish community study: The objective of the expanded fish community study was to test the adequacy of the historical methods used to sample fish communities under the RAMP/JOSMP by comparing the results obtained using the historical five sub-reach sampling approach with the results of an expanded ten sub-reach sampling approach that also used supplemental fishing methods. The results of the study demonstrated that additional information can be gained by expanding the fish sampling effort and that selective electrofishing can improve the ability to identify fish species present at a monitoring reach. The range of potential bias showed that measurement endpoint estimates calculated using the historical survey efforts can be half as much or double those estimated using expanded methods. In addition, estimates generated using an expanded ten sub-reach sampling approach allowed for more precise estimates of measurement endpoints. Selective electrofishing further increased the number of fish species caught at each monitoring reach, including sensitive species that were not recorded using the primary electrofishing methods.

3. Pilot program for evaluating the status of fish in the Athabasca River: The objective of the pilot study was to evaluate the feasibility of monitoring fish populations of the lower Athabasca River using the Alberta Fisheries approach for sampling key sportfish species (walleye, goldeye, lake whitefish, and northern pike), and more generally on the fish community as a whole, during the summer season. Catches of sportfish during the pilot study were low compared to previous summer inventories conducted by the RAMP/JOSMP, and were likely a result of the low water levels in the Athabasca River observed during summer 2015. Results of the pilot study confirmed that summer is typically a poor time to sample for most sportfish species in the study area as resident populations of targeted species are often low.

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Summary assessment of the 2015 aquatic monitoring results in the oil sands region, Alberta.

Watershed/Region	Differences Between *Test* and *Baseline* Conditions						Acid-Sensitive Lakes[7]
	Hydrology[1]	Water Quality[2]	Benthic Invertebrate Communities[3]	Sediment Quality[4]	Fish Communities[5]	Wild Fish Health[6]	
Athabasca River	🟡	🟡	-	-	-	🟡 / 🟠 / 🟤	-
Athabasca River Delta	-	🟡	🟡 / 🟠	n/a	-	-	-
Muskeg River	🟡 / 🟠	🟡	🟡	🟡	🟡	n/a	-
Jackpine Creek	nm	🟡	🟡	🟡	🟡	-	-
Stanley Creek	-	🟡	-	-	-	-	-
Wapasu Creek	-	nm	-	-	-	-	-
Kearl Lake	nm	n/a	🟡	n/a	-	-	-
Steepbank River	🟡	🟡	-	-	🟤	-	-
Tar River	🟤	🟡	🟠	🟡	n/a	-	-
MacKay River	🟡	🟡	-	🟡	🟡	🟡 / 🟠	-
Dover River	nm	🟡	-	🟡	-	n/a	-
Calumet River	🟡	🟡	🟡	🟡 / 🟠	-	-	-
Firebag River	🟡	🟡	🟠	🟡	-	-	-
Moose Creek	nm	-	-	-	-	-	
McClelland Lake	nm	n/a	🟡	n/a	-	-	-
Johnson Lake	-	n/a	n/a	n/a	-	-	-
Ells River	🟡	🟡	🟡	🟡 / 🟠 / 🟤	🟡	🟡 / 🟠	-
Namur Lake	-	n/a	n/a	n/a	-	-	-
Gardiner Lake	-	n/a	n/a	n/a	-	-	-
Clearwater River	🟡	🟡 / 🟠	🟡	🟡	-	-	-
High Hills River	nm	🟡	n/a	-	-	-	-
Christina River	🟡	🟡	🟡 / 🟠	🟡	🟡	-	-
Sawbones Creek	nm	🟡	🟠	🟡	nm	nm	-
Sunday Creek	nm	🟡	🟤	🟡	🟡	nm	-
unnamed creeks (east and south of Christina Lake)	nm	🟡	🟡	🟡	nm	-	-
Birch Creek	nm	🟡	n/a	🟡	nm	-	-
Jackfish River	nm	🟡	🟠	-	🟡	nm	-
Gregoire River	nm	🟡	🟡	-	-	-	-
Christina Lake	nm	n/a	🟤	n/a	-	-	-
Gregoire Lake	nm	n/a	🟡	n/a	-	-	-
Hangingstone River	🟡	🟡 / 🟠	🟡	-	-	n/a	-
Pierre River	nm	🟡	n/a	🟡	-	-	-
Eymundson Creek	nm	🟠	n/a	🟡	-	-	-
Big Creek (Unnamed Creek)	nm	🟡	n/a	🟡	-	-	-
Redclay Creek	nm	🟡	n/a	-	-	-	-
Fort Creek	nm	🟡	🟤	🟡	-	-	-
Poplar Creek	🟡 / 🟤	🟡	🟠	🟡	-	-	-
McLean Creek	-	🟡	-	-	-	-	-
Horse River	-	🟡	-	-	-	-	-
Beaver River	-	🟡	n/a	🟡	-	-	-
Alice Creek	-	🟡	-	🟡	-	n/a	-
Mills Creek	nm	-	-	-	-	-	-
Isadore's Lake	nm	n/a	🟡	n/a	-	-	-
Shipyard Lake	-	n/a	🟡	n/a	-	-	-
Stony Mountains	-	-	-	-	-	-	🟠
West of Fort McMurray	-	-	-	-	-	-	🟡
Northeast of Fort McMurray	-	-	-	-	-	-	🟡
Birch Mountains	-	-	-	-	-	-	🟠
Canadian Shield	-	-	-	-	-	-	🟡
Caribou Mountains	-	-	-	-	-	-	🟠

Legend and Notes

🟡 **Negligible-Low** change — "-" program was not completed in 2015 WY; nm – not measured in the 2015 WY

🟠 **Moderate** change — n/a – classification not completed as there were no *baseline* conditions against which to compare or reach was sampled to add to regional *baseline*

🟤 **High** change

1 **Hydrology:** (i) Measurement endpoints were calculated on differences between observed *test* and estimated *baseline* hydrographs that would have been observed in the absence of oil sands developments in the watershed: 5% - Negligible-Low; ± 15% - Moderate; > 15% - High; (ii) Not all hydrology measurement endpoints were calculated for each watershed because of differing lengths of the hydrographic record for 2015. The hydrology results presented are for those measurement endpoints that were calculated; (iii) Mean Open-Water Season Discharge, Annual Maximum Daily Discharge, and Minimum Open-Water Season Discharge in the Muskeg River assessed as **Negligible-Low**; Mean Winter Discharge assessed as **Moderate**; (iv) Mean Open-Water Season Discharge in Poplar Creek was assessed as **High**, while Mean Winter Discharge, Annual Maximum Daily Discharge, and Mean Open-Water Season Discharge were assessed as **Negligible-Low**.

2 **Water Quality:** (i) Classification based on adaptation of CCME water quality index; see Section 3.2.2.4 for a detailed description of the classification methodology; (ii) Water quality in the Clearwater River was assessed as **Negligible-Low** at the lower station, and **Moderate** at the middle station; (iii) Water quality in the Hangingstone River was assessed as **Moderate** at the lower station and **Negligible-Low** at the middle station.

3 **Benthic Invertebrate Communities:** (i) Classification based on statistical differences in measurement endpoints between *baseline* and *test* reaches as well as comparison to regional *baseline* conditions; see Section 3.2.3.1 for a detailed description of the classification methodology; (ii) Benthic invertebrate communities in the Athabasca River Delta were assessed as **Negligible-Low** at Big Point Channel, the Embarras River, and Fletcher Channel, and **Moderate** at Goose Island Channel; (iii) Benthic invertebrate communities in the Christina River were classified as **Moderate** at the lower reach and **Negligible-Low** at all other reaches.

4 **Sediment Quality:** (i) Classification based on adaptation of CCME sediment quality index (Section 3.2.3.2); (ii) Sediment quality in the Calumet River was assessed as **Moderate** at the lower reach and **Negligible-Low** at the upper reach; (iii) Sediment quality in the Ells River was assessed as **Moderate** near the mouth, High at the lower reach, and **Negligible-Low** at the middle and upper reaches.

5 **Fish Populations (Fish Communities):** Classification based on exceedances of measurement endpoints from the regional variation in baseline reaches (Section 3.2.4.1).

6 **Fish Populations (Wild Fish Health):** (i) Classification based on exceedances of measurement endpoints from the regional variation in baseline reaches (Section 3.2.4.2); (ii) Classification for the Athabasca River was based on exceedances of measurement endpoints at each monitoring reach relative to the reach located immediately upstream on the Athabasca River (i.e., considered a "*baseline*" reach for comparison purposes) in an effort to isolate potential effects related to specific influences of interest; see Section 3.2.4.2 for a detailed description of the classification methodology. Wild fish health in the Athabasca River was assessed as **Negligible-Low** above the Muskeg River, **Moderate** in reaches between Poachers Landing and Northlands (below Fort McMurray), below the Muskeg River and near the Athabasca Delta, and **High** in reaches above the Ells River and below the Firebag River; (iii) Wild fish health in the MacKay River was assessed as **Moderate** at the lower reach and **Negligible-Low** at the middle reach; (iv) Wild fish health in the Ells River was assessed as **Moderate** at the lower reach and **Negligible-Low** at the middle reach.

7 **Acid-Sensitive Lakes:** Classification based on the frequency in which values of seven measurement endpoints in 2015 were more than twice the standard deviation from their long-term mean in each lake.