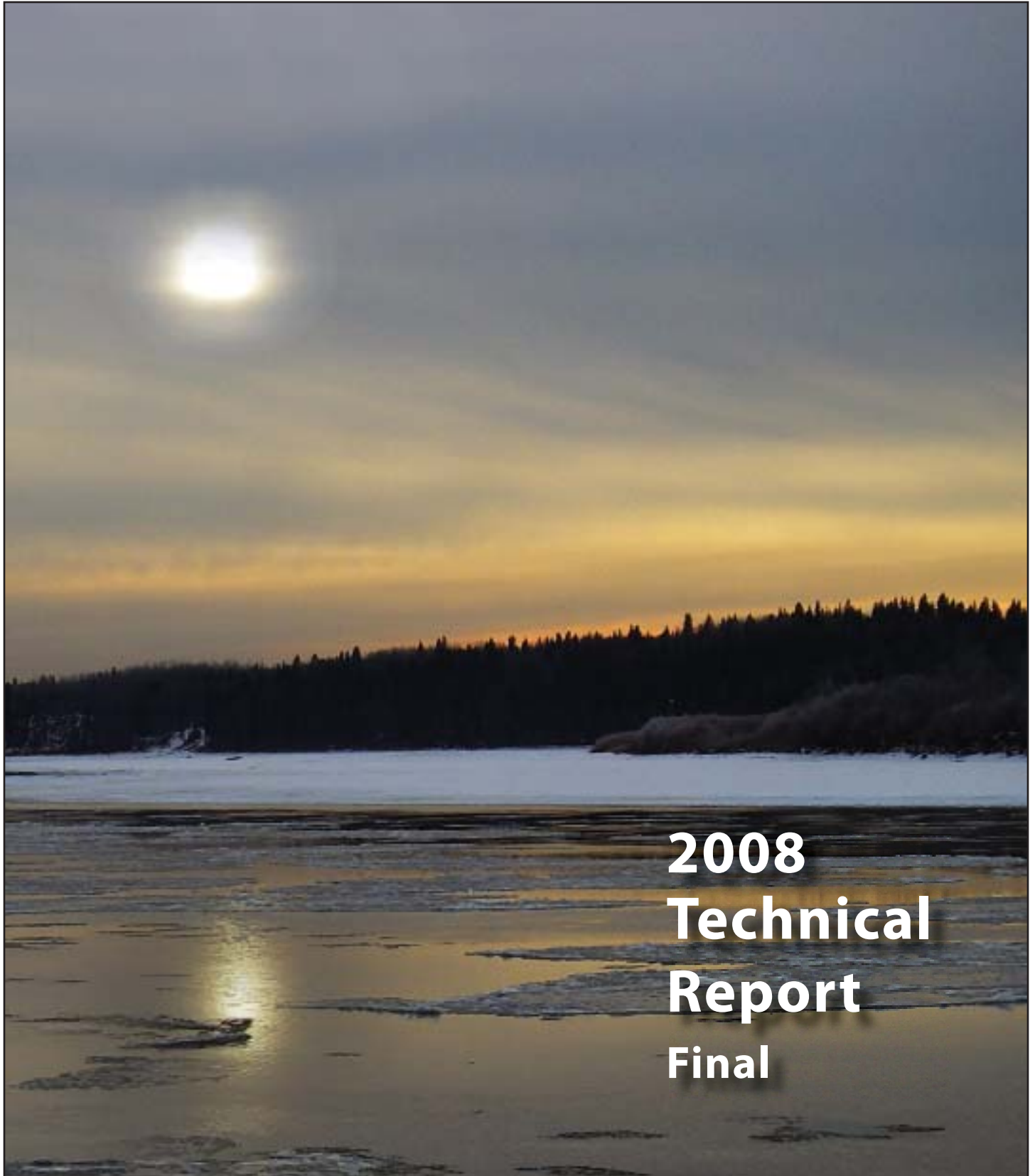




# **RAMP**

**Regional Aquatics  
Monitoring Program**



## **2008 Technical Report Final**





# REGIONAL AQUATICS MONITORING PROGRAM

## 2008 Technical Report

### *FINAL*

*Prepared for:*

**RAMP STEERING COMMITTEE**

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The RAMP chairperson during the 2008 program year was Janice Linehan (Petro-Canada). Patrick O'Brien (Suncor) was chair of the Technical Program Committee, Neil Rutley (Syncrude, Long Lake Project) was chair of the Finance Sub-committee and Melissa Pennell was the Communications Coordinator for RAMP.

RAMP is a multi-stakeholder environmental monitoring program that is composed of representatives from industry; municipal, provincial and federal governments; local aboriginal groups and environmental organizations. Effective implementation of the RAMP requires a number of contributors. We would like to thank the following:

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## 2008 IMPLEMENTATION TEAM

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# EXECUTIVE SUMMARY

## OVERVIEW

The Regional Aquatics Monitoring Program (RAMP) was initiated in 1997 in association with mining development in the Athabasca oil sands region near Fort McMurray, Alberta. RAMP is an industry-funded, multi-stakeholder initiative that monitors aquatic environments in the region. The intent of RAMP is to integrate aquatic monitoring activities so that long-term trends, regional issues and potential cumulative effects related to oil sands development can be identified and assessed. In 2008, RAMP was funded by Suncor Energy Inc., Syncrude Canada Ltd., Shell Canada Ltd., Albion Sands Energy Inc., Canadian Natural, Imperial Oil Resources, Petro-Canada, OPTI Canada Inc./Nexen Inc., Husky Energy, Total E&P Joslyn Ltd., Synenco Energy Inc., and Birch Mountain Resources Ltd. Non-funding participants include provincial government (AENV), federal government (Environment Canada and Health Canada) and Aboriginal groups.

The Regional Municipality of Wood Buffalo in northeastern Alberta is the RAMP Regional Study Area (RSA). Within this area, a Focus Study Area (FSA) has been defined and includes watersheds where oil sands and other developments are occurring or planned, including:

- Lower Athabasca River and Athabasca River Delta;
- Major tributary watersheds/basins of the lower Athabasca River including the Clearwater-Christina rivers, Hangingstone 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, and Fort Creek);
- Specific wetlands and shallow lakes in vicinity of current or planned oil sands and related developments; and
- A selected group of 50 regional acid-sensitive lakes.

RAMP incorporates both stressor- and effects-based monitoring approaches. Using impact predictions from the various oil sands environmental impact assessments, specific potential stressors have been identified that are monitored to document baseline conditions, as well as potential changes related to development. Examples include specific water quality variables and changes in water quantity. In addition, there is a strong emphasis in RAMP on monitoring sensitive biological indicators that reflect the overall condition of the aquatic environment. By combining both monitoring approaches, RAMP strives to achieve a more holistic understanding of potential effects on the aquatic environment related to oil sands development.

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

- Climate and hydrology are monitored to provide a description of changing climatic conditions in the RAMP FSA, as well as changes in the water level of selected lakes and in the quantity of water flowing through rivers and creeks.
- Water quality in rivers, lakes and the Athabasca River Delta is monitored to assess the potential exposure of fish and invertebrates to organic and inorganic chemicals.
- Benthic invertebrate communities and sediment quality in rivers, lakes and the Athabasca River Delta are monitored because they reflect habitat quality, serve as biological indicators, and are important components of fish habitat.
- Fish populations in rivers and lakes are monitored as they are biological indicators of ecosystem integrity and are a highly valued resource in the region.

- Water quality in regional lakes sensitive to acidification is monitored as an early warning indicator of potential effects related to acid deposition.

RAMP is funded by companies that are not exclusively constructing and operating oil sands projects in the RAMP FSA. Therefore, the term “focal projects” is used in the RAMP 2008 Technical Report; focal projects are defined as those projects owned and operated by the 2008 RAMP funders listed above which were under construction or operational in 2008 in the RAMP FSA. For 2008, these projects included a number of oil sands projects and a limestone quarry project.

2008 RAMP funders do have other projects in the RAMP FSA that were in the application stage as of 2008, or which received approval in 2008 or earlier, but on which construction had not yet started as of 2008. These projects are noted throughout this technical report, but are not designated as focal projects, as these projects in 2008 would not have contributed to any possible influences on aquatic resources covered by RAMP components.

The overall analytical approach for the 2008 RAMP Technical Report builds on the methodology used in previous years and the RAMP Technical Design and Rationale document. The analysis:

- is 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;
- uses a set of measurement endpoints representing the health and integrity of valued environmental resources within the component; and
- uses specific criteria (e.g., criteria used in focal project EIAs, AENV, CCME guidelines, generally-accepted EEM effects criteria) for determining whether or not a change in the measurement endpoints has occurred and is significant with respect to the health and integrity of valued environmental resources.

The RAMP 2008 Technical 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 a focal project; data collected from these locations are designated as *test* for the purposes of 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 2008) or were (prior to 2008) upstream of all focal projects; data collected from these locations are to be designated as *baseline* for the purposes of data analysis, assessment, and reporting. The terms *test* and *baseline* depend solely on location of the aquatic resource in relation to the location of the focal projects to allow for long-term comparison of trends between *baseline* and *test* stations.

Satellite imagery was used in 2008 in conjunction with more detailed maps of Athabasca oil sands operations provided by a number of RAMP industry members to estimate the type, location, and amount of land changed by focal projects and other development activities. As of 2008, it is estimated that there were approximately 76,000 ha of the RAMP FSA that have undergone land change from focal projects and other oil sands developments. The percentage of the area of watersheds with land change as of 2008 varies from less than 1% for many watersheds (MacKay, Ells, Christina, Hangingstone, Horse, and Firebag), to 5% to 10% for the Muskeg and Upper Beaver watersheds, Mills Creek and the smaller Athabasca River tributaries from Fort McMurray to the confluence of the Firebag River to more than 20% for the Fort Creek, Tar River, Shipyard Lake, and McLean Creek watersheds.



## ASSESSMENT OF 2008 MONITORING RESULTS

A tabular summary of the 2008 results by watershed and component is presented at the end of this executive summary.

### Lower Athabasca River and Athabasca River Delta

**Hydrology** The observed 2008 discharge for the Athabasca River is estimated to be 1.0% less than the 2008 *baseline* discharge would have been in the absence of focal projects and other oil sands developments in the RAMP FSA. The differences in the Athabasca River between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Fall 2008 water quality at most stations in the Athabasca River was assessed as having **Negligible-Low** differences from regional *baseline* conditions irrespective of whether the stations were designated as *test* or *baseline*. Comparisons among stations designated as *test* with those designated as *baseline* showed similar water quality consistent with regional *baseline* conditions and no consistent pattern between *baseline* and *test* stations in trends in concentration of water quality variables. Water quality at one station, along the east bank upstream of the Steepbank River was assessed as having **Moderate** differences from regional *baseline* conditions, largely through high concentrations of suspended sediments, nitrogen, and some metals.

**Benthic Invertebrate Communities and Sediment Quality** The differences in benthic invertebrate communities in the Athabasca River Delta (ARD) as compared to *baseline* depositional sites in the RAMP FSA are classified as **Negligible-Low**. Levels of benthic invertebrate community measurement endpoints in the ARD continue to be within the range of expected values for *baseline* depositional reaches in the RAMP FSA, and there are no time trends of benthic invertebrate community measurement endpoints that indicate a degradation of community composition over time.

Differences in sediment quality conditions in the lower Athabasca River mainstem and the ARD as compared to regional *baseline* sediment quality conditions are classified as **Negligible-Low**. Concentrations of sediment quality variables from stations in the Athabasca River mainstem and the ARD in 2008 were generally within the range of previously-measured concentrations, there were no exceedances of sediment or soil quality guidelines with the exception of CCME fraction-3 hydrocarbons at one station, and little consistent regional differences in the Athabasca River mainstem and ARD between *test* and *baseline* areas.

**Fish Populations** As of 2008, current and historical fish inventory data from the Athabasca River indicate species-specific variability in relative abundance, length-frequency distribution, and condition factor. Statistically significant differences were observed between years for condition and length-frequency distributions (with the exception of northern pike) of the Key Indicator Resource (KIR) fish species with no positive or negative trends, and a significant increasing trend in relative abundance of walleye and a significant decreasing trend in relative abundance of longnose sucker. With the exception of these results, there were no other significant trends that would suggest a consistent negative or positive change in the populations over time (i.e., likely reflects natural variability).

The average **mercury** concentration in walleye greater than 400mm from the Athabasca River exceeded the subsistence fisher consumption guideline indicating a **High** risk to human health of subsistence fishers and a Moderate risk to human health of general consumers. The average mercury concentration in lake whitefish from the Athabasca River was below the subsistence fisher guideline indicating a **Negligible-Low** risk to human health. All tainting compounds in walleye and lake whitefish muscle tissue from the Athabasca River were below guideline concentrations. There is a **Moderate** risk to lake whitefish health due to levels of copper exceeding the lethal effects

threshold, and selenium levels exceeding the sublethal effects threshold. A **Negligible-Low** risk to walleye was identified given all metals in composite samples were below sublethal effects and no effects criteria. The effects thresholds used for this analyses do not necessarily reflect the toxicity of metals in the Athabasca River, given the sublethal and lethal concentrations were determined from laboratory testing, and will be researched and refined for future studies.

## Muskeg River Watershed

**Hydrology** The observed 2008 discharge for the Muskeg River watershed is estimated to be approximately 4% less than the 2008 *baseline* discharge would have been in the absence of focal projects and other oil sands developments in the Muskeg River watershed. The differences in the Muskeg River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Moderate** for annual maximum daily discharge and **Negligible-Low** for all other calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the Muskeg River watershed as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Most exceedances of water quality guidelines in 2008 occurred at multiple stations (both *test* and *baseline*) in the watershed, and water quality in the upper reach of the Muskeg River mainstem was similar to that observed at the mouth of the river.

**Benthic Invertebrate Communities and Sediment Quality** The differences in benthic invertebrate communities between *test* reaches in the lower and middle Muskeg River watershed as compared to *baseline* data from the upper reach in the watershed are classified as **Negligible-Low**. While there were significant differences in values of benthic invertebrate community measurement endpoints between the lower and upper Muskeg River, these differences are most likely due to differences in habitat (erosional in the lower Muskeg River versus depositional in the upper Muskeg River). In addition, there were no significant differences in values of benthic invertebrate community measurement endpoints between the middle and the upper Muskeg River. Values of all benthic invertebrate community measurement endpoints in the lower and middle *test* reaches of the Muskeg River, as well as the upper reach in 2008, now a *test* reach, were within the normal range of variation for *baseline* reaches in the RAMP FSA. In addition, %EPT in all three sampled reaches in the Muskeg River watershed was high in fall 2008.

The differences in benthic invertebrate community measurement endpoints measured between a *test* reach in the lower Jackpine Creek watershed and a *baseline* reach from the Jackpine Creek watershed are assessed as **Negligible-Low** because there were no significant differences in values of measurement endpoints between the two reaches. Values of benthic invertebrate community measurement endpoints in the lower *test* reach were within the normal range of variation for *baseline* depositional reaches in the RAMP FSA.

Differences in sediment quality in fall 2008 in the Muskeg River watershed as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Sediment quality at all Muskeg River watershed stations sampled by RAMP in 2008 was generally consistent with that of previous years, and within historical and regional *baseline* ranges. Sediment quality in the upper reaches of the Muskeg River mainstem and Jackpine Creek was similar to that observed in lower reaches.

## Steepbank River Watershed

**Hydrology** The observed 2008 discharge for the Steepbank River watershed is estimated to be 0.35% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the Steepbank River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the Steepbank River watershed as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Concentrations of all water quality measurement endpoints were within the range of natural variability as they have consistently been since the beginning of RAMP water quality monitoring in the Steepbank River watershed. In addition, ionic composition at all water quality monitoring stations in the watershed was consistent with previous years and continues to show little year-to-year variation.

**Benthic Invertebrate Communities** The differences in the benthic invertebrate community in the lower Steepbank River compared to the upper Steepbank River are assessed as **Moderate**. While the lower *test* Steepbank River reach has significantly lower total abundance, number of taxa, and %EPT, values of all benthic invertebrate community measurement endpoints in fall 2008, with the exception of %EPT, were within the normal range of variation for *baseline* erosional reaches in the RAMP FSA. There has been a decline in %EPT in the lower *test* Steepbank River reach since RAMP sampling began there in 1998.

## Tar River Watershed

**Hydrology** The observed 2008 discharge for the Tar River watershed is estimated to be 74% less than the 2008 *baseline* discharge in the absence of focal projects. The differences in the Tar River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **High** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the lower Tar River as compared to regional *baseline* conditions are assessed as **High**:

- Concentrations of a number of nutrients and ions have increased to concentrations outside the range of both historical measurements and natural *baseline* concentrations.
- All water quality guideline exceedances of nutrients and ions that occurred in the lower Tar River were not observed in the upper Tar River.
- Ionic composition of water in the lower Tar River has changed since 2005 toward a greater proportion of sulphate and chloride and a reduced proportion of bicarbonate, in contrast to the ion balance of water in the upper Tar River which remains dominated by calcium and bicarbonate.

## MacKay River Watershed

**Hydrology** The observed 2008 discharge for the MacKay River watershed is estimated to be 0.01% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the MacKay River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the MacKay River watershed as compared to regional *baseline* conditions are assessed as **Negligible-Low**:

- Most exceedances of water quality guidelines in 2008 occurred at multiple stations (both *test* and *baseline*) throughout the watershed.
- Almost all concentrations of all water quality measurement endpoints in fall 2008, were within the range of natural variability as they have consistently been since the beginning of RAMP water quality monitoring in the MacKay River watershed.
- Ionic composition at all water quality monitoring stations in the watershed in 2008 was consistent with previous years and continues to show little year-to-year variation.

**Benthic Invertebrate Communities** The differences in the benthic invertebrate community in the lower MacKay River as compared to the upper MacKay River are assessed as **Negligible-Low**. Differences in benthic invertebrate community measurement endpoints between the lower and upper MacKay River were statistically weak and values of all benthic invertebrate community measurement endpoints in the lower MacKay River in fall 2008 were within the normal range of variation for *baseline* erosional reaches in the RAMP FSA.

### **Calumet River Watershed**

**Hydrology** The observed 2008 discharge for the Calumet River watershed is estimated to be approximately 1% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the Calumet River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the Calumet River watershed as compared to regional *baseline* conditions are assessed as **Negligible-Low**.

### **Firebag River Watershed**

**Hydrology** The observed 2008 discharge for the Firebag River is estimated to be 0.04% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the Firebag River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the Firebag River watershed, including McClelland Lake, as compared to regional *baseline* conditions are assessed as **Negligible-Low**.

**Benthic Invertebrate Communities and Sediment Quality** Values of measurement endpoints for the benthic invertebrate community in McClelland Lake were within or above the natural range of variation for *baseline* lakes (i.e., McClelland and Kearsarge lakes) in the RAMP FSA. Differences in sediment quality in McClelland Lake compared to regional *baseline* conditions are assessed as **Negligible-Low**.

### **Ells River Watershed**

**Hydrology** The observed 2008 discharge for the Ells River watershed is estimated to be approximately 0.04% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the Ells River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the lower Ells River as compared to regional *baseline* conditions are assessed as **Negligible-Low**:

- As of 2008, there are no measurable, consistent differences in water quality in the lower and upper Ells River.
- All but one exceedance of water quality guidelines in 2008 occurred at both *test* and *baseline* stations in the watershed.
- Concentrations of all water quality measurement endpoints in both the lower and upper Ells River in fall 2008 were within the range of regional *baseline* conditions as they have been, with few exceptions, since the beginning of RAMP water quality monitoring in the Ells River watershed.

- Ionic composition of sampled water at both the lower and upper Ells River in fall 2008 was consistent with previous years and continues to show little year-to-year variation.

## **Clearwater-Christina River System**

**Hydrology** While hydrologic measurement endpoints for the Christina River watershed could not be estimated because there is no hydrometric station at the mouth of the Christina River, estimated effects of the focal project activities in 2008 were to remove 0.04 mm of runoff depth from the watershed.

**Water Quality** Differences in water quality in fall 2008 in the Clearwater River as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Differences in water quality in fall 2008 in the lower Christina River as compared to regional *baseline* conditions are assessed as **Negligible-Low**, while differences in water quality in fall 2008 in the lower Christina River, as compared to regional *baseline* conditions, are assessed as **Negligible-Low**.

**Benthic Invertebrate Communities and Sediment Quality** Differences in the benthic invertebrate community in the lower Clearwater River as compared to the Clearwater River above its confluence with the Christina River are assessed as **Negligible-Low**. Differences in benthic invertebrate community measurement endpoints between these two reaches of the Clearwater River have remained the same between the period when the lower Clearwater River was designated as *baseline* and when it was designated as *test*. Also, values of all benthic invertebrate community measurement endpoints are currently within the normal range of variation for *baseline* depositional reaches in the RAMP FSA, and both monitored reaches of the Clearwater River in fall 2008 contained a number of benthic invertebrate taxa that are considered sensitive.

Differences in sediment quality in fall 2008 in the lower Clearwater River compared to regional *baseline* conditions, are assessed as **Negligible-Low**. Sediment quality at both the lower Clearwater River and the Clearwater River upstream of its confluence with the Christina River in fall 2008 was generally consistent with that of previous years, with concentrations of sediment quality measurement endpoints largely within previously-measured and regional *baseline* ranges; no clear differences in sediment quality in fall 2008 were apparent between these two parts of the river.

**Fish Populations** The results of the 2008 Clearwater fish inventory indicate:

- few changes or trends in length and age frequency distributions, with the exception of a shift in dominant length class for longnose sucker (increasing) and white sucker (decreasing);
- continued increasing trends in spring and fall total CPUE for all species with the exception of goldeye in the spring;
- increased instances of significant year-to-year variability in condition factor of fish captured in the fall than in the spring;
- longnose sucker and northern pike in *test* reach on the Clearwater River had a greater than 10% difference in condition relative to upstream *baseline* reaches; and
- health assessment index and percentage of fish captured with evidence of external pathology for all species was within previously-measured ranges with the exception of walleye for which both of these measurement endpoints were greater than previously-measured.

## Hangingsstone River Watershed

**Hydrology** The observed 2008 discharge for the Hangingsstone River watershed is estimated to be approximately 0.05% less than the 2008 *baseline* discharge would have been in the absence of focal projects. The differences in the Hangingsstone River watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Negligible-Low** for all calculated hydrologic measurement endpoints.

**Water Quality** Differences in water quality in fall 2008 in the lower Hangingsstone River, designated as *baseline*, as compared to regional *baseline* conditions, are assessed as **Negligible-Low**. Water quality in the lower Hangingsstone River in fall 2008 was characterized by concentrations of a number of measurement endpoints that fell outside historical ranges. Although several endpoints also fell outside the 5<sup>th</sup> to 95<sup>th</sup> percentile of regional *baseline* concentrations, all but one of these was below the 5<sup>th</sup> percentile of regional values, rather than above the 95<sup>th</sup> percentile. A shift in ionic composition towards greater relative concentration of sulphate, sodium, and potassium, and lower relative concentration of bicarbonate and calcium also was measured.

**Benthic Invertebrate Communities** The benthic invertebrate communities of the lower Hangingsstone River in fall 2008 appear to have been influenced by the very high flows in the Hangingsstone River in the second half of August 2008. Total benthic invertebrate community abundance and number of taxa were below the 5<sup>th</sup> percentile of regional *baseline* values for erosional reaches in the RAMP FSA, reflecting possible high rates of benthic drift or burrowing deep into the reach substrate to avoid drifting during the high flow period. Benthic invertebrate community diversity and %EPT in the lower Hangingsstone River in fall 2008 were within regional baselines for erosional reaches in the RAMP FSA, consistent with previous values for these measurement endpoints in the lower Hangingsstone River.

## Miscellaneous Aquatic Systems

**Mills Creek** The differences in the Mills Creek watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Moderate** for all calculated hydrology measurement endpoints.

**Isadore's Lake** The water level of Isadore's Lake was just above the historical minimum until early in the year, but it rose well above its historical median level in April and continued to rise above the historical maximum levels for most of June. Water levels remained above the historical median values until the middle of December.

While significant increases have been measured in concentrations of calcium, magnesium and sulphate over the period of monitoring, differences in water quality in fall 2008 in Isadore's Lake as compared to regional *baseline* conditions are assessed as **Negligible-Low**.

The differences in benthic invertebrate communities between Isadore's Lake and *baseline* lakes in the RAMP FSA (i.e., McClelland and Kearn lakes) are classified as **Moderate**. While the average values of taxa richness, diversity, evenness, and %EPT are significantly lower in Isadore's Lake as compared to the *baseline* lakes in the RAMP FSA and the time trends in diversity and evenness are significantly different in Isadore's Lake than in the *baseline* lakes, taxa richness was the only measurement endpoint in fall 2008 that was lower than the range of natural variability.

Differences in sediment quality in fall 2008 in Isadore's Lake as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Sediment quality in Isadore's Lake in 2008 was generally consistent with that of previous years, and largely within historical and regional *baseline* ranges of concentrations. Although concentrations of some sediment quality measurement endpoints were above the range of regional *baseline* values (i.e., total hydrocarbons, some PAH species, and several metals), these relatively high concentrations were related to the consistently

high organic carbon and fine sediments present in this lake. When total PAH concentrations were corrected for bioavailability and presented as predicted PAH toxicity, the 2008 value of 0.08 was among the lowest observed for any RAMP sediment monitoring location since 1997.

**Poplar Creek and Beaver River** The differences in the Poplar Creek watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **High** for mean open-water season discharge and minimum open-water season discharge, and **Negligible-Low** for the annual maximum daily discharge.

Differences in water quality in fall 2008 in the lower Beaver River as compared to regional *baseline* conditions are assessed as **Moderate**, largely as a result of relatively high concentrations of a number of ions and total dissolved solids. Differences in water quality in fall 2008 in the upper Beaver River, designated as *baseline*, as well as in lower Poplar Creek, designated as *test*, as compared to regional *baseline* conditions are assessed as **Low-Negligible**.

The differences in the benthic invertebrate community in lower Poplar Creek, designated as *test* in 2008, as compared to benthic invertebrate communities in *baseline* depositional reaches, represented by the upper Beaver River are classified as **Moderate**. Lower Poplar Creek had significantly lower Simpson's Diversity and evenness as compared to the upper Beaver River. Also, the diversity was below and taxa richness and %EPT were near the lower minima of their normal range of variation for *baseline* depositional reaches in the RAMP FSA.

Differences in sediment quality at both lower Poplar Creek and the upper Beaver River as compared to regional *baseline* conditions are assessed as **Negligible-Low**, although concentrations of some metals exceeded regional *baseline* ranges in lower Poplar Creek. No sediment quality variables exceeded relevant guidelines at either station.

**McLean Creek** Differences in water quality in fall 2008 in lower McLean Creek as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Water quality in McLean Creek in 2008 was generally consistent with regional *baseline* characteristics, although concentrations of several water quality variables were outside their previously-measured ranges, including total dissolved phosphorus, dissolved organic carbon, and ultra-trace mercury (highs), and conductivity, sodium, calcium, magnesium, and sulphate (lows).

**Fort Creek** The differences in the Fort Creek watershed between the observed hydrograph and the estimated *baseline* hydrograph are assessed as **Moderate** for open-water season discharge, annual maximum daily discharge, and open-season minimum daily discharge.

Differences in water quality in fall 2008 in lower Fort Creek as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Water quality in lower Fort Creek has remained consistent since RAMP initiated monitoring in this watercourse in 2000.

The differences in the benthic invertebrate community in lower Fort Creek between the period it was designated as *baseline* and the period it has been designated as *test* are classified as **High**. Both total abundance and taxa richness are lower in the years lower Fort Creek has been designated as *test* as compared to the years it was designated as *baseline*, and total abundance, taxa richness, and Simpson's diversity were less than the normal range of variation for these measurement endpoints in *baseline* depositional reaches in the RAMP FSA in fall 2008.

Differences in sediment quality in fall 2008 in lower Fort Creek as compared to regional *baseline* conditions are assessed as **Negligible-Low**. Concentrations of sediment quality measurement endpoints in lower Fort Creek in 2008 were largely within previously-measured and regional *baseline* ranges, although sediments contained more sand and less organic carbon in fall 2008 than in previous years.

**Shipyard Lake** Differences in water quality in fall 2008 in Shipyard Lake as compared to regional *baseline* conditions are assessed as **Negligible-Low**. However, slow but statistically-significant increases in concentrations of several ions (sodium, magnesium, potassium, and boron) and a related shift in ion balance in the lake, suggest water quality is changing in Shipyard Lake, with waters becoming more saline.

The differences in benthic invertebrate communities between Shipyard Lake and *baseline* lakes in the RAMP FSA (i.e., McClelland and Kearl lakes) are classified as **Negligible-Low**. Differences in values of benthic invertebrate community measurement endpoints between Shipyard Lake and *baseline* lakes in the RAMP FSA are statistically weak, no measurement endpoints in Shipyard Lake in fall 2008 were at values below the lower limit of their normal range of variability in *baseline* lakes in the RAMP FSA, and the benthic invertebrate community of Shipyard Lake has as high or higher diversity, with about as many or more sensitive taxa (i.e., %EPT) compared to *baseline* lakes in the RAMP FSA.

Differences in sediment quality in fall 2008 in Shipyard Lake as compared to regional *baseline* conditions are assessed as **Moderate**. Sediment quality in Shipyard Lake in 2008 was generally consistent with that of previous years, but high concentrations of some PAH and metal species likely were related primarily to the very high organic carbon and proportion of fine materials in this lake relative to other lakes and stream reaches sampled by RAMP. When these concentrations were normalized to organic carbon or percent fines, resulting concentrations were similar to those at other RAMP sampling locations.

**Big Island Lake and Gardiner (Buffalo) Lake** The measurement endpoint used in the assessment of the results from the Big Island and Gardiner lakes fish tissue sampling program is mercury concentration in fish tissue as it relates to potential risk to human health and fish.

The average mercury concentration in walleye less than 600mm in length, lake whitefish and northern pike from Big Island Lake were below the subsistence fish consumption guideline indicating a **Negligible-Low** risk to human health. The average mercury concentration in walleye, greater than 600mm, from Big Island Lake exceeded the subsistence fisher consumption guideline indicating a High Risk to the health of subsistence fishers and a Moderate risk to the health of general consumers for consumption of fish of that size or greater. The average mercury concentration in walleye less than 500mm in length, lake whitefish in all size classes and northern pike less than 700mm in length was below the subsistence fisher consumption guideline indicating a **Negligible-Low** risk to human health for both subsistence fishers and general consumers. The average mercury concentration in walleye greater than 500mm exceeded the subsistence fisher consumption guideline indicating a High risk to health of subsistence fishers and a Moderate risk to the health of general consumers for consumption of fish of these size classes or greater for each species. Comparisons with historical regional fish tissue mercury data indicated that mercury concentrations from walleye, lake whitefish and northern pike in Gardiner and Big Island lakes were within the range of mercury concentrations observed in this region of Alberta across years.

Fish tissue results for Gardiner Lake in 2008 suggest **Negligible-Low** potential risk to fish health given mercury concentrations did not exceed the lethal and non-lethal effects or no effects thresholds.

## REGIONAL SYNTHESIS

### Hydrology

The hydrologic effects of focal projects and other oil sands developments on the Athabasca River are assessed as being Negligible-Low in magnitude and negative in direction over the past five years (2004 to 2008), with a slight trend toward increasing negative effects on both annual maximum daily discharge and winter minimum discharge since 2005.



Most of the hydrologic assessments at the watershed level are rated as Negligible-Low with the exception of effects on particular hydrologic measurement endpoints in the Muskeg, Tar, Poplar, Mills Creek and Fort Creek watersheds. Specific water withdrawals and releases, and water diversions, were the focal project activities with the greatest influence in 2008 on hydrologic conditions in these watersheds, including:

- discharges via the Aurora Clean Water Diversion into Stanley Creek and on into the Muskeg River;
- increased flows into Poplar Creek via the Beaver River diversion and Poplar Creek Spillway; and
- reduced flows in Tar River due to the filling of CNRL Compensation Lake in spring months and redirection of flow into CNRL tailings pond throughout the remainder of the year.

Activities resulting in closed-circuited areas were the focal project activities that had the second greatest influence on hydrological conditions in 2008 in RAMP FSA watersheds. The largest areas of closed-circuited land are in the minor, unnamed Athabasca River tributaries north of Fort McMurray, followed by the Muskeg, Tar, and Steepbank river watersheds.

Activities resulting in land change areas that were not closed-circuited generally had minor effects on hydrologic conditions in RAMP FSA watersheds in 2008; the largest hydrology change as a result of these activities occurred in the minor, unnamed Athabasca River tributaries north of Fort McMurray, as well as the Muskeg and Steepbank river watersheds.

The cumulative hydrologic effects of focal project activities plus all other active oil sands projects in the RAMP FSA are estimated to be only marginally greater than the hydrologic effects of the focal projects alone.

A review of the average estimated percent change from 2004 to 2008 for each of the four hydrologic measurement endpoints indicates that, in all cases, most of the assessed area has experienced Negligible-Low hydrologic impacts. Therefore, while there have been changes in some hydrologic measurement endpoints in particular watersheds that have been Moderate to High, hydrologic effects of focal projects and other oil sands developments at a regional level, based on watercourses monitored by RAMP, have been largely Negligible-Low to 2008.

## Water Quality

Aside from the exceptions noted below, regional water quality data collected by RAMP in fall 2008 was generally similar for all key water quality measurement endpoints between stations designated as *test* and those designated as *baseline*, as well as generally falling within the range of historical observations from previous years.

Exceptions to the consistent regional water quality results included metals, nutrients and major ions. The main regional exception for metals was ultra-trace mercury which, as in 2007, was detected more frequently in 2008 than in previous years, at both *baseline* and *test* stations. This regional analysis also highlighted the following watershed-specific exceptions:

- **Lower Tar River** – increases in nutrients and various major ions, and deviation of several variables above regional *baseline* conditions;
- **Lower Beaver River** – regionally high concentrations of major anions (sulphate and chloride);

- **Isadore's Lake** – although water quality remains generally within regional *baseline* conditions, there are increasing concentrations of several major ions, including calcium, magnesium and sulphate.
- **Shipyard Lake** – although water quality remains fully within regional *baseline* conditions,, slowly-increasing concentrations of several ions (sodium, magnesium, potassium, and boron) and a related shift in ion balance in the lake suggest water quality is changing in Shipyard Lake, with waters becoming more saline.

## Benthic Invertebrate Communities and Sediment Quality

At the regional level, variations within and among reaches (and lakes) designated as *test* have been within the normal (background) range of variability as observed in *baseline* reaches (and lakes). In addition, with a few exceptions, most differences in benthic invertebrate community measurement endpoints between *test* reaches and *baseline* reaches in watersheds were not significantly different in 2008. The exceptions to this in 2008 were the lower Steepbank River, lower Poplar Creek, lower Fort Creek, and Isadore's Lake, all of which had a number of significant differences between *test* and *baseline* reaches (and lakes), and values of benthic invertebrate community measurement endpoints that were below the 5<sup>th</sup> percentile of *baseline* ranges for the particular habitat type in the RAMP FSA.

Sediments in the RAMP FSA naturally contain hydrocarbons and PAHs at concentrations that may exceed environmental-quality guidelines. Spatial and temporal comparisons of sediment quality over time since monitoring by RAMP began in 1997 did not indicate any consistent trends over time in concentrations of hydrocarbons or metals, any consistent differences in sediment quality between *baseline* and *test* stations, or any relationships between sediment chemistry and composition of benthic communities that would suggest a negative influence of chemicals in sediment on community structure. Sediment toxicity tests showed survival and growth rates for organisms in sediments from all evaluated *baseline* and *test* locations that were similar or greater than those observed in laboratory-control sediments.

## Fish Populations

**Fish Tissue** To provide a regional context for the 2008 fish tissue results for the Athabasca River and Gardiner (Buffalo) and Big Island lakes, the 2008 fish tissue results were compared to mercury concentrations in fish tissue from waterbodies not downstream of focal projects and from previous RAMP sampling programs; data from a total of seventeen waterbodies were considered:

- Walleye in eleven of the seventeen waterbodies (64%) sampled over time showed an exceedance of the subsistence fisher mercury concentration guideline, but none exceeded the general consumer guideline.
- Northern pike in ten of the seventeen waterbodies (59%) sampled showed an exceedance of the subsistence fisher guideline, but none of the individual fish exceeded the general consumer guideline.
- There were no guideline exceedances of mercury concentrations in lake whitefish.
- Mean mercury concentrations in northern pike and walleye in waterbodies downstream of oil sands development (i.e., Athabasca River, Lake Athabasca, Lake Claire and the Muskeg River) fell within range of regional mercury concentrations from fish in waterbodies outside of the influence of oil sands development.

The mean mercury concentration standardized to fish weight in lake whitefish in the Athabasca River has decreased over time for both males and females. The mean concentration in walleye from the Athabasca River has decreased over time in males and remained fairly consistent for females.

Mercury concentrations in Lake Athabasca lake whitefish and northern pike measured in the early 1970s, prior to major oil sands development were similar or higher than mercury concentrations in fish with similar weights in 2008. In 2008, fish mercury results from the Athabasca River, downstream of oil sands development were similar to results from the two regional lakes (Gardiner and Big Island lakes), outside of oil sands development, for lake whitefish and walleye. Although captured downstream of oil sands development, sampled fish from the Athabasca River have migrated between upstream and downstream of oil sands development.

**Fish Inventory** Current and historical fish inventory data from the Athabasca River indicated species-specific variability in relative abundance, length-frequency distribution, and condition factor. Statistically significant differences were observed between years for condition and length-frequency distributions for the KIR fish species, with the exception of northern pike. Two significant trends over time have been observed in the Athabasca River: walleye - increase in relative abundance over time; and longnose sucker – decrease in relative abundance over time.

With the exception of these results, there were no other significant trends that would suggest a consistent negative or positive change in the populations over time. As such, it is likely that the observed variability in measurement endpoints is natural. However, given the lack of long-term fish inventory data from regions outside or upstream of the Athabasca oil sands region, it is not possible to put these results into a regional context.

Similar to the Athabasca River, analyses of fish inventory data from the Clearwater River indicated significant differences among years for KIR fish species, but no clear negative or positive trends in length-frequency distributions, relative abundance, and condition factor. There were more instances of significant year-to-year differences in condition factor of fish captured in the fall than in the spring, likely reflecting physiological changes in fish during spawning periods.

### **Acid-Sensitive Lakes**

The results of the analysis of 2008 RAMP ASL lake data in conjunction with historical RAMP ASL lake data suggest that there has been no significant change in the overall chemistry of the RAMP ASL lakes in 2008 compared to previous years. There is also no evidence to conclude that there have been any significant changes in lake chemistry in the RAMP ASL lakes over the monitoring period.

### **Summary and Recommendations**

The following table provides a summary of the 2008 RAMP monitoring program results, by watershed and component.

The report concludes with a number of recommendations directed towards refining the monitoring program and increasing the value of RAMP monitoring activities. These recommendations are outlined in detail in Section 7 for each RAMP component for consideration during the design of monitoring in future years of RAMP.

## Summary assessment of RAMP 2008 monitoring results.

Watershed/Region	Differences Between <i>Test</i> and <i>Baseline</i> Conditions				Fish Populations: Health Risk from Metals and Organics in Fish Tissue							Acid-Sensitive Lakes: Variation from Long-Term Average Potential for Acidification	
	Hydrology	Water Quality	Benthic Invertebrate Communities	Sediment Quality	Human Health				Fish Health	Fish Palatability			
					Sp.	Size	Sub.	Gen.					
Athabasca River	○	○	-	-	LKWH WALL	all sizes >400mm	○ ●	○ ●	LKWH WALL	○ ○	LKWH WALL	○ ○	-
Athabasca Delta	-	-	○	-	-	-	-	-	-	-	-	-	-
Muskeg River	○	○	○	-	-	-	-	-	-	-	-	-	-
Steepbank River	○	○	○	-	-	-	-	-	-	-	-	-	-
Tar River	●	●	-	-	-	-	-	-	-	-	-	-	-
MacKay River	○	○	○	-	-	-	-	-	-	-	-	-	-
Calumet River	○	○	-	-	-	-	-	-	-	-	-	-	-
Firebag River	○	○	-	-	-	-	-	-	-	-	-	-	-
Ellis River	○	○	-	-	-	-	-	-	-	-	-	-	-
Christina River	nm	○	-	-	-	-	-	-	-	-	-	-	-
Clearwater River	nm	○	○	○	-	-	-	-	-	-	-	-	-
Fort Creek	○	○	●	○	-	-	-	-	-	-	-	-	-
Beaver River	-	○	○	○	-	-	-	-	-	-	-	-	-
McLean Creek	-	○	-	-	-	-	-	-	-	-	-	-	-
Mills Creek	○	-	-	-	-	-	-	-	-	-	-	-	-
Poplar Creek	●	○	○	○	-	-	-	-	-	-	-	-	-
Shipyard Lake	-	○	○	○	-	-	-	-	-	-	-	-	-
Isadore's Lake	nm	○	○	○	-	-	-	-	-	-	-	-	-
Big Island Lake	-	-	-	-	LKWH WALL NRPK	all sizes >600mm all sizes	○ ○ ●	○ ○ ●	All species ○	-	nm	-	-
Gardiner Lake	-	-	-	-	LKWH WALL NRPK	all sizes >500mm >700mm	○ ○ ●	○ ○ ●	All species ○	-	nm	-	-
Stony Mountains	-	-	-	-	-				-	-	-	○	
West of Fort McMurray	-	-	-	-	-				-	-	-	○	
Northeast of Fort McMurray	-	-	-	-	-				-	-	-	○	
Birch Mountains	-	-	-	-	-				-	-	-	○	
Canadian Shield	-	-	-	-	-				-	-	-	○	
Caribou Mountains	-	-	-	-	-				-	-	-	○	

○ Negligible-Low

○ Moderate

● High

"-" program was not completed in 2008.

nm - not measured in 2008.

**Hydrology:** Calculated on differences between observed *test* and estimated *baseline* hydrographs: ± 5% - Negligible-Low; ± 15% - Moderate; > 15% - High.

Note: As not all hydrology measurement endpoints are calculated for each watershed because of differing lengths of the hydrographic record for 2008, hydrology results above are for those endpoints that were calculated.

Note: All calculated hydrology measurement endpoints in the Muskeg River watershed were assessed as Negligible-Low with the exception of Annual Maximum Daily Discharge which was assessed as Moderate.

Note: all calculated hydrology measurement endpoints in the Fort Creek watershed were assessed as High with the exception of Annual Maximum Daily Discharge which was assessed as Negligible-Low.

**Water Quality:** Classification based on adaptation of CCME water quality index.

Note: water quality at all stations in the Athabasca River was assessed as Negligible-Low with the exception of station ATR-SR-E which was assessed as Moderate.

**Benthic Invertebrate Communities:** Classification based on statistical differences in measurement endpoints between *baseline* and *test* areas as well as comparison to regional baselines.

**Sediment Quality:** Classification based on adaptation of CCME sediment quality index.

**Fish Populations:** Uses various USEPA and Health Canada criteria for risks to human health, fish health, and tainting from fish tissue concentrations of various substances.

LKWH-lake whitefish; WALL-walleye; NRPK-northern pike

Note: The classification of risk to human health for fish populations was Negligible-Low below the size class specified.

Note: For Fish Population Human Health Classification - Sub. refers to subsistence fishers; Gen. refers to general consumers as defined by Health Canada.

**Acid-Sensitive Lakes:** Classification based the frequency in each region with which values of seven measurement endpoints in 2008 were more than twice the standard deviation from their long-term mean in each lake.