APPENDIX 2

SIR 11 – Cumulative Effects

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ATTACHMENTS

Attachment A Current Socio-Economic Issues and Responses

1.0 INTRODUCTION

Shell Canada Energy (Shell) submitted the Applications and Environmental Impact Assessment (EIA) for the Jackpine Mine Expansion (JME) and Pierre River Mine (PRM) Project in December 2007. As part of the regulatory process for the JME Application, the Joint Review Panel (JRP) provided Supplemental Information Requests (SIRs) dated January 30, 2012.

In JRP SIR 11 of the January 30 submission, the JRP requested a Pre-Industrial Case (PIC) to take into account the effects that may have already been experienced prior to JME, plus an updated Planned Development Case (PDC) to account for foreseeable projects and activities publicly disclosed since the EIA for JME was completed. The JRP Terms of Reference (dated September 9, 2011) required the updated PDC be current to September 2011. Finally, the JRP requested that Shell include updated forest harvesting information and the effects of past and future forest fires.

Section 2.0 of this appendix presents the PIC information and Section 3.0 presents the 2012 PDC assessment.

The PIC is intended to represent conditions before substantial industrial development occurred in the region. Since information for some components is lacking, the PIC is based on the oldest data available, or on the most representative data available, for each component rather than on a consistent year basis.

The JRP SIR 11 also presents the updated PDC current to September 2011. A detailed list of the projects included in the updated PDC is provided in Appendix 3.1. The updated PDC is referred to as the 2012 PDC in this submission.

The response to JRP SIR 11 was developed with consideration of the other JRP information requests, items raised by regulators and stakeholders during the EIA sufficiency review, and commitments made previously by Shell for supporting assessment work. Accounting for these items in the assessment provides an appropriate and more robust assessment and maintains consistency between this response and the other information presented in the submission. Key assessment approach updates that are included in this submission include:

- Updated Base Case: The EIA Base Case information was updated similar to the 2012 PDC with a project inclusion list current to September 2011. This was done to allow a reasonable comparison between assessment case information within this submission. For example, Total Joslyn North Mine has been added to the EIA Base Case, given that regulatory approval has been granted for this project. A detailed list of the projects included in the updated Base Case is provided in Appendix 3.1 (Section 2.4). This updated assessment case is referred to as the 2012 Base Case in this submission. The 2012 Base Case information is considered in the PIC and some portions of the 2012 PDC assessment.
- Updated Application Case: JRP SIR 8 requested Shell present the effects of JME alone, in isolation from PRM, for specific sections of the EIA. This updated assessment case for JME is referred to as the 2012 JME Application Case throughout the SIR submission and is presented in Appendix 1. The 2012 JME Application Case results are also discussed in the 2012 PDC assessment presented in Section 3.0 of this appendix.
- Updated approach to assessing forest fire and timber harvest: A key change in approach involves use of A Landscape Cumulative Effects Simulator (ALCES®) model to simulate forest fire and harvest information. Landscape simulations were conducted using the ALCES® and ALCES Mapper® computer programs. The

ALCES® program was used to simulate the effects of fire, timber harvest, and industrial development in the Regional Study Area (RSA) over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the PIC, 2012 Base Case, 2012 JME Application Case and 2012 PDC in this submission.

Other approach updates specific to individual technical components are discussed in their respective introductory sections within Sections 2.0 and 3.0 of this appendix.

2.0 PRE-INDUSTRIAL CASE

This section addresses the requirement for a PIC in the JRP Terms of Reference for the Jackpine Mine Expansion (Government of Canada and ERCB 2011) and SIR 11 in the *Joint Review Panel Terms of Reference Supplemental Information Request for the Jackpine Mine Expansion Project* (Government of Canada and ERCB 2012).

2.1 Pre-Industrial Case Approach

The PIC is intended to represent conditions before substantial industrial development occurred in the region. Because information for some components is lacking, the PIC is based on the oldest data available, or on the most representative data available by component rather than on a consistent year basis. As a result, the PIC may not always be representative of true pre-industrial conditions. In the EIA and previous submissions made as part of this regulatory process, data intended to represent pre-industrial conditions has been referred to as Pre-Development or the Pre-Development Case. In the interests of consistency and clarity, this information has been re-titled the Pre-Industrial Case (PIC) for this submission.

Components discussed in the PIC are air quality, health risk, air emissions effects on ecological receptors, aquatic resources (hydrogeology; hydrology; water quality; and fish and fish habitat), terrestrial resources (soils and terrain; terrestrial vegetation; wetlands and forest resources; wildlife; and biodiversity), and human environment (traditional knowledge and land use; and socio-economics).

Data for the PIC were obtained from several sources, including the EIA, the *May 2011, Submission of Information to the Joint Review Panel,* and the Fort McKay Specific Assessment (FMSA) (Fort McKay IRC 2010). Data were developed using the same or similar methods and study areas as the EIA, and incorporate corrections from the *December 2009, Application for Approval of the Jackpine Mine Expansion Project, Supplemental Information* submitted to Alberta Environment.

Where possible, the PIC information is compared with 2012 Base Case information. This comparison will allow the JRP to “take into account the effects that may have already been experienced prior to the Project”. The 2012 Base Case information used in this section is taken primarily from Appendix 1 of this submission and is referred to as the "2012 Base Case” data.

The following sections are included in the PIC section of this document:

- Section 2.2 provides the PIC for Air Quality and Environmental Health, including Human Health Risks and Air Emissions Effects on Ecological Receptors.

- Section 2.3 provides the PIC for Aquatic Resources, including hydrogeology, hydrology, water quality, and fish and fish habitat.
- Section 2.4 provides the PIC for Terrestrial Resources, including soils and terrain; terrestrial vegetation, wetlands and forest resources; wildlife; and biodiversity.
- Section 2.5 provides the PIC for the Human Environment, including traditional knowledge and land use, and socio-economics.
- Section 2.6 provides a summary of the PIC comparison with the 2012 Base Case to enable the JRP to identify the effects that have occurred prior to the Project.

2.2 Air Quality and Environmental Health

This section provides a comparison of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter with a mean aerodynamic diameter of 2.5 µm or smaller ($PM_{2.5}$) concentrations at a PIC (circa 1965) and the 2012 Base Case.

2.2.1 Air Quality

The PIC corresponds to a time before the start of oil sands developments in the region, when the emission sources of SO_2, NO_2 and $PM_{2.5}$ would have been a mix of natural and anthropogenic sources. Natural sources would have included forest fires and windblown dust, while anthropogenic sources could have included vehicle fuel combustion and home heating fuel combustion (e.g., wood or oil). These compounds were selected because they are typically of interest in air quality assessments in the region. In general, before the start of industrial development in the region, the ambient concentrations of most air quality compounds associated with anthropogenic sources would be quite low.

For the purpose of the PIC, natural and anthropogenic background concentrations were estimated separately for SO_2, NO_2 and $PM_{2.5}$. Values were obtained from a report prepared for the Trace Metal and Air Contaminant Working Group of the Cumulative Environmental Management Association (CEMA), titled *Estimating Contributions to Ambient Concentrations in Fort McKay* (Golder 2005). The primary tool used in the study was a wind sector analysis of SO_2, NO_2 and $PM_{2.5}$ monitoring data collected in Fort McKay.

Natural background concentrations were assumed when winds were blowing from a region with no industrial emission sources. The natural background concentrations presented in the CEMA report are summarized in Table 2.2-1. The concentrations are divided into short-term values and long-term values. Short-term concentrations are represented by 1-hour and 24-hour averaging periods. Long-term concentrations are represented by the annual averaging period. Short-term concentrations are provided as a range, where the minimum is the 75th percentile value and the maximum is the 95th percentile value. Long-term concentrations are also provided as a range, where the minimum is the average value and the maximum is the 50th percentile value.

Table 2.2-1 Natural Background SO_2, NO_2 and $PM_{2.5}$ Concentrations in the Athabasca Oil Sands Region

Parameter	Short-Term Concentration [µg/m³]	Long-Term Concentration [µg/m³]
SO_2	0.8 to 2.9	0.0 to 0.9
NO_2	7.5 to 22.6	1.9 to 5.5
$PM_{2.5}$	5.8 to 12.7	3.6 to 4.8

Anthropogenic background concentrations were based on the assumption that there were no major industrial activities in the surrounding areas. The primary anthropogenic emissions in the vicinity of JME before industrial activity were assumed to be from the community of Fort McKay. The community of Fort McMurray would have had higher ambient concentrations than Fort McKay during this period but is distant enough to negligibly influence ambient air quality in the vicinity of JME. Therefore, only activities within Fort McKay were considered to contribute to the overall background air quality. Information on the activities within the community of Fort McKay was gathered anecdotally from community elders. In 1965, Fort McKay had a population of about 150, and included 20 to 30 log cabins. Although there were no motorized land vehicles, motorized boats with 2-cycle engines were being used. Without any fossil heating fuels available, the main source of emissions in the community was home heating using wood. The basis for estimating the home heating emissions by wood stoves and fireplaces was as follows:

- According to community elders, Fort McKay had about 30 log cabins in 1965.
- The home heating requirement per dwelling was assumed to be 128 mmBtu/yr.
- The efficiency of wood stoves was assumed to be 54%, based on the United States Environmental Protection Agency (U.S. EPA) AP-42, Table 1.10-5 (U.S. EPA 1995).
- The heating value of pine wood was assumed to be 0.00914 mmBtu/lb.
- The SO_2, NO_X and $PM_{2.5}$ emission factors were obtained from U.S. EPA AP-42, Tables 1.9-1 and 1.10-1 (U.S. EPA 1995).

Representative estimates of SO_2, NO_X (expressed as NO_2) and $PM_{2.5}$ emissions were calculated and are presented in Table 2.2-2. The emissions data were then entered into the CALPUFF model to obtain ground-level predictions of each of the three compounds.

Table 2.2-2 Estimated SO_2, NO_X and $PM_{2.5}$ Emissions From Activities Within Fort McKay in the Pre-Industrial Case

Parameter	Emission Rate [t/d]
SO_2	1.93×10^{-4}
NO_X (expressed as NO_2)	1.25×10^{-3}
$PM_{2.5}$	1.57×10^{-2}

The 2012 Base Case concentrations of SO_2, NO_2 and $PM_{2.5}$ at Fort McKay were predicted using the EIA modelling assessment methods. The 2012 Base Case regional emissions are provided in Appendix 3.2.

The overall background values for SO_2, NO_2 and $PM_{2.5}$ at Fort McKay were estimated by adding the predicted anthropogenic concentration from Fort McKay to the naturally occurring concentration. A summary of these values is presented in Table 2.2-3. The 2012 Base Case predictions are also shown for comparison. The peak 24-hour $PM_{2.5}$ 2012 Base Case prediction is above the current Alberta Ambient Air Quality Objectives (AAAQO) of 30 µg/m³; however, the 98th percentile 24-hour $PM_{2.5}$ prediction is below the Canada-wide standard of 30 µg/m³ (CCME 2000).

Table 2.2-3 Pre-Industrial Case and 2012 Base Case SO_2, NO_2 and $PM_{2.5}$ Predictions at Fort McKay

Parameter	Maximum 1-hour Concentration[(a)] [µg/m³]		Peak 24-hour Concentration[(a)] [µg/m³]		98th Percentile 24-hour Concentration [µg/m³]		Peak Annual Concentration[(a)] [µg/m³]	
	Pre-Industrial Case	2012 Base Case[(b)]	Pre-Industrial Case	2012 Base Case[(b)]	Pre-Industrial Case	2012 Base Case[(b)]	Pre-Industrial Case	2012 Base Case[(b)]
SO_2	3.2	86.0	3.1	27.6	—	—	0.9	5.0
NO_2	23.3	117.4	23.1	96.3	—	—	5.5	29.8
$PM_{2.5}$	—	—	25.9	34.7	18.4	27.4	7.8	9.6

(a) The peak concentrations represent the highest predictions from the CALPUFF model. The maximum 1-hour concentration excluded the eight highest 1-hour predictions when determining compliance with the AAAQOs, as per the Alberta model guidelines (AENV 2011).

(b) The 2012 Base Case predictions include a contribution from community emission sources.

2.2.2 Human Health Risk

The level of anthropogenic emissions in the region would generally be lower in the PIC than in the 2012 Base Case assessment discussed in Appendix 3.2. Accordingly, while human health risks could not be adequately characterized for the PIC owing to the overall quality of the database of measured air, soil and vegetation data prior to 1965 for the compounds relevant to the Human Health Risk Assessment, there would be lower human health risks via exposure pathways that were dependant on these datasets.

2.2.3 Air Emissions Effects on Ecological Receptors

Air emissions effects on ecological receptors could not be assessed for the PIC as much of the necessary environmental data for the air emissions effect analyses are not available from the PIC period. However, the level of anthropogenic emissions in the region would generally be lower in the PIC than in the 2012 Base Case predictions discussed in Appendix 1.

2.3 Aquatic Resources

This section describes PIC groundwater levels and flow directions, compares PIC and Base Case surface water hydrology statistics, and compares PIC and Base Case water quality data for the Muskeg River watershed and Athabasca River. Base Case surface water hydrology and water quality information for the Muskeg River watershed is based on EIA predictions (EIA Base Case), and Athabasca River predictions are based on updated Base Case predictions (2012 Base Case), as discussed in Appendix 1, Section 3.

The hydrogeology PIC was built from groundwater data that are representative of pre-mining conditions both regionally and within the Muskeg River watershed (circa 1979). These data sets were obtained from historical sources (e.g., Hackbarth and Natasa 1979), the Oil Sands Groundwater Database, and specific case studies

(Canadian Natural 2001; Imperial Oil 2005; Shell 1997, 2002, 2005; Syncrude 1996; TrueNorth 2002; WorleyParsons Komex 2007).

For both the hydrology and water quality components, PIC data are presented in the *Aquatics Environmental Setting Report for JME & PRM, Sections 2 and 3* (Golder 2007a), and modelled PIC scenarios are presented in the EIA, Volume 4A, Sections 6.4 and 6.5. These pre-industrial data were updated for the Muskeg Watershed in the FMSA in Sections 4.3.2, 4.4.2 and 4.5.2 for hydrology, and Sections 5.3.2 and 5.4.2 for water quality (Fort McKay IRC 2010).

A PIC is presented in the following sections for the hydrogeology, hydrology, water quality, and fish and fish habitat components for the Local Study Area (LSA). The PIC includes data collected as part of the Aquatics Environmental Setting Report (Golder 2007a).

2.3.1 Hydrogeology

Available groundwater data representative of pre-mining conditions were compiled for the PIC, including data as old as 1972 and as recent as 2007. The data set included data from Hackbarth and Natasa (1979), the Oil Sands Groundwater Database, where pertinent, and groundwater data from the following baseline assessments conducted in the Muskeg River watershed:

- Aurora North Mine (Syncrude 1996);
- Muskeg River Mine (Shell 1997);
- Jackpine Mine - Phase1 (Shell 2002);
- Kearl Project (Imperial Oil 2005);
- Muskeg River Mine Expansion (Shell 2005); and
- Jackpine Mine Expansion (WorleyParsons Komex 2007).

2.3.1.1 Hydrogeology Assessment Methods

The PIC data used for the steady-state calibration of the Regional Groundwater Model are summarized in the Hydrogeology Modelling Information report in the EIA, Volume 4B, Appendix 4-1, Table 2. The regional model was calibrated to 101 static groundwater levels in the surficial aquifers, five static groundwater levels in the McMurray Formation oil sands, 154 static groundwater levels in the Basal Aquifer and five static water levels in the Methy Formation. The Basal Aquifer data set included only the data unaffected by depressurization at Aurora North Mine and Muskeg River Mine, and is considered representative of pre-mining conditions.

The PIC data used for the steady-state calibration of the JME Local Groundwater Model are summarized in the Hydrogeology Modelling Information report in the EIA, Volume 4B, Appendix 4-1, Table 7. The JME Local Groundwater Model was calibrated to 52 static groundwater levels in the surficial aquifers, three static groundwater levels in the McMurray Formation oil sands, and 55 static groundwater levels in the Basal Aquifer.

2.3.1.2 Hydrogeology Results

The PIC groundwater levels and flow direction in the Basal Aquifer are shown in the EIA, Volume 4A, Figure 6.3-3. In general, within the JME LSA, PIC groundwater flow is in a westerly direction towards the Athabasca River, the major regional groundwater discharge feature.

The PIC groundwater levels and flow directions in the surficial deposits were shown in the EIA, Volume 4A, Figure 6.3-12. Within the Muskeg River watershed, groundwater flow is generally from the topographic highs of the southeast (Muskeg Mountain Plateau) and northwest (Fort Hills upland) towards the Muskeg River.

The PIC and EIA Base Case results for hydrogeology are presented in the EIA, Volume 4A, Section 6.3. Table 6.3-2 presents the water balance within the JME LSA, Table 6.3-3 presents groundwater discharges to major rivers and streams within the JME LSA, and Table 6.3-4 presents groundwater seepage rates from lakes within the JME LSA.

2.3.2 Hydrology

Data for PIC surface water hydrology were reported in the EIA, Volume 4A, Section 6.4 and Appendix 4-7. The data set was built by calibrating the hydrologic model to watershed characteristics with no industrial development. Therefore, the data represent PIC hydrology conditions.

2.3.2.1 Hydrology Assessment Methods

For the hydrologic simulation to characterize the PIC conditions, watersheds characteristics in the LSA were assumed to be undisturbed. The Hydrologic Simulation Program Fortran (HSPF) model was used to generate simulated daily flows in the receiving watercourses. Simulated daily flows were then analyzed to estimate the hydrologic parameters for the PIC.

Flows have been recorded on the Athabasca River at Fort McMurray since 1957. Industrial water withdrawals from oil sands operations are downstream of Fort McMurray and do not influence the flow statistics of the Athabasca River at Fort McMurray. Anthropogenic changes in flow are due to industrial and municipal withdrawals upstream of Fort McMurray. These upstream influences have increased over time since the start of the first pulp mill in Hinton in 1957, with four subsequent pulp mills built and operated in the 1980s and 1990s. Agricultural and municipal growth also increased during that period. However, much of the water withdrawn for these purposes is returned to the river system. The current average annualized net withdrawal rate for these upstream demands is less than 2.6 m^3/s. Therefore, the change in flows due to these demands would be insignificant in the Lower Athabasca River.

The PIC (pre-1967) flows for the Athabasca River at Fort McMurray were derived by adding the upstream withdrawals to data recorded downstream of Fort McMurray at Environment Canada Station 07DA001.

Potential changes to Athabasca River flows due to existing and approved projects (2012 Base Case) were quantified using Athabasca River PIC flow data generated for Environment Canada Station 07DA001, in combination with Steepbank River flow data from Environment Canada Station 07DA006, as recommended by the *Water Management Framework: Instream Flow Needs and Water Management Systems for the Lower Athabasca River* (AENV and DFO 2007).

2.3.2.2 Hydrology Results

The PIC and EIA Base Case flow statistics for Jackpine Creek and four nodes on Muskeg River (Figure 3.3-3), presented in Tables 2.3-1 to 2.3-5, and the Kearl Lake water level and depth statistics presented in Table 2.3-6, are taken from the EIA, Volume 4A, Section 6.4 and Appendix 4-7.

Pre-Industrial Case flow statistics for Athabasca River at Fort McMurray and 2012 Base Case flows in Athabasca River Reach 4 are compared in Table 2.3-7 for mean annual discharge, mean open-water discharge, mean ice-cover discharge, 7Q10 low flow discharge (lowest 7-day consecutive flow that occurs, on average, once every 10 years) and 10-year flood peak discharge. Pre-Industrial Case and 2012 Base Case water level statistics for Athabasca River at Node S24 are provided in Table 2.3-8.

Muskeg drainage and overburden dewatering causes the mean annual flow at Muskeg River Node M3 to increase from the PIC to the EIA Base Case for conditions at the 2012 time snapshot. This flow increase diminishes over time as the total closed-circuit area becomes larger. Flood flows are attenuated by EIA Base Case pit lakes, and low flows increase. After mine closure in 2065, flows are attenuated by the effects of the pit lakes. The 7Q10 low flow for the EIA Base Case is higher than the PIC value. The mean annual flow in the lower Muskeg River is close to the PIC value.

For Athabasca River, the net annual water allocation to all existing and approved oil sands developments represents a reduction in the mean annual Athabasca River flow of about 2.1% based on the recorded river flows at Fort McMurray from PIC to 2012 Base Case. The combined reductions in seasonal flows in Reach 4 are less than 13% for an average year. The predicted combined changes in flow depths at Node S24 are less than 1%.

Table 2.3-1 Muskeg River Flows at Node M0 for Pre-Industrial Case and EIA Base Case

Year	Expected Value of Parameter for Snapshot Conditions	Pre-Industrial Case	EIA Base Case
		Streamflow Discharge [m^3/s]	Streamflow Discharge [m^3/s]
2012	mean annual discharge	1.360	1.340
	mean open-water discharge[(a)]	2.224	2.149
	mean ice-cover discharge[(a)]	0.163	0.197
	7Q10 low flow discharge	0.006	0.048
	10-year flood peak discharge	22.0	21.1
2029	mean annual discharge	1.360	1.301
	mean open-water discharge[(a)]	2.224	1.954
	mean ice-cover discharge[(a)]	0.163	0.410
	7Q10 low flow discharge	0.006	0.275
	10-year flood peak discharge	22.0	15.1
2049	mean annual discharge	1.360	1.187
	mean open-water discharge[(a)]	2.224	1.815
	mean ice-cover discharge[(a)]	0.163	0.325
	7Q10 low flow discharge	0.006	0.185
	10-year flood peak discharge	22.0	14.2
2065 and Far Future	mean annual discharge	1.360	1.342
	mean open-water discharge[(a)]	2.224	1.933
	mean ice-cover discharge[(a)]	0.163	0.511
	7Q10 low flow discharge	0.006	0.110
	10-year flood peak discharge	22.0	10.4

(a) The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

7Q10 = lowest 7-day consecutive flow that occurs, on average, once every 10 years.

Note: Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 5.1-3), with Pre-development information re-titled “Pre-Industrial Case”. However, values for 2029 and 2049 were updated to support the 2008 EIA Update based on updated time snapshots.

Table 2.3-2 Muskeg River Flows at Node M1 for Pre-Industrial Case and EIA Base Case

Year	Expected Value of Parameter for Snapshot Conditions	Pre-Industrial Case	EIA Base Case
		Streamflow Discharge [m^3/s]	Streamflow Discharge [m^3/s]
2012	mean annual discharge	2.426	2.654
	mean open-water discharge[(a)]	3.964	4.232
	mean ice-cover discharge[(a)]	0.300	0.477
	7Q10 low flow discharge	0.008	0.186
	10-year flood peak discharge	40.7	33.2
2029	mean annual discharge	2.426	2.306
	mean open-water discharge[(a)]	3.964	3.432
	mean ice-cover discharge[(a)]	0.300	0.760
	7Q10 low flow discharge	0.008	0.514
	10-year flood peak discharge	40.7	23.1
2049	mean annual discharge	2.426	1.473
	mean open-water discharge[(a)]	3.964	2.233
	mean ice-cover discharge[(a)]	0.300	0.424
	7Q10 low flow discharge	0.008	0.215
	10-year flood peak discharge	40.7	16.4
2065 and Far Future	mean annual discharge	2.426	1.784
	mean open-water discharge[(a)]	3.964	2.515
	mean ice-cover discharge[(a)]	0.300	0.754
	7Q10 low flow discharge	0.008	0.173
	10-year flood peak discharge	40.7	14.0

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

7Q10 = lowest 7-day consecutive flow that occurs, on average, once every 10 years.

Note: Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 5.1-5), with Pre-development information re-titled “Pre-Industrial Case”. The years have been revised from 2033 and 2052 in the EIA to 2029 and 2049 to reflect the updated snapshots presented in the *May 2008 Jackpine Mine Expansion & Pierre River Mine Project EIA Update.*

Table 2.3-3 Muskeg River Flows at Node M2 for Pre-Industrial Case and EIA Base Case

Year	Expected Value of Parameter for Snapshot Conditions	Pre-Industrial Case	EIA Base Case
		Streamflow Discharge [m^3/s]	Streamflow Discharge [m^3/s]
2012	mean annual discharge	3.543	3.737
	mean open-water discharge[(a)]	5.804	6.007
	mean ice-cover discharge[(a)]	0.421	0.589
	7Q10 low flow discharge	0.014	0.202
	10-year flood peak discharge	51.5	43.6
2029	mean annual discharge	3.543	3.424
	mean open-water discharge[(a)]	5.804	5.266
	mean ice-cover discharge[(a)]	0.421	0.867
	7Q10 low flow discharge	0.014	0.516
	10-year flood peak discharge	51.5	38.4
2049	mean annual discharge	3.543	3.134
	mean open-water discharge[(a)]	5.804	4.797
	mean ice-cover discharge[(a)]	0.421	0.811
	7Q10 low flow discharge	0.014	0.262
	10-year flood peak discharge	51.5	30.1
2065 and Far Future	mean annual discharge	3.543	3.705
	mean open-water discharge[(a)]	5.804	5.444
	mean ice-cover discharge[(a)]	0.421	1.256
	7Q10 low flow discharge	0.014	0.240
	10-year flood peak discharge	51.5	28.3

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

7Q10 = lowest 7-day consecutive flow that occurs, on average, once every 10 years.

Note: Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 5.1-7), with Pre-development information re-titled “Pre-Industrial Case”. The years have been revised from 2033 and 2052 in the EIA to 2029 and 2049 to reflect the updated snapshots presented in the *May 2008 Jackpine Mine Expansion & Pierre River Mine Project EIA Update.*

Table 2.3-4 Muskeg River Flows at Node M3 for Pre-Industrial Case and EIA Base Case

Year	Expected Value of Parameter for Snapshot Conditions	Pre-Industrial Case	EIA Base Case
		Streamflow Discharge [m^3/s]	Streamflow Discharge [m^3/s]
2012	mean annual discharge	3.75	4.18
	mean open-water discharge[(a)]	6.13	6.64
	mean ice-cover discharge[(a)]	0.463	0.808
	7Q10 low flow discharge	0.016	0.368
	10-year flood peak discharge	50.8	45.4
2029	mean annual discharge	3.75	3.79
	mean open-water discharge[(a)]	6.13	5.78
	mean ice-cover discharge[(a)]	0.463	1.046
	7Q10 low flow discharge	0.016	0.630
	10-year flood peak discharge	50.8	40.1
2049	mean annual discharge	3.75	3.24
	mean open-water discharge[(a)]	6.13	4.96
	mean ice-cover discharge[(a)]	0.463	0.832
	7Q10 low flow discharge	0.016	0.263
	10-year flood peak discharge	50.8	31.1
2065 and Far Future	mean annual discharge	3.75	3.96
	mean open-water discharge[(a)]	6.13	5.79
	mean ice-cover discharge[(a)]	0.463	1.381
	7Q10 low flow discharge	0.016	0.301
	10-year flood peak discharge	50.8	30.5

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

7Q10 = lowest 7-day consecutive flow that occurs, on average, once every 10 years.

Note: Data reproduced from the Environmental Impact Assessment (EIA, Volume 4A, Section 6.4.5, Table 6.4-11), with Pre-development information re-titled “Pre-Industrial Case”. The years have been revised from 2033 and 2052 in the EIA to 2029 and 2049 to reflect the updated snapshots presented in the *May 2008 Jackpine Mine Expansion & Pierre River Mine Project EIA Update.*

Table 2.3-5 Muskeg River Flow Depths at Environment Canada Hydrometric Station 07DA008 for Pre-Industrial Case and EIA Base Case

Year	Expected Value of Parameter for Snapshot Conditions	Average Flow Depth				Maximum Flow Depth	
		Pre-Industrial Case		EIA Base Case		Pre-Industrial Case	EIA Base Case
		Discharge [m^3/s]	Depth [m]	Discharge [m^3/s]	Depth [m]	Depth [m]	Depth [m]
2012	mean annual discharge	3.75	0.76	4.18	0.78	0.87	0.89
	mean open-water discharge[(a)]	6.13	0.83	6.64	0.84	0.95	0.97
	mean ice-cover discharge[(a)]	0.463	0.68	0.808	0.69	0.76	0.77
	7Q10 low flow discharge	0.016	0.67	0.368	0.68	0.75	0.76
	10-year flood peak discharge	50.8	1.98	45.4	1.84	2.43	2.26
2029	mean annual discharge	3.75	0.76	3.79	0.77	0.87	0.87
	mean open-water discharge[(a)]	6.13	0.83	5.78	0.82	0.95	0.94
	mean ice-cover discharge[(a)]	0.463	0.68	1.046	0.69	0.76	0.78
	7Q10 low flow discharge	0.016	0.67	0.630	0.68	0.75	0.77
	10-year flood peak discharge	50.8	1.98	40.1	1.70	2.43	2.08
2049	mean annual discharge	3.75	0.76	3.24	0.75	0.87	0.86
	mean open-water discharge[(a)]	6.13	0.83	4.96	0.80	0.95	0.91
	mean ice-cover discharge[(a)]	0.463	0.68	0.832	0.69	0.76	0.78
	7Q10 low flow discharge	0.016	0.67	0.263	0.67	0.75	0.76
	10-year flood peak discharge	50.8	1.98	31.1	1.47	2.43	1.78
2065 and Far Future	mean annual discharge	3.75	0.76	3.96	0.77	0.87	0.88
	mean open-water discharge[(a)]	6.13	0.83	5.79	0.82	0.95	0.94
	mean ice-cover discharge[(a)]	0.463	0.68	1.381	0.70	0.76	0.79
	7Q10 low flow discharge	0.016	0.67	0.301	0.68	0.75	0.76
	10-year flood peak discharge	50.8	1.98	30.5	1.45	2.43	1.76

(a) The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

7Q10 = lowest 7-day consecutive flow that occurs, on average, once every 10 years.

Note: Data reproduced from the Environmental Impact Assessment (EIA, Volume 4A, Section 6.4.5, Table 6.4-12), with Pre-development information re-titled “Pre-Industrial Case”. The years have been revised from 2033 and 2052 in the EIA to 2029 and 2049 to reflect the updated snapshots presented in the *May 2008 Jackpine Mine Expansion & Pierre River Mine Project EIA Update.*

Table 2.3-6 Kearl Lake Levels and Depths for Pre-Industrial Case and EIA Base Case

Year	Parameter [m]	Pre-Industrial Case					EIA Base Case				
		Mean Open-Water	Mean Ice-Cover	10% Exceedance	Median	90% Exceedance	Mean Open-Water	Mean Ice-Cover	10% Exceedance	Median	90% Exceedance
2012	water level	331.07	330.99	331.21	331.02	330.91	331.07	330.99	331.21	331.02	330.90
	maximum depth	2.57	2.49	2.71	2.52	2.40	2.57	2.49	2.70	2.52	2.40
2029	water level	331.07	330.99	331.21	331.02	330.91	331.62	331.53	331.76	331.56	331.44
	maximum depth	2.57	2.49	2.71	2.52	2.40	3.12	3.02	3.26	3.06	2.93
2049	water level	331.07	330.99	331.21	331.02	330.91	331.61	331.53	331.74	331.56	331.44
	maximum depth	2.57	2.49	2.71	2.52	2.40	3.11	3.02	3.24	3.06	2.94
2065 and Far Future	water level	331.07	330.99	331.21	331.02	330.91	331.04	330.99	331.21	331.08	330.80
	maximum depth	2.57	2.49	2.71	2.52	2.40	2.54	2.49	2.70	2.58	2.30

Notes: Water level fluctuation ($WL_{1\%}$-$WL_{99\%}$ = 0.624 m) is used as the denominator in estimating the percentage changes in water levels.

All units are in metres unless otherwise shown.

Data reproduced from the Environmental Impact Assessment (EIA, Volume 4A, Section 6.4.5, Table 6.4-13), with Pre-development information re-titled “Pre-Industrial Case”. Data reproduced from the Environmental Impact Assessment (EIA, Volume 4A, Section 6.4.5, Table 6.4-13), with Pre-development information re-titled “Pre-Industrial Case”. The years have been revised from 2033 and 2052 in the EIA to 2029 and 2049 to reflect the updated snapshots presented in the *May 2008 Jackpine Mine Expansion & Pierre River Mine Project EIA Update.*

Table 2.3-7 Athabasca River Flows in Reach 4 for Pre-Industrial Case and 2012 Base Case

Hydrologic Condition	Season	Pre-Industrial Case	2012 Base Case
		Stream Flow Discharge [m^3/s]	Stream Flow Discharge [m^3/s]
Average year	winter	182	159
	spring	531	508
	summer	1,241	1,217
	fall	579	555
10-year dry	winter	120	107
	spring	256	238
	summer	1,041	1,015
	fall	437	413
10-year wet	winter	193	170
	spring	575	553
	summer	1,731	1706
	fall	794	768

Notes Pre-Industrial Case flows were derived by adding the upstream withdrawal to data recorded downstream of Fort McMurray at Environment Canada Station 07DA001 with Pre-development information re-titled "Pre-Industrial Case".

Table 2.3-8 Athabasca River Flow Depths at Node S24 for Pre-Industrial Case and 2012 Base Case

Hydrologic Condition	Season	Pre-Industrial Case	2012 Base Case
		Water Level [m amsl]	Water Level [m amsl]
Average year	winter	225.95	225.91
	spring	226.56	226.52
	summer	227.66	227.63
	fall	226.64	226.60
10-year dry	winter	225.83	225.81
	spring	226.08	226.05
	summer	227.37	227.33
	fall	226.40	226.36
10-year wet	winter	225.97	225.93
	spring	226.63	226.60
	summer	228.30	228.27
	fall	226.99	226.95

Note: Pre-Industrial Case data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-8, Table 6), with Pre-development information re-titled "Pre-Industrial Case".

2.3.3 Surface Water Quality

Data for PIC surface water quality were reported in the Aquatics Environmental Setting Report for the EIA, Section 3 (Golder 2007a), in the EIA, Volume 4A, Section 6.5 and Volume 4B, Appendix 4-7 and in the FMSA (Fort McKay IRC 2010).

2.3.3.1 Surface Water Quality Assessment Methods

Pre-Industrial Case data for the Muskeg River are from the FMSA. Observed data collected up to and including December 31, 1996 represent conditions prior to oil sands development in the Muskeg River watershed. These data were collected by Alberta Environment and industry sources (AENV 2006; RL&L 1989; Shell 1975; Stanley Associates 1982; and Syncrude 1996). Historical trends in the Muskeg River watershed are also discussed in the *2010 Regional Aquatics Monitoring Program, Section 5.2.3* (RAMP 2011) and in *Overview of Water Quality in the Muskeg River Basin July 1972 To March 2001* (AENV 2002).

To represent PIC conditions in the Athabasca River, modelling relied on data from present-day and historical monitoring at points upstream of oil sands developments. It is acknowledged that PIC conditions are different from existing conditions because of industrial and municipal withdrawals upstream of Fort McMurray. However, PIC conditions in the Athabasca River were represented by modelling long-term concentrations in the Lower Athabasca River, and accounting for background concentrations in the Clearwater and Athabasca rivers upstream of Fort McMurray and input from tributaries with undisturbed watersheds. In this way, the modelled PIC conditions account for post-1965 contributions from developments upstream of Fort McMurray, including non-point source releases, pulp mills and sewage treatment plants. Substances of potential concern contributed by pulp mill and sewage releases are different from those of oil sands operations; therefore, for constituents relevant to this assessment, present-day upstream concentrations are representative of PIC concentrations. Historical trends in the Athabasca River are also discussed in Glozier et al. (2009), Hebben (2009) and RAMP (2012).

A literature review was conducted to summarize the current state of the knowledge on contributions of natural sources to changes in Athabasca River water quality. The literature review mainly focused on findings in undisturbed reaches and tributaries of the Athabasca River, which are reflective of PIC conditions. The contribution of natural erosion of the McMurray formation to changes in water quality in the Lower Athabasca and its tributaries is a topic of ongoing scientific research and debate (RSC 2010).

To date, no study has been able to quantify the relative or absolute contribution from natural inputs, despite considerable research effort directed at this topic. Therefore, contribution from this source has not been included in the water quality model. Inclusion of this source term in a water quality model requires numerical inputs, and such an input would at this stage be arbitrary. Moreover, setting PIC concentrations in the model to be equal to those measured upstream of oil sands developments provides a more conservative benchmark against which to measure change, because the upstream concentrations are more sensitive to changes (i.e., loading inputs from oil sands developments cause a higher relative change in concentration if natural sources are not accounted for).

2.3.3.2 Surface Water Quality Results

Pre-Industrial Case data for the Muskeg River watershed are presented in Tables 2.3-9 to 2.3-12. These data are reproduced from the EIA, Volume 4B, Appendix 4-7 with the addition of a new column titled "Observed Natural Variation up to 1996 (PIC)", which is provided for comparison.

Pre-industrial data were used as the basis of the water quality assessment in the EIA. These data were used to calibrate water quality models. In both the small streams and the Athabasca River, total metals and nutrients frequently exceeded guidelines under PIC conditions. Guideline exceedances are generally predicted to increase under the EIA Base Case compared to the PIC, as described in the EIA, Volume 4A, Section 6.5.3.

Pre-Industrial Case data for the Athabasca River (Tables 2.3-12 and 2.3-13) are reproduced without change from the EIA, Volume 4B, Appendix 4-7, with the addition of a new column for 2012 Base Case results to provide information on the potential effects of the JME on water quality in the Athabasca River. The 2012 Base Case water quality predictions were re-assessed based on the updated project inclusion list (Appendix 1, Section 2.2.2). For the 2012 Base Case, the Athabasca River Model results (Tables 2.3-12 and 2.-3-13) indicate that the predicted effects on water quality in the Athabasca River are the same as those described for the EIA Base Case (EIA, Appendix 4-7, Tables 3.1.1-1 and 3.1.1-4). Predicted water quality results indicate that operating and approved developments in the oil sands region will not appreciably change the levels of acute and chronic toxicity, tainting potential or labile and refractory naphthenic acids in the Athabasca River at the assessment nodes. Model results for the 2012 Base Case indicate that median and peak concentrations of aluminum, cadmium, chromium, copper, iron, mercury and total phosphorus, as well as peak concentrations of arsenic, lead, silver, total nitrogen, total phenolics and zinc are predicted to exceed chronic guidelines for the protection of aquatic life in all snapshots. Parameters that are predicted to exceed guidelines under 2012 Base Case snapshots are also predicted to do so in the PIC. The high background levels are generally associated with high total suspended solids from upstream of Fort McMurray and occur mostly during the spring season, consistent with the findings of Glozier et al. (2009).

Table 2.3-9 Predicted Water Quality for Muskeg River Downstream of North Pit Lake (Node M0)

Parameter	Unit	Water Quality Guideline[a]		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
Aluminum	mg/L	0.75	0.1	0.02 (≤0.0022 - 0.72) n = 112	0.01 (<0.01 - 0.1) n = 19	0.033	**0.96**
Ammonia	mg/L	19.9	4.36	<0.05 (<0.01 - 1.48) n = 106	0.08 (0.02 - 1.04) n = 19	0.078	2
Antimony	mg/L	-	-	0.0006 (<0.000004 - 0.011)n = 90	-	0.00064	0.0095
Arsenic	mg/L	0.34	0.005	<0.0004 (≤0.00018 - 0.009) n = 115	0.0004 (<0.0002 - 0.009) n = 25	0.0004	**0.0059**
Barium	mg/L	-	-	0.027 (≤0.012 - 0.2) n = 93	-	0.034	0.58
Beryllium	mg/L	-	-	<0.001 (<0.000003 - 0.00014) n = 93	-	<0.000001	<0.000001
Boron	mg/L	29	1.5	0.02 (<0.004 - 0.16) n = 112	0.03 (<0.01 - 0.16) n = 19	0.042	0.61
Cadmium	mg/L	0.0032	0.00036	<0.0002 (<0.000002 - 0.032) n = 112	<0.001 (<0.001 - <0.001) n = 19	0.00015	**0.0072**
Calcium	mg/L	-	-	42.5 (18.2 - 89.1) n = 70	40 (13.5 - 144) n = 61	30	117
Chloride	mg/L	640	120	1.5 (<0.1 - 6) n = 154	1.4 (0.3 - 6) n = 61	2.4	26
Chromium	mg/L	0.016	0.001	<0.001 (≤0.000086 - 0.016) n = 112	<0.001 (<0.001 - 0.006) n = 19	0.00067	**0.0046**
Cobalt	mg/L	-	-	<0.0002 (≤0.00005 - 0.0082) n = 93	-	0.00024	0.0026
Copper	mg/L	0.02	0.003	<0.001 (<0.00008 - 0.006) n = 112	<0.001 (<0.001 - 0.001) n = 19	0.001	**0.0062**
Dissolved organic carbon	mg/L	-	-	22 (8 - 44) n = 114	24.5 (9 - 44) n = 38	21	52
Iron	mg/L	-	0.3	0.52 (0.073 - 31.9) n = 112	1.8 (0.27 - 21.9) n = 19	**1.1**	**12**
Lead	mg/L	0.14	0.004	<0.0003 (≤0.0000065 - 0.0101) n = 112	<0.002 (<0.002 - 0.003) n = 19	0.00043	**0.007**
Magnesium	mg/L	-	-	12 (6.1 - 28) n = 57	13 (4.2 - 72) n = 61	9.1	58
Manganese	mg/L	-	-	0.039 (≤0.0031 - 1.2) n = 112	0.095 (0.013 - 1.2) n = 19	0.1	1.5
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0043) n = 145	<0.0001 (<0.00005 - 0.0043) n = 61	0.0000004	0.0000043
Molybdenum	mg/L	-	0.073	<0.0001 (≤0.000033 - 0.001) n = 93	-	0.0001	0.0013
Monomer	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids -labile	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids - refractory	mg/L	-	-	-	-	0.67	3.4
Naphthenic acids -total	mg/L	-	-	<1 (<1 - 12) n = 68	-	0.67	3.4
Nickel	mg/L	0.66	0.073	0.000015 (<0.000005 - 0.025) n = 112	<0.001 (<0.001 - 0.003) n = 19	0.00056	0.021
PAH group 1	µg/L	-	0.015	-	-	<0.000001	<0.000001
PAH group 2	µg/L	-	0.018	-	-	<0.000001	<0.000001
PAH group 3	µg/L	-	-	-	-	<0.000001	<0.000001
PAH group 4	µg/L	-	5.8	-	-	<0.000001	<0.000001

Table 2.3-9 Predicted Water Quality for Muskeg River Downstream of North Pit Lake (Node M0) (continued)

Parameter	Unit	Water Quality Guideline[a]		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
PAH group 5	µg/L	-	0.012	-	-	<0.000001	<0.000001
PAH group 6	µg/L	-	-	-	-	<0.000001	<0.000001
PAH group 7	µg/L	-	0.04	-	-	<0.000001	<0.000001
PAH group 8	µg/L	-	1.1	-	-	<0.000001	<0.000001
PAH group 9	µg/L	-	0.025	-	-	<0.000001	<0.000001
Potassium	mg/L	-	-	0.7 (<0.1 - 3.37) n = 57	1.04 (0.1 - 3.5) n = 61	1	5.5
Selenium	mg/L	-	0.001	<0.0004 (<0.0001 - 0.016) n = 109	0.0003 (<0.0002 - 0.0009) n = 19	0.00029	**0.0032**
Silver	mg/L	0.0081	0.0001	<0.000009 (<0.0000005 - 0.001) n = 89	-	0.000004	0.0001
Sodium	mg/L	-	-	5 (1.7 - 9) n = 57	6.3 (2 - 17.5) n = 61	7.5	41
Strontium	mg/L	-	-	0.086 (1.75E-02 - 0.33) n = 86	-	0.12	0.58
Sulphate	mg/L	-	-	3.25 (≤0.1 - 16) n = 154	4.2 (0.1 - 15.5) n = 61	3.3	34
Sulphide	mg/L	-	0.006	0.005 (<0.001 - 0.10) n = 79	<0.05 (<0.01 - <0.05) n = 9	**0.0074**	**0.048**
Tainting potential	TPU	-	1	-	-	<0.000001	<0.000001
Total dissolved solids	mg/L	-	-	190 (60 - 780) n = 154	181 (71 - 780) n = 61	191	774
Total nitrogen	mg/L	-	1	0.87 (<0.05 - 5.5) n = 141	1.068 (0.35 - 5.5) n = 61	0.92	**3.1**
Total phenolics	mg/L	-	0.004	0.004 (<0.001 - 0.12) n = 101	0.004 (<0.001 - 0.023) n = 31	0.0021	**0.029**
Total phosphorus	mg/L	-	0.05	0.031 (≤0.003 - 2.31) n = 150	0.058 (0.017 - 0.34) n = 61	**0.061**	**0.38**
Toxicity -acute	TUa	0.3	-	-	-	<0.000001	<0.000001
Toxicity -chronic	TUc	-	1	-	-	<0.000001	<0.000001
Vanadium	mg/L	-	-	<0.001 (≤0.00012 - 0.005) n = 148	<0.001 (<0.001 - 0.004) n = 55	0.00036	0.0028
Zinc	mg/L	0.17	0.03	0.005 (<0.0002 - 0.13) n = 112	0.003 (<0.001 - 0.02) n = 19	0.0025	**0.045**

[a] From (AENV 1999, AEP 1995, CCME 1999, U.S. EPA 2002), using median pH of 7.5, median temperature of 7°C and median hardness of 149 mg/L (reflective of on-site conditions for calculating pH, hardness and temperature-dependant guidelines). Guidelines for boron, chloride and total phenolics updated since 2007.

[b] Annual median concentrations with range (in parentheses) and sample number, based on information from Muskeg River downstream of North Pit Lake and Muskeg Creek in Aquatics Environmental Setting Report, Volume 1, Section 3 (Golder 2007a).

[c] Annual median concentrations with range (in parentheses) and sample number, based on data collected up to December 31, 1996.

[d] Data reproduced from the EIA, Volume 4B, Appendix 4-7, Table 1.1.1.1-1, with Pre-development information re-titled “Pre-Industrial Case”.

- = No guideline/no data.

Notes: Bold font indicates concentration exceeds guideline value.

PAH = Polycyclic Aromatic Hydrocarbon.

Table 2.3-10 Predicted Water Quality for Muskeg River at the Mouth (Node M3)

Parameter	Unit	Water Quality Guideline		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life[a]				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
Aluminum	mg/L	0.75	0.1	0.050 (<0.01 - 1.2) n = 108	0.05 (<0.01 - 0.11) n = 13	0.036	**0.92**
Ammonia	mg/L	14	3.54	0.04 (<0.01 - 1.63) n = 86	0.05 (<0.01 - 1.63) n = 17	0.044	2.2
Antimony	mg/L	-	-	0.000019(<0.000004 - 0.0045) n = 97	<0.0002 (<0.0002 - <0.0002) n = 3	0.00027	0.0042
Arsenic	mg/L	0.34	0.005	0.00021 (≤ 0.0001 - 0.041) n = 118	0.0002 (≤ 0.0001 - 0.014) n = 23	0.00022	0.0023
Barium	mg/L	-	-	<0.0002 (<0.000003 - 0.0088) n = 104	0.03 (0.00003 - 0.072) n = 17	0.032	0.78
Beryllium	mg/L	-	-	0.049 (0.00003 - 0.92) n = 112	<0.001 (<0.001 - 0.003) n = 10	<0.000001	<0.000001
Boron	mg/L	29	1.5	0.046 (≤ 0.01 - 70) n = 107	0.055 (0.01 - 70) n = 12	0.049	0.62
Cadmium	mg/L	0.0037	0.0004	<0.0002 (<0.000002 - 0.004) n = 120	<0.001 (<0.0002 - 0.004) n = 25	0.000087	**0.0026**
Calcium	mg/L	-	-	48 (1.9 - 160) n = 216	44.5 (15.5 - 160) n = 117	36	141
Chloride	mg/L	640	120	3.8 (≤ 0.5 - 30) n = 259	4.25 (≤ 0.5 - 29.7) n = 122	2.7	29
Chromium	mg/L	0.016	0.001	0.00036 (<0.0001 - 0.017) n = 119	0.003 (<0.001 - 0.017) n = 25	0.00084	**0.0064**
Cobalt	mg/L	-	-	0.00013 (<0.00002 - 0.007) n = 113	0.001 (≤ 0.0005 - 0.007) n = 20	0.0002	0.0017
Copper	mg/L	0.023	0.003	0.00039 (<0.00008 - 0.022) n = 116	<0.001 (≤ 0.0009 - 0.022) n = 22	0.00057	**0.005**
Dissolved organic carbon	mg/L	-	-	21 (6 - 61) n = 247	22.5 (6 - 61) n = 90	18	55
Iron	mg/L	-	0.3	0.93 (0.104 - 4.42) n = 122	1.091 (0.51 - 2.9) n = 27	**1.2**	**9.8**
Lead	mg/L	0.16	0.004	0.000043 (<0.000001 - 0.033) n = 113	<0.0045 (<0.0003 - 0.016) n = 18	0.0002	0.0033
Magnesium	mg/L	-	-	11 (0.54 - 58) n = 188	10.7 (3 - 58) n = 119	11	71
Manganese	mg/L	-	-	0.042 (≤ 0.014 - 1.24) n = 120	0.038 (≤ 0.014 - 0.66) n = 25	0.052	1.7
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0021) n = 171	<0.0001 (<0.00004 - 0.0021) n = 99	0.0000005	**0.0000054**
Molybdenum	mg/L	-	0.073	0.000080 (≤ 0.00003 - 0.005) n = 112	<0.003 (<0.001 - 0.005) n = 17	0.0001	0.0011
Monomer	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids - labile	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids - refractory	mg/L	-	-	-	-	0.7	3.4
Naphthenic acids - total	mg/L	-	-	<1 (≤ 0.005 - 8) n = 53	<1 (<1 - <1) n = 6	0.7	3.4
Nickel	mg/L	0.74	0.083	0.0002 (<0.000005 - 0.20) n = 119	0.0015 (<0.0005 - 0.0316) n = 24	0.00067	0.023
PAH group 1	µg/L	-	0.015	-	-	<0.000001	<0.000001
PAH group 2	µg/L	-	0.018	-	-	<0.000001	<0.000001
PAH group 3	µg/L	-	-	-	-	<0.000001	<0.000001

Table 2.3-10 Predicted Water Quality for Muskeg River at the Mouth (Node M3) (continued)

Parameter	Unit	Water Quality Guideline		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life[a]				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
PAH group 4	µg/L	-	5.8	-	-	<0.000001	<0.000001
PAH group 5	µg/L	-	0.012	-	-	<0.000001	<0.000001
PAH group 6	µg/L	-	-	-	-	<0.000001	<0.000001
PAH group 7	µg/L	-	0.04	-	-	<0.000001	<0.000001
PAH group 8	µg/L	-	1.1	-	-	<0.000001	<0.000001
PAH group 9	µg/L	-	0.025	-	-	<0.000001	<0.000001
Potassium	mg/L	-	-	1.1 (≤ 0.03 - 6) n = 253	0.9 (0.03 - 6) n = 117	0.68	6.2
Selenium	mg/L	-	0.001	<0.0004 (≤ 0.00006 - 0.0013) n = 112	<0.0002 (<0.0001 - 0.0002) n = 17	0.00023	**0.0026**
Silver	mg/L	0.0103	0.0001	<0.000022 (<0.0000005 - 0.003) n = 104	<0.002 (<0.0001 - 0.003) n = 9	0.000002	0.000047
Sodium	mg/L	-	-	12 (0.6 - 50) n = 255	12.7 (2.9 - 50) n = 119	7.3	57
Strontium	mg/L	-	-	0.13 (0.058 - 75) n = 104	0.097 (0.072 - 75) n = 9	0.12	0.59
Sulphate	mg/L	-	-	5 (≤ 0.1 - 99) n = 257	4.4 (≤ 0.1 - 42.5) n = 120	4	33
Sulphide	mg/L	-	0.008	<0.01 (<0.001 - 0.14) n = 129	<0.01 (<0.001 - 0.14) n = 63	0.0033	**0.047**
Tainting potential	TPU	-	1	-	-	<0.000001	<0.000001
Total dissolved solids	mg/L	-	-	227 (72 - 844) n = 192	202 (72 - 844) n = 113	200	865
Total nitrogen	mg/L	-	1	0.88 (0.28 - 3.94) n = 198	1.11 (0.28 - 3.94) n = 92	0.79	**2.5**
Total phenolics	mg/L	-	0.004	0.002 (<0.001 - 0.025) n = 135	0.002 (<0.001 - 0.025) n = 89	0.0026	**0.024**
Total phosphorus	mg/L	-	0.05	0.029 (<0.005 - 0.6) n = 235	0.03 (<0.005 - 0.6) n = 106	0.033	**0.24**
Toxicity -acute	TUa	0.3	-	-	-	<0.000001	<0.000001
Toxicity -chronic	TUc	-	1	-	-	<0.000001	<0.000001
Vanadium	mg/L	-	-	<0.001 (<0.00004 - 0.018) n = 185	<0.001 (<0.001 - 0.006) n = 90	0.00033	0.0032
Zinc	mg/L	0.19	0.03	0.0050 (<0.0002 - 0.16) n = 116	0.008 (<0.001 - 0.115) n = 22	0.0057	**0.038**

[a] From (AENV 1999, AEP 1995, CCME 1999, U.S. EPA 2002) using median pH of 7.7, median temperature of 4.2°C and median hardness of 172 mg/L (reflective of on-site conditions for calculating pH, hardness and temperature-dependant guidelines). Guidelines for boron, chloride and total phenolics updated since 2007

[b] Annual median concentrations with range (in parentheses) and sample number, based on information from Muskeg River at the Mouth in Aquatics Environmental Setting Report, Volume 1, Section 3 (Golder 2007a).

[c] Annual median concentrations with range (in parentheses) and sample number, based on data collected up to December 31, 1996.

[d] Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 1.4.1.1-1), with Pre-development information re-titled “Pre-Industrial Case”

- = No guideline/no data.

Notes: Bold font indicates concentration exceeds guideline value.
PAH = Polycyclic Aromatic Hydrocarbon.

Table 2.3-11 Predicted Water Quality for Jackpine Creek at the Mouth (Node J1)

Parameter	Unit	Water Quality Guideline		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life[a]				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
Aluminum	mg/L	0.75	0.1	0.05 (<0.01 - 0.99) n = 52	0.02 (<0.01 - 0.3) n = 16	0.028	**1**
Ammonia	mg/L	14	3.58	0.03 (<0.01 - 1.6) n = 61	0.06 (<0.01 - 1.6) n = 34	0.052	1.3
Antimony	mg/L	-	-	0.000018 (≤ 0.000013 - 0.0011) n = 39	<0.0002 (<0.0002 - 0.001) n = 3	0.00024	0.0087
Arsenic	mg/L	0.34	0.005	0.00040 (≤ 0.0002 - 0.02) n = 64	0.0004 (≤ 0.0002 - 0.02) n = 28	0.00016	0.0033
Barium	mg/L	-	-	0.027 (0.0102 - 0.20) n = 39	0.02 (0.02 - 0.04) n = 3	0.026	0.54
Beryllium	mg/L	-	-	<0.00004 (≤ 0.0000035 - 0.003) n = 39	0.001 (<0.001 - 0.003) n = 3	<0.000001	<0.000001
Boron	mg/L	29	-	0.05 (0.02 - 0.11) n = 52	0.05 (0.02 - 0.1) n = 16	0.047	0.66
Cadmium	mg/L	0.0022	0.00028	<0.0002 (<0.000002 - 0.004) n = 53	<0.001 (<0.001 - 0.004) n = 17	0.000073	**0.0026**
Calcium	mg/L	-	-	31 (16.4 - 91) n = 30	27.4 (10 - 119) n = 134	37	163
Chloride	mg/L	640	120	2.1 (≤ 0.3 - 24) n = 178	2 (0.3 - 17.2) n = 135	2.5	24
Chromium	mg/L	0.016	0.001	<0.001 (≤ 0.00015 - 0.04) n = 68	<0.01 (<0.001 - 0.04) n = 32	0.00081	**0.012**
Cobalt	mg/L	-	-	0.00014 (≤ 0.000092 - 0.009) n = 43	<0.01 (<0.003 - 0.009) n = 7	0.00023	0.0018
Copper	mg/L	0.014	0.002	0.00029 (<0.00008 - 0.01) n = 51	<0.001 (<0.001 - 0.01) n = 15	0.00051	**0.0036**
Dissolved organic carbon	mg/L	-	-	22 (5 - 89) n = 139	23.5 (5 - 89) n = 86	18	59
Iron	mg/L	-	0.3	0.76 (0.26 - 3.73) n = 54	0.575 (0.26 - 2.83) n = 18	**1.2**	**15**
Lead	mg/L	0.085	0.0033	0.00006 (≤ 0.000032 - 0.006) n = 53	<0.005 (<0.002 - 0.006) n = 17	0.00019	**0.0033**
Magnesium	mg/L	-	-	8 (4.5 - 21) n = 15	8 (3 - 23.8) n = 135	11	63
Manganese	mg/L	-	-	0.028 (<0.004 - 0.52) n = 53	0.021 (<0.004 - 0.14) n = 17	0.058	0.96
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0045) n = 153	<0.0001 (<0.00002 - 0.0045) n = 125	0.0000005	**0.0000061**
Molybdenum	mg/L	-	0.073	0.00011 (≤ 0.00004 - 0.006) n = 39	0.003 (<0.003 - 0.006) n = 3	0.0001	0.0009
Monomer	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids - labile	mg/L	-	-	-	-	<0.000001	<0.000001
Naphthenic acids - refractory	mg/L	-	-	-	-	0.67	3.6
Naphthenic acids - total	mg/L	-	-	<1 (<1 - 3) n = 29	<1 (<1 - <1) n = 3	0.67	3.6
Nickel	mg/L	0.48	0.054	0.00027 (<0.00006 - 0.011) n = 52	<0.0015 (<0.001 - 0.011) n = 16	0.0006	0.016
PAH group 1	µg/L	-	0.015	-	-	<0.000001	<0.000001
PAH group 2	µg/L	-	0.018	-	-	<0.000001	<0.000001
PAH group 3	µg/L	-	-	-	-	<0.000001	<0.000001

Table 2.3-11 Predicted Water Quality for Jackpine Creek at the Mouth (Node J1) (continued)

Parameter	Unit	Water Quality Guideline		Observed Natural Variation up to 2006[b]	Observed Natural Variation up to 1996 (Pre-Industrial Case)[c]	Predicted Concentration[d]	
		Aquatic Life[a]				Pre-Industrial Case	
		Acute	Chronic			Median Concentration	Peak Concentration
PAH group 4	µg/L	-	5.8	-	-	<0.000001	<0.000001
PAH group 5	µg/L	-	0.012	-	-	<0.000001	<0.000001
PAH group 6	µg/L	-	-	-	-	<0.000001	<0.000001
PAH group 7	µg/L	-	0.04	-	-	<0.000001	<0.000001
PAH group 8	µg/L	-	1.1	-	-	<0.000001	<0.000001
PAH group 9	µg/L	-	0.025	-	-	<0.000001	<0.000001
Potassium	mg/L	-	-	1 (0.3 - 1.8) n = 15	0.65 (<0.01 - 3.5) n = 132	0.57	4.7
Selenium	mg/L	-	0.001	<0.0004 (<0.0001 - 0.012) n = 52	0.00025 (<0.0002 - 0.012) n = 16	0.00021	**0.0031**
Silver	mg/L	0.0043	0.0001	<0.000005 (<0.0000005 - 0.005) n = 43	<0.005 (<0.002 - 0.005) n = 7	0.000001	0.000028
Sodium	mg/L	-	-	11 (9 - 28) n = 15	13 (4 - 35.9) n = 133	7.1	38
Strontium	mg/L	-	-	0.11 (0.049 - 0.32) n = 39	0.089 (0.082 - 0.094) n = 3	0.13	0.69
Sulphate	mg/L	-	-	4.5 (≤ 0.1 - 14) n = 178	4.8 (≤ 0.1 - 14) n = 135	4	34
Sulphide	mg/L	-	0.008	<0.01 (<0.001 - 0.16) n = 75	<0.05 (<0.01 - 0.16) n = 37	0.0032	**0.025**
Tainting potential	TPU	-	1	-	-	<0.000001	<0.000001
Total dissolved solids	mg/L	-	-	150 (53 - 551) n = 176	136 (53 - 551) n = 135	199	627
Total nitrogen	mg/L	-	1	0.88 (<0.05 - 4.17) n = 163	0.94 (<0.1 - 4.17) n = 126	0.8	**3.5**
Total phenolics	mg/L	-	0.004	0.003 (<0.001 - 0.13) n = 115	0.003 (<0.001 - 0.126) n = 89	0.0024	**0.035**
Total phosphorus	mg/L	-	0.05	0.034 (<0.005 - 0.5) n = 181	0.035 (<0.005 - 0.5) n = 144	0.03	**0.17**
Toxicity -acute	TUa	0.3	-	-	-	<0.000001	<0.000001
Toxicity -chronic	TUc	-	1	-	-	<0.000001	<0.000001
Vanadium	mg/L	-	-	<0.001 (<0.0002 - 0.011) n = 155	<0.001 (<0.001 - 0.011) n = 119	0.00029	0.0061
Zinc	mg/L	0.12	0.03	0.0055 (≤ 0.00046 - 0.43) n = 53	0.02 (<0.001 - 0.433) n = 17	0.0061	**0.1**

[a] From (AENV 1999, AEP 1995, CCME 1999, U.S. EPA 2002) using median pH of 7.7, median temperature of 7°C and median hardness of 103 mg/L (reflective of on-site conditions for calculating pH, hardness and temperature-dependant guidelines). Guidelines for boron, chloride and total phenolics updated since 2007.

[b] Annual median concentrations with range (in parentheses) and sample number, based on information from Muskeg River at the Mouth in Aquatics Environmental Setting Report, Volume 1, Section 3 (Golder 2007a).

[c] Annual median concentrations with range (in parentheses) and sample number, based on data collected up to December 31, 1996.

[d] Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 1.5.1.1-1), with Pre-development information re-titled “Pre-Industrial Case”.

- = No guideline/no data.

Notes: Bold font indicates concentration exceeds guideline value.

PAH = Polycyclic Aromatic Hydrocarbon.

Table 2.3-12 Predicted Water Quality at the Athabasca River Downstream of the Muskeg River

Parameter	Units	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River near the Muskeg River[c]	Pre-Industrial Case[d]	
		Aquatic Life[b]			Median Concentration	Peak Concentration[e]
		Acute	Chronic			
Aluminum	mg/L	0.75	0.1	0.4755 (0.09 - 14.1) n = 18	**0.42**	**3.8**
Ammonia	mg/L - N	5.6	2.43	0.025 (<0.01 - 0.17) n = 22	0.028	0.35
Antimony	mg/L	-	-	0.0004 (<0.00006 - 0.0025) n = 14	0.00044	0.0017
Arsenic	mg/L	0.34	0.005	0.0008 (<0.0002 - 0.015) n = 31	0.001	**0.0094**
Barium	mg/L	-	-	0.06 (0.00039 - 0.232) n = 24	0.068	0.14
Beryllium	mg/L	-	-	<0.001 (<0.00004 - 0.004) n = 18	0.0003	0.0042
Boron	mg/L	29	1.5	0.0295 (0.015 - 70) n = 18	0.036	0.15
Cadmium	mg/L	0.0026	0.00031	<0.0002 (<0.00001 - 0.002) n = 24	**0.0004**	**0.0086**
Calcium	mg/L	-	-	30.1 (18.9 - 144) n = 192	31	52
Chloride	mg/L	640	120	7.9 (0.3 - 49.5) n = 198	16	52
Chromium	mg/L	0.016	0.001	0.0025 (0.00048 - 0.027) n = 23	**0.0032**	**0.014**
Cobalt	mg/L	-	-	0.0005 (<0.0002 - 0.011) n = 23	0.0011	0.0056
Copper	mg/L	0.017	0.002	0.00155 (<0.001 - 0.0247) n = 22	**0.0027**	**0.011**
Dissolved organic carbon	mg/L	-	-	9 (2.5 - 28.5) n = 77	10	20
Iron	mg/L	-	0.3	0.8735 (0.278 - 35) n = 18	**1.1**	**9.2**
Lead	mg/L	0.103	0.004	0.00135 (<0.0003 - 0.02) n = 18	0.001	**0.0071**
Magnesium	mg/L	-	-	8.1 (4.9 - 72) n = 192	9.0	19
Manganese	mg/L	-	-	0.0355 (0.011 - 1.03) n = 24	0.046	0.25
Mercury	mg/L	0.000013	0.000005	<0.00001 (<0.000006 - 0.0036) n = 180	**0.000015**	**0.00013**
Molybdenum	mg/L	-	0.073	0.00085 (0.0006 - 0.004) n = 24	0.0014	0.011
Monomer	mg/L	-	-	-	<0.001	<0.001
Naphthenic acids - labile	mg/L	-	-	-	<0.01	<0.01
Naphthenic acids - refractory	mg/L	-	-	-	0.19	1.4
Naphthenic acids	mg/L			-	**0.19**	**1.4**
Nickel	mg/L	0.54	0.061	0.0037 (0.00018 - 0.0685) n = 24	0.0052	0.017
PAH group 1	µg/L	-	0.015	<0.1 (<0.04 - <5) n = 9	<0.001	<0.001
PAH group 2	µg/L	-	0.018	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001
PAH group 3	µg/L	-	-	<0.05 (<0.02 - <2) n = 9	<0.001	<0.001
PAH group 4	µg/L	-	5.8	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001

Table 2.3-12 Predicted Water Quality at the Athabasca River Downstream of the Muskeg River (continued)

Parameter	Units	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River near the Muskeg River[c]	Pre-Industrial Case[d]	
		Aquatic Life[b]				
		Acute	Chronic		Median Concentration	Peak Concentration[e]
PAH group 5	µg/L	-	0.012	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001
PAH group 6	µg/L	-	-	<0.04 (<0.04 - <0.1) n = 5	<0.001	<0.001
PAH group 7	µg/L	-	0.04	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001
PAH group 8	µg/L	-	1.1	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001
PAH group 9	µg/L	-	0.025	<0.1 (<0.04 - <1) n = 9	<0.001	<0.001
Potassium	mg/L	-	-	0.795 (0.1 - 3.5) n = 192	1.4	2.6
Selenium	mg/L	-	0.001	<0.0004 (<0.0002 - 0.0014) n = 24	0.00022	0.0008
Silver	mg/L	0.0056	0.0001	<0.0001 (<0.000005 - 0.001) n = 18	0.000018	**0.00013**
Sodium	mg/L	-	-	10 (2 - 37) n = 198	17	45
Strontium	mg/L	-	-	0.209 (0.147 - 333) n = 18	0.27	0.49
Sulphate	mg/L	-	-	20 (0.2 - 49) n = 180	25	54
Sulphide	mg/L	-	0.014	<0.01 (<0.002 - 0.4) n = 50	0.004	0.014
Tainting potential	TPU	-	-	-	<0.001	<0.001
Total dissolved solids	mg/L	-	-	152.5 (40 - 780) n = 192	177	310
Total nitrogen	mg/L	-	1	0.64 (0.06 - 4.9) n = 79	0.7	**2.2**
Total phenolics	mg/L	-	0.004	0.002 (<0.001 - 0.031) n = 188	0.0032	**0.022**
Total phosphorus	mg/L	-	0.05	0.055 (<0.005 - 1.85) n = 193	**0.063**	**0.35**
Toxicity - acute	TUa	0.3	-	-	<0.001	<0.001
Toxicity - chronic	TUc	-	1	-	<0.001	<0.001
Vanadium	mg/L	-	-	<0.002 (<0.001 - 0.05) n = 183	0.0023	0.018
Zinc	mg/L	0.14	0.03	0.01065 (<0.001 - 0.095) n = 20	0.014	**0.062**

[a] No guideline/no data.

[b] From U.S. EPA (1999, 2002) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River). Guidelines for boron, chloride and total phenolics updated since 2007.

[c] Based on information from Golder (1996, 1998, 2001, 2002, 2003), RAMP (2005) and from Alberta Environment Water Data System (WDS) stations: AB07DA0090\0100\0140\0150\0155\0160\0170\0180\0190\1500 (AENV 2006).

[d] Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 3.1.1-1), with Pre-development information re-titled “Pre-Industrial Case”.

[e] Peak concentrations represent 99.91 percentile values calculated from a model dataset containing more than 16,000 datapoints; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: Bold values indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life. PAH = Polycyclic Aromatic Hydrocarbon.

Table 2.3-13 Predicted Water Quality at the Athabasca River at Embarras

Parameter	Units	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream of Embarras [c]	Pre-Industrial Case[d]	
		Aquatic Life[b]			Median Concentration	Peak Concentration[e]
		Acute	Chronic			
Aluminum	mg/L	0.75	0.1	0.344 (<0.01 - 4.791) n = 52	**0.36**	**3.6**
Ammonia	mg/L - N	5.6	2.43	0.03 (<0.01 - 1) n = 168	0.032	0.18
Antimony	mg/L	-	-	<0.0002 (0.00005 - <0.005) n = 21	0.00031	0.00093
Arsenic	mg/L	0.34	0.005	0.0006 (<0.0001 - 0.018) n = 68	0.001	**0.0091**
Barium	mg/L	-	-	0.065 (<0.001 - 0.269) n = 59	0.07	0.15
Beryllium	mg/L	-	-	<0.0002 (<0.00004 - 0.0012) n = 66	0.0003	0.0043
Boron	mg/L	29	1.5	0.03 (<0.01 - 0.137) n = 26	0.037	0.089
Cadmium	mg/L	0.0026	0.00031	<0.001 (<0.00002 - <0.003) n = 64	**0.00039**	**0.0088**
Calcium	mg/L	-	-	33 (<1 - 106) n = 229	31	54
Chloride	mg/L	640	120	15.5 (<0.5 - 150) n = 229	10	34
Chromium	mg/L	0.016	0.001	0.002 (0.00061 - 0.016) n = 87	**0.0029**	**0.013**
Cobalt	mg/L	-	-	0.001 (0.000155 - 0.006) n = 62	0.001	0.0053
Copper	mg/L	0.017	0.002	0.002 (<0.0002 - 0.0122) n = 90	**0.0025**	**0.01**
Dissolved organic carbon	mg/L	-	-	8.35 (0.3 - 30.3) n = 214	10	20
Iron	mg/L	-	0.3	0.74 (<0.001 - 11.8) n = 78	**0.93**	**8.9**
Lead	mg/L	0.103	0.004	0.0012 (<0.0001 - 0.026) n = 53	0.001	**0.0068**
Magnesium	mg/L	-	-	8.8 (<1 - 27.3) n = 228	9.0	16
Manganese	mg/L	-	-	0.043 (<0.001 - 0.592) n = 88	0.052	0.24
Mercury	mg/L	0.000013	0.000005	0.00000715 (<0.0000006 - <0.0002) n = 14	**0.000014**	**0.00013**
Molybdenum	mg/L	-	0.073	0.001 (0.0004 - 0.007) n = 61	0.0013	0.01
Monomer	mg/L	-	-	-	<0.001	<0.001
Naphthenic acids - labile	mg/L	-	-	-	<0.01	<0.01
Naphthenic acids - refractory	mg/L	-	-	<1 (<1 - <1) n = 4	0.21	0.85
Naphthenic acids	mg/L			<1 (<1 - <1) n = 4	**0.21**	**0.85**
Nickel	mg/L	0.54	0.061	0.003 (<0.0002 - 0.04) n = 63	0.0049	0.016
PAH group 1	µg/L	-	0.015	<5 (<0.02 - <5) n = 23	<0.001	<0.001
PAH group 2	µg/L	-	0.018	<1 (<0.02 - <1) n = 23	<0.001	<0.001
PAH group 3	µg/L	-	-	<2 (<0.02 - <2) n = 23	<0.001	<0.001
PAH group 4	µg/L	-	5.8	<1 (<0.02 - <1) n = 23	<0.001	<0.001

Table 2.3-13 Predicted Water Quality at the Athabasca River at Embarras (continued)

Parameter	Units	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream of Embarras [c]	Pre-Industrial Case[d]	
		Aquatic Life[b]				
		Acute	Chronic		Median Concentration	Peak Concentration[e]
PAH group 5	µg/L	-	0.012	<1 (<0.02 - <1) n = 23	<0.001	0.001
PAH group 6	µg/L	-	-	<0.04 (<0.04 - <0.04) n = 1	<0.001	<0.001
PAH group 7	µg/L	-	0.04	<1 (<0.02 - <1) n = 23	<0.001	<0.001
PAH group 8	µg/L	-	1.1	<1 (<0.02 - <1) n = 24	<0.001	<0.001
PAH group 9	µg/L	-	0.025	<1 (<0.02 - <1) n = 23	<0.001	0.006
Potassium	mg/L	-	-	1.2 (<0.1 - 7.1) n = 229	1.4	2.5
Selenium	mg/L	-	0.001	<0.0002 (<0.0001 - 0.0009) n = 62	0.0002	0.00074
Silver	mg/L	0.0056	0.0001	<0.0001 (<0.000005 - 0.0007) n = 15	0.000021	**0.00012**
Sodium	mg/L	-	-	16.5 (<1 - 121) n = 229	15	35
Strontium	mg/L	-	-	0.193 (0.136 - 0.3) n = 21	0.27	0.48
Sulphate	mg/L	-	-	23.6 (<3 - 186) n = 230	24	56
Sulphide	mg/L	-	0.014	<0.005 (<0.001 - 0.02) n = 89	0.004	0.011
Tainting potential	TPU	-	-	-	<0.001	<0.001
Total dissolved solids	mg/L	-	-	178 (16 - 722) n = 227	176	298
Total nitrogen	mg/L	-	1	0.48 (<0.01 - 2.96) n = 220	0.7	**2.1**
Total phenolics	mg/L	-	0.004	<0.001 (<0.001 - 0.042) n = 186	0.0038	**0.018**
Total phosphorus	mg/L	-	0.05	0.043 (0.004 - 0.75) n = 220	**0.062**	**0.34**
Toxicity - acute	TUa	0.3	-	-	<0.001	<0.001
Toxicity - chronic	TUc	-	1	-	<0.001	<0.001
Vanadium	mg/L	-	-	0.002 (0.0007 - 0.02) n = 113	0.0021	0.017
Zinc	mg/L	0.14	0.03	0.0088 (0.0007 - 0.046) n = 81	0.013	**0.042**

[a] No guideline/No Data.

[b] From U.S. EPA (1999, 2001) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River). Guidelines for boron, chloride and total phenolics updated since 2007.

[c] Based on information from Golder (2000, 2001, 2002), and from Alberta Environment WDS stations: AB07DA0010\0040\0060\0080\0250 (AENV 2006).

[d] Data reproduced from the Environmental Impact Assessment (EIA, Volume 4B, Appendix 4-7, Table 3.1.1-4), with Pre-development information re-titled “Pre-Industrial Case”.

[e] Peak concentrations represent 99.91 percentile values calculated from a model dataset containing more than 16,000 datapoints; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: Bold values indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life. PAH = Polycyclic Aromatic Hydrocarbon.

2.3.4 Fish and Fish Habitat

A fish and fish habitat assessment is not included in the PIC. Suitable data for fish population sizes are not available; data is lacking and sampling techniques from historic studies are not comparable to current studies. For the FMSA (Fort McKay IRC 2010), fish catch was sorted by watershed and decade to determine if trends in fish distribution could be detected from PIC to present day. The general trend observed was for an increase in the number of species documented in the watersheds over time within the JME area. However, it is likely that this increase is due to the increase in sampling effort over the past 20 years rather than to a change from PIC conditions. The summary of documented fish distribution presented in the EIA Base Case (EIA, Volume 4A, Section 6.7.3.2) includes all reported historic catch records, including traditional knowledge, and is representative of PIC fish distribution.

2.4 Terrestrial Resources

This section describes the PIC and 2012 Base Case conditions for Terrestrial Resources, including soils and terrain; terrestrial vegetation, wetlands and forests; wildlife; and biodiversity.

The PIC for terrestrial resources is based on a snapshot of the year 1955. However, there are no complete records of aerial imagery, vegetation, or soils information for the RSA in 1955. In addition, 1955 pre-dates the development of the Alberta Vegetation Inventory (AVI) mapping and classification system of ecosite phases and wetland classes for the region, which was initiated in 1986. Soils information can be extrapolated from soil maps of the region completed in 1982 (Turchenek and Lindsay 1982), because it can be assumed that only minor changes in soils occurred in the 27-year interval. To reconstruct the 1955 landscape and to estimate PIC terrestrial resources, 1950s aerial imagery, 1974 and 2005 Landsat imagery, AVI data, and Alberta Sustainable Resource Development fire history records were combined in ArcGIS. More current imagery was replaced by older imagery (1974 and 1950s) in areas where industrial disturbances exist now but did not in the 1950s. The PIC's accuracy is moderate because it is limited by the 30 m by 30 m ground resolution of the satellite imagery. A small portion of the RSA (1.1%, or 24,728 ha of 2,277,376 ha RSA) could not be classified, due to inconsistencies in the imagery and cloud cover.

2.4.1 Soils and Terrain

The EIA Soils Assessment is presented in the EIA, Volume 5, Sections 7.3.2, 7.5.1 and 7.6.1. Details and assessment methods on the development of 2012 Base Case data are described in the Terrestrial Environmental Setting Report for the EIA, Volume 3, Section 2 (Golder 2007b). The PIC for Soils is compared with the 2012 Base Case in Section 2.4.4.2.

2.4.1.1 Soils and Terrain Assessment Methods

The PIC soil map was prepared by extrapolating regional soil information (i.e., soil map units) available from the Alberta Oil Sands Environmental Research Program (AOSERP) soil map (Turchenek and Lindsay 1982) to areas that were disturbances at the time of the 1982 AOSERP soil map, as well as to areas of the RSA that were not covered by the AOSERP soil map. New map units were included as appropriate. This interpretation was completed using a systematic approach to applying a predictive soil model (map units) to the polygons derived for the Regional Land Cover Classes (RLCCs) determined for the vegetation mapping. Landscape patterns predicted for the physiographic subdivisions of Alberta (Pettapiece 1986) and the Natural Subregions of Alberta (NRC 2006) were also consulted to guide the classification of the regional land cover class polygons.

Each soil map unit was assessed to determine which soil series it included. A map unit composition matrix was then used to translate the distribution of map units into a distribution of soil series. Each soil series contains a range of attributes that allow for extrapolation of land capability, reclamation suitability, and parent materials (with assumed ranges of landform characteristics) to the entire RSA. These attributes are discussed in greater detail in the Terrestrial Environmental Setting Report for the EIA, Section 2 (Golder 2007b).

The estimated distribution of soil series in the RSA for the PIC was compared to that of the 2012 Base Case. A negative change in a soil series means that there is less of a particular soil series in the 2012 Base Case than the PIC. New soils, or additional areas of natural soil types already present in the RSA, will not naturally develop in the time frame considered in the assessment. Therefore, it is expected that all soil series extents would be less than or equal to their areal extents in the PIC.

2.4.1.2 Soils and Terrain Results

A comparison between the PIC with the 2012 Base Case is presented in Table 2.4-1.

The increased development activities from the PIC to the 2012 Base Case in the RSA has resulted in a decrease in mineral and organic soils and a corresponding increase in disturbed landscapes. The changes from the PIC to the 2012 Base Case are as follows:

- a decrease in mineral soils from 1,145,463 ha to 1,039,482 ha (a net change of 5% of RSA);
- a decrease in organic soils from 984,149 ha to 917,379 ha (a net change of 3% of RSA); and
- an increase in disturbed landscape from 1,557 ha to 170,483 ha (a net change of 7% of RSA).

Table 2.4-1 Soil Series Types for the Pre-Industrial Case and 2012 Base Case in the Regional Study Area

Dominant Soil Series of Soil Units	Pre-Industrial Case	2012 Base Case	Change from Pre-Industrial Case		
	Area [ha]	Area [ha]	Area [ha]	% of RSA	% of Resource
Mineral Soils					
Algar Lake	47,983	42,359	-5,624	- <1	-12
Bitumount	50,132	38,786	-11,346	- <1	-23
Buckton	31,789	31,738	-51	- <1	- <1
Dover	59,194	51,455	-7,739	- <1	-13
Firebag	74,053	60,413	-13,640	- <1	-18
Fort	2,821	1,631	-1,190	- <1	-42
Gipsy	6,292	6,291	-1	- <1	- <1
Horse River	24,046	23,558	-488	- <1	-2
Joslyn	86,192	66,313	-19,879	- <1	-23
Kearl	3,940	3,886	-55	- <1	-1
Kinosis	54,204	49,593	-4,611	- <1	-9
Legend	127,074	126,288	-787	- <1	- <1
Livock	37,106	36,688	-418	- <1	-1
Marguerite	76,769	71,654	-5,115	- <1	-7
McMurray	56,877	52,879	-3,998	- <1	-7
Mildred	186,704	171,303	-15,400	- <1	-8
Namur	61,299	60,569	-730	- <1	-1
Ruth Lake	16,294	12,483	-3,811	- <1	-23

Table 2.4-1 Soil Series Types for the Pre-Industrial Case and 2012 Base Case in the Regional Study Area (continued)

Dominant Soil Series of Soil Units	Pre-Industrial Case	2012 Base Case	Change from Pre-Industrial Case		
	Area [ha]	Area [ha]	Area [ha]	% of RSA	% of Resource
Steepbank	130,837	120,406	-10,431	- <1	-8
Surmont	11,857	11,189	-669	- <1	-6
subtotal mineral soil	*1,145,463*	*1,039,482*	*-105,982*	*-5*	*-9*
Organic Soils					
Muskeg	240,944	228,588	-12,356	- <1	-5
Bayard	14,662	14,615	-47	- <1	- <1
Conklin	61,760	58,013	-3,747	- <1	-6
Gregoire	20,863	19,583	-1,279	- <1	-6
Hartley	174,524	153,966	-20,558	- <1	-12
Mariana	156,011	139,442	-16,569	-<1	-11
McLelland	152,559	146,026	-6,533	- <1	-4
Mikkwa	126,054	125,267	-786	- <1	- <1
Wabasca	36,774	31,880	-4,894	- <1	-13
subtotal organic soil	*984,149*	*917,379*	*-66,770*	*-3*	*-7*
Other					
Disturbed	1,557	170,483	168,926	7	10,852
Indian Reserve	6,179	6,161	-17	- <1	- <1
Reconstructed Landforms	0	6,492	6,492	<1	n/a
Rough broken/rock	86,070	82,401	-3,670	- <1	-4
Water[(a)]	53,958	54,976	1,019	<1	2
subtotal other	*147,764*	*320,515*	172,749	8	117
Total	**2,277,376**	**2,277,376**	**0**	**0**	**0**

[(a)] Includes reclaimed pit lakes.

n/a = Not applicable.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

2.4.2 Terrestrial Vegetation, Wetlands and Forest Resources

The Terrestrial Vegetation, Wetlands and Forest Resources Assessment is presented in the EIA, Volume 5, Sections 7.3 through 7.6. Details and assessment methods on the development of 2012 Base Case data are described in the Terrestrial Environmental Setting Report for the EIA (Golder 2007b). The PIC for Vegetation Resources, Wetlands and Forest Resources is compared with the 2012 Base Case in Section 2.4.4.2.

2.4.2.1 Terrestrial Vegetation, Wetlands and Forest Resources Assessment Methods

The only disturbances assumed to be present in the PIC are anthropogenic disturbances (primarily associated with settlements), cutblocks from forestry, and natural disturbances such as ALCES®-modelled burned areas. To facilitate comparisons between the cases, forest fires simulated in the 2012 PDC (Appendix 3.1) were also represented in RSA for the PIC and 2012 Base Case. Forest harvest cutblocks simulated in the 2012 PDC were represented in the RSA for the 2012 Base Case, but not the PIC because industrial-scale logging had not occurred in 1955.

A 1955 regional land cover classification map was developed using satellite imagery and ArcGIS to provide information on the relative abundance of land cover classes in the RSA. Image classification is a method of automatically categorizing discrete parts of a satellite image.

The RSA vegetation classification is based on the following specifications for the PIC:

- Landsat 5 satellite imagery with a 30 m × 30 m pixel size for 2005;
- Landsat 1 satellite imagery with a 30 m × 30 m pixel size for 1974; and
- images of industrial and urban areas captured in the 1950s.

The resolution of the satellite imagery is appropriate for a regional level vegetation classification and allows the spatial data to be processed in a reasonable time frame. To minimize missing data from cloud cover, multiple satellite imagery scenes were combined to achieve minimal cloud coverage resulting in a high-quality image. Quality control measures were implemented to georeference the source data in the RSA. The imagery was loaded into remote sensing software (eCognition) for the vegetation classification process.

Land cover classes identified from regional satellite imagery and AVI data (Alberta-Pacific Forest Industries 2000) were used in selecting “training sites” or ground truthing for classification assessments. These training sites were selected to capture the range of variation in the reflectance values or “spectral signature” of the vegetation classes. Based on the spectral signatures, the remote sensing software assigned the best-fit classification to the pixels in the image. Although, some uncertainty in identifying land cover classes is inherent during classification using remote sensing, ground truthing conducted during baseline data collection provides a more accurate representation of the study area. This approach allowed for a more efficient assessment and greater number of vegetation communities identified over a large area, with a reasonable level of accuracy, and within the allotted time frame.

The classification resulted in 13 RLCCs which are assumed to have existed prior to industrial oil sands developments in the RSA. Each class fell into one of the following four broad groups:

- terrestrial;
- wetlands;
- miscellaneous cover types; and
- disturbances.

Terrestrial vegetation is generally defined as occurring on land where the soils are not saturated with water for extended periods of the year. The National Wetlands Working Group (NWWG 1988) defines wetlands as *"…land that is saturated with water long enough to promote wetlands or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment".* Wetlands in the RSA consist of marshes, fens, bogs and swamps. Miscellaneous land cover classes include recently burned areas and water. Disturbances are categorized as cutblocks or "other" such as linear disturbances, urban areas and industrial land, and include both existing and approved projects. A list of the RLCCs found within the RSA is provided in Table 2.4-2.

Table 2.4-2 Regional Land Cover Classes

General Land Category	Regional Land Cover Class
Terrestrial	coniferous jack pine
	coniferous jack pine-black spruce
	coniferous white spruce
	deciduous aspen-balsam poplar
	mixedwood aspen-jack pine
	mixedwood aspen-white spruce
Wetlands	non-treed wetlands
	treed bog/poor fen
	treed fen
Miscellaneous cover type	burn
	water
Disturbances[(a)]	cutblock
	urban/industrial/other disturbances

(a) Existing disturbances from 1955 include forestry, other industry and municipal projects.

Detailed descriptions of the RLCCs are found in the Terrestrial Environmental Setting Report (Golder 2007b). For the PIC, there is also an unclassified cover class that refers to areas that could not be classified due to cloud cover and cloud shadows.

Pre-Industrial information about the vegetation is not at the same accuracy as information that was available for the 2012 Base Case at the time of Project application in 2007. These differences limit some of the parameters used for the vegetation assessment; however, efforts have been made to compensate for these limitations. For example, the PIC contains imagery that was blocked by clouds or cloud shadows; therefore these areas were not classified into RLCCs. The EIA Base Case imagery was free of clouds, and some of the apparent changes from PIC to the 2012 Base Case will be due to this difference, rather than actual changes to the landscape.

2.4.2.2 Terrestrial Vegetation, Wetlands and Forest Resources Results

The total area and percent cover of RLCCs within the RSA for the PIC and 2012 Base Case are shown in Table 2.4-3. The terrestrial RSA as originally described in the EIA covers an area of 2,277,376 ha. The regional vegetation classification identifies 13 RLCCs including six terrestrial classes, three wetlands classes, two miscellaneous land cover classes, and two disturbance classes in the RSA. In addition, there is an unclassified cover class for areas that could not be classified due to cloud cover and cloud shadows in the PIC.

Changes in RLCCs from the PIC to 2012 Base Case range from less than 1% to 13% of the RSA. The largest change occurs in the disturbance category. Total disturbances including cutblocks increased by 288,894 ha (13% of the RSA) due to the loss or alteration of other RLCCs. Approximately 109,254 ha (5% of the RSA) of wetlands were lost or altered. Terrestrial vegetation was also reduced by 154,814 ha (7% of the RSA). The amount of burn decreased by 24,311 ha (1% of the RSA).

Table 2.4-3 Total Area and Percent Cover of Land Cover Classes Within the Regional Study Area for Pre-Industrial Case and 2012 Base Case

Regional Land Cover Class	Pre-Industrial Case[a]	2012 Base Case[b]	Change from Pre-Industrial to 2012 Base Case		
	Area [ha]	Area [ha]	Area [ha][c]	% of RSA	% of Resource[d]
Terrestrial Vegetation					
coniferous jack pine	191,070	167,268	-23,802	-1	-12
coniferous jack pine-black spruce	44,624	40,429	-4,195	-<1	-9
coniferous white spruce	69,421	53,351	-16,069	-1	-23
deciduous aspen-balsam poplar	233,520	182,315	-51,206	-2	-22
mixedwood aspen-jack pine	49,528	39,462	-10,066	-<1	-20
mixedwood aspen-white spruce	197,394	147,918	-49,476	-2	-25
terrestrial vegetation subtotal	*785,557*	*630,743*	*-154,814*	*-7*	*-20*
Wetlands (including Peatlands)					
non-treed wetlands	275,397	245,047	-30,350	-1	-11
treed bog/poor fen	471,749	427,623	-44,126	-2	-9
treed fen	268,124	233,346	-34,778	-2	-13
wetlands subtotal	*1,015,270*	*906,016*	*-109,254*	*-5*	*-11*
Miscellaneous					
burn	420,169	395,857	-24,311	-1	-6
water	54,040	54,244	204	<1	<1
miscellaneous subtotal	*474,209*	*450,101*	*-24,107*	*-1*	-5
Disturbances					
cutblock	65	100,391	100,326	4	155,248
disturbance (urban/industrial/other)	1,557	190,124	188,567	8	12,114
disturbances subtotal	*1,621*	*290,515*	*288,894*	13	*17,819*
Unclassified					
unclassified (cloud/cloud shadow)[e]	719	0	-719	-<1	-100
unclassified subtotal	*719*	*0*	*-719*	*-<1*	*-100*
Total	**2,277,376**	**2,277,376**	**n/a**	**n/a**	**n/a**

[a] Includes burns as modelled by ALCES®.

[b] Includes burns and cutblocks as modelled by ALCES®.

[c] Calculated as difference between the Pre-Industrial Case and 2012 Base Case.

[d] % of Resource is calculated as a percentage of Pre-Industrial Case area; the areas of this column are not additive.

[e] Describes those areas where the imagery of the earth's surface had been blocked during the image capture period.

n/a = Not applicable.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

2.4.3 Wildlife

The Wildlife Assessment is presented in the EIA Volume 5, Sections 7.3.4, 7.5.3, 7.5.4, 7.5.5, and 7.6.3. Details and methods on the development of 2012 Base Case data are described in the *Terrestrial Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project*, Section 5 (Golder 2007b). The PIC for Wildlife is discussed and compared with the 2012 Base Case in Section 2.4.3.2. Wildlife abundance and movement metrics are not available in the PIC, and the change between the PIC and the 2012 Base Case is based on wildlife habitat suitability.

2.4.3.1 Wildlife Habitat Assessment Methods

Habitat Suitability (HS) models were used to predict the distribution and characteristics of wildlife habitat in the PIC and 2012 Base Case. The HS models used were empirically derived Resource Selection Functions (RSFs) for moose, Canada lynx and fisher/marten, and expert knowledge-based Habitat Suitability Index (HSI) models for the remaining Key Indicator Resources (KIRs) and the federally listed Species At Risk (SAR) that may be affected by habitat change. A list of wildlife KIRs and federally listed wildlife SAR is presented in Table 2.4-4.

Table 2.4-4 Wildlife Key Indicator Resources and Species at Risk

Key Indicator Resources	Species at Risk
moose	Canada warbler
Canada lynx	common nighthawk
fisher/marten	horned grebe
black-throated green warbler	olive-sided flycatcher
barred owl	rusty blackbird
yellow rail	short-eared owl
Canadian toad	western (boreal) toad
black bear	wolverine
beaver	wood bison [(a)]
	woodland caribou [(a)]

[(a)] Wood bison in Alberta are not found east of the Athabasca River and woodland caribou are virtually absent from the Local Study Area (LSA), and are therefore not considered valid linkages for the Jackpine Mine Expansion (JME). However, the effects to wood bison and woodland caribou habitat are assessed at the request of the Joint Review Panel (JRP) (i.e., JRP SIRs 19a and 21b) because these species occurred in the LSA in the past.

Details on the structure of models used to predict habitat suitability for wildlife KIRs are outlined in the EIA, (Appendix 5-4, Section 1.2). The structures of models used to predict habitat suitability for federally listed wildlife SAR that may be affected by habitat change in the LSA are outlined in the May 2011, Submission of Information to the Joint Review Panel, Appendix 2, as is the model for wood bison. The model used to predict the distribution of habitat suitability for woodland caribou is provided in Appendix 3.7. The analysis of the effects of development on wildlife in the RSA from the PIC to the 2012 Base Case for each wildlife KIR and selected federally listed SAR focuses on the change in the amount of high and moderate-high suitability habitat.

2.4.3.2 Wildlife and Wildlife Habitat Results

The increase in human disturbances from the PIC to the 2012 Base Case result an increase in the amount of high suitability habitat in the RSA for short-eared owl, due primarily to the increased prevalence of burns in the RSA at the 2012 Base Case. There is a decrease in the amount of high suitability habitat for all remaining KIRs and SAR for which effects on habitat were assessed. The decline in high suitability habitat is of low magnitude

(i.e., a less than 10% change) for common nighthawk and woodland caribou, of high magnitude (i.e., a greater than 20% change) for barred owl, black-throated green warbler, Canada warbler and wood bison, and of moderate magnitude (greater than 10% change, but less than 20%) for all other wildlife KIR and SAR for which changes in habitat were assessed (Table 2.4-5).

Landscape changes should be assessed in the broader context of the overall availability of habitat. The amount of human disturbance in the RSA has been estimated to increase from less than 0.1% at the PIC to 13% of the RSA at the 2012 Base Case (Table 2.4-3). Therefore, at the 2012 Base Case, 87% of the RSA remains undisturbed by humans. In Table 2.4-5 for the PIC, "nil" suitability habitat (i.e., unsuitable) was estimated to make up less than 0.1% of the RSA for wolverine, and 2% of the RSA for black bear, Canada lynx, fisher and moose. For all remaining KIRs and SAR, the few developments in the PIC combined with natural land cover types representing nil habitat suitability for these species (EIA, Volume 5, Section 7.6.3, and May 2011, Submission of Information to the Joint Review Panel) range from 10% of the RSA for common nighthawk to 88% of the RSA for yellow rail. The increase in the areal extent of nil habitat from the PIC to the 2012 Base Case ranges from 1% of the RSA for horned grebe and yellow rail to 20% of the RSA for woodland caribou.

Table 2.4-5 Wildlife Habitat Change in the Regional Study Area From the Pre-Industrial Case to the 2012 Base Case

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change From Pre-Industrial Case to 2012 Base Case		
		Habitat Area [ha]	% of Total Area	Area [ha]	% Resource	% RSA
barred owl	high	222,863	10	-75,962	-34	-3
	moderate	186,478	8	-80,151	-43	-4
	low	925,294	41	-133,739	-14	-6
	nil	942,742	41	289,852	31	13
beaver	high	586,995	26	-69,790	-12	-3
	moderate	0	0	0	0	0
	low	275,397	12	-25,149	-9	-1
	nil	1,414,984	62	94,939	7	4
black bear	high	1,156,744	51	-119,327	-10	-5
	moderate	519,334	23	-26,005	-5	-1
	low	544,983	24	-30,731	-6	-1
	nil	56,314	2	176,063	313	8
black-throated green warbler	high	240,349	11	-81,725	-34	-4
	moderate	231,520	10	-93,751	-40	-4
	low	862,807	38	75,717	9	3
	nil	942,701	41	99,760	11	4
Canada lynx	high	473,755	21	-97,923	-21	-4
	moderate high	428,628	19	-55,965	-13	-2
	moderate	435,964	19	-12,960	-3	>-1
	moderate low	447,484	20	-5,470	-1	>-1
	low	435,230	19	-3,745	>-1	>-1
	nil [(a)]	56,314	2	176,063	313	8
Canadian toad	high	228,234	10	-23,262	-10	-1
	moderate	803,361	35	-66,725	-8	-3
	low	201,585	9	-15,304	-8	>-1
	nil	1,044,196	46	105,292	10	5

Table 2.4-5 Wildlife Habitat Change in the Regional Study Area From the Pre-Industrial Case to the 2012 Base Case (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change From Pre-Industrial Case to 2012 Base Case		
		Habitat Area [ha]	% of Total Area	Area [ha]	% Resource	% RSA
fisher / marten	high	547,806	24	-123,098	-22	-5
	moderate high	463,711	20	-30,194	-7	-1
	moderate	449,251	20	-12,454	-3	>-1
	moderate low	428,437	19	-8,798	-2	>-1
	low	331,857	15	-1,518	>-1	>-1
	nil [(a)]	56,314	2	176,063	313	8
moose	high	474,607	21	-67,107	-14	-3
	moderate high	457,165	20	-39,518	-9	-2
	moderate	446,519	20	-32,955	-7	-1
	moderate low	429,125	19	-24,051	-6	-1
	low	413,645	18	-12,433	-3	>-1
	nil [(a)]	56,314	2	176,063	313	8
Canada warbler	high	186,246	8	-91,110	-49	-4
	moderate	177,765	8	-59,679	-34	-3
	low	45,330	2	-5,324	-12	>-1
	nil	1,868,036	82	156,113	8	7
common nighthawk	high	353,022	16	-34,514	-10	-2
	moderate	1,366,640	60	-108,173	-8	-5
	low	321,427	14	17,009	5	<1
	nil	236,287	10	125,678	53	6
horned grebe	high	287,315	13	-49,950	-17	-2
	moderate	170	<1	17,053	10,013	<1
	low	0	0	0	0	0
	nil	1,989,891	87	32,897	2	1
olive-sided flycatcher	high	440,399	19	-45,542	-10	-2
	moderate	1,049,211	46	-162,806	-16	-7
	low	248,712	11	136,312	55	6
	nil	539,055	24	72,036	13	3
rusty blackbird	high	587,732	26	-102,940	-18	-5
	moderate	608,101	27	-45,931	-8	-2
	low	137	<1	35,267	25,830	2
	nil	1,081,407	47	113,603	11	5
short-eared owl	high	392,447	17	1,645	<1	<1
	moderate	312,601	14	-20,320	-7	>-1
	low	603,490	26	-35,814	-6	-2
	nil	968,838	43	54,489	6	2
western (boreal) toad	high	287,274	13	-55,069	-19	-2
	moderate	429,709	19	-56,960	-13	-3
	low	686,295	30	-30,741	-4	-1
	nil	874,097	38	142,769	16	6

Table 2.4-5 Wildlife Habitat Change in the Regional Study Area From the Pre-Industrial Case to the 2012 Base Case (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change From Pre-Industrial Case to 2012 Base Case		
		Habitat Area [ha]	% of Total Area	Area [ha]	% Resource	% RSA
wolverine	high	2,273,964	100	-406,761	-18	-18
	moderate	0	0	0	0	0
	low	1,856	<1	208,830	11,253	9
	nil	1,557	<1	197,931	12,715	9
wood bison	high	275,067	12	-81,131	-29	-4
	moderate	647,036	28	-52,870	-8	-2
	low	519,110	23	47,273	9	2
	nil	836,163	37	86,728	10	4
woodland caribou	high	423,700	19	-170,431	-40	-7
	moderate	1,794,282	79	-1,649,202	-92	-72
	low	3,181	<1	1,363,554	42,860	60
	nil	56,213	2	456,079	811	20
yellow rail	high	275,245	12	-49,918	-18	-2
	moderate	152	<1	20,254	13,318	<1
	low	0	0	0	0	0
	nil	2,001,979	88	29,664	1	1

(a) Nil includes 717.81 ha of area classified as cloud in Pre-Industrial Case vegetation data due to remote sensing limitations.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

2.4.4 Biodiversity

The Biodiversity Assessment is presented in the EIA, Volume 5, Sections 7.3.5, 7.5.6 and 7.6.4. Details and assessment methods on the development of the PIC and the 2012 Base Case data are the same as for the EIA Base Case data, which are described in *Biodiversity Ranking Protocol and Results for the Oil Sands Region*, found in the Terrestrial Environmental Setting Report for the EIA (Golder 2007b). One notable change from EIA assessment methods is the inclusion of burns and/or cutblocks as modelled by ALCES® (Appendix 3.1). The PIC for biodiversity is compared to 2012 Base Case biodiversity below.

2.4.4.1 Biodiversity Assessment Methods

The first step in the Biodiversity Assessment was to identify areas of high, moderate and low biodiversity potential at the local scale. Biodiversity potential represents the relative contribution of an ecosite phase, wetlands type or other land cover type to the overall biological diversity of an area. To measure biodiversity potential, land cover types were ranked based on the integration of five biodiversity indicators that quantify different components of biodiversity, including rarity on the landscape; plant and wildlife rare species potential; plant and wildlife species richness; species overlap (i.e., proportion of species shared with other land cover types); and structural complexity. The biodiversity potential of each RLCC in the RSA was then derived based on the proportional scores of its contributing land cover types. The total area covered by each biodiversity potential rank was then calculated for the PIC and the 2012 Base Case.

2.4.4.2 Biodiversity Results

The changes in biodiversity potential from the PIC to the 2012 Base Case are shown in Table 2.4-6. The changes range from a loss of 5% within the RSA (moderate-ranked areas) to a gain of 8% (low-ranked areas). The largest changes occur to the disturbance and cutblock RLCCs (both low-ranked), with a combined increase in areal extent of 13% (298,258 ha) from the PIC to 2012 Base Case. Changes in biodiversity potential include the following:

- There is an overall decrease of 65,128 ha (3% of the RSA) in high biodiversity potential areas from 543,521 ha in the PIC to 478,393 ha at 2012 Base Case. This change is nearly equally distributed between losses to non-treed wetlands and treed fens.
- There is an overall decrease of 119,534 ha (5% of the RSA) in moderate biodiversity potential areas from 842,132 ha in the PIC to 722,598 ha at 2012 Base Case. Reductions in the terrestrial RLCCs represent the majority of this change.
- There is an overall increase of 185,380 ha (8% of the RSA) in low biodiversity potential areas from 891,004 ha in the PIC to 1,076,385 ha at 2012 Base Case. The majority of this change is due to additional cutblocks in the landscape.

Table 2.4-6 Biodiversity Potential Change in the Regional Study Area From the Pre-Industrial Case to 2012 Base Case

Regional Land Cover Class	Pre-Industrial Case [ha]	2012 Base Case [ha]	Change from Pre-Industrial Case to 2012 Base Case		
			[ha]	% Resource[a]	% RSA
High Biodiversity Potential					
non-treed wetlands	275,397	245,047	-30,350	-11	-1
treed fen	268,124	233,346	-34,778	-13	-2
subtotal	*543,521*	*478,393*	*-65,128*	*-12*	*-3*
Moderate Biodiversity Potential					
coniferous white spruce	69,421	53,351	-16,069	-23	-1
mixedwood aspen−jack pine	49,528	39,462	-10,066	-20	-<1
mixedwood aspen−white spruce	197,394	147,918	-49,476	-25	-2
treed bog/poor fen	471,749	427,623	-44,126	-9	-2
water	54,040	54,244	204	<1	<1
subtotal	*842,132*	*722,598*	*-119,534*	*-14*	*-5*
Low Biodiversity Potential					
burn	420,169	395,857	-24,311	-6	-1
coniferous jack pine	191,070	167,268	-23,802	-12	-1
coniferous jack pine−black spruce	44,624	40,429	-4,195	-9	-<1
deciduous aspen−balsam poplar	233,520	182,315	-51,206	-22	-2
cutblock	65	100,391	100,326	155,248	4
disturbance	1,557	190,124	188,567	12,114	8
subtotal	*891,004*	*1,076,385*	*185,380*	*21*	*8*
Not Ranked					
cloud[b]	719	0	-719	-100	-<1
Total	**2,277,376**	**2,277,376**	**n/a**	**n/a**	**n/a**

[a] This column is calculated as a percentage of Pre-Industrial Case area; the areas are not additive.

[b] Clouds on the Landsat image prevent interpretation of regional land cover class in some areas for Pre-Industrial Case; therefore, 1% of the Regional Study Area could not be ranked according to biodiversity potential.

n/a = Not applicable.

Notes: Calculations are performed on non-rounded values and some values are then rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

2.5 Human Environment

This section discusses Traditional Land Use (TLU) disturbances and socio-economic conditions prior to large-scale oil sands development in the region (i.e., early 1960s).

The PIC for TLU and Socio-Economics uses the early 1960s as a reference point. Land disturbance calculations are based on information for 1965. The Human Environment components do not rely on specific KIRs as used in other components. Rather, the assessments consider the potential effects on humans and the specific categories of resource uses.

The TLU Assessment calculates and compares disturbance data for the RSAs of the Athabasca Chipewyan First Nation (ACFN), Mikisew Cree First Nation (MCFN), and Fort McKay First Nation (FMFN) between the PIC and the 2012 Base Case. Comparisons are also made for the FMFN Culturally Significant Ecosystems (CSEs) for All Traditional Uses, Large Game Harvesting, and Traditional Plant Harvesting.

The Socio-economic Assessment tracks changes in several socio-economic areas over time. The analysis relies upon, among other things, information collected from past socio-economic reports, available historical data, and interviews and consultation activities conducted for previous socio-economic impact assessments.

The PIC mapping for TLU was completed as outlined in Section 2.5.2 for the portions of the TLU study areas overlapping the terrestrial RSA. Section 2.5.2 presents the results for the following TLU study areas:

- Fort McKay First Nation's CSEs – All Traditional Uses;
- Fort McKay First Nation's CSEs – Large Game Harvesting;
- Fort McKay First Nation's CSEs – Traditional Plants;
- RSA – Athabasca Chipewyan First Nation; and
- RSA – Mikisew Cree First Nation.

Further description of FMFN's CSEs and the RSAs can be found in the Traditional Land Use Assessment for the EIA, Volume 5, Section 8.3.24.

The results of the Socio-Economic Assessment are found in Section 2.5.2 below.

2.5.1 Traditional Knowledge and Land Use

Within Fort McKay's CSE, between 15% and 31% of the pre-industrial landscape used has been disturbed at 2012 Base Case, when cutblocks and burned areas are included.

The changes in disturbances for the All Traditional Uses CSE from the PIC to the 2012 Base Case are shown in Table 2.5-1. Under the PIC, anthropogenic disturbances represent 1,714 ha, or about 0.05% of the total area of the CSE. The additional 2012 Base Case disturbances represent about 20% of the total area of the CSE.

Table 2.5-1 Disturbances Within Fort McKay's Culturally Significant Ecosystems – All Traditional Uses

CSE	Area of CSE [ha]	Pre-Industrial Case[(a)]	2012 Base Case	Change from Pre-Industrial Case	
		Area [ha]	Area [ha]	Area [ha]	Change [% of CSE Area]
Low Use	2,142,679	91	311,203	311,112	15
Moderate Use	861,563	1,476	248,841	247,365	29
Intense Use	309,215	148	94,401	94,253	31
Total	**3,313,457**	**1,714**	**674,968**	**673,254**	**20**

(a) Adapted from the Fort McKay Specific Assessment, Table 9-5 (Fort McKay IRC 2010).

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The changes in disturbances for the Large Game Harvesting CSE from the PIC to the 2012 Base Case are shown in Table 2.5-2. Under the PIC, anthropogenic disturbances represent 1,711 ha, or about 0.04% of the total area of the CSE. The additional 2012 Base Case disturbances represent about 17% of the total area of the CSE.

Table 2.5-2 Disturbances Within Fort McKay's Culturally Significant Ecosystems – Large Game Harvesting

CSE	Area of CSE [ha]	Pre-Industrial Case[(a)]	2012 Base Case	Change from Pre-Industrial Case	
		Area [ha]	Area [ha]	Area [ha]	Change [% of CSE Area]
Low Use	1,347,998	0	46,019	46,019	4
Moderate Use	1,723,226	1,186	325,961	324,765	19
Intense Use	1,018,146	525	302,988	302,463	30
Total	**4,089,370**	**1,711**	**674,968**	**673,257**	**17**

(a) Adapted from the Fort McKay Specific Assessment, Table 9-6 (Fort McKay IRC 2010).

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The changes in disturbances for the Traditional Plants CSE from the PIC to the 2012 Base Case are shown in Table 2.5-3. Under the PIC, anthropogenic disturbances represent 1,712 ha, or about 0.09% of the total area of the CSE. Additional 2012 Base Case disturbances represent about 26% of the total area of the CSE.

Table 2.5-3 Disturbances Within Fort McKay's Culturally Significant Ecosystems – Traditional Plant Harvesting

CSE	Area of CSE [ha]	Pre-Industrial Case[(a)]	2012 Base Case	Change from Pre-Industrial Case	
		Area [ha]	Area [ha]	Area [ha]	Change [% of CSE Area]
Low Use	1,396,491	1,235	322,515	321,280	23
Moderate Use	396,759	477	123,063	122,586	31
Intense Use	74,917	0	35,268	35,268	47
Total	**1,868,167**	**1,712**	**480,846**	**479,134**	**26**

(a) Adapted from the Fort McKay Specific Assessment, Table 9-7 (Fort McKay IRC 2010).

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The change in disturbances within the RSAs for the ACFN, MCFN, and FMFN from the PIC to the 2012 Base Case are shown in Table 2.5-4. Under the PIC, anthropogenic disturbances represent 85,378 ha, or about 2% of the RSA of the ACFN. PIC anthropogenic disturbances represent 115,347 ha, or about 1.3% of the RSA of the MCFN. PIC anthropogenic disturbances represent 135,249 ha, or about 4% of the area of the RSA of the FMFN. The additional disturbances under the 2012 Base Case represent about 9% of the RSA area of the ACFN, about 5% of the RSA area of the MCFN, and about 15% of the area of the FMFN.

Table 2.5-4 2012 Base Case Disturbances Within Regional Study Areas of the Fort McKay First Nation, Athabasca Cree First Nation and Mikisew Cree First Nation

Regional Study Area	Total RSA [ha]	Pre-Industrial Case[(a)] Area [ha]	2012 Base Case[(a)] Area [ha]	Change from Pre-Industrial Case	
				Area [ha]	Change [% of RSA Area]
ACFN	4,383,440	85,378	474,280	388,902	9
FMFN	3,525,101	135,249	650,454	515,205	15
MCFN	8,641,594	115,347	523,501	408,154	5

(a) Data reproduced from the Environmental Impact Assessment (EIA, Volume 5, Section 8, Table 8.3-6), with Pre-development information re-titled "Pre-Industrial Case".
Note: Percentages have been rounded to the nearest whole percent.

2.5.2 Socio-Economic

This section discusses socio-economic conditions in the early 1960s before large-scale oil sands development began in the region and tracks changes in several socio-economic areas over time. The analysis relies on information collected from past socio-economic reports, available historical data, and interviews and consultation activities conducted for previous socio-economic impact assessments.

The challenge in carrying out this analysis is that historical data are sometimes not available, or were often collected only infrequently, and are affected by changing definitions and assessment methods. This challenge is especially true for areas outside Fort McMurray that were rural, isolated, and sparsely populated.

2.5.2.1 Socio-Economic Setting

This section provides the historical context for socio-economic conditions for communities and Aboriginal peoples in the region and describes the PIC and EIA Base Case.

2.5.2.1.1 Historical Context

Aboriginal peoples have lived in northeastern Alberta for 10,000 years or more, and evidence of their presence can be found throughout the region. For example, the Cree Burn Lake site was a hub for trading and cultural activities dating back some 8,000 years. It was designated as a Provincial Historic Resource in 1999. Prior to contact with European settlers, Aboriginal peoples maintained a relatively stable way of life based on hunting, fishing, and the gathering of food and medicinal plants.

European settlers first came to the region as explorers and fur traders in the 18th century. Fur trading posts were established at Fort Chipewyan (1788), Fort McKay (1820) and Fort McMurray (1870). Located at the confluence of the Clearwater and Athabasca rivers, Fort McMurray developed into a major staging point for travellers and freight bound for the North via the Slave River, Great Slave Lake and Mackenzie River.

2.5.2.1.2 Pre-Industrial Case – Early 1960s

This section presents regional data which generally refers to the town of Fort McMurray, the unincorporated communities of Fort Chipewyan, Fort McKay, Anzac, and their surrounding areas

In the early 1960s, the region was a relatively isolated part of the province with a small, predominantly Aboriginal population. Prior to 1966, there was no all-weather road access from the region to the southern parts of the province. Ground transportation was dependent on the railway, completed in the early 1920s, or on winter access via forestry roads.

In 1961 the population of the region was about 2,600. Approximately one-half resided in Fort McMurray with most of the remainder in the unincorporated communities of Fort Chipewyan, Fort McKay and Anzac. There were just over 600 housing units in the region, split fairly evenly between Fort McMurray and the other smaller communities. Housing was predominantly single family dwellings (AOSERP 1979).

The scattered urban settlements, most significantly Fort McMurray, provided only a basic level of services to the region (AOSERP 1979). As an example, in 1960, Fort McMurray had a hospital with 25 beds and just one constable without a police vehicle (AOSERP 1980).

Before large-scale development of the oil sands began, the region's economy was reliant on its function as a transportation thoroughfare to other regions in the Far North, and on traditional resource industries such as hunting, fishing, trapping and forestry. With Fort McMurray as its southern terminus, Athabasca River barge transport was an important route for communities in northeastern Alberta, northwestern Saskatchewan and the Far North. While the expansion of highway systems in the late 1950s and early 1960s began diverting traffic away from the barge transport system, it nonetheless remained an important transportation route for many northern communities without rail or all weather road access, such as Fort Chipewyan.

In 1961 Fort McMurray's employed labour force was 330 (AOSERP 1979). The percentage of the population aged 15 and over that was employed was less than 49%, below the provincial average of 55%. The construction and mining sectors comprised a relatively minor share of the employment base of the community at that time. More than one-third of the labour force was engaged in the transportation and communications industry, reflecting the town's importance as a rail and waterways transportation hub.

The region had previously been marked by successions of booms and recessions associated with natural resources and transportation (AOSERP 1978). The oil sands in particular had attracted interest prior to 1960, including:

- the turn of the 20th century, when speculators trying to drill for oil below the oil sands caused a minor boom;
- the late 1920s, when the newly formed Research Council of Alberta made serious efforts to find a method of extracting oil from oil sands deposits; and
- the 1950s, when the exploration period for the Great Canadian Oil Sands (GCOS) began (AOSERP 1980).

Most of the economic effects for these developments fell on the community of Fort McMurray.

The smaller, predominantly Aboriginal communities in the region were largely dependent on renewable resource harvesting, seasonal firefighting, local administration, and social assistance. The relationship between Aboriginal peoples of the region and their traditional lands had changed since pre-European contact times. The arrival of the Europeans and the fur trade ensured that trapping now supplemented traditional hunting, fishing and

gathering activities. By the 1960s, Aboriginal persons in the region were also engaging in various wage-employment opportunities in renewable resource sectors, such as fishing and forestry. For example, commercial fishing on Lake Athabasca provided a relatively significant amount of seasonal employment to Aboriginal people in the Fort Chipewyan area in the early 1960s (AOSERP 1979).

The living patterns of Aboriginal peoples in the region also began changing in the early 1960s as they settled more permanently in stable communities as a result of the declining fur trade and under the pressure of government policies. As part of the same process, they were obliged to rely increasingly on government transfer payments and the surrounding wage economy to supplement their livelihood from traditional hunting and gathering activities.

2.5.2.1.3 Regional Development From 1960s to Current Day

Large-scale development of the region's oil sands resource began in the mid-1960s and helped lead to several significant changes over the next five decades. Development of the region from the 1960s to today can be divided into four distinct time periods associated with oil sands development:

- Early 1960s to 1986 was the first major growth period. Fort McMurray's population grew from 1,200 to nearly 37,000.
- From 1986 to the late 1990s was a period of little growth. Population was essentially stable as oil sands industry employment declined marginally through productivity improvement measures.
- Late 1990s to 2008 was the second major growth period. Employment growth drove rapid population growth in the region, leading to high demand for regional infrastructure and services. The population of Fort McMurray increased to over 70,000.
- From 2008 to 2011, growth in the region moderated as a result of the global economic downturn.

An overview of regional development by socio-economic area in each of these time periods is provided in Table 2.5-5.

2.5.2.2 Socio-Economic Results

Without oil sands development, the regional population would be much smaller than it is today and communities in the region would not have experienced many of the socio-economic challenges precipitated by development. At the same time, neither would the region or its residents have realized many of the benefits of development, including jobs, income, and increased service offerings and amenities. Although growth is a pathway by which many socio-economic effects occur, the level of that growth alone is not a sufficient indicator of the nature and magnitude of these effects. Consideration must be given to the availing processes and systems in place to handle and address these effects. In the Wood Buffalo region, these processes and systems have expanded considerably over time, especially in recent years as a response to rapid growth in the late-1990s to 2008 period.

Table 2.5-5 Regional Development, 1960 to 2011

Socio-Economic Area	Period 1: Early 1960s to 1986	Period 2: 1986 to Late 1990s	Period 3: Late 1990s to 2008	Period 4: 2008 to 2011
Oil Sands Economy	• First wave of development: Great Canadian Oil Sands Ltd. (now Suncor [Suncor] Energy Inc.) builds its base plant starting in 1964 and commences operations in 1967. • Second wave of development: Construction of the Syncrude Canada Ltd. (Syncrude) facility starts in the 1970s; first production in 1978. • Third wave of development centred around the Alsands Project falters in early 1980 under pressure of technical challenges, rising costs, and depressed product prices. • The labour force of Fort McMurray was estimated at 7,600 in 1976, of which 55% worked outside the town boundaries, mostly at the Suncor and Syncrude plants. In 1980, the labour force was estimated at 13,230, of which 55% worked in the oil sands plants or in construction (AMA 1975, 1976, 1980).	• Technology change in oil sands industry. Movement from bucket wheel to truck and shovel mining. Emergence of in situ production methods. • Debottlenecking and other improvements to processes and facilities. • Stable or marginally declining oil sands industry employment due to productivity improvement measures. • Generic royalty regime, improved plant reliability, improving product prices, and other drivers stimulate the first expansion of the industry since 1976: Steepbank mine, an expansion mine of Suncor, opens in 1999. • Syncrude moves its senior management and administration to the region from Calgary and Edmonton. Suncor has operations-related administration in the region, but retains its corporate functions in Calgary.	• Period of regional economic expansion. Construction and sustaining capital expenditures in the province's oil sands industry increased from $1.5 billion in 1998 to over $18 billion in 2008. • Expansion from a two-company to a multi-company industry. Major new facilities from Shell, Canadian Natural Resources Limited, ConocoPhillips Canada, Cenovus Energy Inc, Cenovus FCCL Ltd and others. • Employment growth: As of 2007, over 11,000 operations workers were directly employed by the oil sands industry in the region—more than double the number before 1996. • Labour shortages are occurring across several sectors and the region is experiencing an increasing number of mobile workers from elsewhere in Alberta and Canada. Total number of camp-based mobile workers is over 26,000 in 2008 (Nichols 2007).	• A number of oil sands projects are halted in response to the global financial and debt crisis in autumn 2008. • Between 2008 and 2009, annual construction and capital expenditures in the province's oil sands industry dropped by nearly 40%. • Ongoing investment in facility maintenance and operations; Imperial Oil sanctions its Kearl Mine in early 2009. • Major merger of Suncor and Petro-Canada, consolidating a suite of oil sands projects. • Most projects that were halted in 2008/09 are back on track by the end of 2011. • Skill shortages have been reduced by the recession of 2008 to 2009, but are again on the upswing.
Other Economic Sectors	• Regional economy includes house and commercial construction, natural gas exploration and production, forestry development, tourism, and the emergence of a service sector. • Strong demand for workers in the oil sands industry creates labour recruitment and retention difficulties for all sectors. • Traditional economy remains important for many people in the region, especially in the outlying areas.	• Retrenchment of the construction industry in Fort McMurray. Home and commercial construction starts to pick up after 1995 as oil sands industry expansion gets under way.	• Period of expansion for many industries in the region, especially the land development, commercial and residential construction, commercial and retail sectors. • Strong demand for workers in the oil sands industry creates labour recruitment and retention issues for all sectors. Limited availability and high cost of housing contributes to worker recruitment and retention issues. • Emergence of mostly oil sands industry-focused industrial, commercial, and professional services and manufacturing sectors.	• Reduced demand for workers in the oil sands industry eases but does not eliminate labour recruitment and retention issues for all sectors. • Regional Municipality of Wood Buffalo (RMWB) economic development function places increased emphasis on economic diversification.
Population	• Rapid population growth. • Regional population growth, starting in early 1960s from about 2,600 to over 26,000 in 1978, an annual growth rate of 15%. • Most of this growth occurs in Fort McMurray which accounts for over 90% of the regional population, or 24,500, in 1978. • Fort McMurray continues to grow, reaching 36,810 in 1986. Growth in the outlying areas was more modest (AOSERP 1979; AMA 1975, 1980). • Construction of oil sands plants leads to fluctuating camp populations in the region. The camp population reached peaks of about 2,300 in 1966 during the Great Canadian Oil Sands (GCOS) construction phase, and 6,500 in 1977, during Syncrude base plant construction.	• Stable population in Fort McMurray and the region as employment in the oil sands industry marginally declines. • The population of Fort McMurray is approximately 36,500 in 1999 and virtually unchanged from 1986 (RMWB 1999). • The population of the outlying communities is estimated at 2,850 in 1996. Fort Chipewyan is the largest of the outlying communities with an estimated population of 1,020 (RMWB 1999). • The regional camp population is estimated at approximately 3,500 in 1999 (RMWB 1999). • Population of the small communities is relatively stable.	• Rapid population growth. • Municipal census indicates that the resident population of the region increased from 39,280 in 1999 to 74,160 in 2008, an annual average growth rate of 7%. Most of this growth is concentrated in the region's Urban Service Area. • Growth in the non-resident population. As of 2008, over 26,280 workers, or over 90% of the non-resident population, lived in work camps in the outlying rural areas. The remainder lived in hotels, motels and campgrounds in the Urban Service Area. • Most of the workforce camps are temporary construction camps; longer-term operations camps start to emerge in the later part of the period. In 2008, there are three permanent operation camps in the region. • Anzac emerges as a growth community and starts to function as a residential centre. • Population of the other small communities is relatively stable.	• Moderate population growth. • The resident population in the region reaches nearly 80,000 in 2010 (RMWB 2010). The urban communities accounted for about 95% of the resident population, while the rural communities accounted for the remaining 5%. • The population in Fort McMurray grew by an estimated 3% per year between 2008 and 2010, as compared with over 6% between 2000 and 2008 (RMWB 2010). • The non-resident population is approximately 25,000 in 2010. It was composed of mobile workers living primarily in camps, but also in hotels, motels and campgrounds in the region (RMWB 2010).
Land	• The geography and location of Fort McMurray at the confluence of the Clearwater and Athabasca rivers creates land development challenges and a non-concentric city shape. • Active intervention by (Alberta Housing Corporation to develop land for housing, roads, and commercial facilities. • Expansion of housing subdivisions in Fort McMurray (e.g., Beacon Hill and Thickwood Heights in 1973). • Development of Timberlea (Area Structure Plan in 1980, first houses built in 1985/86).	• Limited or no demand for residential, commercial, and industrial land. • Substantial availability of developed land in Timberlea throughout most of the period. Re-emergence of oil sands industry development sees increased land uptake in Timberlea in the mid to late 1990s.	• Absorption of available lands in Timberlea by resurgence of home building in late 1990s. • Predominance of provincially owned Crown lands in the region and especially around Fort McMurray creates challenges for the timely availability of developable land for residential, commercial and industrial uses. • Piecemeal release of land for development, including Parsons Creek and North Parsons. • Emerging demand for developable land in outlying communities (e.g., Anzac) and for commercial and industrial land. • Fort McKay First Nation opens an industrial park on reserve lands near Shell and Syncrude mines, north of the Peter Lougheed Bridge. • High land prices.	• Release of land for the North Parsons and Saline developments. • Development of few industrial subdivisions. • Memorandum of Understanding between the RMWB and Alberta regarding the establishment of an Urban Development Sub-region that will give the municipality jurisdiction over sufficient land to undertake residential, commercial and industrial development for up to 200,000 residents.

Table 2.5-5 Regional Development, 1960 to 2011 (continued)

Socio-Economic Area	Period 1: Early 1960s to 1986	Period 2: 1986 to Late 1990s	Period 3: Late 1990s to 2008	Period 4: 2008 to 2011
Housing	• The number of dwelling units in Fort McMurray increases from 300 in 1961 to more than 8,500 units in 1978, and then to over 12,000 in 1986 (AOSERP 1979; RMWB 1999). • Emergence of duplexes, row housing, apartments, including high-rise apartment buildings, and mobile dwellings. • Focus of initial development is on the lower townsite, Beacon Hill, Waterways, and Gregoire Park. • Residential development in Thickwood Heights across the Athabasca River starts in the mid 1970s. • Housing prices increases from below to well above Edmonton equivalents during Syncrude construction. Prices moderate after its completion and fall with the cancellation of the Alsands project in early 1980s. • Syncrude, Suncor, and the Alberta Housing Corporation, a provincial Crown corporation, have a large and direct involvement in the housing market.	• Period with high rental vacancies, depressed housing prices, limited new residential construction, and the withdrawal of Syncrude, Suncor, and the Alberta Housing Corporation from direct involvement in the housing market. • The housing stock is estimated at 12,755 units in 1999, a very slight increase from 1986 (RMWB 1999). • Limited residential growth in the Thickwood Heights and adjacent Timberlea area.	• Period of housing expansion. • Housing prices in Fort McMurray more than doubled between 2003 and 2008 (FMREB 2009). By 2008, rental rates are the highest in Canada and vacancy rates remain close to zero (CMHC 2008). • The impact of the high housing costs on residents depends on income level. Higher wages for many residents, particularly those working in the oil sands sector, help to offset high housing prices. A formal and informal market for room rental also provides homeowners with additional income. • Housing affordability challenges for middle and low income residents, particularly those working in the service sector. • The Government of Alberta and the RMWB provide cost-of-living allowance to their employees, including all provincially funded organizations in Fort McMurray. • Escalating housing costs and the availability of sufficient land to accommodate future growth are central to growth pressure concerns voiced by stakeholders in the region (e.g., Wood Buffalo Business Case 2003 and 2005). • Alberta responds with the Radke Commission to investigate growth pressures and recommend solutions. • In 2007, RMWB releases the *Fringe Area Development Assessment*, Urban Service Area report (Preitsakis 2007) to guide further development decisions such as land release. • In 2008, the Government of Alberta announces plans to develop two new communities in Fort McMurray: Parsons Creek and Saline Creek Plateau. • Several oil sands projects in the area also begin moving towards an ”operations camp” model which serves to limit the near-term impact of these projects on the local housing market.	• The average price for single family dwellings drops in 2009 in response to the economic recession. House prices begin increasing again in 2010, rising to levels comparable with 2008. In 2011 house prices continue climbing in Fort McMurray, with an average selling price of over $730,000 (FMREB 2012). • Rental rate increases have moderated in Fort McMurray in recent years, but rents remain the highest among all urban centres in Alberta (CMHC 2010). • Housing costs remain the principal contributor to the high cost of living in Fort McMurray. • Many rural communities in the RMWB are also experiencing housing pressures as a result of: community members returning, often from Fort McMurray, to avoid high housing prices there; a young population and early family formation; and housing policies and funding allocations by Aboriginal Affairs and Northern Development Canada that do not tend to respond quickly to changing situations.
Transportation Infrastructure	• Expansion of transportation infrastructure in the region. • Highway 63 linking Fort McMurray to the rest of the province is completed in 1963. • Air traffic to and from the region and also intra-regional traffic (primarily Fort McMurray-Fort Chipewyan) increases significantly (AOSERP 1979). An airport is completed in 1967 and scheduled service begins in 1973 (AOSERP 1979). • Construction of the Peter Lougheed Bridge over the Athabasca River north of Fort McKay to gain access to oil sands leases east of the Athabasca.	• Upgrades on Highway 63 up to the Peter Lougheed Bridge over the Athabasca River just north of Fort McKay. • Completion of Highway 881 as a gravel road. • Cessation of dredging of the Athabasca River and much reduced barging services to Fort Chipewyan and other communities on Lake Athabasca. • Abandonment of the rail line between Lynton, near Saprae Creek and Waterways.	• Oil sands expansion leads to increased traffic throughout the region and beyond. For example, traffic on Highway 63 between Fort McMurray and Suncor increases from an estimated 6,570 vehicle movements per day in 2000 to 16,870 in 2007 (AT 2011). • Traffic concerns among local residents included: the increase in traffic congestion, including long traffic jams during peak hours; and the increase in traffic accidents and traffic fatalities. • Many road infrastructure improvement projects in the region, including twinning sections of Highway 63 between Fort McMurray and Suncor and Syncrude; upgrade of Highway 881 to all-weather road status. • New aerodromes at Shell and Canadian Natural and other projects. • Rail upgrades, but rail traffic remains constrained by limited load capacity and challenging rail bed conditions.	• Road infrastructure in the area continues to undergo changes and improvements. Road work recently completed or underway includes: • improvements to the intersection of Highway 63 with the Fort McKay access road; • construction of a new five-lane bridge on Highway 63 over the Athabasca River, on the northern edge of Fort McMurray; and • Highway 63 interchanges with Thickwood Boulevard and Confederation Way as well as the Morrison and Hardin Street intersections bypass lane. • Long-term planning is underway for future infrastructure requirements, including highways required for oil sands growth (e.g., highway improvements recommended in the Athabasca Oil Sands Area Comprehensive Regional Infrastructure Sustainability Plan).
Local Government	• Fort McMurray is designated as a “New Town” under the *New Towns Act*. • Extensive involvement of the provincial government in administration, planning and community development, coordinated through the Northeast Commission. • Fort McMurray attains city status in 1980, giving more autonomy to the local government authorities. • Alberta Municipal Affairs administers Improvement District 18 (ID 18), which is composed the rural area and the hamlets in the area. Residents of ID 18 have an advisory role in the conduct of municipal affairs by means of two Advisory Committees. • Each of the five First Nations bands (Athabasca Chipewyan First Nation, Mikisew Cree First Nation, Fort McKay First Nation, Fort McMurray First Nation, and Chipewyan Prairie Dene First Nation) is governed by a Chief and Council.	• Creation of the Regional Municipality of Wood Buffalo in 1995. It comprises both the City of Fort McMurray (now the urban service area of Fort McMurray) and the rural area, including the hamlets of Fort Chipewyan, Fort McKay, Anzac, Janvier and Conklin. • Both the urban and rural areas have formal representation on the Regional Council. • With the creation of the Regional Municipality, the relationship between the provincial government and local government becomes the same as in other areas of the province. • Each of the five First Nations bands is governed by a Chief and Council.	• In 2007 the provincial government establishes the Oil Sands Sustainable Development Secretariat to coordinate and improve planning, communications and service delivery to Alberta’s oil sands regions, including the Wood Buffalo region. • The provincial government also provides the municipality with $3.6 million over three years (2007 to 2010) for strategic planning support. • Each of the five First Nations bands is governed by a Chief and Council.	• Extensive planning for growth, by the municipality and Alberta. • The Oil Sands Sustainable Development Secretariat develops Responsible Actions: A Plan for Alberta’s Oil Sands (Government of Alberta 2009), and the Athabasca Oil Sands Area Comprehensive Regional Infrastructure Sustainability Plan (Government of Alberta 2011). • Each of the five First Nations bands is governed by a Chief and Council.

Table 2.5-5 Regional Development, 1960 to 2011 (continued)

Socio-Economic Area	Period 1: Early 1960s to 1986	Period 2: 1986 to Late 1990s	Period 3: Late 1990s to 2008	Period 4: 2008 to 2011
Municipal Finance	• Extensive direct provincial government investment in municipal infrastructure and services.	• Integration of rural (industrial) and urban (residential/ commercial) tax base through the creation of the Regional Municipality of Wood Buffalo. • Limited or no assessment and tax revenue growth and general era of reduced government support for municipalities. • Focus is on municipal costs containment and fiscal balance.	• Rapid increase in municipal infrastructure and service demands linked to population growth. • Expansion of municipal capital and operating budgets. Concerns about debt financing, but the limited capacity to execute projects keeps debt well within set limits. • Rapid growth in assessment and municipal tax revenue, but the growth lags relative to infrastructure and service demands. • Some provincial support for municipal infrastructure financing.	• Reduced pace of infrastructure and service demands, allowing the RMWB to catch up, in part, on earlier demand. • Continued rapid growth in assessment and municipal tax revenue as new facilities come on stream.
Municipal Infrastructure and Services	• Municipal Infrastructure reflects the growth waves of the 1960s and 1970s. Some municipal infrastructure (e.g., deep servicing of part of Timberlea) are in place when growth declines in early 1980s with the cancellation of the Alsands project. • Most of the residential, commercial and industrial development in the 1960s is concentrated in and around the lower town site. • The second wave of municipal infrastructure development extends to north of the Athabasca River. • Expansion of municipal service delivery capacity in Fort McMurray; limited capabilities to deliver municipal services in ID 18 and later the rural services area.	• Period of low population and municipal infrastructure demands. • Surplus capacity in most municipal infrastructure. Much of the urban service area's municipal infrastructure is sized to accommodate a population in excess of 50,000. • Retrenchment of municipal service delivery, reflecting low growth in assessment and reduction in provincial supports for all municipalities.	• Period of high demand for municipal infrastructure and services. • Expansion of basic municipal infrastructure, such as potable water and wastewater/solids treatment facilities that required additional capacity. • Ability to put in place infrastructure is limited by available resources to plan, engineer, and build projects. • Cost inflation for all infrastructure and services. • Challenges to recruit and retain municipal staff. • Most municipal infrastructure and services focus on the urban services area of Fort McMurray, where most population growth occurs.	• The municipality's planning initiatives to accommodate future growth include: updating the Municipal Development Plan; updating several municipal infrastructure master plans; and developing a population forecasting tool. • The redeveloped McDonald Island Park opens in 2009. It is billed as Canada's largest community, recreation, and leisure centre. Expansion plans are under way in early 2012. • As of August 2010, the RMWB has $1.4 billion of major infrastructure works in progress, including water, sewer, roads and expansion to water and wastewater treatment facilities (Kuehne 2010)
Services and Amenities	• Pressures on local services and infrastructure as population grows. These pressures are especially pronounced during the construction phases of the Suncor and Syncrude projects. • Expansion in available services and amenities in the region. • Construction of the Northern Lights Hospital (1979/80). • By 1976, Fort McMurray has four primary schools and one high school with an additional two under construction and one in the planning stage. • Keyano College builds and operates a Heavy Industrial Campus and a downtown campus focused on academic and industry training.	• Period of consolidation in services and amenities. • By 1996, Fort McMurray has 18 primary and secondary schools, a college with a campus in downtown Fort McMurray and on the south side of Fort McMurray, an 84-bed acute care hospital, and a broad range of protective, emergency, and social services.	• Increased demands on social infrastructure. Available resources often do not keep pace with this growth leading to increased strains and pressure on regional service providers. • In response, government and industry increase funding for social infrastructure and introduce new planning processes and initiatives to alleviate the pressures of rapid growth and to enhance the quality of life of local residents (e.g., the Syncrude Community Sport and Wellness Centre and Arts Centre at Keyano College).	• Between the end of 2008 and early 2011, the region sees an easing of some of the pressures associated with the high growth period of 2000 to 2008. • Recent positive developments in addressing social infrastructure challenges include: new agencies and structures (e.g., Oil Sands Sustainable Development Secretariat); new planning initiatives (e.g., the Athabasca Oil Sands Area Comprehensive Regional Infrastructure Sustainability Plan, Municipal Development Plan); new forecasting tools and information systems (e.g., the RMWB's Population and Employment Projection Model); and additional funding (e.g., over $2 billion since 2007 from the provincial government for infrastructure and services). • As of mid-2011, service delivery outcomes have improved in several social infrastructure areas, such as health and emergency services (e.g., reduced emergency department wait times, targeted emergency response times being met).

2.5.2.2.1 Regional Socio-Economic Effects

From the early 1960s to today, the region has transitioned from a relatively isolated part of the province with small communities and few amenities, into a region that is home to one of Alberta's larger urban centres. While these changes to some degree reflect the general enhancement of services and facilities which occurred throughout the province during this same timeframe, many of these changes were precipitated by the nature and pace of oil sands development.

Residents of the region have experienced the benefits of growth, driven by expansion of the oil sands industry, in a variety of ways, including:

- increased employment and contracting opportunities for residents, including for those groups that are currently under-represented in the labour force (e.g., Aboriginal persons);
- increased wages and benefits, which can be used by local workers to purchase goods and services;
- increased industry support for community programs and infrastructure used by residents;
- increased revenues to local government, which can be used to increase investment in public infrastructure and services or lower taxes;
- increased revenues to the provincial government, which can be used for province-wide funding, programs, and initiatives that will also benefit the region; and
- a broader range of local services and amenities, including both commercial (e.g., retail, industrial) and public (e.g., education, health, emergency services).

Along with, and sometimes as a direct result of, these benefits, growth over the years has also led to residents experiencing socio-economic challenges, primarily during the two major growth periods noted in Section 2.5.3.1.3 above. These pressures include:

- a shortage of housing, particularly affordable housing, due to high demand for accommodation;
- a rising cost of living, driven especially by housing costs;
- increased demand for regional services, including health, education, emergency, municipal, and social services;
- difficulties for both public and private sector service providers in meeting increased demand because of:
  - difficulties in attracting and retaining personnel because service providers are unable to offer higher wages to offset the high cost of living;
  - funding that has not kept pace with increasing demand from both the resident and non-resident population and rising service delivery costs; and
  - pre-existing structural issues in certain areas such as health care that are further exacerbated by growth in the region.
- increased pressure on physical public infrastructure in the region, including municipal infrastructure and the regional road network;

- increased numbers of non-permanent residents (e.g., camp-based workers) who draw on regional services and infrastructure;
- reduced community cohesion and a sense of transience among residents; and
- increased social stressors related to growth, such as work demands that take time away from family and community life.

Many of these socio-economic concerns do not exist in isolation but have influenced one another and further exacerbated socio-economic challenges in the region. For example, while the lack of affordable housing has created a demand on social service agencies in the area, it has also made it difficult for these same agencies to attract and retain the needed personnel to meet this increased demand.

The ability of service providers to address these challenges has expanded over the years as a result of increased resources (e.g., funding) and growth in the breadth and nature of social infrastructure services available. For example, police, emergency, education, social and health services have all expanded the size and nature of their service offerings. While responsible authorities in the region have often been stuck in catch-up mode in responding to socio-economic issues during periods of rapid growth, many of these service providers, such as the Regional Municipality of Wood Buffalo (RMWB), the Royal Canadian Mounted Police, Alberta Health Services, and others, have also developed into sophisticated organizations that are aware of, and are directly and vigorously engaged in, addressing these challenges. As noted in Table 2.5-5, recent positive developments (2008 to 2011) have expanded the capacity of responsible authorities to address socio-economic challenges. A number of these developments are further discussed in Attachment A.

2.5.2.2.2 Socio-Economic Effects on Aboriginal Peoples

Over the last 50 years, Aboriginal peoples in the region have experienced many of the same benefits and challenges related to regional growth as identified in above. Their way of life has changed enormously, including:

- settlement into permanent communities;
- changes in family and community practices and relations (e.g., child rearing, education, visiting);
- declining Aboriginal language skills;
- declining reliance on traditional harvesting;
- fewer traditional practices being carried out;
- increasing reliance on non-traditional activities for their livelihood (e.g., wage economy opportunities, government assistance);
- increasing social challenges, including alcohol and drug abuse; and
- increasing access to improved amenities and services (e.g., health care, emergency and social services).

Many of these changes are shared with other Aboriginal peoples across Canada and have been brought about by increasing contact with non-Aboriginal peoples, values and norms as a result of external influences largely outside their control, including:

- increased use of traditional lands for non-traditional purposes, whether it be resource development such as oil sands development in the Wood Buffalo region, diamond mining in the Northwest Territories, or increased agricultural development and encroaching urbanization in others parts of the country;
- education initiatives that have limited learning traditional knowledge values and practices; and
- increased access to other cultural influences through advancements in technology (e.g., television, computers, satellite, internet, cell phones).

Among these external influences, oil sands development has undoubtedly had a strong effect on the Aboriginal population in the region. These effects are detailed further in Table 2.5-6.

Table 2.5-6 Oil Sands Development Effects on the Local Aboriginal Population

Oil Sands Development Practices	Effects on the Local Aboriginal Population
Taking up portions of land for a period of time	• Reducing opportunities to carry out traditional activities on oil sands industry-affected lands and to transmit traditional culture and oral history while on the land. • Raising concerns regarding the effect of pollutants on traditional land and resources, thereby affecting how and where traditional practices are carried out.
Drawing on regional sources of water	• Raising concerns about the quantity and quality of water in the region that is relied upon for carrying out traditional activities (e.g., fishing, means of accessing traditional lands).
Offering opportunities for increased engagement in the wage economy	• Limiting opportunities to carry out traditional pursuits and transfer traditional knowledge to Aboriginal youth while on the land. • Providing greater household spending power, lower need for government transfer payments, and an improved sense of self-worth for some. • Increasing incomes, which may lead to increased disparity and social stratification within Aboriginal communities. • Increasing incomes, which may contribute to negative behaviours, including increased alcohol and drug abuse and gambling, especially among those lacking financial experience.
Increasing the non-Aboriginal population in the region	• Increasing competition for traditional resources from non-Aboriginal community members. • Increasing the exposure to outside cultural values.

Aboriginal peoples in the region are concerned that environmental effects related to industrial development have affected their way of life. Along with various other changes, the use of land and regional water sources by industry has contributed to a declining reliance on traditional harvesting and fewer traditional practices being carried out. This, in turn, has driven socio-economic change within Aboriginal communities by increasing the reliance of local Aboriginal peoples on non-traditional activities for their livelihood and contributing to ongoing social changes within the community (e.g., changes in family and community practices and relations).

Oil sands development has also had a number of positive socio-economic effects on Aboriginal peoples in the, region such as employment and contracting income.

2.6 Conclusions

This section provides conclusions of the comparison between the PIC and the 2012 Base Case to enable the JRP to take into account the effects that may have occurred prior to JME.

2.6.1 Air Quality and Environmental Health Summary

The level of anthropogenic emissions in the region would generally be lower in the PIC than in the 2012 Base Case, discussed in Appendices 1 and 3.2. Accordingly, while human health risks could not be adequately characterized for the PIC owing to the overall quality of the database of measured air, soil and vegetation data prior to 1965 for the compounds relevant to the Human Health Risk Assessment, there would be lower human health risks via exposure pathways that were dependant on these datasets. The air emissions effects on ecological receptors could also not be assessed for the PIC, as much of the essential environmental data for the air emissions effect analyses are not available from the PIC period. As already stated, the level of anthropogenic emissions in the region would generally be lower in the PIC than in the 2012 Base Case predictions.

2.6.2 Aquatic Resources Summary

Muskeg drainage and overburden dewatering cause changes in the flow of the Muskeg River which fluctuate over the lives of the projects in the 2012 Base Case. Accordingly, the difference in conditions between PIC and 2012 Base Case are examined at four snapshots in time to show the effects to flows over the progression of development from dewatering, through closed-circuit conditions, to reclamation.

For the 2012 snapshot, mean annual flow at Node M3 in the Muskeg River (i.e., downstream of the 2012 Base Case developments) increases from PIC levels with the added contributions from mine dewatering activities. This flow increase compared to PIC diminishes over time as the total closed-circuit area of the combined 2012 Base Case projects becomes larger (i.e., for the 2029 and 2049 snapshots). In 2065 when developments in the 2012 Base Case have reached Closure and pit lakes are introduced, flood flows are attenuated and low flows increased. This results in a 2065 snapshot where the 7Q10 low flow (lowest 7-day consecutive flow that occurs, on average, once every 10 years) remains higher than the PIC value while the mean annual flow in the lower Muskeg River returns close to the PIC conditions.

For the Athabasca River, the net annual water allocation to all existing and approved oil sands developments represents a reduction in the mean annual Athabasca River flow of about 2.1% based on the recorded river flows at Fort McMurray from PIC to 2012 Base Case. The combined reductions in seasonal flows in Reach 4 are less than 13% for an average year. The predicted combined changes in flow depths at Node S24 (i.e., downstream of the projects in the 2012 Base Case) are less than 1%.

For water quality in both the small streams and the Athabasca River, total metals and nutrients frequently exceeded guidelines under PIC conditions and therefore guideline exceedances are generally predicted to increase due to industrialization from PIC to 2012 Base Case.

2.6.3 Terrestrial Resources Summary

The increased development activities from the PIC to the 2012 Base Case in the RSA has resulted in a decrease in mineral and organic soils and a corresponding increase in disturbed landscapes. The increased development activities from the PIC to the 2012 Base Case in the RSA has resulted in a decrease in mineral and organic soils and a corresponding increase in disturbed landscapes.

The regional vegetation classification identifies 13 RLCCs including six terrestrial classes, three wetlands classes, two miscellaneous land cover classes, and two disturbance classes in the RSA. Changes in RLCCs from the PIC to 2012 Base Case range from less than 1% to 13% of the RSA. The largest change occurs in the disturbance category. Total disturbances including cutblocks increased by 288,894 ha (13% of the RSA) due to the loss or alteration of other RLCCs. Approximately 109,254 ha (5% of the RSA) of wetlands were lost or altered. Terrestrial vegetation was also reduced by 154,814 ha (7% of the RSA). The amount of burn decreased by 24,311 ha (1% of the RSA).

The increase in human disturbances from the PIC to the 2012 Base Case is predicted to result in an increase in the amount of high suitability habitat in the RSA for short-eared owl. There is a decrease in the amount of high suitability wildlife habitat for all remaining KIRs and SAR for which effects on habitat were assessed. The decline in high suitability habitat is of low magnitude (i.e., a less than 10% change) for common nighthawk and woodland caribou, of high magnitude (i.e., a greater than 20% change) for barred owl, black-throated green warbler, Canada warbler and wood bison, and of moderate magnitude (greater than 10% change, but less than 20%) for all other wildlife KIR and SAR for which changes in habitat were assessed.

For the PIC, “nil” suitability habitat (i.e., unsuitable) was estimated to make up less than 0.1% of the RSA for wolverine, and 2% of the RSA for black bear, Canada lynx, fisher and moose. However, for all remaining wildlife KIRs and SAR, the few developments in the PIC combined with natural land cover types representing nil habitat suitability for these species (EIA, Volume 5, Section 7.6.3, and May 2011, Submission of Information to the Joint Review Panel), range from 10% of the RSA for common nighthawk to 88% of the RSA for yellow rail. The increase in the areal extent of nil habitat from the PIC to the 2012 Base Case ranges from 1% of the RSA for horned grebe and yellow rail to 20% of the RSA for woodland caribou.

The changes in biodiversity potential from the PIC to 2012 Base Case range from a loss of 5% of the RSA (moderate-ranked areas) to a gain of 8% of the RSA (low-ranked areas). The largest changes occur to the disturbance and cutblock RLCCs (both low-ranked), with a combined increase of 13% of the RSA (298,258 ha). There is an overall decrease of 65,128 ha (3% of the RSA) in high biodiversity potential areas from 543,521 ha in the PIC to 478,393 ha at 2012 Base Case. This change is nearly equally distributed between losses to non-treed wetlands and treed fens. There is an overall decrease of 119,534 ha (5% of the RSA) in moderate biodiversity potential areas from 842,132 ha in the PIC to 722,598 ha at 2012 Base Case. Reductions in the terrestrial RLCCs represent the majority of this change. There is an overall increase of 185,380 ha (8% of the RSA) in low biodiversity potential areas from 891,004 ha in the PIC to 1,076,385 ha at 2012 Base Case. The majority of this change is due to additional cutblocks in the landscape.

2.6.4 Human Environment Summary

The cumulative effects of development between the PIC and the 2012 Base Case have disturbed between 17% and 26% of the FMFN CSE. The cumulative effects of development between the PIC and the 2012 Base Case have disturbed 7% of the area of the ACFN RSA, and 4% of the area of the MCFN RSA.

Without oil sands development, the regional population would be much smaller than it is today and communities in the region would not have experienced many of the socio-economic challenges precipitated by development. At the same time, the region and its residents would not have realized many of the benefits of development, including jobs, income, and increased service offerings and amenities. Although growth is a pathway by which many socio-economic effects occur, the level of that growth alone is not a sufficient indicator of the nature and magnitude of these effects. Consideration must be given to the availing processes and systems in place to handle and address these effects. In the Wood Buffalo region, these processes and systems have expanded considerably over time, especially in recent years as a response to rapid growth in the late-1990s to 2008 period.

3.0 PLANNED DEVELOPMENT CASE

3.1 Introduction and Approach

Shell Canada Energy (Shell) submitted the Applications and supporting Environmental Impact Assessment (EIA) for the Jackpine Mine Expansion (JME) and Pierre River Mine (PRM) Project in December 2007. As part of the regulatory process for the JME Application, the Joint Review Panel (JRP) provided Supplemental Information Requests (SIRs) dated January 30, 2012.

In JRP SIR 11 of the January 30 submission, the JRP requested, among other items an updated Planned Development Case (PDC) to account for foreseeable projects and activities publicly disclosed since the EIA for JME was completed. Also, the JRP requested that Shell include updated forest harvesting information and the effects of past and future forest fires. This section of Appendix 2 presents the updated PDC assessment.

The JRP Terms of Reference required the EIA PDC be updated to be current to September 2011. A detailed list of the projects included in the updated PDC is provided in Appendix 3.1. For the purposes of this submission, the updated PDC is referred to as the 2012 PDC and supercedes the EIA PDC. The PRM is included as a planned development in the 2012 PDC assessment.

The approach to conducting cumulative effects assessments defined by the *Canadian Environmental Assessment Act* indicates that environmental effects should be considered when they accumulate or interact with those of other developments. Therefore, only residual impacts that were considered to have low, moderate or high environmental consequences in the either the EIA Application Case or the 2012 JME Application Case (Appendix 1), as applicable, have been assessed. Residual impacts resulting in a negligible rating indicate that the cumulative effects of JME emissions are not distinguishable from Base Case conditions. Therefore, there is no appreciable incremental change with the addition of JME to the Base Case conditions, and no requirement for a further cumulative assessment.

The response to JRP SIR 11 was developed with consideration of the other JRP information requests, items raised by regulators and stakeholders during the EIA sufficiency review, and commitments made previously by Shell for supporting assessment work. Accounting for these items in the assessment provides an appropriate and more robust assessment and maintains consistency between this response and the other information presented in the submission. Key assessment approach updates that are included in this submission include:

- Updated Base Case: The EIA Base Case information was updated similar to the 2012 PDC with a project inclusion list current to September 2011. This was done to allow a reasonable comparison between assessment case information within this submission. For example, Total Joslyn North Mine has been added to the Base Case, given that regulatory approval has been granted for this project. A detailed list of the projects included in the updated Base Case is provided in Appendix 3.1 (Section 2.4). This updated assessment case is referred to as the 2012 Base Case in this submission. The 2012 Base Case information is considered in the PIC and some portions of the 2012 PDC assessment.
- Updated Application Case: JRP SIR 8 requested Shell present the effects of JME alone, in isolation from PRM, for specific sections of the EIA. This updated assessment case for JME is referred to as the 2012 JME Application Case throughout the JRP SIR submission and is presented in Appendix 1. The 2012 JME Application Case results are also discussed in the 2012 PDC assessment. Updated approach to assessing forest fire and timber harvest: A key change in approach involves use of A Landscape Cumulative Effects

Simulator (ALCES) model to simulate forest fire and harvest information to address a portion of JRP SIR 11. Landscape simulations were conducted using the ALCES and ALCES Mapper® computer programs. The ALCES® program was used to simulate the effects of fire, timber harvest, and industrial development in the RSA over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the Pre-Industrial Case, 2012 Base Case, 2012 JME Application Case and 2012 PDC in this submission.

Other approach updates specific to individual technical components are discussed in their respective introductory sections within this appendix: Section 3.2 for Air Quality and Environmental Health, Section 3.3 for Aquatic Resources, Section 3.4 for Terrestrial Resources and Section 3.5 for Human Environment.

3.2 Air Quality and Environmental Health

This section provides the results of the 2012 PDC assessments for Air Quality and Environmental Health to inform the cumulative effects on air quality, human health risk, wildlife health risk and air emission effects on ecological receptors. The 2012 PDC includes a review of the cumulative air quality effects that could result from the existing and approved developments, JME and PRM, and the planned (publicly disclosed) developments in the Oil Sands Region, as of September 2011.

These assessments focus on determining changes to the chemical composition of the air and the effects of these changes in air quality and deposition to the receiving environment. Potential short-term (acute) and long-term (chronic) health risks to people and wildlife are assessed, as well as effects on ecological receptors, including aquatic and terrestrial resources.

The approaches used for these assessments are the same as those used in the EIA with the following exceptions:

- Shell has adjusted its assumptions around mine fleet emissions used in the assessment of potential acid input given the introduction of *Regulations Amending the Off-Road Compression-Ignition Engine Emission Regulations* by the Government of Canada (December 2011). Further discussion on this is provided in Appendix 3.2.
- The Alberta Ambient Air Quality Objectives (AAAQOs) for sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter with a mean aerodynamic diameter of 2.5 µm or smaller ($PM_{2.5}$) have been revised since the EIA (AENV 2011), as presented in Appendix 3.1.
- The Human Health Risk Assessment updated the following aspects of the assessment:
  - Description of the existing conditions, including exposure and health studies;
  - Problem formulation, including changes to the final list of Chemicals of Potential Concern (COPCs) and revisions to the consumption rates;
  - Exposure assessment, including a re-evaluation of how the physical-chemical characteristics were used to identify the non-volatile, potentially bioaccumulative chemicals; and
  - Toxicity assessment, including an update of any new health-based exposure limits.

3.2.1 Air Quality Assessment

3.2.1.1 Regional Emissions

The 2012 PDC includes planned projects that have not received approval to operate, some of which have yet to apply for approval. Although most of these planned developments are only disclosed and have not yet been the subject of formal approval applications, they would result in additional environmental effects in the Oil Sands Region should they proceed. The developments included in the 2012 PDC compared to those included in the EIA PDC are presented in Table 3.2-1. Projects included in the 2012 PDC that were updated since the EIA PDC are also indicated. Appendix 3.1 provides additional details on the 2012 PDC project inclusion list.

The emissions calculated for the 2012 PDC are, in part, speculative given that limited emission information is available for future planned projects. Because these developments are in various stages of planning, the following should be noted:

- There is uncertainty about whether these planned developments will proceed.
- All of the planned developments must submit applications, undergo assessment, and receive approval before proceeding.

Table 3.2-1 Oil Sands Activities Included in the EIA Planned Development Case and the 2012 Planned Development Case

Oil Sands Development	EIA PDC	2012 PDC	Location	
			Distance [km]	Direction
Shell Canada Limited				
Jackpine Mine Expansion & Pierre River Mine Project	Yes	Updated	–	–
Jackpine Mine - Phase 1	Yes	Yes	–	–
Orion Enhanced Oil Recovery (EOR) Project	Yes	Yes	306.9	SSE
Grosmont Pilot	No	Yes	138.9	WSW
Shell Canada Limited / Albian Sands Energy Inc.				
Muskeg River Mine and Muskeg River Mine Expansion	Yes	Updated	7.1	WNW
Alberta Oilsands Inc.				
Clearwater West Pilot Project	No	Yes	67.4	S
Athabasca Oil Sands Corp. (AOSC)				
Dover Pilot Project	No	Yes	81.3	W
Dover Commercial Project	No	Yes	75.4	W
Dover West Clastics Phase 1	No	Yes	103.8	WSW
Dover West Leduc Carbonate Pilot	No	Yes	103.8	WSW
Hangingstone Experimental In-Situ Project	No	Yes	89.9	S
Hangingstone Project Phase 1	No	Yes	84.5	S
MacKay River Pilot Project	No	Yes	61.2	SW
MacKay River Commercial Project	No	Yes	66.0	SW
BlackPearl Resources Inc.				
Blackrod SAGD Pilot and Commercial Project	No	Yes	196.0	SSW
Canadian Natural Resources Limited				
Birch Mountain East Project (formerly Horizon In-Situ Project)	Yes	Updated	27.0	WNW
Burnt Lake Pilot Project	Yes	Yes	278.7	SSE

Table 3.2-1 Oil Sands Activities Included in the EIA Planned Development Case and the 2012 Planned Development Case (continued)

Oil Sands Development	EIA PDC	2012 PDC	Location	
			Distance [km]	Direction
Grouse In-Situ Oil Sands Project	No	Yes	198.3	S
Horizon Oil Sands Project	Yes	Updated	23.6	WNW
Kirby In-Situ Oil Sands Project (formerly Enerplus Resources Kirby In-Situ Project)	Yes	Updated	195.6	S
Kirby In-Situ Oil Sands Expansion Project	No	Yes	195.6	S
Primrose East In-Situ Project	Yes	Updated	279.8	SSE
Primrose North In-Situ Project	Yes	Updated	267.5	S
Primrose South In-Situ Project	Yes	Updated	279.0	S
Wolf Lake In-Situ Project	Yes	Updated	285.9	S
Cenovus Energy				
Telephone Lake SAGD Project (formerly Borealis In-Situ Project)	Yes	Updated	61.8	E
Grand Rapids SAGD Pilot Project	No	Yes	181.4	SW
Pelican Lake SAGD Project	No	Yes	173.5	SW
Cenovus FCCL Ltd.				
Christina Lake Thermal Project	Yes	Updated	187.0	S
Christina Lake Thermal Project Expansion	No	Yes	187.0	S
Foster Creek Thermal Project	Yes	Updated	247.4	SSE
Foster Creek Thermal Project Expansion	No	Yes	247.4	SSE
Narrows Lake Project	No	Yes	179.5	S
Connacher Oil and Gas Limited				
Algar Oil Sands Project	No	Yes	126.6	S
Great Divide Oil Sands Project	Yes	Updated	127.9	SSW
Great Divide Oil Sands Expansion Project	No	Yes	126.7	S
ConocoPhillips Canada Resource Ltd.				
Surmont Pilot and Commercial SAGD Project	Yes	Updated	116.7	SSE
Devon NEC Corporation				
Jackfish SAGD Project	Yes	Updated	193.0	S
Jackfish SAGD Project 2	Yes	Updated	192.2	S
Jackfish SAGD Project 3	No	Yes	193.6	S
Devon Energy and BP Canada				
Pike Project	No	Yes	202.7	S
E-T Energy				
Poplar Creek In-Situ Pilot	No	Yes	47.8	S
Poplar Creek ET-DSP Project	No	Yes	44.2	S
Grizzly Oil Sands				
Algar Lake SAGD Project	No	Yes	100.9	SSW
Harvest Operations Corp.				
Blackgold Oil Sands Project and Expansion	No	Yes	186.2	S
Husky Energy Inc.				
Caribou Lake Thermal Demonstration Project	No	Yes	258.7	S
McMullen Thermal Pilot Project	No	Yes	227.3	SW
Sunrise Thermal Project	Yes	Yes	20.0	E
Tucker Thermal Project	Yes	Yes	301.8	S

Table 3.2-1 Oil Sands Activities Included in the EIA Planned Development Case and the 2012 Planned Development Case (continued)

Oil Sands Development	EIA PDC	2012 PDC	Location	
			Distance [km]	Direction
Imperial Oil Resources Ltd.				
Cold Lake In-Situ Project	Yes	Yes	294.6	S
Imperial Oil Resources Ventures Ltd.				
Kearl Oil Sands Project	Yes	Yes	26.8	NE
Ivanhoe Energy Inc.				
Tamarack Integrated Oil Sands Project	No	Yes	46.1	S
Japan Canada Oil Sands Ltd.				
Hangingstone Pilot In-Situ Project	Yes	Updated	103.4	S
Hangingstone SAGD Project	Yes	Updated	107.8	S
MEG Energy Corp.				
Christina Lake Regional Project - Pilot, Phases 2and 2B	Yes	Updated	180.0	SSE
Christina Lake Regional Project - Phase 3	No	Yes	187.7	SSE
Surmont Project	No	Yes	137.6	SSE
Koch Exploration Canada				
Germini Oil Sands Project	No	Yes	346.2	S
Laricina Energy Ltd.				
Germain Phase 1 and Expansion	No	Yes	158.5	SW
Saleski Pilot and Phase 1	No	Yes	131.0	SW
OPTI Canada Inc. / Nexen Canada Ltd.				
Long Lake Pilot Project	Yes	Yes	96.9	SSE
Long Lake Commercial Project	Yes	Yes	96.3	SSE
Long Lake Project Phases 1 and 2	No	Yes	107.2	SSE
Oak Point Energy Ltd.				
Lewis Pilot	No	Yes	29.2	SE
OSUM Oil Sands Corp.				
Taiga Project	No	Yes	295.1	SSE
Paramount Resources Limited				
Hoole Project	No	Yes	193.4	SW
Petrobank Energy and Resources Ltd.				
May River Phase 1 Project and Expansion	No	Yes	175.7	S
Whitesands Pilot Project	Yes	Updated	175.4	S
Whitesands Expansion Project	No	Updated	175.4	S
Suncor Energy Inc. (formerly Petro-Canada Oil Sands Inc.)				
Fort Hills Oil Sands Project	Yes	Updated	20.2	NNW
SilverBirch Energy				
Frontier Project	No	Yes	51.2	NNW
Southern Pacific Resource Corporation				
MacKay River Project and Expansion	No	Yes	65.1	SW
StatoilHydro Canada Ltd.				
Kai Kos Dehseh SAGD Project	Yes	Updated	158.2	S
Suncor Energy Inc.				
Chard Project	No	Yes	148.8	S
Dover SAGD Pilot and VAPEX Pilot	Yes	Yes	37.8	WSW

Table 3.2-1 Oil Sands Activities Included in the EIA Planned Development Case and the 2012 Planned Development Case (continued)

Oil Sands Development	EIA PDC	2012 PDC	Location	
			Distance [km]	Direction
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	Yes	Yes	33.5	E
Firebag SAGD Project	Yes	Updated	32.7	E
Lease 86/17, Steepbank & Millennium Mines	Yes	Updated	31.2	S
Lewis SAGD Project	Yes	Yes	43.0	SSE
MacKay River In-Situ	Yes	Updated	38.0	SW
MacKay River Expansion SAGD Project	Yes	Updated	36.1	WSW
Meadow Creek In-Situ	Yes	Updated	98.2	S
Meadow Creek Expansion SAGD Project	Yes	Updated	98.2	S
Millennium Coker Unit (MCU)	Yes	Updated	26.1	SSW
Millennium Vacuum Unit (MVU)	Yes	Updated	25.9	SSW
North Steepbank Extension Mine and Millennium Dump 9	Yes	Updated	24.3	S
South Tailings Pond	Yes	Updated	40.8	S
Upgrader Complex	Yes	Updated	26.3	SSW
Voyageur South Project	Yes	Yes	37.0	SSW
Voyageur Upgrader	Yes	Updated	30.7	SSW
Fort Hills Oil Sands Project	Yes	Updated	20.2	NNW
Sunshine Oil Sands Ltd.				
Harper Pilot	No	Yes	147.8	W
Legend Lake SAGD Project Phase 1	No	Yes	87.7	W
Thickwood SAGD Project Phase 1	No	Yes	95.5	WSW
Syncrude Canada Ltd.				
Aurora North Mine	Yes	Yes	9.6	NW
Aurora South Mine	Yes	Updated	9.9	ESE
Mildred Lake Upgrader	Yes	Yes	25.7	SSW
Total E&P Canada Ltd.				
Joslyn Creek SAGD Project - Phase 1 and Commercial	Yes	Updated	30.8	W
Joslyn Creek SAGD Expansion	Yes	Yes	30.7	W
Joslyn North Mine Project	Yes	Updated	26.0	W
Joslyn Mine Expansion	No	Updated	30.7	W
Northern Lights Project[(b)]	Yes	No	41.4	NNE
Value Creation Inc. (VCI)				
Terre de Grace Pilot and SAGD Project	No	Yes	41.7	WNW
TriStar Pilot Project	No	Yes	74.3	S
Other Industries	Yes	Updated	–	–
Communities	Yes	Updated	–	–

(a) Distance and direction are relative to the Jackpine Mine Expansion plant site.

(b) The Northern Lights Project application has been postponed.

– = Not applicable.

The oil sands industrial and non-industrial source emissions used in the 2012 PDC are summarized in Table 3.2-2. Details on the emission source parameters and emission rates for 2012 PDC sources are presented in Appendix 3.2 of this submission.

Table 3.2-2 Summary of 2012 Planned Development Case Emissions

Source	Emissions Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC[b] [t/d]	TRS[b] [t/d]
Shell Project and Jackpine Mine - Phase 1	0.09	0.09	29.22	26.89	1.19	43.33	0.36
other Shell projects	2.00	2.00	2.06	2.37	0.33	0.10	0.00
Shell/Albian Sands	0.61	0.61	30.73	27.03	1.61	26.80	0.13
Suncor Energy Inc.	63.52	91.65	167.64	90.35	12.04	345.39	3.52
Syncrude Canada Ltd.	67.17	100.17	101.21	98.73	8.72	183.94	3.12
Canadian Natural Resources Limited	22.62	27.71	79.76	56.86	4.40	158.86	2.42
other industrial[c]	137.53	141.16	330.88	543.79	19.99	346.88	1.70
gas plants	2.18	2.18	22.56	5.82	0.28	0.70	0.00
communities	0.76	0.76	4.89	–[d]	–[d]	14.39	0.00
Total	**296.48**	**366.33**	**768.95**	**851.83**	**48.56**	**1,120.40**	**11.25**

(a) Emissions are expressed as tonnes per stream-day (t/sd), tonnes per calendar-day (t/cd) or tonnes per day (t/d).

(b) VOC and TRS emissions for Suncor, Canadian Natural Horizon, Imperial Oil Kearl, Syncrude Aurora South, Suncor Fort Hills and Total Joslyn tailings ponds represent the maximum daily emission rates and vary as discussed in EIA, Volume 3, Appendix 3-8, Section 3.5. The emissions presented for SilverBirch Frontier tailings represent the maximum annual emission rates and also vary. (Teck 2011).

(c) The "other industrial" category includes the emissions from other oil sands developments and industrial sources.

(d) Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in the EIA Volume 3, Appendix 3-8, Section 2.3.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.

3.2.1.2 Assessment Results

The approach to conducting cumulative effects assessments defined by the *Canadian Environmental Assessment Act* (CEAA) indicates that environmental effects should be considered when they accumulate or interact with those of other developments. Although modelling was conducted to predict concentrations of SO_2, NO_2, CO, $PM_{2.5}$, select TRS, Volatile Organic Compounds (VOCs), PAHs and metals in the region and at selected regional communities, only those compounds that had a low, moderate or high environmental consequence are included in this section. This is consistent with the approach used in the EIA (Volume 3, Section 2.1.2). All of the predictions for the 2012 PDC are presented in Appendix 3.2.

Ambient Air Quality

The 2012 JME Application Case resulted in low, moderate or high environmental consequences for the following compounds: hydrogen sulphide (H_2S) and select VOCs. The 2012 PDC predictions for these parameters are presented in this section along with a comparison with the 2012 Base Case and 2012 JME Application Case predictions. Other air quality parameters were also assessed and the results are provided in Appendix 3.2. The modelling results were compared to the AAAQOs (AENV 2011) or other criteria, where applicable. Some parameters (e.g., VOCs) have possible effects on the health of the people and wildlife in the region. The dispersion modelling results for these compounds have been assessed in the Environmental Health section (Sections 3.2.2, 3.2.3 and 3.2.4).

The 2012 Base Case, 2012 JME Application Case and 2012 PDC emissions are summarized in Table 3.2-3 for the air quality parameters included in the 2012 PDC impact assessment. When the 2012 Base Case and 2012

PDC emissions are compared, there is a projected increase of 58% for VOCs and 46% for Total Reduced Sulphur (TRS) due to planned projects in the region.

Table 3.2-3 Summary of 2012 Base, 2012 JME Application and 2012 Planned Development Case Emissions

Descriptions	2012 Base Case	2012 JME Application Case	2012 Planned Development Case
VOC emissions [t/d][(a)]	708.39	716.29	1,120.40
TRS emissions [t/d][(a)]	7.73	7.80	11.25

(a) The VOC and TRS emissions for Suncor, Canadian Natural Horizon, Imperial Oil Kearl, Syncrude Aurora South, Suncor Fort Hills and Total Joslyn tailings ponds represent the maximum daily emission rates and vary as discussed in Appendix 3.2. The emissions presented for SilverBirch Frontier tailings represent the maximum annual emission rates and also vary.

Comparisons of the 2012 Base Case, 2012 JME Application Case and 2012 PDC predictions in the regional communities for H_2S are provided in Table 3.2-4. The 2012 PDC predictions in the regional communities are within AAAQOs.

A comparison of the 2012 Base Case, 2012 JME Application Case and 2012 PDC VOC predictions in the regional communities is presented in Table 3.2-5. The 2012 PDC predicted VOC concentrations are within applicable AAAQOs and other criteria at all locations except Fort McMurray, Cabin J and Cabin K.

Cabin J is located 19 km north-northwest of the Jackpine Mine plant site and within another regional project lease. For the purposes of this assessment, Cabin J is assumed to remain in its current location; however, it should be noted that this cabin will likely be relocated due to planned development. The 2012 Base Case and 2012 JME Application Case maximum 1-hour acrolein predictions at Cabin J are slightly above the Texas Commission on Environmental Quality (TCEQ) Effects Screening Level (ESL) of 2.3 µg/m³ (TCEQ 2003); however, there is no change due to JME. As a result of changes to other regional projects mine fleets in the future, the 2012 PDC predictions are lower than 2012 Base Case. The peak 1-hour cyclohexane is above the TCEQ ESL of 1,400 µg/m³; however, it is only predicted to occur one hour per year (i.e., 0.01% of the time). The peak 1-hour ethylbenzene concentration is predicted to be above the AAAQO of 2,000 µg/m³ 30 hours per year (i.e., 0.3% of the time), while the 1-hour xylene concentration is predicted to be above the AAAQO of 2,300 µg/m³ 38 hours per year (i.e., 0.4% of the time). These exceedances are due to other regional projects.

Cabin K is located 17 km north-northwest of the Jackpine Mine plant site and within another regional project lease. For the purposes of this assessment, Cabin K is assumed to remain in its current location; however, it should be noted that this cabin will likely be relocated due to planned development. The 2012 PDC peak 1-hour xylene prediction is above the AAAQO of 2,300 µg/m³ at Cabin K; however, it is only predicted to occur two hours per year (i.e., 0.01% of the time). These exceedances are due to other regional projects.

The 2012 PDC 1-hour benzene concentration is above the AAAQO of 30 µg/m³ in Fort McMurray and is predicted to exceed 2% of the time (215 hours per year). The 1-hour benzene exceedance is primarily due to the estimated increase in benzene emissions from future population growth in Fort McMurray.

Table 3.2-4 Comparison of Hydrogen Sulphide Predictions in the Regional Communities

Community	Peak 1-Hour H_2S[(a)(b)] [µg/m³]			Peak 24-Hour H_2S[(a)(b)] [µg/m³]			Peak Annual Average H_2S[(a)(b)] [µg/m³]		
	2012 Base Case	2012 JME Application Case	2012 Planned Development Case	2012 Base Case	2012 JME Application Case	2012 Planned Development Case	2012 Base Case	2012 JME Application Case	2012 Planned Development Case
Anzac	1.2	1.2	1.2	0.4	0.4	0.4	0.04	0.04	0.04
Conklin	0.2	0.2	0.2	0.1	0.1	0.1	0.01	0.01	0.01
Fort Chipewyan	0.2	0.2	0.2	0.1	0.1	0.1	0.00	0.00	0.01
Fort McKay	1.3	1.3	1.4	0.5	0.5	0.5	0.09	0.09	0.10
Fort McMurray	0.5	0.5	0.6	0.2	0.2	0.2	0.02	0.02	0.02
Janvier/Chard (IR 194)	0.2	0.2	0.2	0.1	0.1	0.1	0.01	0.01	0.01
Clearwater (IR 175)	0.3	0.3	0.4	0.1	0.1	0.1	0.01	0.01	0.02
Namur River (IR 174A)	0.5	0.5	0.5	0.1	0.1	0.2	0.01	0.01	0.01
Poplar Point (IR 201G)	0.3	0.4	0.9	0.2	0.2	0.3	0.02	0.02	0.03
Cabin A	0.8	0.8	6.5	0.4	0.4	1.2	0.03	0.03	0.15
Cabin B	0.4	0.4	0.8	0.2	0.2	0.3	0.02	0.02	0.04
Cabin C	0.7	0.7	3.5	0.4	0.4	0.8	0.03	0.03	0.08
Cabin D	0.8	0.8	5.3	0.4	0.4	0.8	0.04	0.04	0.09
Cabin E	0.6	0.6	6.1	0.3	0.3	0.6	0.03	0.03	0.06
Cabin F	0.6	0.6	8.3	0.3	0.4	0.6	0.03	0.04	0.06
Cabin G	0.8	0.8	0.9	0.3	0.3	0.3	0.03	0.03	0.04
Cabin H	1.3	1.5	2.5	0.3	0.3	0.4	0.04	0.04	0.06
Cabin I	2.0	2.0	2.0	0.5	0.5	0.6	0.09	0.09	0.12
Cabin J	5.6	5.6	6.0	0.9	0.9	2.2	0.10	0.10	0.33
Cabin K	6.9	6.9	7.1	0.9	0.9	0.9	0.09	0.10	0.15
Cabin L	2.2	2.2	8.7	0.5	0.5	1.6	0.05	0.05	0.17
Descharme Lake, SK	0.1	0.1	0.1	0.0	0.0	0.0	0.00	0.00	0.00
La Loche, SK	0.1	0.1	0.2	0.0	0.0	0.1	0.01	0.01	0.01
Oil Sands Lodge	1.3	1.3	1.3	0.6	0.6	0.6	0.09	0.09	0.11
PTI Camp	3.3	3.3	3.4	0.5	0.5	0.6	0.11	0.11	0.12

(a) The peak concentrations include the eight highest 1-hour predictions from the model.

(b) The 1-hour and 24-hour AAAQOs for H_2S are 14 and 4 µg/m³, respectively (AENV 2011).

Table 3.2-5 Comparison of Volatile Organic Compound Predictions in the Regional Communities

Parameter	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]
	Anzac			**Conklin**		
Maximum 1-hour acrolein	0.1587	0.1582	0.1706	0.1874	0.1872	0.1842
Peak annual acrolein	0.0140	0.0140	0.0147	0.0099	0.0099	0.0102
Maximum 1-hour benzene	1.3764	1.3764	1.3987	0.4315	0.4315	0.4349
Peak 1-hour cyclohexane	2.6541	2.6708	8.2100	0.5601	0.5631	1.9809
Peak annual cyclohexane	0.0533	0.0538	0.1278	0.0127	0.0128	0.0411
Peak 1-hour ethylbenzene	1.5760	1.6021	17.0660	0.3990	0.4006	3.9101
Peak 1-hour xylenes	7.0068	7.0647	24.5870	1.5038	1.5143	5.8699
	Fort Chipewyan			**Fort McKay**		
Maximum 1-hour acrolein	0.1427	0.1427	0.1427	1.3214	1.3213	1.3239
Peak annual acrolein	0.0213	0.0213	0.0215	0.1336	0.1336	0.1353
Maximum 1-hour benzene	2.7483	2.7483	2.7483	4.4366	4.4366	4.6914
Peak 1-hour cyclohexane	1.0654	1.0708	6.7686	22.1330	22.1350	34.5010
Peak annual cyclohexane	0.0256	0.0260	0.1141	1.2285	1.2325	1.8238
Peak 1-hour ethylbenzene	0.9677	0.9814	14.4220	16.2560	16.2610	77.3110
Peak 1-hour xylenes	2.9964	3.0157	20.5250	55.3860	55.3930	105.1100
	Fort McMurray			**Janvier/Chard (IR 194)**		
Maximum 1-hour acrolein	0.8585	0.8586	2.1255	0.0728	0.0725	0.0702
Peak annual acrolein	0.0682	0.0681	0.1553	0.0053	0.0053	0.0055
Maximum 1-hour benzene	25.2570	25.2570	**64.6100**	0.2663	0.2693	0.3794
Peak 1-hour cyclohexane	7.1757	7.1892	15.9820	1.4412	1.4475	4.0971
Peak annual cyclohexane	0.1657	0.1666	0.3346	0.0208	0.0210	0.0653
Peak 1-hour ethylbenzene	3.2909	3.3018	31.7230	0.7653	0.7716	6.7325
Peak 1-hour xylenes	17.7360	17.7800	47.3570	3.8096	3.8315	11.6910
	Clearwater (IR 175)			**Namur River (IR 174A)**		
Maximum 1-hour acrolein	0.2525	0.2511	0.1985	0.1726	0.1720	0.1942
Peak annual acrolein	0.0124	0.0123	0.0135	0.0057	0.0057	0.0063
Maximum 1-hour benzene	0.8000	0.8130	1.6359	0.4770	0.4770	0.5152
Peak 1-hour cyclohexane	3.5182	3.5478	13.7510	4.3430	4.3430	13.0730
Peak annual cyclohexane	0.1009	0.1019	0.2202	0.0638	0.0643	0.1614
Peak 1-hour ethylbenzene	2.0922	2.1390	31.6090	2.8241	2.8283	30.0830
Peak 1-hour xylenes	9.4531	9.5582	41.7830	10.9530	10.9530	39.7990
	Poplar Point (IR 201G)			**Cabin A**		
Maximum 1-hour acrolein	0.3169	0.3132	0.3071	0.6262	0.6243	0.6253
Peak annual acrolein	0.0154	0.0153	0.0161	0.0352	0.0351	0.0404
Maximum 1-hour benzene	0.6109	0.6301	0.9037	1.4494	1.4608	2.8117
Peak 1-hour cyclohexane	3.5898	3.6218	65.2600	9.6551	9.6681	447.2300
Peak annual cyclohexane	0.1336	0.1359	1.0988	0.3901	0.3940	7.3035
Peak 1-hour ethylbenzene	4.3993	4.4590	150.5400	10.2120	10.2430	1,034.1000
Peak 1-hour xylenes	9.7878	10.0050	198.3300	26.7260	26.7700	1,358.9000

Table 3.2-5 Comparison of Volatile Organic Compound Predictions in the Regional Communities (continued)

Parameter	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]
	Cabin B			**Cabin C**		
Maximum 1-hour acrolein	0.6141	0.6104	0.5922	0.7790	0.7806	0.7504
Peak annual acrolein	0.0290	0.0289	0.0291	0.0363	0.0362	0.0388
Maximum 1-hour benzene	0.9628	1.0104	1.1718	1.5831	1.5992	2.0205
Peak 1-hour cyclohexane	6.3979	6.5041	54.4780	10.8930	10.9020	239.6100
Peak annual cyclohexane	0.1879	0.1932	1.0671	0.3587	0.3646	3.5482
Peak 1-hour ethylbenzene	5.4449	5.5505	125.7100	11.6920	11.7280	553.7400
Peak 1-hour xylenes	18.0360	18.3900	165.6300	30.0690	30.1000	728.1500
	Cabin D			**Cabin E**		
Maximum 1-hour acrolein	0.8341	0.8358	0.8025	0.8715	0.8706	0.8745
Peak annual acrolein	0.0413	0.0413	0.0450	0.0450	0.0446	0.0455
Maximum 1-hour benzene	1.7631	1.7732	2.2763	1.3721	1.4316	1.6073
Peak 1-hour cyclohexane	11.9610	11.9640	369.0000	10.0870	10.1260	420.9900
Peak annual cyclohexane	0.4302	0.4364	3.8215	0.3429	0.3537	1.7480
Peak 1-hour ethylbenzene	15.1790	15.2260	853.6400	12.5100	12.5100	973.1300
Peak 1-hour xylenes	33.4790	33.4920	1,121.3001	27.8340	27.9650	1,279.4000
	Cabin F			**Cabin G**		
Maximum 1-hour acrolein	0.8533	0.8537	0.8618	1.1740	1.1716	1.1837
Peak annual acrolein	0.0489	0.0486	0.0494	0.0560	0.0558	0.0558
Maximum 1-hour benzene	1.3405	1.3853	1.5951	2.0989	2.3585	2.5347
Peak 1-hour cyclohexane	9.8835	9.9089	571.4300	5.4273	5.5671	23.0410
Peak annual cyclohexane	0.3735	0.3859	1.7584	0.2415	0.2465	0.6565
Peak 1-hour ethylbenzene	12.4490	12.4490	1,320.7000	6.3133	6.4528	52.7890
Peak 1-hour xylenes	27.2060	27.2940	1,736.6000	19.9160	20.1040	72.0190
	Cabin H			**Cabin I**		
Maximum 1-hour acrolein	0.7956	0.7750	0.8556	1.1368	1.1368	1.0509
Peak annual acrolein	0.0550	0.0533	0.0541	0.0796	0.0795	0.0904
Maximum 1-hour benzene	1.8700	2.2841	11.6770	2.6992	2.6992	2.8076
Peak 1-hour cyclohexane	19.2350	19.2350	567.2600	19.8390	19.8720	51.9230
Peak annual cyclohexane	0.3964	0.4090	2.3275	1.0248	1.0277	2.1798
Peak 1-hour ethylbenzene	11.5960	11.6050	1,303.8001	44.4020	44.4350	116.9900
Peak 1-hour xylenes	47.3470	47.3470	1,721.6000	60.5900	60.6930	158.0900
	Cabin J			**Cabin K**		
Maximum 1-hour acrolein	**2.3602**	**2.3602**	2.1250	1.9888	1.9865	1.9545
Peak annual acrolein	0.1434	0.1434	0.1402	0.1245	0.1245	0.1246
Maximum 1-hour benzene	21.0170	21.0190	19.5150	5.4053	5.4053	12.1430
Peak 1-hour cyclohexane	473.0000	473.0000	**1,405.9000**	55.6390	55.6400	840.2700
Peak annual cyclohexane	33.9126	33.9220	51.3741	2.0925	2.1086	11.6992
Peak 1-hour ethylbenzene	1,094.0000	1,094.0000	**3,248.1001**	117.8500	117.8500	1,933.4000
Peak 1-hour xylenes	1,437.1000	1,437.1000	**4,271.2998**	166.9900	167.0000	**2,552.3001**

Table 3.2-5 Comparison of Volatile Organic Compound Predictions in the Regional Communities (continued)

Parameter	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]	2012 Base Case [µg/m³]	2012 JME Application Case [µg/m³]	2012 Planned Development Case [µg/m³]
	Cabin L			Descharme Lake, SK		
Maximum 1-hour acrolein	1.2453	1.2465	1.1725	0.0406	0.0404	0.0398
Peak annual acrolein	0.0648	0.0648	0.0817	0.0024	0.0024	0.0024
Maximum 1-hour benzene	2.6457	2.6680	3.0098	0.1454	0.1480	0.2095
Peak 1-hour cyclohexane	18.9860	19.0640	604.5300	0.9391	0.9392	6.3578
Peak annual cyclohexane	0.8828	0.8884	3.7004	0.0210	0.0212	0.0727
Peak 1-hour ethylbenzene	30.3560	30.4340	1,398.4000	0.9421	0.9479	14.5550
Peak 1-hour xylenes	56.2470	56.4990	1,836.9000	2.3569	2.3573	19.3210
	La Loche, SK			Oil Sands Lodge		
Maximum 1-hour acrolein	0.1667	0.1666	0.1665	1.8324	1.8328	1.8340
Peak annual acrolein	0.0330	0.0330	0.0330	0.1553	0.1552	0.1541
Maximum 1-hour benzene	1.4099	1.4099	1.4134	3.8170	3.8201	3.9748
Peak 1-hour cyclohexane	0.8580	0.8580	2.3112	21.4400	21.4400	38.4640
Peak annual cyclohexane	0.0282	0.0286	0.0835	1.1642	1.1706	1.8059
Peak 1-hour ethylbenzene	0.5278	0.5393	5.1013	18.7760	18.7850	87.4250
Peak 1-hour xylenes	2.1887	2.1887	7.0853	53.4840	53.4850	117.2100
	PTI Camp					
Maximum 1-hour acrolein	0.9510	0.9509	0.9704			
Peak annual acrolein	0.0725	0.0725	0.0744			
Maximum 1-hour benzene	7.0241	7.0241	7.2447			
Peak 1-hour cyclohexane	36.3800	36.3820	39.8710			
Peak annual cyclohexane	2.3674	2.3714	2.8729			
Peak 1-hour ethylbenzene	14.6940	14.6980	68.1050			
Peak 1-hour xylenes	90.0870	90.0920	99.1170			

Note: Bold values indicate exceedance of the applicable AAAQO. The 1-hour AAAQOs for benzene, ethylbenzene and xylenes are 30 µg/m³, 2,000 µg/m³ and 2,300 µg/m³, respectively (AENV 2011).

Residual Impact Classification for Ambient Air Quality

The 2012 PDC emissions were predicted to result in changes to regional air quality. The impacts associated with these changes have been evaluated using the assessment methods described in EIA Volume 3, Section 3.2. In general, the impacts have been described according to six criteria: direction, magnitude, geographic extent, duration, reversibility and frequency. The assessment method outlined in EIA Volume 3, Section 3.2.3.9 was used to classify the magnitude of air quality impacts. The assessment method compares the predicted ambient air quality to applicable air quality criteria, when criteria exist. The results of the impact classification for changes to the ambient air quality are presented in Tables 3.2-6 (H_2S) and 3.2-7 (VOCs).

Not all of the parameters have air quality guidelines and standards against which the predicted concentrations could be evaluated. In such cases, the results of the modelling analyses were evaluated in the Environmental Health section (Sections 3.2.3, 3.2.4 and 3.2.5).

By consolidating the impact measurements listed in Tables 3.2-6 and 3.2-7, it is possible to determine an overall rating of the "environmental consequence" for each of the ambient air quality parameters that were evaluated. The rating assessment methods are described in EIA Volume 3, Section 3.2.3.7.

Table 3.2-6 Residual Impact Classification for Changes to the Ambient Air Quality (Hydrogen Sulphide)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour H_2S	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (6)
community annual H_2S	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (6)

Note: Numerical scored for ranking of environmental consequence are explained in the EIA Volume 3, Section 1.3.6

Table 3.2-7 Residual Impact Classification for Changes to the Ambient Air Quality (Volatile Organic Compounds)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour acrolein	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (6)
community annual acrolein	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (7)
community 1-hour benzene	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	high (16)
community 1-hour cyclohexane	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	high (16)
community annual cyclohexane	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (7)
community 1-hour ethylbenzene	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	high (16)
community 1-hour xylenes	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	high (16)

Note: Numerical scored for ranking of environmental consequence are explained in the EIA Volume 3, Section 1.3.6

Of the nine ambient air quality parameters assessed for the 2012 PDC, five are rated as having a low environmental consequence and four are rated as having a high environmental consequence.

The community 1-hour benzene is classified as having a high environmental consequence. This classification is primarily due to the estimated increase in benzene emissions from future population growth in Fort McMurray. The JME did not cause a change in the benzene predictions in Fort McMurray. Further discussion of the effects of these predictions is discussed in the Environmental Health assessment (Appendix 3.3).

The community 1-hour cyclohexane, ethylbenzene and xylene are also classified as having a high environmental consequence due to the exceedance of the applicable AAAQOs at Cabins J and K. The high environmental consequence is due to the proximity of the cabins to a planned project in the region. The JME does not cause a change in these compounds in the region. Since the effects of exposure to these compounds are related to human health, the evaluation of effects of these predictions is discussed in the HHRA and WHRA (Sections 3.2.3 and 3.2.4).

Acid-Forming Compounds

The approach to conducting cumulative effects assessments defined by the *Canadian Environmental Assessment Act* indicates that environmental effects should be considered when they accumulate or interact with those of other developments. Therefore, only residual impacts that were considered to have low, moderate

or high environmental consequences have been assessed for the 2012 PDC. Residual impacts resulting in a negligible rating indicate that the cumulative effects of the 2012 JME Application Case emissions are not distinguishable from 2012 Base Case conditions. Therefore, there is no appreciable incremental change with the addition of JME to the 2012 Base Case conditions, and no requirement for a further cumulative assessment.

Since the residual impact for the 2012 JME Application Case Potential Acid Input (PAI) presented in the Air Emission Effects on Ecological Receptors resulted in a negligible environmental consequence (Appendix 1), the effects of PAI were not assessed in the this section.

The PAI predictions for the 2012 PDC are provided in Appendix 3.2. The predictions for the 2012 PDC PAI on ecological receptors is provided in Appendix 3.2.

3.2.1.3 Summary of Results

The air quality assessment of the 2012 PDC was conducted using the same approach and assessment methods as used in the EIA. The CALPUFF modelling system with two years of meteorological data (1995 and 2002) was used to predict concentrations of SO_2, NO_2, CO, $PM_{2.5}$, select TRS, VOCs, Polycyclic Aromatic Hydrocarbons (PAHs) and metals in the region and at selected regional communities. Potential acid input was also assessed. Only those compounds that had a low, moderate or high environmental consequence are included in this section; however, predictions for air quality compounds considered are provided in Appendix 3.2. The air predictions for this assessment provided data for the Environmental Health assessment (Sections 3.2.2, 3.2.3 and 3.2.4).

Only H_2S and select VOCs were assessed in the 2012 PDC. The H_2S predictions at the regional communities remain below the AAAQOs. The 2012 PDC predicted VOC concentrations are within applicable AAAQOs and other applicable criteria at most locations. There are some exceedances at Cabins J and K due to their proximity to a planned project in the region. The exceedance of the 1-hour benzene AAAQO at Fort McMurray is primarily due to the estimated increase in benzene emissions from future population growth in Fort McMurray. Further discussion of the effects of these predictions is provided in the HHRA and WHRA (Sections 3.2.2 and 3.2.3).

3.2.2 Human Health Risk Assessment

The 2012 Human Health Risk Assessment (HHRA) addressed the JRP requests for an assessment of the 2012 PDC. The full 2012 HHRA is presented in Appendix 3.3. The assessment methods used for this 2012 HHRA were consistent with those applied to the EIA HHRA, with a number of minor changes in the exposure and toxicity assessments. Over time, such changes are typical for health risk assessments, although the changes specific to this 2012 HHRA did not have a material impact on the EIA findings.

Overall, the changes between the 2012 Base Case and 2012 PDC risks are generally small. Cumulative environmental risks associated with the additional projects and activities planned for the region are not expected to result in adverse health effects. Based on the re-analysis, the 2012 PDC does not alter the assessment results or the conclusions originally presented in the HHRA of the EIA.

3.2.3 Wildlife Health Risk Assessment

The potential risks to terrestrial wildlife were re-assessed based on the 2012 PDC update. The full 2012 Wildlife Health Risk Assessment (WHRA) is presented as an attachment to the 2012 HHRA (Appendix 3.3, Attachment A).

The results of the 2012 WHRA indicate that the overall risks posed to wildlife health will be low. Therefore, no impacts to wildlife populations are expected based on estimated wildlife exposures to predicted maximum acute and chronic air concentrations or predicted soil and surface water concentrations. These conclusions are consistent with those presented in the EIA WHRA.

3.2.4 Air Emissions Effects on Ecological Receptors Assessment

The approach to conducting cumulative effects assessments defined by the *Canadian Environmental Assessment Act* indicates that environmental effects should be considered when they accumulate or interact with those of other developments. Therefore, only residual impacts that were considered to have low, moderate or high environmental consequences have been assessed for the 2012 PDC. Residual impacts resulting in a negligible rating indicate that the cumulative effects of the 2012 JME Application Case emissions are not distinguishable from 2012 Base Case conditions. Therefore, there is no appreciable incremental change with the addition of JME to the 2012 Base Case conditions, and no requirement for a further cumulative assessment.

Since the 2012 JME Application Case assessment of air emissions effects on ecological receptors resulted in negligible environmental consequences, a classification of 2012 PDC effects was not completed. The PDC air quality predictions of regional SO_2, NO_X and PAI are presented in Appendix 3.2.

3.3 Aquatic Resources

This section provides the results of the 2012 PDC assessments for Aquatic Resources to inform the cumulative effects on the aquatic environment. The 2012 PDC includes a review of the cumulative effects that could result from the existing and approved developments, JME, and the planned (publicly disclosed) developments in the Oil Sands Region (including PRM), as of September 2011.

The approach used for this assessment is the same as the approach used in the EIA with the following exceptions:

- While no appreciable water quality changes were predicted for the EIA Application Case or EIA PDC relative to the PIC or EIA Base Case at Embarras, which is upstream of the PAD in the EIA, an evaluation of air quality, hydrology and water quality in the Peace-Athabasca Delta was developed specifically to address issues identified by federal reviewers, and concerns expressed by potentially affected Aboriginal communities and public stakeholders. The evaluation of air quality, hydrology and water quality effects on the Peace-Athabasca Delta is provided in Appendix 3.4.
- Potential impacts of aerial deposition to snowpack and snowmelt water concentrations have been raised as a potential issue in the region in recent years. Potential incremental changes to water quality resulting from aerial deposition of polycyclic aromatic compounds (PAC) were evaluated using a non-steady-state, mass-balance and multi-compartment fate model. The model was used to estimate the contribution of snowmelt to surface water concentrations. Similarly, a conservative mass-balance approach was developed for

metals deposition. Appendix 3.5, Section 2.0 summarizes the methods used to quantify the fate and transport of aerially deposited PACs and metals to the snowpack.

- Aquatic health assessments for oil sands developments have traditionally applied a combination of generic guidelines from the provincial government, the Canadian Council of Ministers of the Environment and derivations of site-specific benchmarks using species sensitivity distributions. The EIA (2007) included derivations of Chronic Effects Benchmarks (CEBs), as described in Volume 4B, Appendix 4-2, Section 3. However, while these CEBs were being derived, CCME (2007) developed a refined stepwise procedure for site-specific derivations that is now preferred by regulators and provides a consistent framework for future evaluations. Appendix 3.6, Section 2.0 presents updated CEBs that follow the approach described by CCME (2007).
- Four pit lakes will be created during the closure management phase of the Jackpine Mine – Phase 1 and JME. These lakes are described in the EIA (Volume 4A, Appendix 4-2, Section 2.1.3). The pit lakes presented in the *May 2011, Submission of Information to the Joint Review Panel,* Section 3.4 were updated by excluding MFT from all four Jackpine pit lakes. In the *May 2011, Submission of Information to the Joint Review Panel*, hydrodynamic modelling was completed to evaluate meromictic conditions in the deeper pit lakes, but a full suite of water quality constituents was not considered necessary because the water quality was assumed to be improved from previous assessments. The updated modelling presented in Appendix 3.6, Section 4.0 does present a full suite of water quality constituents, as the full suite was required for the 2012 PDC small streams assessment.
- An update is provided to the naphthenic acids concentrations that were predicted for all nodes within the JME LSA for the same snapshots and cases reported in the EIA (Volume 4A, Section 6.5). The updated predictions were derived by adjusting sub-groups of naphthenic acids and degradation rates to align with recent studies, keeping all other inputs consistent with the EIA. The intent of the work, as described in Appendix 3.6, Section 3.0, is to compare naphthenic acids predictions based on the updated method and to show how the updated predictions compare to the original predictions in the EIA.

3.3.1 Hydrogeology Assessment

This assessment focuses on Basal Aquifer depressurization and overburden dewatering from the developments with potential to overlap with the groundwater resources and geographic area affected by JME. It addresses effects on groundwater levels and flows.

The assessment methods used in the EIA (Volume 4A, Appendix 4-1 were also used in this assessment. Because the timing of planned projects is uncertain, Basal Aquifer depressurization and overburden dewatering at planned developments were simulated assuming that all developments were simultaneously at their maximum extent of build out over the 2008 to 2065 time period that corresponds to the original development timeline of JME. This assumption means that groundwater levels in Basal Aquifer and surficial deposits would be drawn down at all locations and at all times over this period. The approach taken, therefore, overestimates potential effects on groundwater levels and flows and is conservative for assessing the effects of planned developments.

3.3.1.1 Assessment Results

The following figures illustrate the effects on groundwater levels due to depressurization and dewatering from developments in the 2012 PDC:

- Figure 3.3-1: incremental drawdown in Basal Aquifer due to planned projects; and
- Figure 3.3-2: incremental drawdown in surficial deposits due to planned projects.

Incremental drawdown is equal to 2012 PDC drawdown minus the 2012 JME Application Case drawdown, and is, therefore the maximum extent of drawdown due to depressurization and dewatering at planned projects. These figures do not correspond to a specific snapshot because all developments were assumed to be at their maximum extent of build out over the entire 2008 to 2065 time period.

Suncor Energy Inc.'s Voyageur South Project depressurization and dewatering were represented in simulations. However, drawdown from Voyageur South does not extend into the map area shown in Figure 3.3-1 and Figure 3.3-2 and is limited to an area south of the map area.

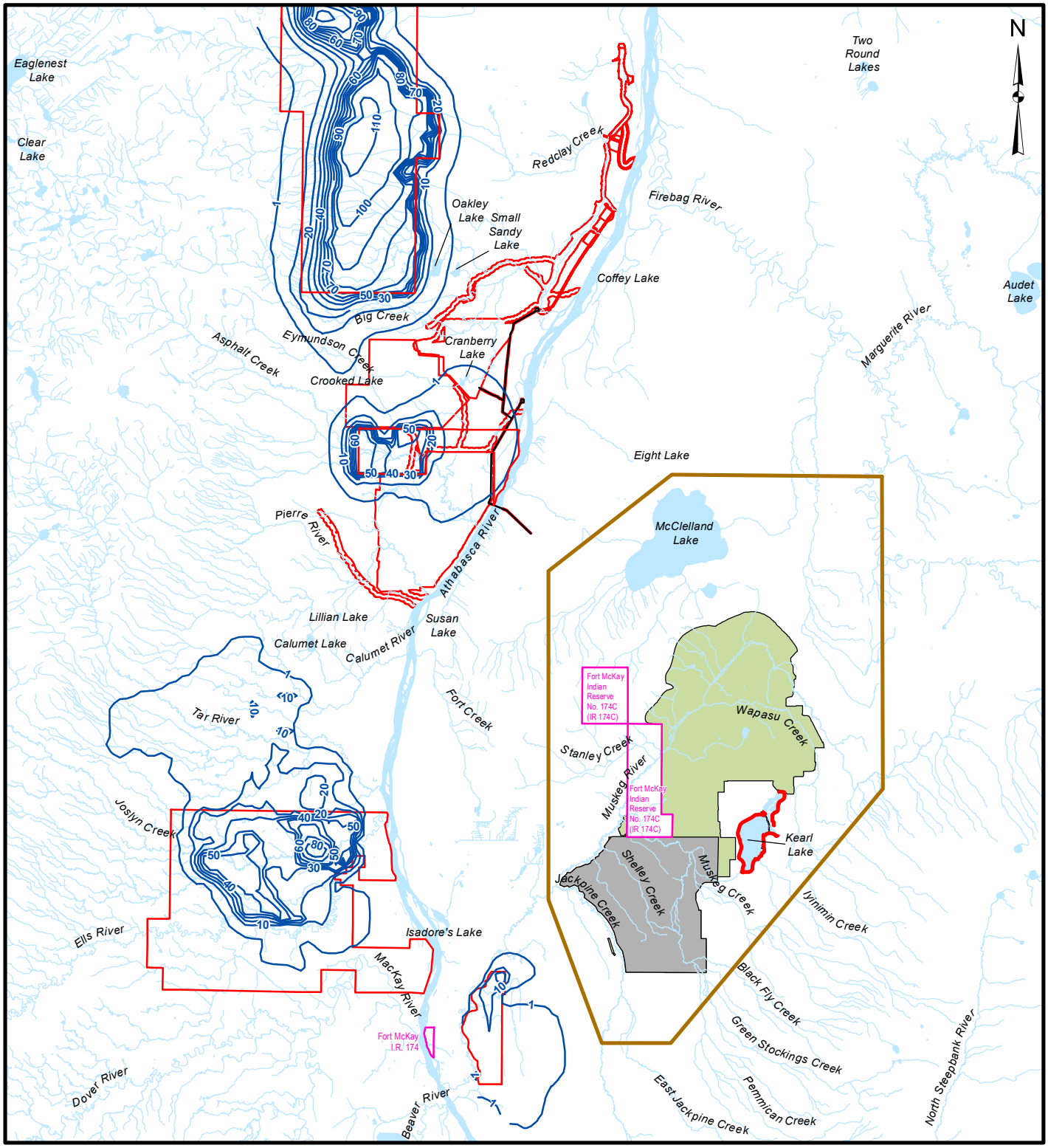
With the removal of Synenco's (now Total E&P Joslyn Ltd.) Northern Lights Project from the 2012 PDC, the effects from the planned developments are all located outside the JME LSA. The results presented in Figures 3.3-1 and 3.3-2 indicate that no interaction is expected between JME and other planned projects.

Simulated major groundwater balance components for the JME LSA at the 2052 snapshot are listed in Table 3.3-1. This represents the snapshot with the greatest effect on groundwater flows for the EIA Application Case (EIA, Volume 4A, 6.3.5.2). There is a 70 L/s decrease in outflows due to mine activities (depressurization and dewatering) from the EIA PDC to the 2012 PDC. Net groundwater inflows to the LSA do not change between the EIA and 2012 PDC. Therefore, the additional 70 L/s reduction in outflows to surface waters within the JME LSA is the result of removing the Northern Lights Project. The 2012 PDC and the EIA Application Case are identical within the JME LSA.

Table 3.3-1 Jackpine Mine Expansion Local Study Area Major Water Balance Components for the Planned Development Case

Component	EIA PDC Flow [L/s]	2012 PDC Flow [L/s]	Change [L/s]	
			[L/s]	[%]
2052				
Net Inflows	440	440	0	0
Outflows due to Mine Activities	190	120	-70	37
Outflows to Surface Water Resources	250	320	70	27

Notes: Net inflows include recharge, seepage from lakes, aquifer storage and lateral inflows/outflows.
Mine activities include overburden dewatering and Basal Aquifer depressurization (open mines) and pumping (SAGD).
2052 in the hydrogeology assessment corresponds with 2049 in the surface water assessment.
Outflows to surface water resources (rivers/streams, wetlands and lakes) equal net inflows minus flows allocated by mine activities.
Mass balance calculations are for JME local study area.
Values rounded to nearest 10 L/s.



10 0 10

KILOMETRES

SCALE 1:400,000

LEGEND

- JACKPINE MINE EXPANSION LOCAL STUDY AREA
- INDIAN RESERVE
- JACKPINE MINE - PHASE 1
- JACKPINE MINE EXPANSION
- PLANNED OIL SANDS DEVELOPMENTS
- WATERBODIES
- DRAWDOWN CONTOUR (m) CONTOUR INTERVAL = 10 m; 1 m CONTOUR ALSO SHOWN
- KEARL LAKE PERIMETER LEVEE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS (SEPTEMBER 2004); PLANNED DEVELOPMENTS OBTAINED FROM GOLDER; MINING AREAS OBTAINED FROM SHELL.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

JACKPINE MINE EXPANSION

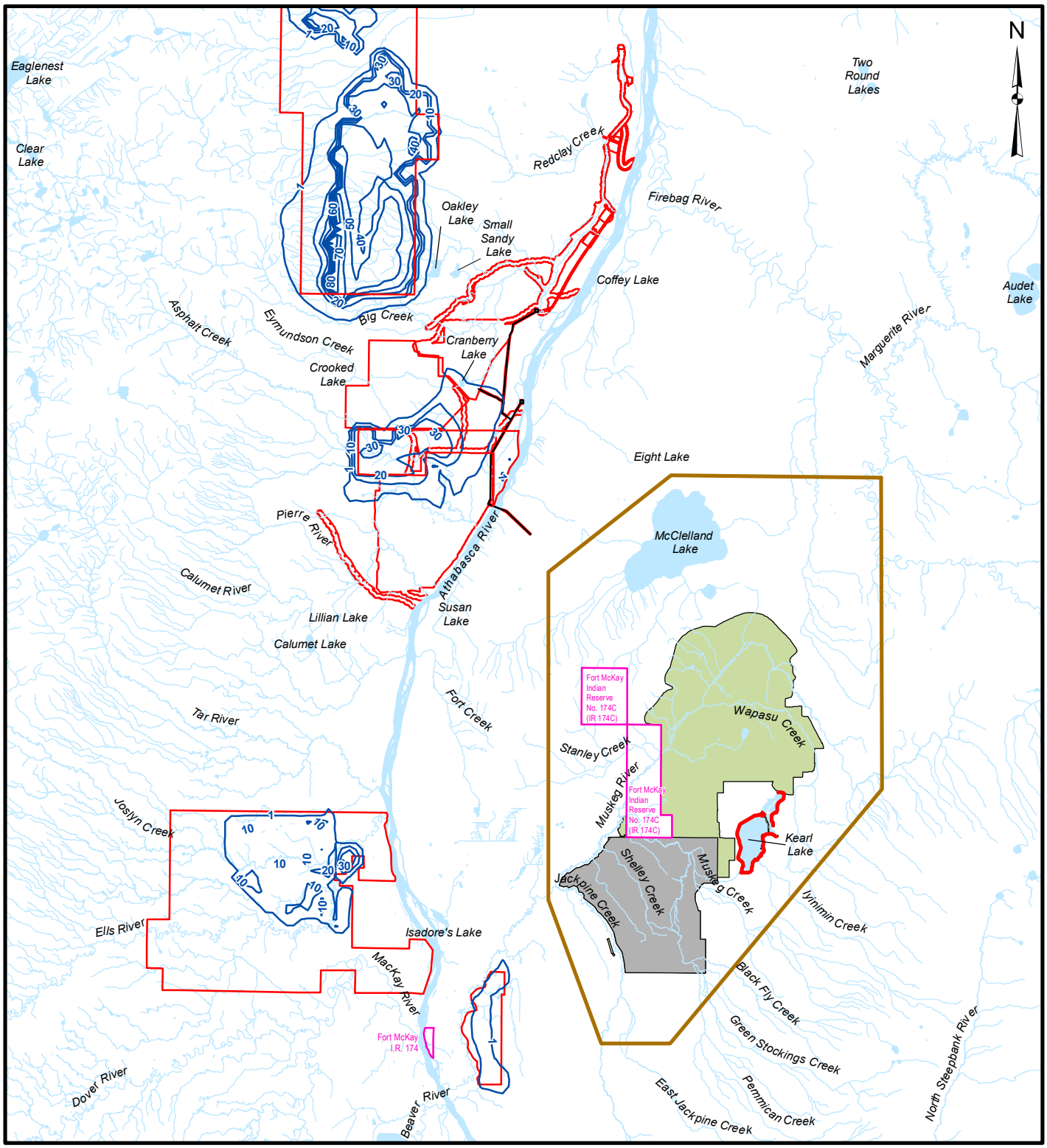
TITLE

INCREMENTAL DRAWDOWN IN BASAL AQUIFER DUE TO PLANNED PROJECTS

Shell Canada Limited

PROJECT No. 10-1346-0001			SCALE AS SHOWN	REV. 0
DESIGN	JH	25 Jun. 2007	FIGURE: 3.3-1	
GIS	PK	15 May 2012		
CHECK	TB	15 May 2012		
REVIEW	TB	15 May 2012		

FILE: Q:\GBS\Shell\307075_00877\ArcGIS\MXDs\307075_00877_FIG-352-1_JPM_DD_basalREVD.mxd Issued By: Edmonton GIS



10 0 10

KILOMETERS

SCALE 1:400,000

LEGEND

- JACKPINE MINE EXPANSION LOCAL STUDY AREA
- INDIAN RESERVE
- JACKPINE MINE - PHASE 1
- JACKPINE MINE EXPANSION
- PLANNED OIL SANDS DEVELOPMENTS
- WATERBODIES
- DRAWDOWN CONTOUR (m) CONTOUR INTERVAL = 10 m; 1 m CONTOUR ALSO SHOWN
- KEARL LAKE PERIMETER LEVEE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS (SEPTEMBER 2004); PLANNED DEVELOPMENTS OBTAINED FROM GOLDER; MINING AREAS OBTAINED FROM SHELL.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

JACKPINE MINE EXPANSION

TITLE

INCREMENTAL DRAWDOWN IN SURFICIAL DEPOSITS DUE TO PLANNED PROJECTS

Shell Canada Limited

PROJECT No. 10-1346-0001			SCALE AS SHOWN	REV. 0
DESIGN	JH	25 Jun. 2007	FIGURE: 3.3-2	
GIS	PK	15 May 2012		
CHECK	TB	15 May 2012		
REVIEW	TB	15 May 2012		

FILE: Q:\GBS\Shell\307075_00877\ArcGIS\MXDs\307075_00877_FIG-352-2_JPM_DD_surficialREVD.mxd Issued By: Edmonton GIS

An Athabasca River assessment was conducted for the 2031 snapshot, which represents the greatest effect on groundwater discharge to the Athabasca River for the 2012 JME Application Case. No additional effects from planned developments are expected for the Athabasca River reaches between Nodes A1 and A3 (Table 3.3-2). This result is consistent with the limited additional drawdown predicted in the Basal Aquifer in the immediate vicinity of the river.

Table 3.3-2 Comparison of Groundwater Discharge to the Athabasca River – 2012 JME Application Case and 2012 PDC

Assessment Nodes	2012 JME Application Case [L/s]	2012 PDC [L/s]	Change	
			[L/s]	[%]
2031				
A1 to A2	10	10	0	0
A2 to A3	210	210	0	0

Note: Values rounded to nearest 10 L/s.
2031 in the hydrogeology assessment corresponds with 2029 in the surface water assessment.
A description of how assessment nodes were chosen and their location is provided in the EIA, Volume 4a, Section 6.2.3.
Aquatic Resources assessment nodes are presented in the EIA, Volume 4a, Section 6.2.3, Figure 6.2-5.

3.3.1.1 Summary of Results

The 2012 PDC and the 2012 JME Application Case are identical within the JME LSA. An Athabasca River assessment was conducted for the 2031 snapshot, which represents the greatest effect on groundwater discharge to the Athabasca River for the 2012 JME Application Case. No additional effects from planned developments are expected for the Athabasca River reaches between Nodes A1 and A3. This result is consistent with the limited additional drawdown predicted in the Basal Aquifer in the immediate vicinity of the Athabasca River.

3.3.2 Hydrology Assessment

The Hydrology Assessment for JME was presented in Volume 4A, Section 6.4 of the EIA. The hydrology assessment was updated in the *May 2011, Submission of Information to the Joint Review Panel* for 2029, 2049 and Far-Future snapshots.

The 2012 PDC includes the following changes in the LSA and RSA:

- an update to Aurora South Mine 2009 (Syncrude 2009) and Fort Hills Oil Sands Project (FHEC 2010), which will affect the surface water hydrology assessment for the 2012 PDC of the JME LSA; and
- planned development of the Frontier Project and Joslyn South Mine in the RSA of JME, which will affect the surface water hydrology assessment for Athabasca River.

The LSA and RSA assessment nodes are similar to the nodes presented in Volume 4A, Section 6.2.3 of the EIA. The time snapshots are also similar to the time snapshots presented in Volume 4A, Section 2.6.1 of the 2008 EIA update for JME.

The mine plans for the 2012 PDC along with assessment nodes are shown in Figures 3.3-3 to 3.3-6, respectively. These plans are used in the Aquatic Resources Assessment.

The approach used to assess the effects of JME for 2012 PDC is the same as the approach outlined in the Volume 4A, Section 6.4.2.7 of the EIA.

460000 E
480000 E
500000 E
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6340000N
Tp 97
Tp 96
Tp 95
Tp 94
Rg 11
Rg 10 W4M
Rg 9
Rg 8
Rg 7
Fort Creek
Athabasca River
Fort McKay Indian Reserve No.174C(IR174C)
Fort Hills Oil Sands Project
Aurora North Mine
Jackpine Mine Expansion
Kearl Oil Sands Project
Wapasu Creek
River
Stanley Creek
Muskeg
M0
2012
2013
2008
Jackpine Mine Compensation Lake
Fort McKay Indian Reserve No.174C(IR174C)
Kearl Compensation Lake
Kearl Lake
K1
Muskeg River Mine and Muskeg River Mine Expansion
Muskeg Creek
Shelley Creek
M1
M2
J1
Jackpine Mine — Phase 1
Jackpine Creek
Khahago Creek
Iyinimin Creek
Wesutkemina Creek
Mills Creek
Isadore's Lake
Fort McKay
Fort McKay Indian Reserve No.174
M3
Aurora South Project
Blackfly Creek
Pemmican Creek
East Jackpine Creek
Green Stockings Creek
Diversion Channel (2012 - 2044)

LEGEND

- DIVERSION OR COLLECTOR DITCH
- MINE DEVELOPMENT BOUNDARY
- PUBLIC ROAD
- WATERSHED DIVIDE
- INDIAN RESERVE
- LAKE / WATERBODY
- CLEARED AREA
- CLOSED-CIRCUIT AREA
- GRAVEL DEPOSIT AND STOCKPILE
- OPEN-CIRCUIT OVERBURDEN DISPOSAL AREA AND RECLAMATION MATERIAL STOCKPILE
- OPEN-CIRCUIT DRAINAGE AREA
- MUSKEG DRAINAGE AND OVERBURDEN DEWATERING AREA
- PROPOSED COMPENSATION LAKE
- M1 RECEIVING SURFACE WATER ASSESSMENT NODE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004).
USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12

3 0 3
SCALE KILOMETRES

PROJECT

JACKPINE MINE EXPANSION

TITLE

2012 PLANNED DEVELOPMENT CASE ACTIVITIES IN THE JME LOCAL STUDY AREA - YEAR 2012

Shell Canada Limited

PROJECT	10.1346.0001.8014		FILE No.	10134600018014A006	
DESIGN	DS	13 Jan. 2012	SCALE	AS SHOWN	REV. 0
CADD	PSR	16 Apr. 2012			
CHECK	GB	19 Apr. 2012			
REVIEW	WES	19 Apr. 2012			

FIGURE: 3.3-3

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480000 E
500000 E
6360000N
6340000N
Tp 97
Tp 96
Tp 95
Tp 94
Rg 11
Rg 10 W4M
Rg 9
Rg 8
Rg 7
Athabasca River
Fort Creek
Fort McKay Indian Reserve No.174C(IR174C)
Fort Hills Oil Sands Project
Aurora North Mine
Jackpine Mine Expansion
Kearl Oil Sands Project
Stanley Creek
River
Wapasu Creek
Muskeg
2017-2032
2012-2032
2023
2032
M0
Jackpine Mine Compensation Lake
Kearl Compensation Lake
Kearl Lake
K1
Muskeg River Mine and Muskeg River Mine Expansion
Mills Creek Sedimentation Pond
M1
J1
M2
Jackpine Mine — Phase 1
Mills Creek
Isadore's Lake
Fort McKay
Fort McKay Indian Reserve No.174
M3
Aurora South Project
East Jackpine Creek
Jackpine Creek
Green
Stockings Creek
Diversion Channel (2012 - 2044)

LEGEND

- DIVERSION OR COLLECTOR DITCH
- MINE DEVELOPMENT BOUNDARY
- PUBLIC ROAD
- WATERSHED DIVIDE
- INDIAN RESERVE
- LAKE / WATERBODY
- CLEARED AREA
- CLOSED-CIRCUIT AREA
- OPEN-CIRCUIT OVERBURDEN DISPOSAL AREA AND RECLAMATION MATERIAL STOCKPILE
- OPEN-CIRCUIT DRAINAGE AREA
- MUSKEG DRAINAGE AND OVERBURDEN DEWATERING AREA
- PROPOSED COMPENSATION LAKE
- RETENTION POND
- M1 RECEIVING SURFACE WATER ASSESSMENT NODE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004). USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12

3 0 3
SCALE KILOMETRES

PROJECT
JACKPINE MINE EXPANSION

TITLE
2012 PLANNED DEVELOPMENT CASE ACTIVITIES IN THE JME LOCAL STUDY AREA - YEAR 2029

Shell Canada Limited

PROJECT	10.1346.0001.8014			FILE No.	10134600018014A007
DESIGN	DS	13 Jan. 2012		SCALE AS SHOWN	REV. 0
CADD	PSR	16 Apr. 2012			
CHECK	GB	19 Apr. 2012			
REVIEW	WES	19 Apr. 2012			

FIGURE: 3.3-4

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Tp 94
Rg 11
Rg 10 W4M
Rg 9
Rg 8
Rg 7
Fort Creek
Athabasca River
Fort Hills Oil Sands Project
Aurora North Mine
Muskeg River Mine and Muskeg River Mine Expansion
Jackpine Mine — Phase 1
Jackpine Mine Expansion
Kearl Oil Sands Project
Aurora South Project
Fort McKay Indian Reserve No.174C(IR174C)
FORT HILLS OBDA
2041-CLOSURE
2032-CLOSURE
Stanley Creek
Muskeg
M0
M1
M2
M3
J1
K1
Jackpine Mine Compensation Lake
Kearl Compensation Lake
Kearl Lake
2036-2045 Wapasu Creek Diversion Ditch
2017
2023
2032
2035
2045
Diversion Channel (2044 - 2065)
Mills Creek
Isadore's Lake
Fort McKay
Fort McKay Indian Reserve No.174
East Jackpine Creek
Jackpine Creek
Green
Stockings Creek

LEGEND

- MAIN CHANNEL
- SECONDARY CHANNEL
- DIVERSION OR COLLECTOR DITCH
- DIVERSION PIPELINE
- LAKE PERIMETER DYKE
- MINE DEVELOPMENT BOUNDARY
- OPERATIONAL BERM (BREACHED AT APPROXIMATELY 500 m SPACING AT CLOSURE)
- PUBLIC ROAD
- WATERSHED DIVIDE
- INDIAN RESERVE
- LAKE / WATERBODY
- CLEARED AREA
- CLOSED-CIRCUIT AREA
- CLOSURE LAKE
- CLOSURE WETLANDS
- DIVERTED AREA FROM MUSKEG RIVER WATERSHED
- OPEN-CIRCUIT OVERBURDEN DISPOSAL AREA AND RECLAMATION MATERIAL STOCKPILE
- OPEN-CIRCUIT DRAINAGE AREA
- MUSKEG DRAINAGE AND OVERBURDEN DEWATERING AREA
- PROPOSED COMPENSATION LAKE
- M1 RECEIVING SURFACE WATER ASSESSMENT NODE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004).
USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12

3 0 3
SCALE KILOMETRES

PROJECT
JACKPINE MINE EXPANSION

TITLE
2012 PLANNED DEVELOPMENT CASE ACTIVITIES IN THE JME LOCAL STUDY AREA - YEAR 2049

Shell Canada Limited

PROJECT	10.1346.0001.8014			FILE No.	10134600018014A008
DESIGN	DS	13 Jan. 2012		SCALE AS SHOWN	REV. 0
CADD	PSR	16 Apr. 2012		FIGURE: 3.3-5	
CHECK	GB	19 Apr. 2012			
REVIEW	WES	19 Apr. 2012			

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Tp 96
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Tp 94
Rg 11
Rg 10 W4M
Rg 9
Rg 8
Rg 7
Athabasca River
Fort Creek
Fort Hills Oil Sands Project
Aurora North Mine
Muskeg River Mine and Muskeg River Mine Expansion
Kearl Oil Sands Project
Aurora South Project
Fort McKay Indian Reserve No.174C(IR174C)
Fort McKay Indian Reserve No.174
Fort McKay
FORT HILLS OBDA
NORTHEAST PIT LAKE 286,5 m
NORTHWEST PIT LAKE 285 m
JACKPINE MINE EXPANSION
CELL 7
CELL 6
CELL 5
CELL 4
CELL 3
CELL 2
CELL 1
C11
C8
C7
C3
C2
C1
EXTERNAL TAILINGS DISPOSAL AREA-B
EXTERNAL TAILINGS DISPOSAL AREA-A
KEARL COMPENSATION LAKE
JACKPINE SOUTH CENTRAL PIT LAKE 281 m
JACKPINE SOUTH PIT LAKE 303m
WEST OBDA
EAST OBDA
JACKPINE MINE — PHASE 1
320 m
Stanley Creek
Muskeg
Mills Creek
Isadore's Lake
East Jackpine Creek
Jackpine Creek
Green
Stockings Creek
M0
M1
M2
M3
J1
K1

LEGEND

- MINE DEVELOPMENT BOUNDARY
- PUBLIC ROAD
- WATERSHED DIVIDE
- OPERATIONAL BERM (BREACHED AT APPROXIMATELY 500 m SPACING AT CLOSURE)
- INDIAN RESERVE
- LAKE / WATERBODY
- CLOSURE LAKE
- CLOSURE WETLANDS
- PROPOSED COMPENSATION LAKE
- FINAL RECLAIMED AREA
- M1 RECEIVING SURFACE WATER ASSESSMENT NODE

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004).
USED UNDER LICENSE. DATUM: NAD83 PROJECTION: UTM ZONE 12

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SCALE KILOMETRES

PROJECT
JACKPINE MINE EXPANSION

TITLE
2012 PLANNED DEVELOPMENT CASE ACTIVITIES IN THE JME LOCAL STUDY AREA - YEAR 2065 AND FAR FUTURE

Shell Canada Limited

PROJECT	10.1346.0001.8014		FILE No.	10134600018014A009	
DESIGN	DS	13 Jan. 2012	SCALE	AS SHOWN	REV. 0
CADD	PSR	16 Apr. 2012	FIGURE: 3.3-6		
CHECK	GB	19 Apr. 2012			
REVIEW	WES	19 Apr. 2012			

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3.3.2.1 Assessment Results

The 2012 PDC assessment considers the cumulative effects of existing and approved developments, JME, and planned developments including PRM within the LSA and RSA.

The hydrology assessments for JME and PRM for the LSAs were presented separately in the EIA, Volume 4A, Section 6.4. For JME, the hydrology assessment was updated in the 2008 EIA Update and in the *May 2011 Submission of Information to the Joint Review Panel* for 2029, 2049 and Far Future snapshots.

The hydrologic assessment presented in the EIA Application Case does not include a PDC assessment in the JME LSA, since there were no planned developments in this LSA in 2007. Since the EIA, the planned projects in the LSA and RSA include updates to Aurora South and Fort Hills mines in the JME LSA, the Frontier Project and Total Joslyn South Mine in the RSA. It is assumed that the water withdrawal location for Joslyn South Mine will be in Reach 4 of the Athabasca River.

Jackpine Mine Expansion Local Study Area

The JME hydrologic assessment for the 2012 PDC includes incremental changes in Muskeg River and Jackpine Creek flows due to an updated mine plan for Aurora South and Fort Hills projects for four time snapshots (2012, 2029, 2049 and Far-Future) at five effect assessment nodes (J1, M0, M1, M2 and M3). Changes to flow depths for the Muskeg River at the Environment Canada hydrometric station (07DA008) about 6 km from the mouth of the river, and changes in Kearl Lake water levels, are also presented as part of hydrologic assessment for the 2012 PDC. The predicted incremental changes in flow and water depth/level parameters are presented in Tables 3.3-3 to 3.3-11.

Table 3.3-3 2012 Planned Development Case for Muskeg River below Stanley Creek (Node M0)

Year	Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
			2012 Planned Development Case	Change From EIA Application Case	
		[m^3/s]	[m^3/s]	[m^3/s]	[%]
2012[b]	mean annual discharge	1.34	1.28	-0.058	-4.3
	mean open-water discharge [a]	2.15	2.06	-0.091	-4.2
	mean ice-cover discharge [a]	0.200	0.180	-0.016	-8.0
	7Q10 low flow discharge	0.050	0.050	-0.003	-5.9
	10-year flood peak discharge	21.1	18.7	-2.400	-11.4
2029[b]	mean annual discharge	2.14	2.02	-0.124	-5.8
	mean open-water discharge [a]	3.30	3.11	-0.187	-5.7
	mean ice-cover discharge [a]	0.61	0.565	-0.045	-7.4
	7Q10 low flow discharge	0.33	0.316	-0.014	-4.3
	10-year flood peak discharge	18.5	18.2	-0.255	-1.4
2049[c]	mean annual discharge	1.09	1.02	-0.069	-6.3
	mean open-water discharge [a]	1.65	1.55	-0.096	-5.8
	mean ice-cover discharge [a]	0.313	0.291	-0.022	-7.2
	7Q10 low flow discharge	0.183	0.183	0.000	0.2
	10-year flood peak discharge	12.7	11.6	-1.076	-8.5
Far-Future[c]	mean annual discharge	1.46	1.44	-0.025	-1.7
	mean open-water discharge [a]	1.71	1.67	-0.042	-2.4
	mean ice-cover discharge [a]	1.12	1.11	-0.001	-0.1
	7Q10 low flow discharge	0.248	0.224	-0.024	-9.8
	10-year flood peak discharge	6.00	5.81	-0.190	-3.2

[a] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

[b] May 2008 EIA Update.

[c] *May 2011, Submission of Information to the Joint Review Panel,* Appendix 1.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.3-4 2012 Planned Development Case for Muskeg River below Muskeg Creek (Node M1)

Year	Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
			2012 Planned Development Case	Change from EIA Application Case	
		[m^3/s]	[m^3/s]	[m^3/s]	[%]
2012[b]	mean annual discharge	2.59	2.64	0.048	1.9
	mean open-water discharge [a]	4.09	4.16	0.070	1.7
	mean ice-cover discharge [a]	0.486	0.519	0.033	6.8
	7Q10 low flow discharge	0.179	0.189	0.010	5.3
	10-year flood peak discharge	38.0	35.3	-2.679	-7.1
2029[c]	mean annual discharge	2.43	2.31	-0.129	-5.3
	mean open-water discharge [a]	3.63	3.44	-0.185	-5.1
	mean ice-cover discharge [a]	0.853	0.810	-0.043	-5.0
	7Q10 low flow discharge	0.565	0.555	-0.010	-1.7
	10-year flood peak discharge	19.3	18.7	-0.519	-2.7
2049[d]	mean annual discharge	1.78	1.55	-0.234	-13.1
	mean open-water discharge [a]	2.69	2.33	-0.365	-13.6
	mean ice-cover discharge [a]	0.522	0.472	-0.050	-9.6
	7Q10 low flow discharge	0.246	0.229	-0.017	-6.7
	10-year flood peak discharge	16.3	14.0	-2.295	-14.1
Far-Future[d]	mean annual discharge	2.44	2.40	-0.038	-1.5
	mean open-water discharge [a]	3.13	2.92	-0.212	-6.8
	mean ice-cover discharge [a]	1.46	1.67	0.207	14.2
	7Q10 low flow discharge	0.383	0.360	-0.023	-6.1
	10-year flood peak discharge	13.1	10.7	-2.361	-18.0

(a) The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

(b) From the EIA.

(c) May 2008 EIA Update.

(d) *May 2011, Submission of Information to the Joint Review Panel,* Appendix 1.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.3-5 Planned Development Case for Muskeg River below Jackpine Creek (Node M2)

Year	Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
			2012 Planned Development Case	Change from EIA Application Case	
		[m^3/s]	[m^3/s]	[m^3/s]	[%]
2012[b]	mean annual discharge	3.79	3.80	0.005	0.1
	mean open-water discharge [a]	6.07	6.07	0.004	0.1
	mean ice-cover discharge [a]	0.603	0.632	0.029	4.8
	7Q10 low flow discharge	0.210	0.215	0.005	2.5
	10-year flood peak discharge	47.9	46.2	-1.744	-3.6
2029[c]	mean annual discharge	3.55	3.37	-0.182	-5.1
	mean open-water discharge [a]	5.46	5.17	-0.284	-5.2
	mean ice-cover discharge [a]	0.965	0.920	-0.045	-4.6
	7Q10 low flow discharge	0.574	0.566	-0.008	-1.3
	10-year flood peak discharge	34.4	30.7	-3.664	-10.7
2049[d]	mean annual discharge	2.87	2.62	-0.246	-8.6
	mean open-water discharge [a]	4.49	4.10	-0.395	-8.8
	mean ice-cover discharge [a]	0.621	0.572	-0.049	-7.9
	7Q10 low flow discharge	0.252	0.238	-0.014	-5.7
	10-year flood peak discharge	28.9	26.7	-2.192	-7.6
Far-Future[d]	mean annual discharge	3.82	3.70	-0.124	-3.3
	mean open-water discharge [a]	5.32	4.96	-0.355	-6.7
	mean ice-cover discharge [a]	1.71	1.92	0.203	11.8
	7Q10 low flow discharge	0.433	0.429	-0.004	-0.9
	10-year flood peak discharge	25.8	17.3	-8.576	-33.2

[a] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

[b] From the EIA.

[c] May 2008 EIA Update.

[d] *May 2011, Submission of Information to the Joint Review Panel,* Appendix 1.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.3-6 2012 Planned Development Case for Muskeg River at the Confluence with the Athabasca River (Node M3)

Year	Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
			2012 Planned Development Case	Change from EIA Application Case	
		[m^3/s]	[m^3/s]	[m^3/s]	[%]
2012[b]	mean annual discharge	4.24	4.24	0.004	0.1
	mean open-water discharge [a]	6.71	6.71	0.002	0.0
	mean ice-cover discharge [a]	0.819	0.847	0.028	3.4
	7Q10 low flow discharge	0.374	0.380	0.006	1.5
	10-year flood peak discharge	48.9	47.4	-1.508	-3.1
2029[c]	mean annual discharge	3.92	3.73	-0.188	-4.8
	mean open-water discharge [a]	5.98	5.69	-0.289	-4.8
	mean ice-cover discharge [a]	1.15	1.10	-0.044	-3.8
	7Q10 low flow discharge	0.687	0.681	-0.006	-0.9
	10-year flood peak discharge	36.0	32.4	-3.667	-10.2
2049[d]	mean annual discharge	2.98	2.70	-0.285	-9.6
	mean open-water discharge [a]	4.65	4.21	-0.443	-9.5
	mean ice-cover discharge [a]	0.642	0.586	-0.056	-8.7
	7Q10 low flow discharge	0.254	0.239	-0.015	-5.8
	10-year flood peak discharge	29.8	27.3	-2.521	-8.5
Far-Future[d]	mean annual discharge	4.08	3.95	-0.124	-3.0
	mean open-water discharge [a]	5.67	5.31	-0.353	-6.2
	mean ice-cover discharge [a]	1.84	2.04	0.200	10.9
	7Q10 low flow discharge	0.438	0.439	0.001	0.3
	10-year flood peak discharge	27.7	24.1	-3.549	-12.8

[a] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

[b] From the EIA.

[c] May 2008 EIA Update.

[d] *May 2011, Submission of Information to the Joint Review Panel,* Appendix 1.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.3-7 2012 Planned Development Case for Muskeg River Flow Depths at Environment Canada Hydrometric Station, Snapshot 2012

Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case[b]	2012 Planned Development Case		
		2012 Planned Development Case	Change from EIA Application Case	
	[m]	[m]	[m]	[%]
Average flow depth				
mean annual discharge	0.78	0.78	0.00	0.0
mean open-water discharge [a]	0.84	0.84	0.00	0.0
mean ice-cover discharge [a]	0.69	0.69	0.00	0.1
7Q10 low flow discharge	0.68	0.68	0.00	0.0
10-year flood peak discharge	1.93	1.89	-0.04	-2.0
Maximum flow depth				
mean annual discharge	0.89	0.89	0.00	0.0
mean open-water discharge [a]	0.97	0.97	0.00	0.0
mean ice-cover discharge [a]	0.77	0.78	0.01	0.1
7Q10 low flow discharge	0.76	0.76	0.00	0.0
10-year flood peak discharge	2.37	2.32	-0.05	-2.1

[a] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

[b] From the EIA. Flow depths were calculated from reported discharges.

Table 3.3-8 2012 Planned Development Case for Muskeg River Flow Depths at Environment Canada Hydrometric Station, Snapshot 2029

Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
		2012 Planned Development Case	Change from EIA Application Case	
	[m]	[m]	[m]	[%]
Average flow depth				
mean annual discharge	0.77	0.76	-0.01	-0.6
mean open-water discharge [a]	0.82	0.81	-0.01	-0.9
mean ice-cover discharge [a]	0.70	0.70	0.00	-0.2
7Q10 low flow discharge	0.69	0.69	0.00	0.0
10-year flood peak discharge	1.60	1.50	-0.10	-5.9
Maximum flow depth				
mean annual discharge	0.88	0.87	-0.01	-0.7
mean open-water discharge [a]	0.95	0.94	-0.01	-1.0
mean ice-cover discharge [a]	0.79	0.78	-0.01	-0.2
7Q10 low flow discharge	0.77	0.77	0.00	0.0
10-year flood peak discharge	1.94	1.82	-0.12	-6.3

[a] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

Table 3.3-9 2012 Planned Development Case for Muskeg River Flow Depths at Environment Canada Hydrometric Station, Snapshot 2049

Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
		2012 Planned Development Case	Change from EIA Application Case	
	[m]	[m]	[m]	[%]
Average flow depth				
mean annual discharge	0.74	0.74	-0.00	-1.0
mean open-water discharge [(a)]	0.79	0.78	-0.01	-1.5
mean ice-cover discharge [(a)]	0.68	0.68	0.00	-0.2
7Q10 low flow discharge	0.67	0.67	0.00	-0.1
10-year flood peak discharge	1.44	1.37	-0.07	-4.5
Maximum flow depth				
mean annual discharge	0.85	0.84	-0.01	-1.1
mean open-water discharge [(a)]	0.90	0.89	-0.01	-1.6
mean ice-cover discharge [(a)]	0.77	0.77	0.00	-0.2
7Q10 low flow discharge	0.76	0.76	0.00	-0.1
10-year flood peak discharge	1.74	1.65	-0.09	-4.8

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

Table 3.3-10 2012 Planned Development Case for Muskeg River Flow Depths at Environment Canada Hydrometric Station, Snapshot Far Future

Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case	2012 Planned Development Case		
		2012 Planned Development Case	Change from EIA Application Case	
	[m]	[m]	[m]	[%]
Average flow depth				
mean annual discharge	0.77	0.77	0.00	-0.4
mean open-water discharge [(a)]	0.81	0.80	-0.01	-1.1
mean ice-cover discharge [(a)]	0.72	0.72	0.00	0.7
7Q10 low flow discharge	0.68	0.68	0.00	0.0
10-year flood peak discharge	1.38	1.29	-0.09	-6.6
Maximum flow depth				
mean annual discharge	0.88	0.88	0.00	-0.5
mean open-water discharge [(a)]	0.94	0.92	-0.02	-1.3
mean ice-cover discharge [(a)]	0.81	0.82	0.01	0.8
7Q10 low flow discharge	0.76	0.76	0.00	0.0
10-year flood peak discharge	1.67	1.55	-0.12	-7.1

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

Table 3.3-11 2012 Planned Development Case for Kearl Lake Water Level (Node K1)

Year	Expected Value of Parameter Under Conditions for Given Snapshot	EIA Application Case[(b)]	2012 Planned Development Case		
			2012 Planned Development Case	Change from EIA Application Case	
		[m]	[m]	[m]	[%]
2012	mean water level for open water season[(a)]	331.10	331.12	0.02	0.0
	mean water level for ice cover season[(a)]	331.01	331.01	0.00	0.0
	water level for 10th percentile	331.22	331.24	0.02	0.0
	water level for median	331.03	331.03	0.00	0.0
	water level for 90th percentile	330.96	330.98	0.02	0.0
2029	mean water level for open water season[(a)]	331.37	331.34	-0.03	0.0
	mean water level for ice cover season[(a)]	331.13	331.11	-0.02	0.0
	water level for 10th percentile	331.61	331.57	-0.04	0.0
	water level for median	331.20	331.17	-0.03	0.0
	water level for 90th percentile	331.04	331.02	-0.02	0.0
2049	mean water level for open water season[(a)]	331.37	331.31	-0.06	0.0
	mean water level for ice cover season[(a)]	331.14	331.12	-0.02	0.0
	water level for 10th percentile	331.62	331.53	-0.09	0.0
	water level for median	331.20	331.17	-0.03	0.0
	water level for 90th percentile	331.05	331.04	-0.01	0.0
Far-Future	mean water level for open water season[(a)]	331.12	331.11	-0.01	0.0
	mean water level for ice cover season[(a)]	331.04	331.06	0.02	0.0
	water level for 10th percentile	331.21	331.19	-0.02	0.0
	water level for median	331.06	331.08	0.02	0.0
	water level for 90th percentile	331.00	331.02	0.02	0.0

[(a)] The "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

[(b)] From the EIA.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

During the operational phase of JME, the magnitude of predicted changes in flow parameters from the EIA Application Case for operational time snapshots are slightly less for all nodes on Muskeg River. The reduction in flow parameters for the 2012 PDC is mainly due to increased closed-circuit operations for Fort Hills and Aurora South projects.

After mine closure in 2065, the expected mean annual flows for all nodes on Muskeg River are slightly less than the EIA Application Case with the exception of Node M0. The mean open-water and the 10-year peak flow will be reduced and the mean ice-cover flow and 7Q10 low flow will be increased due to the attenuation effects of the pit lakes.

The incremental changes to the annual average flow depth and annual maximum flow depth for the 2012 PDC are also very small.

The incremental changes in Kearl Lake water levels for the 2012 PDC are negligible, as shown in Table 3.3-11.

Athabasca River

An updated summary of current Alberta water licence allocations, return flows and projected annual allocations of all existing, approved and planned oil sands developments for surface water withdrawals from the Athabasca River and its tributary watercourses is provided in Table 3.3-12. It is assumed that the water withdrawal locations for the planned projects will be in Reach 4. Hence, the Water Management Framework withdrawal restrictions for Reach 4 will apply to all operators.

The 2012 PDC assessment for the Athabasca River includes quantification of the potential changes in the surface water hydrology in the RSA, using the same assessment methods presented in the EIA, Volume 4B, Appendix 4-8, Section 2.

Table 3.3-12 Water Allocations from Athabasca River and Tributaries

Purpose	Existing Licences and Licence Applications for Water Allocations (dam^3) [a]						Peak Instantaneous Licence Allocations [m^3/s]
	Interim Licenses	WRLIC Licenses[b]	WALIC Licenses[c]	Total Withdrawals	Return Flows	Net Water Allocations	
agricultural	24	686	56	766	0	766	n/a
commercial[d]	4,783	145,784	3,772	154,339	123,562	30,777	n/a
dewatering	280	35,367	0	35,647	1,293	34,354	n/a
habitat enhancement	14	1,413	0	1,427	0	1,427	n/a
industrial	4,517	36,547	53,507	94,571	2,772	91,799	n/a
irrigation	37	2,773	858	3,668	1,381	2,287	n/a
municipal	7,997	32,227	2,416	42,640	34,851	7,789	n/a
water management	0	21,590	1	21,591	2,221	19,370	n/a
other use	2	125	29	156	2	154	n/a
subtotal	*17,654*	*276,512*	*60,639*	*354,805*	*166,082*	*188,723*	*n/a*
Water Licences for Oil Sands:							
Base Case:							
Syncrude[e]	0	60,441	0	60,441	0	60,441	4.17
Suncor[f]	0	62,825	0	62,825	38,655	24,170	3.79
Albian Sands[g]	0	0	55,100	55,100	0	55,100	3.33[h]
Petro-Canada Fort Hills[i]	0	0	39,270	39,270	0	39,270	1.67
Canadian Natural Resources Limited Horizon[j]	0	0	79,320	79,320	0	79,320	3.1
Shell Jackpine Mine – Phase 1[k]	0	0	63,500	63,500	0	63,500	0.84[h]
Imperial Oil Kearl[l]	0	0	80,000	80,000	0	80,000	4.6
Total – Joslyn Creek[m]	0	0	22,000	22,000	0	22,000	1.4[n]
subtotal	*0*	*123,266*	*339,190*	*462,456*	*38,655*	*423,801*	*22.90*
2012 JME Application Case							
JME[o]	0	0	18,000	18,000	0	18,000	0.55[o]
subtotal[p]	*0*	*0*	*18,000*	*18,000*	*0*	*18,000*	*0.55*

Table 3.3-12 Water Allocations from Athabasca River and Tributaries (continued)

Purpose	Existing Licences and Licence Applications for Water Allocations (dam^3) [a]						Peak Instantaneous Licence Allocations [m^3/s]
	Interim Licenses	WRLIC Licenses[b]	WALIC Licenses[c]	Total Withdrawals	Return Flows	Net Water Allocations	
2012 Planned Development Case							
PRM[q]	0	0	55,000	55,000	0	55,000	4.17[q]
Synenco[m]	0	0	20,900	20,900	0	20,900	1.33[n]
Joslyn South Mine[r]	0	0	22,000	22,000	0	22,000	1.4
Frontier Project[s]	0	0	71,500	71,500	0	71,500	4.2
subtotal	*0*	*0*	*169,400*	*169,400*	*0*	*169,400*	*11.10*
Totals (dam^3) [p]	**17,654**	**399,778**	**587,229**	**1,004,661**	**204,737**	**799,924**	**34.55**

(a) 1 dam^3 = 1,000 m^3.

(b) Water Resources Licenses issued before 1999 under *Water Resources Act.*

(c) Water Act Licenses issued from 1999 under *Water Act*.

(d) Except oil sands mines.

(e) Syncrude License letter attached to Cumulative Environmental Management Association (CEMA) Report (Golder 2005a).

(f) Suncor License letter from Alberta Environment Web Site.

(g) Albian License letter attached to CEMA Report (Golder 2005a). Daily water withdrawal is restricted to 1.8% of Athabasca River Flow at Fort McMurray.

(h) Jackpine Mine – Phase 1, Muskeg River Mine and Expansion share the same water intake. The combined peak instantaneous of 4.17 m^3/s is approved as part of Jackpine Mine – Phase 1 application.

(i) Fort Hills License letter attached to CEMA Report (Golder 2005a).

(j) Canadian Natural Resources Ltd. license letter attached to CEMA Report (Golder 2005a).

(k) Shell License letter attached to CEMA Report (Golder 2005a). For Stage 2, the mean annual water requirement will be 35.3 million m^3.

(l) Based on EIA application documents approved by the Energy Resources Conservation Board (ERCB).

(m) Based on EIA application submitted to EUB (currently known as ERCB).Shell requires an additional water withdrawal for Jackpine

(n) Peak instantaneous rates were assumed for these projects.

(o) Expansion Mine during Stage 2 operations (2016 to 2052) only. Shell will apply to increase the combined peak instantaneous from 4.17 to 4.72 m^3/s.

(p) Application Case Sub-total and Total sum does not include additional water withdrawal for Jackpine Mine Expansion during Stage 2 operations since the Stage 1 withdrawal is used to assess effects on Athabasca River flow parameters.

(q) Based on EIA application submitted to EUB. For Stage 2 (2029 to 2039), the mean annual water requirement will be 45 million m^3.

(r) Assumed to be the same as Joslyn North Mine based on application submitted to ERCB (Deer Creek 2006; TOTAL 2010).

(s) Based on EIA application documents submitted to Alberta Energy Resources Conservation Board (ERCB) by Teck/SilverBirch for Frontier Project.

The total annual net water requirement from the Athabasca River for the regional developments excluding oil sands projects is 188.7 million m^3 (5.98 m^3/s). The total projected net water allocations to existing, approved and planned oil sands mining projects is about 611 million m^3 (19.4 m^3/s). This represents about 76% of the total net water allocation of 799 million m^3 (25.4 m^3/s) in the Athabasca River basin.

Effects of the 2012 PDC on the Athabasca River flows and water levels were quantified for Reach 4 and Node S24, respectively. The total peak water withdrawal for the 2012 PDC is about 34.6 m^3/s compared to 27.6 m^3/s for 2012 JME Application Case.

The predicted reduction in mean seasonal Athabasca River flows for the 2012 PDC ranges from 0% in winter under 10-year dry hydrologic conditions to 1.1% in winter under 10-wet hydrologic conditions (Table 3.3-13). The incremental water level reductions due to planned developments in the Athabasca River water levels are less than 1 cm of the mean seasonal flow depths (Table 3.3-14). The incremental changes in flows and water level reductions for Athabasca River due to updated planned developments are very small.

Table 3.3-13 Changes to the Athabasca River Flows in Reach 4 for the 2012 Planned Development Case

Hydrologic Condition	Season	2012 JME Application Case	2012 Planned Development Case[(a)]		
			2012 Planned Development Case	Change from 2012 JME Application Case	
		[m^3/s]	[m^3/s]	[m^3/s]	[%]
average year	winter	158	154	-4.0	-2.5
	spring	507	500	-7.0	-1.4
	summer	1,217	1,206	-11.0	-0.9
	fall	554	543	-11.0	-2.0
10-year dry	winter	107	107	0.0	0.0
	spring	238	236	-2.0	-0.8
	summer	1,014	1,003	-11.0	-1.1
	fall	413	404	-9.0	-2.2
10-year wet	winter	170	166	-4.0	-2.4
	spring	553	547	-6.0	-1.1
	summer	1,705	1694	-11.0	-0.6
	fall	767	756	-11.0	-1.4

(a) Peak water withdrawals were used as an upper limit although the Water Management Framework allows withdrawal up to 15% of average weekly flows for the green zone.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.3-14 Changes to the Athabasca River Flow Depths in Reach 4 for the 2012 Planned Development Case

Hydrologic Condition	Season	2012 JME Application Case	2012 Planned Development Case		
			2012 Planned Development Case	Change from 2012 JME Application Case	
		[m]	[m]	[m]	[%]
average year	winter	225.91	225.90	-0.010	0.00
	spring	226.52	226.51	-0.010	0.00
	summer	227.63	227.61	-0.020	-0.01
	fall	226.6	226.58	-0.020	-0.01
10-year dry	winter	225.81	225.81	0.000	0.00
	spring	226.05	226.05	0.000	0.00
	summer	227.33	227.32	-0.010	0.00
	fall	226.36	226.34	-0.020	-0.01
10-year wet	winter	225.93	225.92	-0.010	0.00
	spring	226.6	226.59	-0.010	0.00
	summer	228.27	228.26	-0.010	0.00
	fall	226.95	226.93	-0.020	-0.01

Shell also considered the effects on water level changes and flooding in the PAD due to JME in conjunction with existing, approved and planned developments. Based on the assessment detailed in Appendix 3.4, the effects for the 2012 PDC on water levels and flooding in the PAD are considered negligible.

3.3.2.2 Summary of Results

For Muskeg River, during the operational phase of JME, the magnitude of predicted changes in flow parameters from 2012 JME Application Case to the 2012 PDC for operational time snapshots are slightly less for all nodes on Muskeg River. The reduction in flow parameters for the 2012 PDC is mainly due to increased closed-circuit operations for Fort Hills and Aurora South projects. After mine closure in 2065, the expected mean annual flows for the 2012 PDC for all nodes on Muskeg River are slightly less than for the 2012 JME Application Case, with the exception for Node M0. The mean open-water and the 10-year peak flow will be reduced and the mean ice-cover flow and 7Q10 low flow will be increased due to the attenuation effects of the pit lakes. The incremental changes to the annual average flow depth and annual maximum flow depth for the 2012 PDC are very small compared to 2012 JME Application Case.

The incremental changes in Kearl Lake water levels for 2012 PDC are negligible compared to the 2012 JME Application Case.

The total annual net water requirement from the Athabasca River for the regional developments excluding the oil sands projects is 188.7 million m^3 (5.98 m^3/s). The total projected annual net water allocations to existing, approved and planned oil sands mining projects are about 611 million m^3. This represents about 76% of the total annual net water allocation of 799 million m^3 (25.4 m^3/s) in the Athabasca River basin.

Effects of the 2012 PDC on the Athabasca River flows and water levels were quantified for Reach 4 and Node S24, respectively. The total peak water withdrawal for the 2012 PDC is about 34.6 m^3/s, compared to 27.6 m^3/s for the 2012 JME Application Case.

The predicted reduction in mean seasonal Athabasca River flows for the 2012 PDC ranges from 0% in winter under 10-year dry hydrologic conditions to 1.1% in winter under 10-wet hydrologic conditions. The incremental water level reductions due to planned developments in the Athabasca River water levels are less than 1 cm for the mean seasonal flow depths.

3.3.3 Water Quality Assessment

This section presents the 2012 PDC water quality assessment. The water quality assessment considers potential changes in concentrations of constituents in watercourses and waterbodies due to effects of the existing, approved and planned developments on water quality during construction, operation and closure phases of JME. Potential changes to water quality resulting from aerial deposition of metals and PAHs are evaluated separately in Appendix 3.5. This potential change was evaluated separately, owing to the preliminary nature of the assessment. An evaluation of water quality in the Peace-Athabasca Delta is provided in Appendix 3.4. This assessment was completed to verify that the selection of RSA in the EIA was appropriate.

The EIA Application Case (EIA, Volume 4A, Section 6.5.3.3), and the 2012 PDC include changes to the operational and closure drainage plans for oil sands mines in the JME LSA and the RSA. Planned projects and drainage plan integration will result in different water chemistry and flow rates of mine-affected water releases and natural flows from undisturbed areas. The changes in amounts and chemistry of water releases may affect constituent concentrations in receiving watercourses and waterbodies.

The modelling approach in this 2012 PDC is identical to the EIA PDC approach described in EIA, Volume 4B, Appendix 4-2, Section 2.1.

All water quality constituents modelled are consistent with the EIA. However, the approach to modelling naphthenic acids now considers labile, refractory and inert naphthenic acids, and the proportions and rates of these fractions have been updated based on recent publications. These updates were made in response to reviews by Environment Canada in September 2011, and were developed in consultation with experts from Environment Canada, as described in Appendix 3.6.

Assessment methods used to screen and assess the results of water quality model predictions in this submission are also consistent with those used in the EIA, Volume 4A, Section 6.5.5.3. Predictions for the 2012 PDC were compared to water quality guidelines, Pre-Industrial concentrations and EIA Base Case concentrations. The 2012 PDC predictions are accompanied by these reference values in all results tables in this section.

3.3.3.1 Assessment Results

Jackpine Mine Expansion Local Study Area

This assessment compares 2012 PDC conditions to EIA Base and EIA Application Case conditions for waterbodies and watercourses in the Muskeg River watershed.

Within the Muskeg River watershed, acute and chronic toxicity and tainting potential levels are predicted to be appreciably lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2012 PDC at all assessment nodes (Tables 3.3-15 to 3.3-18).

Table 3.3-15 Predicted Water Quality for the Muskeg River (Node M0)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Muskeg River	Pre-Industrial Case		EIA Base Case/2012 Base Case[e]										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Aluminum	mg/L	0.75	0.1	0.02 (≤ 0.0022 - 0.72) n = 112	0.033	**0.96**	0.035	0.032	0.058	**0.23**	**0.12**	**0.86**	**1.0**	**1.0**	**0.57**	**0.57**	0.038	0.036	0.061	**0.24**	**0.12**	**0.87**	**1.0**	**1.1**	**0.78**	**0.4**
Ammonia	mg/L	13.3	4.36	<0.05 (<0.01 - 1.48) n = 106	0.078	2	0.059	0.043	0.069	0.0058	0.005	1.6	2.3	1.1	0.88	1.8	0.065	0.078	0.071	0.0001	0.0002	1.8	1.9	1.1	0.14	0.21
Antimony	mg/L	-	-	0.0006 (<0.000004 - 0.011) n = 90	0.00064	0.0095	0.00015	0.00022	0.00019	0.00037	0.00041	0.0033	0.0047	0.0023	0.002	0.0021	0.00016	0.00036	0.00021	0.00036	0.00035	0.0038	0.0046	0.0018	0.0005	0.00069
Arsenic	mg/L	0.34	0.005	<0.0004 (≤ 0.00018 - 0.009) n = 115	0.0004	**0.0059**	0.00011	0.00017	0.0004	0.00043	0.00029	0.0014	0.0028	**0.0086**	0.0011	0.0011	0.00011	0.00036	0.00046	0.00043	0.00029	0.0017	0.0028	**0.0093**	0.00048	0.00034
Barium	mg/L	-	-	0.027 (≤ 0.012 - 0.2) n = 93	0.034	0.58	0.05	0.041	0.083	0.032	0.022	0.61	0.8	0.39	0.36	0.69	0.059	0.058	0.083	0.03	0.046	0.63	0.65	0.21	0.1	0.15
Beryllium	mg/L	-	-	<0.001 (<0.000003 - 0.00014) n = 93	0	0	0	0	0.0001	0.0005	0.0002	0	0.0001	0.0008	0.0007	0.0007	0	0	0.0001	0.0005	0.0003	0	0	0.0008	0.0005	0.0004
Boron	mg/L	29	1.5	0.02 (<0.004 - 0.16) n = 112	0.042	0.61	0.053	0.048	0.061	0.7	0.28	0.57	0.64	0.52	1.0	0.47	0.054	0.051	0.067	0.64	0.35	0.58	0.68	0.49	0.75	0.47
Cadmium	mg/L	0.0037	0.0004	<0.0002 (<0.000002 - 0.032) n = 112	0.00015	**0.0072**	0.00005	0.000063	0.000084	0.00024	0.00017	**0.0021**	**0.0023**	**0.0015**	**0.00084**	**0.0009**	0.00005	0.00011	0.000096	0.00024	0.00021	**0.0022**	**0.0033**	**0.0018**	0.00036	0.00036
Calcium	mg/L	-	-	42.5 (18.2 - 89.1) n = 70	30	117	49	37	70	34	29	129	148	189	107	153	51	41	74	38	42	134	141	199	65	79
Chloride	mg/L	640	120	1.5 (<0.1 - 6) n = 154	2.4	26	7.7	3.7	4.2	28	10	38	34	21	54	31	8.2	4.9	3.7	27	16	35	30	20	35	23
Chromium	mg/L	0.016	0.001	<0.001 (≤ 0.000086 - 0.016) n = 112	0.00067	**0.0046**	0.00044	0.00069	**0.0019**	**0.0022**	**0.0011**	**0.003**	**0.0095**	**0.077**	**0.0029**	**0.0017**	0.00044	0.00072	**0.0022**	**0.0023**	**0.0011**	**0.0029**	**0.0059**	**0.093**	**0.0025**	**0.0014**
Cobalt	mg/L	-	-	<0.0002 (≤ 0.00005 - 0.0082) n = 93	0.00024	0.0026	0.00013	0.00017	0.00072	0.00062	0.00023	0.0011	0.0032	0.0081	0.001	0.0011	0.00015	0.00024	0.00083	0.00064	0.00027	0.0012	0.0014	0.0091	0.00075	0.0005
Copper	mg/L	0.023	0.003	<0.001 (<0.00008 - 0.006) n = 112	0.001	**0.0062**	0.00071	0.00064	0.0017	0.0015	0.00079	**0.0052**	**0.0072**	**0.028**	**0.0051**	**0.0064**	0.0008	0.00082	0.0019	0.0018	0.001	**0.0054**	**0.005**	**0.031**	0.0021	0.0016
Dissolved organic carbon	mg/L	-	-	22 (8 - 44) n = 114	21	52	22	19	18	20	17	62	56	39	42	52	25	23	18	18	22	51	52	33	25	30
Iron	mg/L	-	0.3	0.52 (0.073 - 31.9) n = 112	**1.1**	**12**	**1.6**	**1.2**	**0.83**	**0.59**	**1.0**	**8.5**	**10**	**13**	**2.0**	**2.7**	**1.6**	**1.3**	**0.72**	**0.6**	**1.3**	**9.4**	**10**	**14**	**2.6**	**2.2**
Lead	mg/L	0.163	0.0063	<0.0003 (≤ 0.0000065 - 0.0101) n = 112	0.00043	**0.007**	0.00012	0.00016	0.0002	0.00023	0.00024	0.0022	0.0031	0.0018	0.0013	0.0017	0.00014	0.00037	0.00021	0.00021	0.00022	0.0024	0.0042	0.0019	0.00034	0.00026
Magnesium	mg/L	-	-	12 (6.1 - 28) n = 57	9.1	58	15	11	15	11	8.9	68	74	50	46	70	16	12	15	10	12	69	68	39	23	30
Manganese	mg/L	-	-	0.039 (≤ 0.0031 - 1.2) n = 112	0.1	1.5	0.094	0.055	0.11	0.034	0.038	1.3	1.9	1.8	0.51	1.2	0.1	0.089	0.12	0.035	0.053	1.4	1.6	1.9	0.13	0.17
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0043) n = 145	0.0000004	0.0000043	0.0000007	0.0000006	0.0000006	0.0000038	0.0000017	**0.000014**	**0.0000059**	**0.000013**	**0.000013**	**0.0000067**	0.0000007	0.0000007	0.0000007	**0.0000063**	**0.000009**	**0.000011**	**0.0000063**	**0.0000089**	**0.000018**	**0.000012**
Molybdenum	mg/L	-	0.073	<0.0001 (≤ 0.000033 - 0.001) n = 93	0.0001	0.0013	0.0001	0.0001	0.0022	**0.079**	0.03	0.0012	0.0014	0.029	**0.18**	0.056	0.0001	0.0001	0.0018	**0.09**	0.043	0.0012	0.0011	0.028	**0.1**	0.064
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile[d]	mg/L	-	-	-	0	0	0	0	0	0.051	0.013	0	0	0	0.23	0.05	0	0	0	0.0015	0.0012	0	0	0	0.0095	0.0081
Naphthenic Acids - Refractory[d]	mg/L	-	-	-	0.67	3.4	0.68	0.7	0.97	8.5	2.2	6.0	3.8	5.2	16	3.9	0.7	0.7	1	5.6	2.2	5.7	3.8	5.7	5.9	2.5
Naphthenic Acids - Total	mg/L	-	-	-	0.67	3.4	0.68	0.7	0.97	8.6	2.2	6.0	3.8	5.2	16	4.0	0.7	0.7	1	7.1	3.1	5.7	3.8	5.7	8.6	3.5
Nickel	mg/L	0.742	0.083	0.000015 (<0.000005 - 0.025) n = 112	0.00056	0.021	0.00069	0.00073	0.0058	0.0079	0.003	0.043	0.03	0.04	0.023	0.021	0.00071	0.00066	0.0087	0.0091	0.0038	0.044	0.031	**0.082**	0.013	0.012
PAH group 1	µg/L	-	0.015	-	0	0	0	0	0.0068	0.0015	0.0003	0	**0.017**	**0.028**	0.0035	0.0007	0	0	0.0084	0.0007	0.0001	0	0	**0.029**	0.0013	0.0003
PAH group 2	µg/L	-	0.018	-	0	0	0	0	0.011	0.01	0.0021	0	**0.025**	**0.054**	0.016	0.0038	0	0	0.014	0.0053	0.0022	0	0	**0.053**	0.0075	0.004
PAH group 3	µg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0002	0
PAH group 4	µg/L	-	5.8	-	0	0	0	0	0.026	0.0009	0.0001	0	0.042	0.11	0.0047	0.0005	0	0	0.032	0.0002	0	0	0	0.13	0.0007	0.0001
PAH group 5	µg/L	-	0.012	-	0	0	0	0	0.011	0.002	0.0003	0	0	**0.039**	**0.018**	0.0034	0	0	**0.015**	0.0001	0	0	0	**0.049**	0.0004	0.0002
PAH group 6	µg/L	-	-	-	0	0	0	0	0	0.0017	0.0011	0	0	0	0.01	0.0028	0	0	0	0.0013	0.0012	0	0	0	0.0024	0.0024
PAH group 7	µg/L	-	0.04	-	0	0	0	0	0	0.0061	0.0008	0	0	0	0.012	0.0022	0	0	0	0.0002	0.0002	0	0	0	0.0011	0.0009
PAH group 8	µg/L	-	1.1	-	0	0	0	0	0	0.024	0.0035	0	0	0	0.046	0.013	0	0	0	0.0019	0.0011	0	0	0	0.0047	0.0027
PAH group 9	µg/L	-	0.025	-	0	0	0	0	0.005	0.0012	0.0005	0	0.01	0.016	0.0035	0.0016	0	0	0.0063	0.0004	0.0002	0	0	0.017	0.0009	0.0005
Potassium	mg/L	-	-	0.7 (<0.1 - 3.37) n = 57	1	5.5	1.1	0.81	1.4	2.2	0.94	5.5	6.6	3.8	4.0	4.0	1.2	1.1	1.4	1.7	1.5	5.4	5.7	3.9	2.0	2.4
Selenium	mg/L	-	0.001	<0.0004 (<0.0001 - 0.016) n = 109	0.00029	**0.0032**	0.0002	0.00022	0.00015	0.00055	0.00039	**0.0028**	**0.0023**	**0.0011**	0.00081	0.00072	0.00021	0.00025	0.00014	0.00049	0.00042	**0.0027**	**0.0027**	**0.0011**	0.00053	0.00048
Silver	mg/L	0.0103	0.0001	<0.000009 (<0.0000005 - 0.001) n = 89	0.000004	0.0001	0.000002	0.000002	0.000024	0.000012	0.000006	0.000036	0.000055	0.000064	0.000025	0.000024	0.000002	0.000003	0.000031	0.000011	0.000008	0.000033	0.00005	0.000069	0.000012	0.000011
Sodium	mg/L	-	-	5 (1.7 - 9) n = 57	7.5	41	11	8.2	10	41	16	50	79	40	71	45	12	11	9.6	36	22	58	63	41	39	31
Strontium	mg/L	-	-	0.086 (1.75E-02 - 0.33) n = 86	0.12	0.58	0.21	0.15	0.22	0.38	0.19	0.79	0.69	0.55	0.62	0.66	0.24	0.18	0.23	0.41	0.28	0.65	0.63	0.52	0.47	0.44
Sulphate	mg/L	-	-	3.25 (≤ 0.1 - 16) n = 154	3.3	34	3.6	4.1	31	140	38	24	198	451	208	72	3.7	3.6	34	163	45	24	26	432	175	76

Table 3.3-15 Predicted Water Quality for the Muskeg River (Node M0) (continued)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation in Muskeg River [c]	Pre-Industrial Case		EIA Base Case/2012 Base Case[e]										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Sulphide	mg/L	-	0.006	0.005 (<0.001 - 0.10) n = 79	**0.0074**	**0.048**	0.0027	0.0029	0.0038	0.0002	0.0002	**0.037**	**0.055**	**0.028**	**0.036**	**0.04**	0.0029	0.0055	0.0043	0	0	**0.04**	**0.041**	**0.023**	0.004	0.0044
Tainting potential	TPU	-	1	-	0	0	0	0	0	0.1	0.0051	0	0	0	0.3	0.023	0	0	0	0.0007	0.0005	0	0	0	0.0034	0.0019
Total dissolved solids	mg/L	-	-	190 (60 - 780) n = 154	191	774	307	215	290	541	258	842	913	689	849	885	328	243	298	480	355	873	823	506	589	595
Total nitrogen	mg/L	-	1	0.87 (<0.05 - 5.5) n = 141	0.92	**3.1**	0.74	0.75	0.75	**1.9**	**1.2**	**2.4**	**2.5**	**3.7**	**2.4**	**1.6**	0.77	0.81	0.75	**2.0**	**1.4**	**2.5**	**2.6**	**4**	**2.4**	**1.5**
Total phenolics	mg/L	-	0.004	0.004 (<0.001 - 0.12) n = 101	0.0021	**0.029**	0.002	0.0024	**0.0041**	0	0.0001	**0.019**	**0.024**	**0.021**	**0.005**	**0.0073**	0.002	0.0022	0.0046	0	0	**0.02**	**0.025**	**0.025**	0.0018	0.002
Total phosphorus	mg/L	-	0.05	0.031 (≤ 0.003 - 2.31) n = 150	**0.061**	**0.38**	0.041	0.038	**0.1**	0.04	0.026	**0.53**	**0.26**	**0.51**	**0.29**	**0.4**	0.047	**0.052**	**0.11**	**0.053**	0.046	**0.51**	**0.26**	**0.51**	**0.11**	**0.12**
Toxicity- acute	TUa	0.3	-	-	0	0	0	0	0	0.041	0.0076	0	0	0	0.065	0.013	0	0	0	0.0027	0.0017	0	0	0	0.0076	0.0048
Toxicity- chronic	TUc	-	1	-	0	0	0	0	0	0.071	0.012	0	0	0	0.15	0.03	0	0	0	0.0022	0.0015	0	0	0	0.0086	0.0058
Vanadium	mg/L	-	-	<0.001 (≤ 0.00012 - 0.005) n = 148	0.00036	0.0028	0.00036	0.00032	0.00058	0.0038	0.0014	0.0025	0.0036	0.0068	0.0052	0.0033	0.00039	0.00039	0.00062	0.0037	0.0018	0.0027	0.0031	0.0068	0.004	0.0027
Zinc	mg/L	0.19	0.03	0.005 (<0.0002 - 0.13) n = 112	0.0025	**0.045**	0.0028	0.0047	0.011	0.0083	0.0073	0.027	**0.042**	**0.14**	0.019	0.019	0.0027	0.0047	0.013	0.0089	0.0057	0.027	**0.046**	**0.15**	0.018	0.016

(a) - = No guideline / no data.

(b) From AENV (1999), CCME (1999), U.S. EPA (2002) using median pH of 7.5, median temperature of 7°C and median hardness of 149 mg/L (reflective of on-site conditions).

(c) Observed natural variation from Muskeg River downstream of North Pit Lake and Muskeg Creek (EIA, Volume 4B, Section 6.5.5.3, Table 6.5-8).

(d) The values of labile and refractory naphthenic acids were updated in this submission for the Pre-Industrial Case and the 2012 Base and 2012 Planned Development cases.

(e) The 2065 and 2165 predictions are based on new modelling results.

Note: Bold font indicates concentration exceeds at least one guideline.
Pre-Development information retitled “Pre-Industrial Case”.

Table 3.3-16 Predicted Water Quality for the Muskeg River (Node M3)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Muskeg River	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Aluminum	mg/L	0.75	0.1	0.050 (<0.01 - 1.2) n = 108	0.036	**0.92**	0.059	0.06	**0.13**	**0.17**	**0.11**	**0.83**	**0.93**	**0.82**	**0.69**	**0.63**	0.06	0.07	0.064	**0.24**	**0.12**	**0.82**	**0.88**	**0.8**	**0.79**	**0.63**
Ammonia	mg/L	9.6	3.58	0.04 (<0.01 - 1.63) n = 86	0.044	2.2	0.11	0.084	0.041	0.014	0.025	1.4	1.3	0.93	0.8	0.98	0.094	0.079	0.035	0.012	0.014	1.2	1.0	1	1.1	1.3
Antimony	mg/L	-	-	0.000019(<0.000004 - 0.0045) n = 97	0.00027	0.0042	0.00027	0.00029	0.00049	0.00051	0.00066	0.0033	0.0035	0.003	0.0024	0.0028	0.00035	0.00027	0.00027	0.0004	0.00042	0.0035	0.0032	0.0023	0.0024	0.0029
Arsenic	mg/L	0.34	0.005	0.00021 (≤ 0.0001 - 0.041) n = 118	0.00022	0.0023	0.00049	0.00055	0.00066	0.00061	0.00066	**0.0071**	**0.0063**	0.0026	0.005	0.0016	0.00056	0.00054	0.00027	0.00047	0.00034	**0.0068**	**0.0051**	0.0013	0.0046	0.0015
Barium	mg/L	-	-	<0.0002 (<0.000003 - 0.0088) n = 104	0.032	0.78	0.099	0.086	0.064	0.05	0.054	0.52	0.54	0.38	0.35	0.39	0.096	0.081	0.034	0.038	0.051	0.48	0.44	0.43	0.49	0.56
Beryllium	mg/L	-	-	0.049 (0.00003 - 0.92) n = 112	0	0	0.0001	0.0001	0.0001	0.0003	0.0001	0.0006	0.0005	0.0005	0.0007	0.0007	0.0001	0.0001	0.0001	0.0003	0.0002	0.0006	0.0005	0.0006	0.0006	0.00066
Boron	mg/L	29	1.5	0.046 (≤ 0.01 - 70) n = 107	0.049	0.62	0.068	0.076	0.24	0.45	0.24	0.55	0.6	0.62	0.72	0.56	0.068	0.077	0.1	0.46	0.3	0.56	0.57	0.57	0.72	0.59
Cadmium	mg/L	0.0037	0.0004	<0.0002 (<0.000002 - 0.004) n = 120	0.000087	**0.0026**	0.0001	0.00013	0.00034	0.00036	0.00037	**0.0021**	**0.0022**	**0.0019**	**0.0017**	**0.0018**	0.00012	0.00012	0.00016	0.00028	0.00024	**0.002**	**0.0018**	**0.0016**	**0.0019**	**0.0021**
Calcium	mg/L	-	-	53 (21 - 119) n = 94	36	141	86	70	48	39	37	211	163	131	101	107	81	80	47	41	42	191	169	154	135	145
Chloride	mg/L	640	120	3.8 (≤ 0.5 - 30) n = 259	2.7	29	4.4	5.1	16	25	12	24	29	38	45	29	4.3	5	9.2	27	15	23	27	39	65	41
Chromium	mg/L	0.016	0.001	0.00036 (<0.0001 - 0.017) n = 119	0.00084	**0.0064**	**0.0023**	**0.0023**	**0.0018**	**0.002**	**0.0015**	**0.058**	**0.049**	**0.016**	**0.0041**	**0.0035**	**0.0024**	**0.0025**	**0.0012**	**0.0022**	**0.0011**	**0.053**	**0.042**	**0.035**	**0.0048**	**0.0044**
Cobalt	mg/L	-	-	0.00013 (<0.00002 - 0.007) n = 113	0.0002	0.0017	0.00079	0.00076	0.00069	0.00067	0.00043	0.0087	0.005	0.003	0.0019	0.0011	0.00074	0.00075	0.00031	0.00065	0.0003	0.0064	0.0043	0.0017	0.0019	0.0013
Copper	mg/L	0.023	0.003	0.00039 (<0.00008 - 0.022) n = 116	0.00057	**0.005**	0.0017	0.0016	0.0015	0.0015	0.00096	**0.0078**	**0.015**	**0.0086**	**0.0059**	**0.0042**	0.0017	0.0016	0.00086	0.0017	0.001	**0.0076**	**0.013**	**0.0062**	**0.0053**	**0.0044**
Dissolved organic carbon	mg/L	-	-	21 (6 - 61) n = 247	18	55	21	19	20	20	20	46	46	41	40	43	22	19	16	19	22	45	42	43	46	52
Iron	mg/L	-	0.3	0.93 (0.104 - 4.42) n = 122	**1.2**	**9.8**	**1.0**	**0.98**	**0.9**	**0.77**	**1.1**	**5.7**	**7.9**	**4.6**	**3.2**	**3.7**	**1.0**	**0.88**	**0.93**	**0.78**	**1.3**	**5.4**	**6.5**	**8.8**	**4.0**	**4.3**
Lead	mg/L	0.16	0.0063	0.000043 (<0.000001 - 0.033) n = 113	0.0002	0.0033	0.00028	0.0003	0.00037	0.00034	0.00051	0.0027	0.0024	0.002	0.0016	0.002	0.00035	0.00028	0.00016	0.00026	0.00026	0.0027	0.0025	0.0016	0.0016	0.0017
Magnesium	mg/L	-	-	12 (5.8 - 22) n = 43	11	71	18	15	12	12	11	56	55	44	41	43	17	17	12	12	12	53	49	50	53	60
Manganese	mg/L	-	-	0.042 (≤ 0.014 - 1.24) n = 120	0.052	1.7	0.14	0.12	0.077	0.051	0.07	1.3	1.0	0.67	0.48	0.68	0.15	0.12	0.048	0.042	0.064	1.2	0.86	0.79	0.63	0.78
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0021) n = 171	0.0000005	**0.0000054**	0.0000007	0.0000011	0.0000025	0.0000036	0.0000022	**0.000017**	**0.000011**	**0.0000091**	**0.000021**	**0.000017**	0.0000007	0.000001	0.0000009	0.0000047	**0.0000056**	**0.000012**	**0.000013**	**0.00001**	**0.000021**	**0.000021**
Molybdenum	mg/L	-	0.073	0.000080 (≤ 0.00003 - 0.005) n = 112	0.0001	0.0011	0.0005	0.0027	0.027	0.055	0.029	0.0076	0.052	0.06	**0.16**	0.067	0.0005	0.002	0.0084	0.064	0.036	0.0066	0.047	0.049	**0.11**	**0.077**
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile[d]	mg/L	-	-	-	0	0	0	0.02	0.032	0.053	0.032	0	0.29	0.11	0.16	0.082	0	0.0037	0.023	0.017	0.015	0	0.1	0.11	0.22	0.26
Naphthenic Acids - Refractory[d]	mg/L	-	-	-	0.7	3.5	0.99	1.1	2.3	6.2	3.4	5.0	3.6	4.7	9.7	6.5	0.97	1.2	1.2	3.8	2.2	4.7	3.5	4.9	5.8	3.8
Naphthenic Acids - Total	mg/L	-	-	-	0.7	3.5	0.99	1.1	2.3	6.3	3.4	5.0	3.9	4.8	10	6.8	0.97	1.2	1.2	4.6	2.8	4.7	3.6	5.0	8.2	4.4
Nickel	mg/L	0.735	0.082	0.0002 (<0.000005 - 0.20) n = 119	0.00067	0.023	0.0048	0.0047	0.0046	0.0065	0.0038	0.04	0.031	0.021	0.021	0.02	0.0045	0.0058	0.013	0.0076	0.0035	0.038	0.027	**0.52**	0.015	0.014
PAH group 1	µg/L	-	0.015	-	0	0	0.0059	0.0055	0.0027	0.0013	0.0003	**0.024**	**0.023**	0.014	0.01	0.0009	0.0048	0.0068	0.0034	0.0009	0.0002	**0.022**	**0.021**	**0.02**	0.0096	0.0035
PAH group 2	µg/L	-	0.018	-	0	0	0.01	0.01	0.0084	0.0085	0.0023	**0.044**	**0.046**	**0.027**	**0.02**	0.0066	0.009	0.013	0.0063	0.005	0.002	**0.042**	**0.041**	**0.041**	0.017	0.012
PAH group 3	µg/L	-	-	-	0	0	0	0.0002	0.0001	0.0001	0.0001	0.0006	0.0027	0.0009	0.0007	0.00065	0	0	0.0001	0	0	0	0.0005	0.0011	0.0007	0.0008
PAH group 4	µg/L	-	5.8	-	0	0	0.02	0.017	0.0086	0.0012	0.0003	0.081	0.085	0.057	0.022	0.0023	0.016	0.02	0.012	0.001	0.0003	0.079	0.088	0.092	0.022	0.02
PAH group 5	µg/L	-	0.012	-	0	0	0.01	0.011	0.0065	0.0044	0.002	**0.049**	**0.13**	**0.032**	**0.024**	**0.022**	0.0072	0.011	0.0097	0.0022	0.0019	**0.025**	**0.039**	**0.082**	**0.042**	**0.043**
PAH group 6	µg/L	-	-	-	0	0	0.0001	0.0004	0.0016	0.0023	0.0011	0.0019	0.0081	0.0047	0.0075	0.0027	0	0.0001	0.0003	0.001	0.0008	0	0.002	0.004	0.0035	0.0042
PAH group 7	µg/L	-	0.04	-	0	0	0.0002	0.0012	0.0015	0.0036	0.0011	0.018	**0.077**	0.017	0.017	0.014	0	0.0004	0.0017	0.001	0.0009	0	0.015	0.039	**0.063**	**0.096**
PAH group 8	µg/L	-	1.1	-	0	0	0.0003	0.0024	0.0044	0.012	0.0037	0.049	0.18	0.039	0.041	0.028	0	0.0008	0.0034	0.0037	0.003	0	0.038	0.094	0.046	0.05
PAH group 9	µg/L	-	0.025	-	0	0	0.0042	0.0045	0.0024	0.0013	0.0005	0.016	0.024	0.0091	0.0081	0.0022	0.0033	0.0048	0.0028	0.0007	0.0003	0.015	0.015	0.012	0.0069	0.0043
Potassium	mg/L	-	-	1.47 (<0.3 - 13) n = 43	0.68	6.2	1.6	1.5	1.8	2.0	1.5	5.2	5.2	4.2	4.2	4.0	1.6	1.5	0.91	1.7	1.5	4.6	4.6	3.9	4.0	4.6
Selenium	mg/L	-	0.001	<0.0004 (≤ 0.00006 - 0.0013) n = 112	0.00023	**0.0026**	0.00018	0.00019	0.00033	0.00042	0.00038	**0.002**	**0.0017**	**0.0016**	**0.0012**	**0.0012**	0.0002	0.00018	0.00023	0.00042	0.0004	**0.002**	**0.0015**	**0.0012**	**0.0012**	**0.0013**
Silver	mg/L	0.0101	0.0001	<0.000022 (<0.0000005 - 0.003) n = 104	0.000002	0.000047	0.000027	0.00003	0.000029	0.000025	0.00002	0.000063	0.00008	0.000057	0.000059	0.000056	0.000022	0.00002	0.000009	0.000013	0.000012	0.000057	0.000049	0.000036	0.000064	0.000076

Table 3.3-16 Predicted Water Quality for the Muskeg River (Node M3) (continued)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation in Muskeg River [c]	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Sodium	mg/L	-	-	12 (6 - 23) n = 43	7.3	57	13	13	29	39	22	38	45	64	86	55	13	12	13	32	22	38	46	54	76	59
Strontium	mg/L	-	-	0.13 (0.058 - 75) n = 104	0.12	0.59	0.23	0.21	0.23	0.29	0.19	0.55	0.55	0.49	0.51	0.47	0.23	0.22	0.17	0.34	0.25	0.53	0.5	0.53	0.55	0.56
Sulphate	mg/L	-	-	5 (≤ 0.1 - 99) n = 257	4	33	19	21	41	87	24	73	141	182	193	62	18	28	20	111	37	72	131	306	202	56
Sulphide	mg/L	-	0.008	<0.01 (<0.001 - 0.14) n = 129	0.0033	**0.047**	0.0045	0.0031	0.0019	0.0007	0.0007	**0.039**	**0.038**	**0.038**	**0.036**	**0.039**	0.0036	0.0034	0.0014	0.0008	0.0008	**0.04**	**0.036**	**0.028**	**0.025**	**0.03**
Tainting potential	TPU	-	1	-	0	0	0	0.0018	0.0057	0.04	0.0046	0	0.057	0.056	0.099	0.031	0	0.0001	0.0076	0.005	0.0036	0	0.066	0.083	0.05	0.043
Total dissolved solids	mg/L	-	-	227 (72 - 844) n = 192	200	865	306	284	339	428	276	686	698	666	696	593	294	293	259	438	331	653	645	702	742	728
Total nitrogen	mg/L	-	1	0.88 (0.28 - 3.94) n = 198	0.79	**2.5**	0.74	0.77	**1.4**	**1.7**	**1.1**	**2.2**	**2.2**	**2.3**	**2.7**	**2.1**	0.76	0.75	0.79	**1.8**	**1.3**	**2.0**	**2.2**	**2.2**	**2.7**	**2.1**
Total phenolics	mg/L	-	0.004	0.002 (<0.001 - 0.025) n = 135	0.0026	**0.024**	0.004	0.0031	0.0017	0.0004	0.0004	**0.02**	**0.02**	**0.018**	**0.01**	**0.011**	0.0029	0.0029	0.0025	0.0004	0.0003	**0.017**	**0.018**	**0.019**	**0.014**	**0.014**
Total phosphorus	mg/L	-	0.05	0.029 (<0.005 - 0.6) n = 235	0.033	**0.24**	**0.1**	**0.1**	**0.073**	**0.054**	0.038	**0.46**	**0.39**	**0.28**	**0.28**	**0.25**	**0.096**	**0.096**	0.042	**0.053**	0.045	**0.36**	**0.35**	0.21	**0.32**	**0.23**
Toxicity- acute	TUa	0.3	-	-	0	0	0	0.0005	0.017	0.031	0.007	0	0.0079	0.04	0.049	0.014	0	0.0003	0.0029	0.0052	0.0037	0	0.0075	0.014	0.025	0.022
Toxicity- chronic	TUc	-	1	-	0	0	0	0.0049	0.035	0.06	0.019	0	0.068	0.077	0.11	0.062	0	0.003	0.018	0.014	0.012	0	0.067	0.089	0.12	0.11
Vanadium	mg/L	-	-	<0.001 (<0.00004 - 0.018) n = 185	0.00033	0.0032	0.00064	0.00069	0.0016	0.0026	0.0016	0.0037	0.0041	0.0036	0.0059	0.0043	0.00063	0.00069	0.00069	0.003	0.0017	0.0036	0.0036	0.0033	0.0059	0.005
Zinc	mg/L	0.188	0.03	0.0050 (<0.0002 - 0.16) n = 116	0.0057	**0.038**	0.014	0.014	0.011	0.011	0.011	**0.1**	**0.1**	**0.036**	**0.038**	**0.033**	0.014	0.015	0.0079	0.0099	0.0072	**0.092**	**0.086**	**0.05**	**0.04**	**0.04**

(a) - = No guideline / no data.

(b) From AENV (1999), CCME (1999), U.S. EPA (2002) using median pH of 7.7, median temperature of 4.2°C and median hardness of 172 mg/L (reflective of on-site conditions).

(c) Observed natural variation from Muskeg River downstream of North Pit Lake and Muskeg Creek (EIA, Volume 4B, Section 6.5.3.3, Table 6.5-7).

(d) The values of labile and refractory naphthenic acids were updated in this submission for the Pre-Industrial Case and the 2012 Base and 2012 Planned Development cases.

Note: Bold font indicates concentration exceeds at least one guideline.
Pre-Development information retitled “Pre-Industrial Case”.

Table 3.3-17 Predicted Water Quality for Jackpine Creek (Node J1)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Jackpine Creek	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Aluminum	mg/L	0.75	0.1	0.05 (<0.01 - 0.99) n = 52	0.028	**1**	0.03	0.031	0.032	0.038	0.038	**0.99**	**1.0**	**0.86**	**0.87**	**0.87**	0.031	0.029	0.031	0.042	0.04	**0.95**	**1.1**	**0.91**	**0.85**	**0.84**
Ammonia	mg/L	9.6	3.58	0.03 (<0.01 - 1.6) n = 61	0.052	1.3	0.092	0.071	0.07	0.069	0.07	1.3	2.7	1.1	1.0	1.2	0.046	0.046	0.043	0.068	0.07	1.2	1.9	0.96	1.0	1.0
Antimony	mg/L	-	-	0.000018 (≤ 0.000013 - 0.0011) n = 39	0.00024	0.0087	0.00027	0.00027	0.00029	0.00031	0.0003	0.0059	0.004	0.0042	0.0036	0.0036	0.00023	0.00022	0.00024	0.00028	0.0003	0.0046	0.004	0.0043	0.0033	0.0033
Arsenic	mg/L	0.34	0.005	0.00040 (≤ 0.0002 - 0.02) n = 64	0.00016	0.0033	0.00024	0.00024	0.00024	0.00023	0.00023	0.0029	**0.0056**	0.0017	**0.0086**	0.0014	0.00016	0.00016	0.00016	0.00024	0.00023	0.0023	0.0019	0.002	0.0026	0.0017
Barium	mg/L	-	-	0.027 (0.0102 - 0.20) n = 39	0.026	0.54	0.036	0.034	0.031	0.029	0.031	0.53	0.75	0.44	0.45	0.46	0.026	0.028	0.024	0.032	0.032	0.51	0.62	0.43	0.43	0.43
Beryllium	mg/L	-	-	<0.00004 (≤ 0.0000035 - 0.003) n = 39	0	0	0	0	0	0	0	0.0007	0.0015	0.0008	0.0007	0.0006	0	0	0	0	0	0	0	0	0.0007	0.0007
Boron	mg/L	29	1.5	0.05 (0.02 - 0.11) n = 52	0.047	0.66	0.051	0.051	0.05	0.058	0.058	0.65	0.69	0.56	0.58	0.58	0.047	0.047	0.046	0.066	0.065	0.62	0.71	0.59	0.57	0.57
Cadmium	mg/L	0.0022	0.00028	<0.0002 (<0.000002 - 0.004) n = 53	0.000073	**0.0026**	0.000094	0.00009	0.000099	0.0001	0.0001	**0.0026**	**0.002**	**0.0026**	**0.0022**	**0.0022**	0.00008	0.000079	0.00008	0.00011	0.00011	**0.0025**	**0.0023**	**0.0026**	**0.0022**	**0.0022**
Calcium	mg/L	-	-	31 (16.4 - 91) n = 30	37	163	41	42	39	38	38	162	157	158	157	157	38	38	37	38	37	158	156	149	146	146
Chloride	mg/L	640	120	2.1 (≤ 0.3 - 24) n = 178	2.5	24	2.8	2.8	2.7	3.4	3.5	24	34	22	**145**	**145**	2.6	2.6	2.4	4.6	4.4	24	27	22	30	27
Chromium	mg/L	0.016	0.001	<0.001 (≤ 0.00015 - 0.04) n = 68	0.00081	**0.012**	0.001	**0.0011**	**0.0011**	0.001	0.001	**0.01**	**0.01**	**0.0085**	**0.0083**	**0.0089**	0.00087	0.00084	0.00086	**0.0012**	0.00099	**0.011**	**0.011**	**0.0099**	**0.0092**	**0.0092**
Cobalt	mg/L	-	-	0.00014 (≤ 0.000092 - 0.009) n = 43	0.00023	0.0018	0.00031	0.0003	0.00028	0.00026	0.00026	0.0015	0.0021	0.0015	0.0017	0.0013	0.00023	0.00022	0.00022	0.00032	0.00027	0.0016	0.0015	0.0015	0.0015	0.0014
Copper	mg/L	0.015	0.002	0.00029 (<0.00008 - 0.01) n = 51	0.00051	**0.0036**	0.00057	0.00061	0.00061	0.00062	0.00061	**0.0034**	**0.0051**	**0.0031**	**0.005**	**0.0029**	0.00051	0.00051	0.00051	0.00066	0.00057	**0.0033**	**0.0031**	**0.0031**	**0.0037**	**0.003**
Dissolved organic carbon	mg/L	-	-	22 (5 - 89) n = 139	18	59	18	18	17	17	17	57	53	52	52	52	18	18	18	17	17	55	54	52	50	50
Iron	mg/L	-	0.3	0.76 (0.26 - 3.73) n = 54	**1.2**	**15**	**1.4**	**1.3**	**1.3**	**1.3**	**1.3**	**14**	**18**	**17**	**12**	**12**	**1.2**	**1.1**	**1.1**	**1.2**	**1.2**	**17**	**17**	**17**	**11**	**11**
Lead	mg/L	0.086	0.0033	0.00006 (≤ 0.000032 - 0.006) n = 53	0.00019	0.0033	0.00032	0.00031	0.00031	0.00028	0.00028	0.0032	0.0032	0.0024	0.0019	0.002	0.00019	0.00019	0.00019	0.00027	0.00028	0.0024	0.0025	0.0023	0.0021	0.0021
Magnesium	mg/L	-	-	8 (4.5 - 21) n = 15	11	63	12	12	11	11	11	62	61	61	60	61	11	11	11	11	11	61	60	57	56	56
Manganese	mg/L	-	-	0.028 (<0.004 - 0.52) n = 53	0.058	0.96	0.07	0.059	0.06	0.055	0.055	0.85	1.5	0.68	0.65	0.68	0.052	0.049	0.049	0.052	0.054	0.88	1.6	0.68	0.59	0.64
Mercury	mg/L	0.000013	0.000005	<0.0001 (<0.0000006 - 0.0045) n = 153	0.0000005	**0.0000061**	0.0000015	0.0000014	0.0000013	0.0000018	0.0000018	**0.000026**	**0.000046**	**0.000027**	**0.000053**	**0.000053**	0.0000005	0.0000005	0.0000005	0.0000014	0.0000013	**0.0000064**	**0.0000064**	**0.0000064**	**0.00002**	**0.00002**
Molybdenum	mg/L	-	0.073	0.00011 (≤ 0.00004 - 0.006) n = 39	0.0001	0.0009	0.0002	0.0003	0.0002	0.0005	0.0003	0.0028	0.05	0.0034	0.065	0.006	0.0001	0.0001	0.0001	0.0013	0.0011	0.0009	0.0009	0.0009	0.034	0.021
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile[d]	mg/L	-	-	-	0	0	0	0	0	0.034	0.034	0	0	0	0.22	0.22	0	0	0	0.014	0.014	0	0	0	0.21	0.21
Naphthenic Acids - Refractory[d]	mg/L	-	-	-	0.67	3.7	0.7	0.73	0.72	1.4	1.4	3.6	3.8	3.3	12	12	0.69	0.68	0.69	0.87	0.86	3.4	3.6	3.4	3.6	3.4
Naphthenic Acids - Total	mg/L	-	-	-	0.67	3.7	0.7	0.73	0.72	1.4	1.4	3.6	3.8	3.3	12	12	0.69	0.68	0.69	0.88	0.87	3.4	3.6	3.4	4.7	3.6
Nickel	mg/L	0.485	0.054	0.00027 (<0.00006 - 0.011) n = 52	0.0006	0.016	0.00078	0.00088	0.00078	0.00095	0.0009	0.015	0.021	0.013	0.016	0.013	0.00057	0.00058	0.00057	0.0013	0.00093	0.015	0.02	0.013	0.014	0.014
PAH group 1	µg/L	-	0.015	-	0	0	0.001	0.001	0.0008	0.0009	0.0008	**0.022**	**0.042**	**0.027**	**0.023**	**0.021**	0	0	0	0.001	0.0008	0	0	0	**0.023**	**0.022**
PAH group 2	µg/L	-	0.018	-	0	0	0.0016	0.0018	0.0014	0.0015	0.0014	**0.15**	**0.35**	**0.16**	**0.15**	**0.15**	0	0	0	0.0018	0.0015	0	0	0	**0.16**	**0.16**
PAH group 3	µg/L	-	-	-	0	0	0.0004	0.0003	0.0003	0.0003	0.0003	0.03	0.06	0.031	0.019	0.019	0	0	0	0.0003	0.0003	0	0	0	0.019	0.019
PAH group 4	µg/L	-	5.8	-	0	0	0.0013	0.0017	0.0011	0.0014	0.0012	0.1	0.33	0.12	0.1	0.098	0	0	0	0.0019	0.0013	0	0	0	0.1	0.1
PAH group 5	µg/L	-	0.012	-	0	0	0.0033	0.0031	0.0032	0.0031	0.003	**1.1**	**3.3**	**1.2**	**0.83**	**0.83**	0	0	0	0.0048	0.0047	0	0	0	**0.89**	**0.89**
PAH group 6	µg/L	-	-	-	0	0	0.001	0.0009	0.0008	0.0008	0.0008	0.061	0.14	0.069	0.055	0.055	0	0	0	0.0008	0.0008	0	0	0	0.056	0.056
PAH group 7	µg/L	-	0.04	-	0	0	0.0021	0.0019	0.0019	0.0018	0.0018	**0.63**	**0.8**	**0.64**	**0.43**	**0.43**	0	0	0	0.0024	0.0024	0	0	0	**0.48**	**0.48**
PAH group 8	µg/L	-	1.1	-	0	0	0.0029	0.0024	0.0027	0.0027	0.0027	**1.4**	**3.0**	**1.5**	**1.2**	**1.2**	0	0	0	0.0042	0.0042	0	0	0	**1.2**	**1.2**
PAH group 9	µg/L	-	0.025	-	0	0	0.0015	0.0016	0.0014	0.0014	0.0013	**0.12**	**0.28**	**0.12**	**0.089**	**0.089**	0	0	0	0.0015	0.0014	0	0	0	**0.094**	**0.094**

Table 3.3-17 Predicted Water Quality for Jackpine Creek (Node J1) (continued)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Jackpine Creek	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Potassium	mg/L	-	-	1 (0.3 - 1.8) n = 15	0.57	4.7	0.77	0.8	0.77	0.75	0.76	4.6	7.7	4.3	4.2	4.3	0.66	0.67	0.64	0.77	0.77	4.3	4.9	3.8	4.2	4.2
Selenium	mg/L	-	0.001	<0.0004 (<0.0001 - 0.012) n = 52	0.00021	**0.0031**	0.00022	0.00024	0.00024	0.00026	0.00026	**0.0031**	**0.003**	**0.0028**	**0.0027**	**0.0027**	0.00022	0.00022	0.00022	0.00023	0.00024	**0.0028**	**0.0029**	**0.0028**	**0.0027**	**0.0027**
Silver	mg/L	0.0043	0.0001	<0.000005 (<0.0000005 - 0.005) n = 43	0.000001	0.000028	0.00002	0.000019	0.000017	0.000017	0.000017	**0.00044**	**0.00084**	**0.00054**	**0.00042**	**0.00042**	0.000001	0.000001	0.000001	0.000017	0.000017	0.00002	0.000028	0.000021	**0.00043**	**0.00043**
Sodium	mg/L	-	-	11 (9 - 28) n = 15	7.1	38	8.9	8.1	7.9	8.2	8.4	45	106	58	82	82	6.8	7.0	6.3	9.6	9.3	38	70	29	44	40
Strontium	mg/L	-	-	0.11 (0.049 - 0.32) n = 39	0.13	0.69	0.14	0.13	0.13	0.13	0.13	0.69	1.1	0.68	0.68	0.68	0.13	0.12	0.12	0.14	0.13	0.71	0.73	0.73	0.67	0.67
Sulphate	mg/L	-	-	4.5 (≤ 0.1 - 14) n = 178	4	34	4.8	5.6	4.7	5.5	4.9	35	147	43	159	33	4.1	3.9	4.1	8.8	5.5	35	36	34	126	39
Sulphide	mg/L	-	0.008	<0.01 (<0.001 - 0.16) n = 75	0.0032	**0.025**	0.0041	0.0035	0.0037	0.0034	0.0034	**0.024**	**0.059**	**0.022**	**0.036**	**0.036**	0.003	0.0029	0.003	0.0037	0.0037	**0.022**	**0.02**	**0.017**	**0.034**	**0.034**
Tainting potential	TPU	-	1	-	0	0	0	0	0	0.0003	0.0003	0	0	0	0.025	0.025	0	0	0	0.0068	0.0025	0	0	0	0.26	0.052
Total dissolved solids	mg/L	-	-	150 (53 - 551) n = 176	199	627	219	226	214	215	214	614	792	610	743	744	198	194	194	215	206	609	739	572	573	572
Total nitrogen	mg/L	-	1	0.88 (<0.05 - 4.17) n = 163	0.8	**3.5**	0.86	0.91	0.88	0.91	0.91	**3.0**	**3.1**	**2.8**	**2.6**	**2.6**	0.79	0.78	0.79	0.93	0.88	**2.8**	**2.8**	**2.8**	**2.6**	**2.6**
Total phenolics	mg/L	-	0.004	0.003 (<0.001 - 0.13) n = 115	0.0024	**0.035**	0.003	0.0033	0.0033	0.0028	0.0028	**0.034**	**0.041**	**0.033**	**0.031**	**0.031**	0.0025	0.0024	0.0025	0.0026	0.0028	**0.034**	**0.034**	**0.033**	**0.03**	**0.031**
Total phosphorus	mg/L	-	0.05	0.034 (<0.005 - 0.5) n = 181	0.03	**0.17**	0.045	0.044	0.039	0.038	0.038	**0.19**	**0.54**	**0.26**	**0.35**	**0.22**	0.028	0.026	0.027	0.039	0.037	**0.22**	**0.22**	**0.23**	**0.21**	**0.19**
Toxicity- acute	TUa	0.3	-	-	0	0	0	0	0	0.0019	0.0019	0	0	0	0.086	0.086	0	0	0	0.0026	0.0026	0	0	0	0.087	0.087
Toxicity- chronic	TUc	-	1	-	0	0	0	0	0	0.0067	0.0067	0	0	0	0.2	0.2	0	0	0	0.013	0.013	0	0	0	0.2	0.2
Vanadium	mg/L	-	-	<0.001 (<0.0002 - 0.011) n = 155	0.00029	0.0061	0.00036	0.00039	0.00037	0.00039	0.00039	0.0053	0.0037	0.0036	0.0034	0.0034	0.00032	0.00033	0.00031	0.00047	0.00045	0.0044	0.0042	0.004	0.0039	0.0039
Zinc	mg/L	0.124	0.03	0.0055 (≤ 0.00046 - 0.43) n = 53	0.0061	**0.1**	0.0065	0.0062	0.0059	0.0063	0.0062	**0.088**	**0.08**	**0.061**	**0.061**	**0.051**	0.0063	0.0061	0.006	0.0069	0.0063	**0.078**	**0.072**	**0.071**	**0.049**	**0.048**

(a) - = No guideline / no data.

(b) From AENV (1999), CCME (1999), U.S. EPA (2002) using median pH of 7.7, median temperature of 7°C and median hardness of 103 mg/L (reflective of on-site conditions).

(c) Observed natural variation from Muskeg River downstream of North Pit Lake and Muskeg Creek (EIA, Volume 4B, Section 6.5.3.3, Table 6.5-8).

(d) The values of labile and refractory naphthenic acids were updated in this submission for the Pre-Industrial Case and the 2012 Base and 2012 Planned Development cases.

Note: Bold font indicates concentration exceeds at least one guideline.
Pre-Development information retitled “Pre-Industrial Case”.

Table 3.3-18 Predicted Water Quality for Kearl Lake (Node K1)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Kearl Lake	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
Aluminum	mg/L	0.75	0.1	0.02 (<0.01 - 0.13) n = 29	0.1	**0.49**	0.1	**0.13**	**0.15**	**0.13**	**0.12**	**0.46**	**0.29**	**0.28**	**0.19**	**0.19**	0.054	0.098	**0.11**	**0.37**	**0.18**	**0.74**	**0.44**	**0.43**	**0.75**	**0.25**
Ammonia	mg/L	6.8	2.8	0.035 (<0.01 - 2.01) n = 32	0.1	0.48	0.082	0.0015	0.0009	0.0004	0.0006	0.48	0.032	0.019	0.009	0.012	0.0075	0.002	0.0018	0.0009	0.0015	0.16	0.045	0.042	0.011	0.02
Antimony	mg/L	-	-	0.000020 (≤ 0.00001 - 0.0023) n = 21	0.0014	0.0054	0.0013	0.0015	0.0012	0.001	0.0013	0.0046	0.003	0.0023	0.0018	0.0023	0.00096	0.0011	0.0011	0.00097	0.0012	0.0056	0.0034	0.0033	0.0016	0.0021
Arsenic	mg/L	0.34	0.005	<0.00037 (≤ 0.0001 - 0.006) n = 30	0.0018	**0.0051**	0.0014	0.0017	0.00096	0.0012	0.0022	0.0036	0.0031	0.0019	0.0021	0.0043	0.00085	0.00085	0.0008	0.0014	0.0011	**0.0053**	0.0028	0.0028	0.0021	0.0022
Barium	mg/L	-	-	0.014 (0.001 - 0.12) n = 26	0.051	0.13	0.039	0.043	0.024	0.069	0.083	0.092	0.074	0.053	0.1	0.14	0.022	0.021	0.019	0.058	0.04	0.068	0.049	0.049	0.088	0.069
Beryllium	mg/L	-	-	<0.001 (<0.000003 - 0.0005) n = 23	0	0	0	0	0	0.0001	0.0001	0	0.0001	0.0001	0.0002	0.0001	0	0	0	0.0002	0.0001	0	0.0001	0.0001	0.0002	0.0001
Boron	mg/L	29	1.5	0.049 (<0.01 - 0.08) n = 29	0.1	0.33	0.095	0.1	0.1	0.3	0.12	0.31	0.22	0.19	0.58	0.2	0.056	0.077	0.082	0.41	0.3	0.47	0.29	0.28	0.59	0.53
Cadmium	mg/L	0.0016	0.00022	<0.0002 (<0.000002 - 0.0005) n = 32	**0.00049**	**0.0028**	**0.0004**	**0.00046**	**0.00033**	**0.00087**	**0.00063**	**0.0018**	**0.0014**	**0.00094**	**0.0016**	**0.0015**	**0.00025**	**0.0003**	**0.0003**	**0.00072**	**0.00053**	**0.0031**	**0.0013**	**0.0014**	**0.0012**	**0.0015**
Calcium	mg/L	-	-	18 (<0.3 - 49) n = 21	31	53	28	28	22	44	48	48	40	40	59	71	22	20	21	38	31	39	37	38	63	50
Chloride	mg/L	640	120	0.46 (≤ 0.28 - 2) n = 33	2.6	9.8	2.2	2.4	1.9	32	4.5	6.5	4.4	3.6	66	6.4	1.6	1.6	1.6	27	7.4	6.2	3.4	3.5	69	15
Chromium	mg/L	0.016	0.001	<0.0008 (≤ 0.00014 - 0.35) n = 32	**0.0029**	**0.0078**	**0.0022**	**0.0026**	**0.0014**	**0.0023**	**0.0036**	**0.0052**	**0.004**	**0.0021**	**0.0037**	**0.0071**	**0.0012**	**0.0013**	**0.0012**	**0.0032**	**0.0016**	**0.0048**	**0.0024**	**0.0023**	**0.0045**	**0.0032**
Cobalt	mg/L	-	-	<0.0002 (≤ 0.00003 - 0.016) n = 26	0.00073	0.0014	0.00054	0.00063	0.0003	0.0009	0.00093	0.00095	0.00078	0.00044	0.0016	0.0017	0.00031	0.00028	0.00025	0.0015	0.00053	0.0009	0.00053	0.0005	0.0025	0.001
Copper	mg/L	0.011	0.002	<0.001 (<0.00005 - 0.0077) n = 31	0.0011	**0.0025**	0.0011	0.0012	0.0012	0.0013	0.0011	**0.0023**	0.0017	0.0017	**0.0021**	0.0017	0.00094	0.00091	0.001	**0.0028**	0.0013	**0.0034**	0.0019	0.002	**0.0044**	**0.0022**
Dissolved organic carbon	mg/L	-	-	21 (<0.2 - 40) n = 29	26	43	23	23	21	25	26	40	34	31	39	43	21	19	21	25	23	33	26	29	39	39
Iron	mg/L	-	0.3	0.08 (≤ 0.003 - 2.4) n = 32	**1**	**4.8**	**1.0**	**1.1**	**0.9**	**1.2**	**1.5**	**3.4**	**2.2**	**1.4**	**1.5**	**2.3**	**0.87**	**0.79**	**0.82**	**0.77**	**1.0**	**3.7**	**1.9**	**1.7**	**1.3**	**1.8**
Lead	mg/L	0.059	0.0023	<0.0003 (≤ 0.00002 - 0.005) n = 29	0.0016	**0.0058**	0.0013	0.0016	0.001	0.0012	0.0018	**0.0046**	**0.0034**	0.0021	0.0018	**0.0038**	0.00083	0.00089	0.00089	0.0009	0.001	**0.0049**	**0.0032**	**0.0031**	0.0013	0.0017
Magnesium	mg/L	-	-	6.5 (<0.2 - 12.4) n = 15	10	17	8.9	8.8	7.0	12	13	15	11	10	18	21	7.1	6.4	6.6	13	9.0	11	9.9	10	21	14
Manganese	mg/L	-	-	0.020 (<0.004 - 0.30) n = 32	0.097	0.25	0.084	0.095	0.065	0.16	0.19	0.19	0.19	0.18	0.21	0.26	0.075	0.065	0.064	0.069	0.11	0.28	0.17	0.18	0.11	0.22
Mercury	mg/L	0.000013	0.000005	<0.0000008 (<0.0000006 - 0.0003) n = 30	0.0000005	0.0000012	0.0000005	0.0000005	0.0000005	0.0000005	0.0000003	0.0000011	0.0000007	0.0000008	0.0000011	0.0000007	0.0000004	0.0000004	0.0000004	0.000002	0.0000006	0.0000018	0.000001	0.000001	0.000004	0.0000012
Molybdenum	mg/L	-	0.073	0.0001 (≤ 0.00006 - 0.003) n = 26	0.0002	0.0006	0.0002	0.0002	0.001	0.045	0.0003	0.0006	0.0004	0.0014	**0.094**	0.0005	0.0002	0.0002	0.0002	0.044	0.025	0.0007	0.0004	0.0004	0.067	0.053
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile[d]	mg/L	-	-	-	0	0	0	0	0	0.0021	0.0001	0	0	0	0.013	0.0002	0	0	0	0.0039	0.0038	0	0	0	0.027	0.027
Naphthenic Acids - Refractory[d]	mg/L	-	-	-	0.81	1.2	0.79	0.78	0.8	2.3	0.34	1.2	0.97	0.93	3.2	0.86	0.72	0.7	0.77	2.8	2.6	1.5	1.0	1.1	4.3	4.0
Naphthenic Acids - Total	mg/L	-	-	-	0.81	1.2	0.79	0.78	0.8	2.3	0.45	1.2	0.97	0.93	4.1	0.91	0.72	0.7	0.77	3.1	2.8	1.5	1.0	1.1	4.8	4.5
Nickel	mg/L	0.376	0.042	0.00035 (≤ 0.000075 - 0.0057) n = 32	0.001	0.0046	0.001	0.0011	0.0013	0.0045	0.0029	0.0045	0.0033	0.0035	0.0072	0.0039	0.00071	0.00084	0.00094	0.0066	0.0032	0.0069	0.0038	0.0039	0.0099	0.0048
PAH group 1	µg/L	-	0.015	-	0	0	0	0	0.0001	0.0005	0	0	0	0.0002	0.0008	0	0	0	0	0.0008	0.0002	0	0	0	0.0014	0.0003
PAH group 2	µg/L	-	0.018	-	0	0	0	0	0.0003	0.0038	0	0	0	0.0006	0.0047	0.0001	0	0	0	0.0043	0.0016	0	0	0	0.0065	0.0025
PAH group 3	µg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0001	0
PAH group 4	µg/L	-	5.8	-	0	0	0	0	0.0001	0.0003	0	0	0	0.0007	0.0019	0	0	0	0	0.0005	0	0	0	0	0.0042	0.0002
PAH group 5	µg/L	-	0.012	-	0	0	0	0	0	0.0003	0	0	0	0.00025	0.0017	0	0	0	0	0.0003	0.0001	0	0	0	0.0019	0.0017
PAH group 6	µg/L	-	-	-	0	0	0	0	0	0.0019	0	0	0	0	0.0038	0.0001	0	0	0	0.0004	0.0002	0	0	0	0.0008	0.0004
PAH group 7	µg/L	-	0.04	-	0	0	0	0	0	0.0003	0	0	0	0	0.0015	0	0	0	0	0.0007	0.0007	0	0	0	0.0016	0.0016
PAH group 8	µg/L	-	1.1	-	0	0	0	0	0	0.0014	0	0	0	0	0.0032	0	0	0	0	0.0041	0.004	0	0	0	0.0078	0.0077

Table 3.3-18 Predicted Water Quality for Kearl Lake (Node K1) (continued)

Parameter	Unit	Water Quality Guideline [a]		Observed Natural Variation [c] in Kearl Lake	Pre-Industrial Case		EIA Base Case										2012 Planned Development Case									
		Aquatic Life [b]			Median	Peak	Median Concentration					Peak Concentration					Median Concentration					Peak Concentration				
		Acute	Chronic		Concentration	Concentration	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165	2012	2029	2049	2065	2165
PAH group 9	µg/L	-	0.025	-	0	0	0	0	0.0001	0.0005	0	0	0	0	0.0001	0.0011	0	0	0	0	0.0004	0.0001	0	0	0	0.001	0.0004
Potassium	mg/L	-	-	0.8 (<0.3 - 1.2) n = 15	1.2	2.2	1.0	1.0	0.69	2.1	1.6	1.8	1.3	1.1	3.7	2.5	0.7	0.66	0.66	2.4	1.4	1.2	1.1	1.1	4.5	2.4
Selenium	mg/L	-	0.001	<0.0004 (<0.0001 - 0.0009) n = 30	0.00047	**0.0013**	0.00046	0.00044	0.00042	0.00049	0.00045	**0.0011**	0.00075	0.00063	0.00083	0.00076	0.00038	0.00038	0.00041	0.00047	0.00047	**0.0015**	0.00081	0.00079	0.00071	0.00081
Silver	mg/L	0.0026	0.0001	<0.000005 (<0.0000005 - 0.003) n = 23	0.000008	0.000032	0.000007	0.000009	0.000008	0.00008	0.000069	0.000031	0.000082	0.000083	**0.00011**	**0.00011**	0.000005	0.000005	0.000005	0.000026	0.000035	0.000057	0.000071	0.000074	0.000041	**0.00011**
Sodium	mg/L	-	-	9 (<0.5 - 15) n = 15	15	23	11	13	6.7	52	21	17	16	11	102	36	6.8	6.2	5.6	45	19	15	11	11	73	35
Strontium	mg/L	-	-	0.061 (<0.02 - 0.22) n = 23	0.11	0.22	0.1	0.1	0.091	0.23	0.17	0.17	0.16	0.16	0.38	0.25	0.086	0.079	0.083	0.28	0.18	0.17	0.15	0.15	0.4	0.29
Sulphate	mg/L	-	-	4.9 (<0.1 - 10.6) n = 37	5.2	11	4.9	5.0	7.7	26	6.5	10	7.5	11	56	10	4.1	4.0	4.3	78	27	16	8.2	8.5	130	51
Sulphide	mg/L	-	0.011	0.003 (<0.002 - 0.04) n = 21	**0.015**	**0.026**	0.011	0	0	0	0	**0.02**	0.0008	0.00035	0.0002	0.0003	0	0	0	0	0	0.0025	0.0008	0.0007	0.0004	0.0007
Tainting potential	TPU	-	1	-	0	0	0	0	0	0.0005	0	0	0	0	0.003	0.0001	0	0	0	0.0015	0.0014	0	0	0	0.0077	0.0075
Total dissolved solids	mg/L	-	-	120 (2 - 280) n = 35	168	285	162	156	155	312	215	274	218	216	539	303	146	133	143	378	228	259	203	211	577	375
Total nitrogen	mg/L	-	1	1.1 (<0.05 - 3.5) n = 35	**1.1**	**2.2**	**1.1**	1.0	1.0	**1.3**	**1.1**	**2.2**	**1.7**	**1.6**	**2.3**	**1.7**	0.94	0.96	1.0	**2.0**	**1.3**	**1.9**	**1.4**	**1.6**	**2.9**	**2.3**
Total phenolics	mg/L	-	0.004	0.004 (<0.001 - 0.022) n = 22	**0.0045**	**0.013**	**0.0046**	0	0	0	0	**0.013**	0.0026	0.0028	0.0002	0.0003	0.0001	0	0	0	0	**0.013**	**0.0053**	**0.0057**	0.0003	0.0006
Total phosphorus	mg/L	-	0.05	0.023 (≤ 0.009 - 0.041) n = 37	0.038	**0.15**	0.037	0.035	0.038	**0.053**	0.047	**0.15**	**0.053**	**0.057**	**0.085**	**0.066**	0.034	0.032	0.034	**0.084**	0.043	**0.11**	**0.056**	**0.062**	**0.13**	**0.069**
Toxicity- acute	TUa	0.3	-	-	0	0	0	0	0	0.0008	0	0	0	0	0.0021	0	0	0	0	0.0046	0.0044	0	0	0	0.0095	0.0093
Toxicity- chronic	TUc	-	1	-	0	0	0	0	0	0.0019	0	0	0	0	0.0097	0	0	0	0	0.0062	0.0059	0	0	0	0.022	0.022
Vanadium	mg/L	-	-	<0.0005 (≤ 0.00019 - 0.005) n = 32	0.00078	0.0037	0.00064	0.00073	0.00044	0.002	0.0011	0.0024	0.0016	0.00066	0.0039	0.002	0.00041	0.00039	0.00038	0.0034	0.0017	0.002	0.001	0.00079	0.0058	0.0035
Zinc	mg/L	0.096	0.03	0.0084 (≤ 0.0005 - 0.062) n = 32	0.018	**0.042**	0.015	0.017	0.01	0.016	0.023	**0.032**	0.025	0.018	0.027	**0.049**	0.008	0.0079	0.0074	0.015	0.013	**0.033**	0.023	0.024	0.023	0.023

(a) - = No guideline / no data.

(b) From AENV (1999), CCME (1999), U.S. EPA (2002) using median pH of 8, median temperature of 16°C and median hardness of 75 mg/L (reflective of on-site conditions).

(c) Observed natural variation from Muskeg River downstream of North Pit Lake and Muskeg Creek (EIA, Volume 4B, Section 6.5.3.3, Table 6.5-9).

(d) The values of labile and refractory naphthenic acids were updated in this submission for the Pre-Industrial Case and the 2012 Base and 2012 Planned Development cases.

Note: Bold font indicates concentration exceeds at least one guideline.
Pre-Development information retitled “Pre-Industrial Case”.

Muskeg River Downstream of the North Pit Lake (Node M0)

Predicted concentrations for the 2012, 2029 and 2049 snapshots were similar to predictions made for the EIA Application Case (EIA, Volume 4A, Section 6.5.5.2) at the Muskeg River Downstream of the North Pit Lake (Node M0) (Table 3.3-15).

In Closure and Far Future, median and peak concentrations of mercury are predicted to increase relative to the EIA Application Case concentrations due to discharges from the JME North Pit Lakes. Mercury concentrations are predicted to exceed corresponding aquatic life guidelines. These exceedances are related to old data with high detection limits, which are known to bias the input data upward. While there are more recent data that would improve prediction of some constituents, and mercury in particular, the inputs were kept consistent with the EIA wherever possible to facilitate comparison with previous predictions. At Closure, peak concentrations of polycyclic aromatic hydrocarbons (PAH) group 3 are also predicted to increase compared to the EIA Application Case concentrations. For both the Closure and Far Future snapshots, naphthenic acids concentrations are similar to those predicted for the EIA Application Case because the Application Case predictions were updated for the pit lakes, as described in Appendix 3.6.

There are no additional guideline exceedances in this watercourse in the 2012 PDC relative to the EIA Application Case. Changes in water quality are assessed for aquatic, human and wildlife health risk in Sections 3.3.4, 3.2.2 and 3.2.3, respectively.

Muskeg River at the Mouth (Node M3)

In general, predicted concentrations for the 2012, 2029 and 2049 snapshots for Muskeg River at the Mouth (Node M3) are similar to predictions made in the EIA Application Case (EIA, Volume 4A, Section 6.5.5.2). Up to 2029, the only changes to water quality in the 2012 PDC relative to the EIA Application Case are due to small changes in the amount of lands cleared (Table 3.3-16).

At Closure, predicted concentrations were similar to those made in the EIA Application Case. In Far Future, median and peak concentrations of mercury were predicted to exceed the EIA Application Case concentrations due to discharges from the JME North Pit Lakes, as described for Node M0.

There are no additional guideline exceedances in this watercourse in the 2012 PDC relative to the EIA Application Case. Changes in water quality are assessed for aquatic health (Section 3.3.4) and human and wildlife health risk (Sections 3.2.3 and 3.2.4).

Jackpine Creek at the Mouth (Node J1)

In 2012, there are no changes to Jackpine Creek at the Mouth (Node J1) from the EIA Application Case to the 2012 PDC except for total phosphorus. A slight increase is predicted in peak concentrations of total phosphorus due to the changes in the drainage areas (Table 3.3-17).

In both Closure and Far Future, Jackpine Creek and its tributaries will receive inputs from process-affected seepages and surficial groundwater from JME and the Aurora South Mine. Under the 2012 PDC, median concentrations of barium at Closure and peak concentrations of PAH group 7 at Closure and Far Future are predicted to increase relative to the EIA Application Case concentrations. There are no additional guideline exceedances in this watercourse in the 2012 PDC relative to the EIA Application Case. Changes predicted for

Jackpine Creek generally occur during low flow in Jackpine Creek and have little effect on water quality in the Muskeg River.

Changes in water quality are assessed for aquatic health (Section 3.3.4) and human and wildlife health (Sections 3.2.2 and 3.2.3).

Kearl Lake (Node K1)

In 2012, peak concentrations of cadmium, manganese, selenium and sulphate are predicted to increase in Kearl Lake (Node K1) under the 2012 PDC relative to the EIA Application Case because of the changes in the integrated drainage plan (Table 3.3-18).

In general, predicted concentrations for 2029 and 2049 snapshots are similar to or lower than predictions made in the EIA Application Case (EIA, Volume 4A, Section 6.5.5.2).

In Closure and Far Future, concentrations of several constituents, including all forms of naphthenic acids, are predicted to decrease in Kearl Lake relative to the EIA Application Case due to a reduction in tailings placed in the Aurora South Pit Lake. However, median concentrations of aluminum, chromium, total phosphorus and peak concentrations of aluminum, cobalt, copper, magnesium, total nitrogen and PAH group 3, are predicted to increase relative to the EIA Application Case due to other changes in the reclaimed landscape in the Aurora South mining area.

There are no additional guideline exceedances in Kearl Lake in the 2012 PDC relative to the EIA Application Case. Changes in water quality are assessed for aquatic health (Section 3.3.4) and human and wildlife health (Sections 3.2.3 and 3.2.4).

Athabasca River

Key water quality constituents, including tainting potential and chronic and acute toxicity, are predicted to be appreciably lower than the corresponding guideline or threshold values at all nodes and snapshots in the Athabasca River (Tables 3.3-19 and 3.3-20). Concentrations of all constituents at both assessment nodes are predicted to be similar to those under the EIA PDC, which show few changes and no additional guideline exceedances compared to EIA Base Case conditions.

Table 3.3-19 Predicted Water Quality at the Athabasca River downstream of the Muskeg River

Parameter	Unit	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream the Muskeg River[c]	2012 Base Case										2012 Planned Development Case									
		Aquatic Life[b]			2012		2029		2049		2065		Far Future		2012		2029		2049		2065		Far Future	
		Acute	Chronic		Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]
Aluminum	mg/L	0.75	0.1	0.4755 (0.09 - 14.1) n = 18	**0.42**	**3.8**	**0.42**	**3.8**	**0.42**	**3.8**	**0.43**	**3.8**	**0.42**	**3.8**	**0.42**	**3.8**	**0.42**	**3.8**	**0.42**	**3.8**	**0.43**	**3.8**	**0.42**	**3.8**
Ammonia	mg/L	5.6	2.43	0.025 (0 - 0.17) n = 22	0.03	0.31	0.03	0.26	0.029	0.19	0.029	0.19	0.03	0.2	0.029	0.29	0.03	0.2	0.029	0.15	0.028	0.13	0.029	0.16
Antimony	mg/L	-	-	0.0004 (<0.00006 - 0.0025) n = 14	0.00044	0.0015	0.00044	0.0015	0.00046	0.0015	0.00046	0.0014	0.00047	0.0015	0.00045	0.0015	0.00044	0.0015	0.00044	0.0014	0.00045	0.0014	0.00046	0.0014
Arsenic	mg/L	0.34	0.005	0.0008 (<0.0002 - 0.015) n = 31	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**	0.001	**0.0094**
Barium	mg/L	-	-	0.06 (0.00039 - 0.232) n = 24	0.069	0.13	0.068	0.11	0.068	0.1	0.068	0.1	0.068	0.1	0.069	0.12	0.068	0.11	0.068	0.11	0.068	0.11	0.068	0.11
Beryllium	mg/L	-	-	0 (<0.00004 - 0.004) n = 18	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042	0.0003	0.0042
Boron	mg/L	29	1.5	0.0295 (0.015 - 70) n = 18	0.038	0.14	0.039	0.13	0.042	0.12	0.062	0.23	0.052	0.17	0.038	0.14	0.039	0.12	0.04	0.11	0.06	0.25	0.055	0.2
Cadmium	mg/L	0.0026	0.00031	<0.0002 (<0.00001 - 0.002) n = 24	**0.0004**	**0.0086**	**0.0004**	**0.0086**	**0.0004**	**0.0086**	**0.00041**	**0.0086**	**0.00041**	**0.0086**	**0.0004**	**0.0086**	**0.0004**	**0.0086**	**0.0004**	**0.0086**	**0.00041**	**0.0086**	**0.00041**	**0.0086**
Calcium	mg/L	-	-	30.1 (18.9 - 144) n = 192	32	54	31	52	31	52	31	52	31	52	32	53	31	52	31	52	31	52	31	52
Chloride	mg/L	640	120	7.9 (0.3 - 49.5) n = 198	16	52	16	52	16	52	17	53	16	52	16	52	16	52	16	53	17	53	17	52
Chromium	mg/L	0.016	0.001	0.0025 (0.00048 - 0.027) n = 23	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**	**0.0032**	**0.014**
Cobalt	mg/L	-	-	0.0005 (<0.0002 - 0.011) n = 23	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056	0.0011	0.0056
Copper	mg/L	0.017	0.002	0.00155 (0 - 0.0247) n = 22	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**	**0.0027**	**0.011**
Dissolved organic carbon	mg/L	-	-	9 (2.5 - 28.5) n = 77	10	20	10	20	10	20	10	20	10	20	10	20	10	20	9.0	20	10	20	10	20
Iron	mg/L	-	0.3	0.8735 (0.278 - 35) n = 18	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.0**	**9.2**	**1.1**	**9.2**
Lead	mg/L	0.103	0.004	0.00135 (<0.0003 - 0.02) n = 18	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**	0.001	**0.0071**
Magnesium	mg/L	-	-	8.1 (4.9 - 72) n = 192	9.0	19	9.0	15	9.0	15	9.0	15	9.0	15	9.0	18	9.0	15	8.0	15	8.0	15	9.0	15
Manganese	mg/L	-	-	0.0355 (0.011 - 1.03) n = 24	0.051	0.25	0.048	0.24	0.046	0.23	0.045	0.23	0.047	0.23	0.051	0.24	0.048	0.23	0.045	0.23	0.044	0.24	0.047	0.23
Mercury	mg/L	0.000013	0.000005	<0.00001 (<0.000006 - 0.0036) n = 180	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00014**	**0.000015**	**0.00013**
Molybdenum	mg/L	-	0.073	0.00085 (0.0006 - 0.004) n = 24	0.0016	0.011	0.0019	0.011	0.0026	0.011	0.0048	0.026	0.0038	0.014	0.0016	0.011	0.0018	0.011	0.0022	0.011	0.0049	0.031	0.0041	0.02
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile	mg/L	-	-	-	0.004	0.033	0.019	0.085	0.024	0.094	0.033	0.15	0.034	0.17	0.004	0.033	0.016	0.083	0.018	0.09	0.019	0.09	0.029	0.17
Naphthenic Acids - Refractory	mg/L	-	-	-	0.22	1.4	0.21	1.3	0.23	1.4	0.38	1.6	0.29	1.4	0.21	1.4	0.22	1.3	0.22	1.3	0.36	1.7	0.31	1.5
Naphthenic Acids - Total	mg/L	-	-	-	0.22	1.4	0.23	1.4	0.25	1.5	0.41	1.8	0.33	1.6	0.22	1.4	0.24	1.4	0.24	1.4	0.38	1.8	0.34	1.6
Nickel	mg/L	0.547	0.061	0.0037 (0.00018 - 0.0685) n = 24	0.0053	0.017	0.0057	0.04	0.0057	0.039	0.011	0.055	0.0053	0.017	0.0053	0.017	0.0053	0.017	0.0053	0.017	0.0054	0.017	0.0053	0.017
PAH group 1	µg/L	-	0.015	<0.1 (<0.04 - <5) n = 9	0	0.001	0	0.002	0	0.001	0	0.001	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0
PAH group 2	µg/L	-	0.018	<0.1 (<0.04 - <1) n = 9	0	0.002	0	0.002	0	0.002	0	0.003	0	0.001	0	0.002	0	0.002	0	0.003	0	0.003	0	0.001
PAH group 3	µg/L	-	-	<0.05 (<0.02 - <2) n = 9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	µg/L	-	5.8	<0.1 (<0.04 - <1) n = 9	0.001	0.004	0	0.004	0	0.003	0	0.003	0	0	0.001	0.003	0.001	0.003	0	0.005	0	0.004	0	0
PAH group 5	µg/L	-	0.012	<0.1 (<0.04 - <1) n = 9	0	0.002	0	0.004	0	0.002	0	0.003	0	0.001	0	0.001	0	0.001	0	0.003	0	0.003	0	0.002
PAH group 6	µg/L	-	-	<0.04 (<0.04 - <0.1) n = 5	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 7	µg/L	-	0.04	<0.1 (<0.04 - <1) n = 9	0	0	0	0.002	0	0.001	0	0.002	0	0.001	0	0	0	0	0	0.001	0	0.001	0	0.001
PAH group 8	µg/L	-	1.1	<0.1 (<0.04 - <1) n = 9	0	0.002	0	0.005	0	0.002	0.001	0.004	0	0.002	0	0	0	0.001	0	0.001	0	0.004	0	0.004
PAH group 9	µg/L	-	0.025	<0.1 (<0.04 - <1) n = 9	0	0.001	0	0.001	0	0.001	0	0.001	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0
Potassium	mg/L	-	-	0.795 (0.1 - 3.5) n = 192	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6	1.4	2.6
Selenium	mg/L	-	0.001	<0.0004 (<0.0002 - 0.0014) n = 24	0.00022	0.00079	0.00022	0.00079	0.00022	0.00079	0.00023	0.0008	0.00022	0.00079	0.00022	0.00079	0.00022	0.00079	0.00022	0.00079	0.00023	0.0008	0.00023	0.00079
Silver	mg/L	0.0056	0.0001	<0.0001 (<0.000005 - 0.001) n = 18	0.000019	**0.00013**	0.000019	**0.00013**	0.000023	**0.00013**	0.000019	**0.00013**	0.000019	**0.00013**	0.000019	**0.00013**	0.000018	**0.00013**	0.000018	**0.00013**	0.000019	**0.00013**	0.000018	**0.00013**
Sodium	mg/L	-	-	10 (2 - 37) n = 198	17	44	17	45	17	45	19	46	18	46	17	44	17	44	17	45	19	46	18	46
Strontium	mg/L	-	-	0.209 (0.147 - 333) n = 18	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49	0.27	0.49
Sulphate	mg/L	-	-	20 (0.2 - 49) n = 180	25	54	25	54	25	54	26	54	25	54	25	54	25	55	25	54	27	56	25	54
Sulphide	mg/L	-	0.014	0 (<0.002 - 0.4) n = 50	0.0036	0.013	0.0036	0.011	0.0036	0.01	0.0035	0.01	0.0035	0.01	0.0036	0.013	0.0036	0.01	0.0035	0.0095	0.0035	0.0093	0.0035	0.0092
Tainting potential	TPU	-	1	-	0.0003	0.0087	0.0013	0.024	0.0038	0.028	0.0038	0.028	0.0024	0.046	0.0003	0.0087	0.0011	0.024	0.0014	0.024	0.0018	0.025	0.0024	0.047
Total dissolved solids	mg/L	-	-	152.5 (40 - 780) n = 192	179	314	177	302	177	302	188	324	180	302	179	310	176	300	176	300	187	316	182	303
Total nitrogen	mg/L	-	1	0.64 (0.06 - 4.9) n = 79	0.7	**2.2**	0.7	**2.2**	0.7	**2.2**	0.8	**2.2**	0.7	**2.2**	0.7	**2.2**	0.7	**2.2**	0.7	**2.2**	0.8	**2.2**	0.8	**2.2**
Total phenolics	mg/L	-	0.004	0.002 (0 - 0.031) n = 188	0.0032	**0.021**	0.0032	**0.021**	0.0031	**0.022**	0.0031	**0.021**	0.0031	**0.021**	0.0032	**0.021**	0.0032	**0.021**	0.0032	**0.022**	0.0031	**0.021**	0.0031	**0.021**
Total phosphorus	mg/L	-	0.05	0.055 (<0.005 - 1.85) n = 193	**0.065**	**0.35**	**0.064**	**0.35**	**0.064**	**0.35**	**0.064**	**0.35**	**0.063**	**0.35**	**0.065**	**0.35**	**0.064**	**0.35**	**0.063**	**0.35**	**0.064**	**0.35**	**0.063**	**0.35**

Table 3.3-19 Predicted Water Quality at the Athabasca River downstream of the Muskeg River (continued)

Parameter	Unit	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream the Muskeg River[c]	2012 Base Case										2012 Planned Development Case									
		Aquatic Life[b]			2012		2029		2049		2065		Far Future		2012		2029		2049		2065		Far Future	
		Acute	Chronic		Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]
Toxicity- acute	TUa	0.3	0.3	-	0	0.002	0.001	0.005	0.002	0.008	0.002	0.013	0.002	0.01	0	0.002	0.001	0.005	0.001	0.005	0.001	0.006	0.001	0.01
Toxicity- chronic	TUc	-	1	-	0.001	0.01	0.004	0.019	0.006	0.023	0.008	0.032	0.007	0.037	0.001	0.01	0.003	0.019	0.004	0.023	0.005	0.025	0.007	0.037
Vanadium	mg/L	-	-	<0.002 (0 - 0.05) n = 183	0.0023	0.018	0.0023	0.018	0.0024	0.018	0.0024	0.018	0.0023	0.018	0.0023	0.018	0.0023	0.018	0.0023	0.018	0.0024	0.018	0.0023	0.018
Zinc	mg/L	0.14	0.03	0.01065 (0 - 0.095) n = 20	0.014	**0.062**	0.014	**0.062**	0.014	**0.061**	0.014	**0.061**	0.014	**0.061**	0.014	**0.062**	0.014	**0.062**	0.014	**0.062**	0.014	**0.06**	0.014	**0.06**

(a) - = No guideline/No Data.

(b) From U.S. EPA (2002) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River).

(c) Observed natural variation from 1976 to 2004, based on information from Golder (2000, 2001, 2002), and from Alberta Environment WDS stations: AB07DA0270\0280\0320\0390\0400\0410\1520 (AENV 2006).

(d) Peak concentrations represent 99.91 percentile values calculated from a model dataset containing more than 16,000 data points; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: Bold values indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life.

Table 3.3-20 Predicted Water Quality at the Athabasca River at Embarras

Parameter	Unit	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream of Embarras[d]	2012 Base Case										2012 Planned Development Case									
		Aquatic Life[b]			2012		2029		2049		2065		Far Future		2012		2029		2049		2065		Far Future	
		Acute	Chronic		Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]
Aluminum	mg/L	0.75	0.1	0.344 (0 - 4.791) n = 52	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.6**	**0.36**	**3.5**	**0.36**	**3.6**
Ammonia	mg/L	5.6	2.43	0.03 (0 - 1) n = 168	0.036	0.19	0.036	0.19	0.038	0.2	0.038	0.2	0.036	0.19	0.034	0.18	0.036	0.18	0.038	0.19	0.037	0.19	0.036	0.18
Antimony	mg/L	-	-	<0.0002 (0.00005 - <0.005) n = 21	0.00031	0.00091	0.00031	0.00091	0.00032	0.00092	0.00032	0.00091	0.00032	0.00092	0.00031	0.00091	0.00031	0.00091	0.00031	0.00091	0.00032	0.00091	0.00032	0.00093
Arsenic	mg/L	0.34	0.005	0.0006 (<0.0001 - 0.018) n = 68	0.001	**0.0091**	0.001	**0.0091**	0.001	**0.009**	0.001	**0.009**	0.001	**0.009**	0.001	**0.009**	0.001	**0.0091**	0.001	**0.009**	0.001	**0.0091**	0.001	**0.009**
Barium	mg/L	-	-	0.065 (0 - 0.269) n = 59	0.07	0.15	0.07	0.15	0.07	0.15	0.07	0.15	0.07	0.15	0.071	0.15	0.07	0.15	0.07	0.15	0.07	0.15	0.071	0.15
Beryllium	mg/L	-	-	<0.0002 (<0.00004 - 0.0012) n = 66	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043	0.0003	0.0043
Boron	mg/L	29	1.5	0.03 (0 - 0.137) n = 26	0.038	0.088	0.039	0.087	0.044	0.093	0.048	0.11	0.047	0.1	0.038	0.087	0.039	0.085	0.043	0.092	0.053	0.12	0.051	0.11
Cadmium	mg/L	0.0026	0.00031	0 (<0.00002 - <0.003) n = 64	**0.0004**	**0.0087**	**0.0004**	**0.0087**	**0.00041**	**0.0087**	**0.00041**	**0.0086**	**0.00041**	**0.0086**	**0.00039**	**0.0086**	**0.0004**	**0.0087**	**0.00041**	**0.0086**	**0.00042**	**0.0085**	**0.00041**	**0.0085**
Calcium	mg/L	-	-	33 (<1 - 106) n = 229	32	55	32	54	32	54	32	54	32	54	32	55	32	54	32	54	32	54	32	54
Chloride	mg/L	640	120	15.5 (<0.5 - 150) n = 229	10	33	10	33	11	35	11	35	11	35	10	33	10	33	11	35	11	35	11	35
Chromium	mg/L	0.016	0.001	0.002 (0.00061 - 0.016) n = 87	**0.003**	**0.013**	**0.0029**	**0.013**	**0.0029**	**0.013**	**0.003**	**0.013**	**0.003**	**0.013**	**0.003**	**0.013**	**0.0029**	**0.013**	**0.0029**	**0.013**	**0.003**	**0.013**	**0.003**	**0.013**
Cobalt	mg/L	-	-	0.001 (0.000155 - 0.006) n = 62	0.001	0.0053	0.001	0.0053	0.0011	0.0053	0.0011	0.0053	0.0011	0.0053	0.0011	0.0053	0.001	0.0053	0.0011	0.0053	0.0011	0.0053	0.0011	0.0053
Copper	mg/L	0.017	0.002	0.002 (<0.0002 - 0.0122) n = 90	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**	**0.0026**	**0.01**
Dissolved organic carbon	mg/L	-	-	8.35 (0.3 - 30.3) n = 214	10	20	10	20	10	20	10	20	10	20	10	20	10	19	10	19	10	19	10	20
Iron	mg/L	-	0.3	0.74 (0 - 11.8) n = 78	**0.93**	**8.9**	**0.93**	**8.9**	**0.93**	**8.9**	**0.93**	**8.8**	**0.93**	**8.8**	**0.95**	**8.9**	**0.91**	**8.9**	**0.91**	**8.9**	**0.91**	**8.9**	**0.95**	**8.9**
Lead	mg/L	0.103	0.004	0.0012 (<0.0001 - 0.026) n = 53	0.001	**0.0068**	0.001	**0.0068**	0.0011	**0.0068**	0.0011	**0.0068**	0.0011	**0.0068**	0.001	**0.0068**	0.001	**0.0068**	0.0011	**0.0068**	0.0011	**0.0069**	0.0011	**0.0068**
Magnesium	mg/L	-	-	8.8 (<1 - 27.3) n = 228	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16	9.0	16
Manganese	mg/L	-	-	0.043 (0 - 0.592) n = 88	0.054	0.24	0.054	0.24	0.053	0.24	0.053	0.24	0.052	0.23	0.055	0.28	0.053	0.23	0.053	0.23	0.053	0.23	0.055	0.23
Mercury	mg/L	0.000013	0.000005	0.00000715 (<0.0000006 - <0.0002) n = 14	**0.000014**	**0.00013**	**0.000014**	**0.00013**	**0.000015**	**0.00013**	**0.000014**	**0.00013**	**0.000014**	**0.00013**	**0.000014**	**0.00012**	**0.000014**	**0.00013**	**0.000015**	**0.00013**	**0.000015**	**0.00013**	**0.000014**	**0.00013**
Molybdenum	mg/L	-	0.073	0.001 (0.0004 - 0.007) n = 61	0.002	0.011	0.0022	0.011	0.0027	0.011	0.0031	0.011	0.0027	0.011	0.002	0.011	0.0022	0.011	0.0026	0.011	0.0037	0.013	0.0032	0.011
Monomer	mg/L	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Labile	mg/L	-	-	-	0.012	0.083	0.02	0.13	0.034	0.24	0.036	0.24	0.037	0.25	0.012	0.083	0.02	0.14	0.034	0.24	0.037	0.24	0.038	0.26
Naphthenic Acids - Refractory	mg/L	-	-	<1 (<1 - <1) n = 4	0.23	0.86	0.23	0.86	0.26	0.88	0.29	0.96	0.27	0.89	0.23	0.86	0.23	0.86	0.26	0.88	0.31	1.0	0.29	0.92
Naphthenic Acids - Total	mg/L	-	-	<1 (<1 - <1) n = 4	0.24	0.94	0.25	1	0.29	1.1	0.32	1.2	0.31	1.1	0.24	0.94	0.25	1	0.29	1.1	0.35	1.3	0.33	1.2
Nickel	mg/L	0.547	0.061	0.003 (<0.0002 - 0.04) n = 63	0.005	0.016	0.0051	0.016	0.0051	0.016	0.0059	0.016	0.005	0.016	0.005	0.016	0.005	0.016	0.005	0.016	0.0051	0.016	0.005	0.016
PAH group 1	µg/L	-	0.015	<5 (<0.02 - <5) n = 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 2	µg/L	-	0.018	<1 (<0.02 - <1) n = 23	0	0	0	0	0	0	0	0.001	0	0	0	0.001	0	0	0	0.004	0	0.001	0	0.002
PAH group 3	µg/L	-	-	<2 (<0.02 - <2) n = 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	µg/L	-	5.8	<1 (<0.02 - <1) n = 23	0	0.001	0	0.001	0	0	0	0.001	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0
PAH group 5	µg/L	-	0.012	<1 (<0.02 - <1) n = 23	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001	0	0.008	0	0	0	0.008	0	0.001	0	0.005
PAH group 6	µg/L	-	-	<0.04 (<0.04 - <0.04) n = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0
PAH group 7	µg/L	-	0.04	<1 (<0.02 - <1) n = 23	0	0	0	0	0	0	0	0	0	0	0	0.007	0	0	0	0.012	0	0.001	0	0.006
PAH group 8	µg/L	-	1.1	<1 (<0.02 - <1) n = 24	0	0	0	0.001	0	0.001	0	0.001	0	0.001	0	0	0	0	0	0.001	0	0.002	0	0.001
PAH group 9	µg/L	-	0.025	<1 (<0.02 - <1) n = 23	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006	0	0.006
Potassium	mg/L	-	-	1.2 (<0.1 - 7.1) n = 229	1.4	2.5	1.4	2.5	1.4	2.5	1.5	2.5	1.5	2.5	1.4	2.5	1.4	2.5	1.5	2.5	1.5	2.6	1.5	2.6
Selenium	mg/L	-	0.001	<0.0002 (<0.0001 - 0.0009) n = 62	0.0002	0.00074	0.0002	0.00074	0.00021	0.00074	0.00021	0.00074	0.00021	0.00074	0.0002	0.00074	0.0002	0.00074	0.00021	0.00074	0.00021	0.00074	0.00021	0.00074
Silver	mg/L	0.0056	0.0001	<0.0001 (<0.000005 - 0.0007) n = 15	0.000021	**0.00012**	0.000021	**0.00012**	0.000022	**0.00012**	0.000022	**0.00012**	0.000021	**0.00012**	0.000022	**0.00012**	0.000021	**0.00012**	0.000022	**0.00012**	0.000022	**0.00012**	0.000022	**0.00012**
Sodium	mg/L	-	-	16.5 (<1 - 121) n = 229	15	35	15	35	16	37	16	38	16	38	15	35	15	35	15	37	16	39	16	39
Strontium	mg/L	-	-	0.193 (0.136 - 0.3) n = 21	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48	0.27	0.48
Sulphate	mg/L	-	-	23.6 (<3 - 186) n = 230	25	56	25	56	25	57	26	57	25	57	25	56	25	57	25	57	26	58	26	58
Sulphide	mg/L	-	0.014	<0.005 (0 - 0.02) n = 89	0.0037	0.011	0.0037	0.011	0.0037	0.011	0.0036	0.011	0.0036	0.011	0.0037	0.011	0.0036	0.008	0.0036	0.0079	0.0035	0.0078	0.0036	0.0084
Tainting potential	TPU	-	1	-	0.0009	0.024	0.0015	0.038	0.0037	0.064	0.004	0.065	0.0035	0.069	0.0009	0.024	0.0015	0.038	0.0032	0.064	0.0056	0.067	0.004	0.07
Total dissolved solids	mg/L	-	-	178 (16 - 722) n = 227	177	300	177	300	180	305	181	308	180	307	178	302	177	301	179	306	183	313	182	313
Total nitrogen	mg/L	-	1	0.48 (0 - 2.96) n = 220	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**	0.8	**2.1**
Total phenolics	mg/L	-	0.004	0 (0 - 0.042) n = 186	0.0038	**0.018**	0.0038	**0.018**	0.0038	**0.018**	0.0038	**0.018**	0.0038	**0.018**	0.0039	**0.018**	0.0039	**0.018**	0.0038	**0.018**	0.0038	**0.018**	0.0038	**0.018**

Table 3.3-20 Predicted Water Quality at the Athabasca River at Embarras (continued)

Parameter	Unit	Water Quality Guidelines[a]		Natural Variation Observed in the Athabasca River Upstream of Embarras[d]	2012 Base Case										2012 Planned Development Case									
		Aquatic Life[b]			2012		2029		2049		2065		Far Future		2012		2029		2049		2065		Far Future	
		Acute	Chronic		Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]	Median	Peak[d]
Total phosphorus	mg/L	-	0.05	0.043 (0.004 - 0.75) n = 220	**0.063**	**0.34**	**0.062**	**0.34**	**0.062**	**0.34**	**0.063**	**0.34**	**0.062**	**0.34**	**0.063**	**0.34**	**0.062**	**0.34**	**0.062**	**0.34**	**0.062**	**0.34**	**0.062**	**0.34**
Toxicity- acute	TUa	0.3	0.3	-	0.001	0.005	0.001	0.008	0.002	0.015	0.002	0.015	0.002	0.015	0	0.005	0.001	0.008	0.002	0.015	0.003	0.016	0.002	0.016
Toxicity- chronic	TUc	-	1	-	0.005	0.032	0.007	0.044	0.009	0.059	0.01	0.061	0.007	0.048	0.005	0.031	0.007	0.043	0.009	0.059	0.01	0.062	0.007	0.049
Vanadium	mg/L	-	-	0.002 (0.0007 - 0.02) n = 113	0.0026	0.017	0.0026	0.017	0.0026	0.017	0.0026	0.017	0.0022	0.017	0.0026	0.017	0.0026	0.017	0.0026	0.017	0.0027	0.017	0.0022	0.017
Zinc	mg/L	0.14	0.03	0.0088 (0.0007 - 0.046) n = 81	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**	0.013	**0.042**

(a) - = No guideline/No Data.

(b) From U.S. EPA (2002) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River).

(c) Based on information from Golder (2000, 2001, 2002), and from Alberta Environment WDS stations: AB07DA0010\0040\0060\0080\0250 (AENV 2006).

(d) Peak concentrations represent 99.91 percentile values calculated from a model data set containing more than 16,000 datapoints; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: Bold values indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life.

3.3.3.2 Summary of Results

Within the Muskeg River watershed, acute and chronic toxicity and tainting potential levels are predicted to be appreciably lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2012 PDC at all assessment nodes.

For Muskeg River downstream of the North Pit Lake (Node M0), predicted concentrations for the 2012, 2029 and 2049 snapshots were similar to predictions made for the EIA Application Case (EIA, Volume 4A, Section 6.5.5.2). Changes to water quality in Jackpine Creek and Kearl Lake mainly reflect improvements made to the Aurora South project during operations, though land use changes are predicted to increase the concentrations of some constituents at Closure.

For the Athabasca River, key water quality constituents, including tainting potential and chronic and acute toxicity are predicted to be appreciably lower than the corresponding guideline or threshold values at all nodes and snapshots. Concentrations of all constituents at all assessment nodes are predicted to be similar to those under the 2007 PDC, which show few changes and no additional guideline exceedances compared to EIA Base Case conditions.

3.3.4 Aquatic Health Assessment

This section presents the 2012 PDC aquatic health assessment. Aquatic health refers to health of aquatic biota including fish and benthic invertebrates. The aquatic health assessment considers the potential effects on fish and benthic invertebrates due to changes in water quality from planned developments. The assessment considered potential effects on the most sensitive life stages of fish, including eggs and fry. This section addresses the effects of JME and the operating, approved and planned developments on aquatic health in the study areas during construction, operation and closure phases of JME and PRM.

The aquatic health assessment methods were consistent with those outlined in the EIA, Volume 4A, Section 6.6.2, with one exception. For this assessment, the Chronic Effects Benchmarks (CEBs) were updated following the approach outlined in Appendix 3.6. Updates to the CEBs, and implications to the aquatic health assessment of the EIA Base and Application cases due to changes in CEBs, are discussed in Appendix 3.6. The CEBs represent concentrations beyond which changes to aquatic health could occur on the scale of individual organisms within populations of sensitive species. The benchmarks are less conservative than water quality guidelines, but retain a level of conservatism for the evaluation of both community level effects and population level effects for most species that would be predicted to occur at concentrations above the CEBs described below. Consequently, the benchmarks are considered to be conservative thresholds by which potential effects on aquatic health can be assessed. The CEBs that were used in the aquatic health assessment for the EIA and the CEBs that were updated following the approach outlined in Appendix 3.6 are listed in Table 3.3-21.

Table 3.3-21 Chronic Effects Benchmarks Used in the Aquatic Health Assessment

Constituent	Units	Chronic Effects Benchmarks	
		Environmental Impact Assessment	May 2012, JME JRP SIR
Aluminum	mg/L	0.68	0.1
Ammonia	mg/L N	-	2
Antimony	mg/L	0.58	0.157
Arsenic	mg/L	0.191	0.033
Barium	mg/L	5.8	5.8
Beryllium	mg/L	0.0053	0.0053
Boron	mg/L	8.157	1.5
Cadmium	mg/L	0.00042[(a)]	0.00061
Chromium (III)	mg/L	0.00248	0.089
Chromium (VI)	mg/L	-	0.0083
Cobalt	mg/L	0.0093	0.004
Copper	mg/L	0.073	0.0256
Iron	mg/L	0.57	0.3
Lead	mg/L	-	0.005
Manganese	mg/L	1.455	1.455
Mercury	mg/L	-	0.00005
Molybdenum	mg/L	0.703	38.7
Naphthenic acids – labile	mg/L	-	1
Nickel	mg/L	-	0.125
PAH group 1	µg/L	0.15	0.281
PAH group 2	µg/L	0.18	0.278
PAH group 3	µg/L	0.07	0.99
PAH group 4	µg/L	-	41.5
PAH group 5	µg/L	0.12	5.6
PAH group 6	µg/L	29	64
PAH group 7	µg/L	0.4	5.9
PAH group 8	µg/L	-	32
PAH group 9	µg/L	-	2.3
Silver	mg/L	0.00017	0.00022
Strontium	mg/L	0.2	0.54 to 6.26
Sulphide	mg/L	-	0.002
Total Dissolved Solids	mg/L	-	500 to 1,000
Total Phenolics	mg/L	-	0.04
Vanadium	mg/L	0.16	0.0338
Zinc	mg/L	-	0.138

- = Benchmark not derived.

[(a)] Based on a hardness of 180 mg/L.

3.3.4.1 Assessment Results

This section provides information regarding the impact assessment for aquatic health in the LSA in relation to the 2012 PDC.

Jackpine Mine Expansion Local Study Area

Within the Muskeg River watershed, activities associated with the existing, approved and planned developments have valid linkages with changes in water quality and tissue concentrations. Linkages to changes in sediment quality and acidification were not assessed as they were predicted to be negligible in the EIA Application Case.

Changes in Water Quality

Whole Effluent Toxicity

Levels of acute and chronic toxicity in Jackpine Creek, Kearl Lake and the Muskeg River are predicted to be below the guidelines recommended by Alberta Environment and Water (AEP 1995) throughout the active life of JME and into the Far Future (Section 3.3.4). These guidelines represent no-effects thresholds for sensitive aquatic organisms. Compliance with acute and chronic guidelines provides confidence that aquatic health in Jackpine Creek, Kearl Lake and the Muskeg River will be protected.

Individual Substances

The Substances of Potential Concern (SOPCs) that were identified in Jackpine Creek, Kearl Lake and the Muskeg River are listed in Table 3.3-22. Several constituents were identified as SOPCs under EIA Application Case conditions and have not been re-evaluated under the 2012 PDC. For a discussion of these constituents, see Appendix 3.6 and EIA, Volume 4A, Section 6.6.

Table 3.3-22 Summary of Substances of Potential Concern Carried Forward to the 2012 Planned Development Case Aquatic Health Assessment

Substance of Potential Concern	Watercourses
Aluminum	Kearl Lake
Barium	Jackpine Creek
Cadmium	Kearl Lake
Chromium	Kearl Lake
Cobalt	Kearl Lake
Copper	Kearl Lake
Magnesium	Kearl Lake
Manganese	Kearl Lake
Mercury	Muskeg River (M3, M0)
PAH group 3	Kearl Lake; Muskeg River (M0)
PAH group 7	Jackpine Creek
Selenium	Kearl Lake
Sulphate	Kearl Lake
Total nitrogen	Kearl Lake
Total phosphorus	Jackpine Creek; Kearl Lake

Chronic effects benchmarks were defined for all of the SOPCs, with the exception of the major ions (i.e., calcium, magnesium, potassium, sodium and sulphate) and nutrients (i.e., total nitrogen and total phosphorus). The benchmarks were derived following the approach outlined in Appendix 3.6.

Calcium, chloride, magnesium, potassium, sodium and sulphate are components of Total Dissolved Solids (TDS). As such, they were evaluated as part of TDS, which was evaluated with respect to its projected

concentration and expected composition. Potential detrimental affects resulting from total nitrogen were evaluated considering predicted ammonia concentrations, while total phosphorus concentrations were evaluated with respect to the potential to cause eutrophication. The evaluation of each of these SOPCs is discussed in more detail below.

Total Dissolved Solids

The screening evaluation of fish and benthic invertebrate toxicity (Appendix 3.6) indicates that adverse effects are not expected for relevant species at concentrations below 1,000 mg/L TDS. The potential effects on sensitive zooplankton at this concentration would be mitigated by the chemical composition of the site-specific TDS mixture, and the relative tolerance of other zooplankton species (i.e., a viable zooplankton community would be present even at 1,000 mg/L). Concentrations of TDS are predicted to remain below this screening concentration at all nodes and during all snapshots. Therefore, the predicted changes in TDS levels in the LSA, resulting from either JME or approved developments, would have a negligible effect on aquatic health. This conclusion applies over the operational phase of JME and into the Far Future.

Sulphate

There are no Alberta provincial WQGs for sulphate, but Alberta Environment and Water (2008) recently evaluated the British Columbia provincial sulphate WQG of 100 mg/L in deriving of sulphate water quality targets and limits for the Muskeg River. However, there are indications that the British Columbia WQG for sulphate might be overly conservative when applied to moderately hard waters (Davies 2002, 2007). This conclusion is attributable to the hardness-dependence of sulphate toxicity, with toxicity ameliorated by increasing hardness (Singleton 2000). Correspondingly, site-specific water quality objectives for sulphate have been developed at some moderately hard to hard water sites to provide a less stringent guideline that is more relevant for these sites (Elphick et al. 2008). As the LSA is characterized by moderately hard waters, comparisons to the sulphate WQG of 100 mg/L are believed to be over-protective.

Predicted changes in sulphate concentrations in Kearl Lake are expected to have a negligible effect on aquatic biota, given the moderately hard waters in these watercourses. Predicted concentrations are below the effects-based water quality limit of 500 mg/L recently proposed by Alberta Environment and Water (AENV 2008).

Nutrients

Because watercourses in the LSA are relatively nutrient-rich, they are less sensitive to nutrient inputs relative to oligotrophic watercourses. Changes in nutrient concentrations in watercourses in the LSA have been evaluated in terms of the potential for eutrophication relative to Pre-Industrial conditions and the snapshots in the EIA Base Case, based on predicted median concentrations for the 2012 PDC that are greater than 10% higher than the corresponding snapshot predictions for the EIA Base Case (EIA, Volume 4A, Section 6.6.2.12). The potential for eutrophication has been based on changes in total phosphorus concentrations because algal productivity is most likely to be limited by phosphorus, and national trigger levels have been established for this indicator substance (CCME 2004; Wetzel 2001). Under Pre-Industrial conditions, total phosphorus concentrations were frequently measured in the eutrophic range and sometimes in the hyper-eutrophic range for this nutrient (Water Quality Environmental Setting Report). This trophic status is not expected to change based on predicted changes in median phosphorus concentrations. Therefore, negligible effects on aquatic biota are expected in these watercourses under the snapshot years for the 2012 PDC.

As phosphorus and nitrogen contribute to nutrient enrichment in aquatic systems, it is possible that predicted increases in total nitrogen may lead to some nutrient enrichment. However, trophic values are not well established for nitrogen and less is known about the relationship between this nutrient and enrichment effects, relative to phosphorus. Consequently, environmental responses from simulated changes in total nitrogen concentrations are expected to be negligible in the LSA under the 2012 PDC snapshot years. This conclusion is mainly based on the potential for toxic effects from increased concentrations of ammonia, rather than the potential for nutrient enrichment, because phosphorus is expected to be the primary nutrient limiting algal growth.

Other Substances of Potential Concern

Jackpine Creek

Other SOPCs identified in Jackpine Creek include barium and PAH group 7. Predicted peak concentrations for all SOPCs were less than the corresponding CEBs (Table 3.3-23). As such, predicted changes to the concentrations of barium and PAH Group 7 are expected to result in negligible effects on aquatic health in Jackpine Creek.

Table 3.3-23 Comparison of Predicted Peak Concentrations in Jackpine Creek With Chronic Effects Benchmarks

Substance of Potential Concern	Units	Chronic Effects Benchmark [(a)]	Predicted Peak Water Quality Concentrations 2012 PDC				
			2012	2029	2049	2065	2165
Barium	mg/L	5.8	-	-	-	0.43	-
PAH group 7	µg/L	5.9	-	-	-	0.48	0.48

[(a)] Chronic effects benchmarks were derived following the approach outlined in Appendix 3.6.

– = Constituent not identified as a substance of potential concern in the snapshot indicated.

Kearl Lake

Other SOPCs identified in Kearl Lake include aluminum, cadmium, chromium, cobalt, copper, manganese, PAH group 3 and selenium. With the exception of aluminum, cadmium and selenium, predicted peak concentrations for all SOPCs were less than the corresponding chronic effect benchmark (CEB) (Table 3.3-24). As such, predicted changes to the concentrations of chromium, cobalt, copper, manganese and PAH group 3 are expected to result in negligible effects on aquatic health in Kearl Lake.

In the 2012 snapshot year, the predicted peak concentration of cadmium was higher than the CEB (Table 3.3-24). The increase in cadmium is the result of an increase in the Kearl Lake drainage area by the Aurora South Mine diversions. Changes in the drainage area are predicted to increase the flow rate of natural waters through Kearl Lake; increased flows will decrease the residence time, leading to higher peak concentrations relative to EIA Base Case concentrations. Potential impacts associated with changes in cadmium were, therefore, rated as being low in magnitude, moderate in frequency and local in geographical extent. Duration was rated as short-term, because the predicted increase in in-stream concentrations are projected to occur during construction.

Table 3.3-24 Comparison of Predicted Peak Concentrations in Kearl Lake With Chronic Effects Benchmarks

Substance of Potential Concern	Units	Chronic Effects Benchmark [(a)]	Predicted Peak Water Quality Concentrations 2012 PDC				
			2012	2029	2049	2065	2165
Aluminum	mg/L	0.1	-	-	-	**0.75**	**0.25**
Cadmium	mg/L	0.00061	**0.0031**	-	-	-	-
Chromium	mg/L	0.074	-	-	-	0.0045	-
Cobalt	mg/L	0.004	-	-	-	0.0025	-
Copper	mg/L	0.0256	-	-	-	0.0044	-
Manganese	mg/L	1.455	0.28	-	-	-	-
PAH group 3	µg/L	0.99	-	-	-	0.0001	-
Selenium	mg/L	-	0.0015	-	-	-	-

[(a)] Chronic effects benchmarks were derived following the approach outlined in Appendix 3.6.

Note: Bold font indicates a value that exceeds a chronic effects benchmark.

– = Constituent not identified as a substance of potential concern in the snapshot indicated or chronic effects benchmark not developed.

In the 2012 snapshot year, the predicted peak concentration of selenium was higher than the aquatic life guideline (Table 3.3-24). A CEB for selenium has not been developed for reasons outlined in Appendix 3.6. The increase in selenium is also the result of an increase in the Kearl Lake drainage area. Potential impacts associated with changes in selenium were, therefore, rated as being low in magnitude, moderate in frequency and local in geographical extent. Duration was rated as short-term, because the predicted increase in in-stream concentrations are projected to occur during construction.

In 2065 and 2165, predicted peak concentrations of aluminum were higher than the CEB (Table 3.3-24). The increase in aluminum is the result of discharge from the Aurora South pit lake.

Muskeg River (M0)

In the Muskeg River (M0), additional parameters identified as SOPCs include mercury and PAH group 3. Predicted peak concentrations for both SOPCs were less than the corresponding CEBs (Table 3.3-25). As such, predicted changes to the concentrations of mercury and PAH group 3 are expected to result in negligible effects on aquatic health in the Muskeg River (M0).

Table 3.3-25 Comparison of Predicted Peak Concentrations in Muskeg River (M0) With Chronic Effects Benchmarks

Substance of Potential Concern	Units	Chronic Effects Benchmark [(a)]	Predicted Peak Water Quality Concentrations 2012 PDC				
			2012	2029	2049	2065	2165
Mercury	mg/L	0.00005	-	-	0.000016	0.000018	0.000012
PAH group 3	µg/L	0.99	-	-	-	0.0002	-

[(a)] Chronic effects benchmarks were derived following the approach outlined in Appendix 3.6.

– = Constituent not identified as a substance of potential concern in the snapshot indicated.

Muskeg River (M3)

In Muskeg River (M3), mercury was identified as an SOPC. Predicted peak concentrations for mercury were less than the corresponding CEB (Table 3.3-26). As such, predicted changes to the concentrations of mercury are expected to result in negligible effects on aquatic health in Muskeg River (M3).

Table 3.3-26 Comparison of Predicted Peak Concentrations in Muskeg River (M3) With Chronic Effects Benchmarks

Substance of Potential Concern	Units	Chronic Effects Benchmark [(a)]	Predicted Peak Water Quality Concentrations 2012 PDC				
			2012	2029	2049	2065	2165
Mercury	mg/L	0.00005	-	-	0.000012	-	0.000021

[(a)] Chronic effects benchmarks were derived following the approach outlined in Appendix 3.6.

– = Constituent not identified as a substance of potential concern in the snapshot indicated.

Potential for Effects Related to Changes to Fish Tissue Quality

Predicted changes in fish tissue metal concentrations are projected to be below toxicological benchmarks for all constituents considered in Jackpine Creek, Kearl Lake and the Muskeg River (M3) (Tables 3.3-27 to 3.3-29). For these reasons, predicted changes to water quality in Jackpine Creek, Kearl Lake and the Muskeg River (M3) are projected to result in negligible changes to fish tissue quality and, by association, negligible impacts to aquatic health.

In the Muskeg River (M0), predicted changes in fish tissue metal concentrations were projected to be below toxicological benchmarks for all constituents considered, except nickel (Table 3.3-30). However, negligible effects on fish health are expected, because the predicted concentration only slightly exceeds EIA Base Case concentrations, and the nickel benchmark is based on a No Observable Effects Concentration (NOEC) value. Concentrations in excess of NOEC values will not necessarily result in detrimental effects. In addition, the bioaccumulation factor used in the assessment was developed based largely on non-detectable fish tissue nickel concentrations. Non-detects were replaced with values equal to half the detection limit, which resulted in the production of conservative multiplication factors. For these reasons, predicted changes to water quality in the Muskeg River (M0) are projected to result in negligible changes to fish tissue quality and, by association, negligible impacts to aquatic health.

Residual Impact Classification

Activities associated with the 2012 PDC are predicted to produce changes in water quality in the Jackpine Creek, Kearl Lake and the Muskeg River. Potential effects on aquatic health were evaluated in consideration of two potential effects pathways: direct effects occurring as a result of predicted changes to water quality and indirect effects related to dietary consumption and possible accumulation of material within fish tissue. This information was used to assign environmental consequence according to criteria specified in the EIA, Volume 4A, Section 1.3.6.1.

As discussed in Section 3.3.4, whole effluent acute and chronic toxicity levels in Jackpine Creek, Kearl Lake and the Muskeg River are predicted to be below guideline levels throughout the life of JME and into the Far Future. Constituent concentrations within fish tissues are also predicted to remain below toxicological benchmarks, with the possible exception of nickel. However, as discussed above, risks to fish health as a result of these fish tissue predictions are expected to be negligible.

Table 3.3-27 Predicted Changes in Fish Tissue Metal Concentrations in Jackpine Creek

Constituent	Units	Toxicological Benchmark[(a)] [mg/kg ww]	Bioaccumulation Factor	EIA Base Case		2012 Planned Development Case	
				Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
				[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	mg/kg	20	32	0.038	1.2	0.035	1.1
Antimony	mg/kg	30	25	0.00031	0.01	0.0003	0.0075
Arsenic	mg/kg	6.1	103	0.00024	0.02	0.00029	0.03
Cadmium	mg/kg	0.6	95	0.0001	0.01	0.00013	0.012
Chromium	mg/kg	0.58	53	0.0011	0.06	0.0013	0.069
Copper	mg/kg	3.4	734	0.00062	0.46	0.0007	0.51
Lead	mg/kg	4	57	0.00032	0.02	0.00034	0.019
Mercury	mg/kg	5	226,509	0.0000018	0.41	0.0000019	0.43
Nickel	mg/kg	0.82	92	0.00095	0.09	0.0015	0.14
Selenium	mg/kg	2.58	225	0.00026	0.06	0.00025	0.056
Vanadium	mg/kg	0.41	74	0.00039	0.03	0.00054	0.04
Zinc	mg/kg	60	747	0.0065	4.9	0.0068	5.1

Note: Base Case information for this node is presented in the EIA, Volume 4A, Section 6.6.4.3, Table 6.6-8.

(a) Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

Table 3.3-28 Predicted Changes in Fish Tissue Metal Concentrations in Kearl Lake

Constituent	Units	Toxicological Benchmark[(a)] [mg/kg ww]	Bioaccumulation Factor	EIA Base Case		2012 Planned Development Case	
				Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
				[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	mg/kg	20	32	0.15	4.8	0.37	12
Antimony	mg/kg	30	25	0.0015	0.04	0.0012	0.03
Arsenic	mg/kg	6.1	103	0.0017	0.18	0.0014	0.14
Cadmium	mg/kg	0.6	95	0.00087	0.08	0.00072	0.068
Chromium	mg/kg	0.58	53	0.0026	0.14	0.0032	0.17
Copper	mg/kg	3.4	734	0.0013	1	0.0028	2.1
Lead	mg/kg	4	57	0.0016	0.09	0.001	0.057
Mercury	mg/kg	5	226,509	0.0000005	0.1	0.000002	0.45
Nickel	mg/kg	0.82	92	0.0045	0.41	0.0066	0.61
Selenium	mg/kg	2.58	225	0.00049	0.11	0.00047	0.11
Vanadium	mg/kg	0.41	74	0.002	0.15	0.0034	0.25
Zinc	mg/kg	60	747	0.017	13	0.015	11

Note: Base Case information for this node is presented in the EIA, Volume 4A, Section 6.6.4.3, Table 6.6-11.

(a) Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

Table 3.3-29 Predicted Changes in Fish Tissue Metal Concentrations in Muskeg River (M3)

Constituent	Units	Toxicological Benchmark[(a)] [mg/kg ww]	Bioaccumulation Factor	EIA Base Case		2012 Planned Development Case	
				Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
				[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	mg/kg	20	32	0.17	5.5	0.24	7.7
Antimony	mg/kg	30	25	0.00051	0.01	0.00042	0.01
Arsenic	mg/kg	6.1	103	0.00066	0.07	0.00056	0.058
Cadmium	mg/kg	0.6	95	0.00036	0.03	0.00028	0.027
Chromium	mg/kg	0.58	53	0.0023	0.12	0.0024	0.13
Copper	mg/kg	3.4	734	0.0017	1.2	0.0017	1.2
Lead	mg/kg	4	57	0.00037	0.02	0.00035	0.02
Mercury	mg/kg	5	226,509	0.0000036	0.82	0.0000057	1.3
Nickel	mg/kg	0.82	92	0.0065	0.6	0.0076	0.7
Selenium	mg/kg	2.58	225	0.00042	0.09	0.00042	0.094
Vanadium	mg/kg	0.41	74	0.0026	0.19	0.003	0.22
Zinc	mg/kg	60	747	0.014	10	0.014	10

Note: Base Case information for this node is presented in the EIA, Volume 4A, Section 6.6.4.3, Table 6.6-9.

(a) Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

Table 3.3-30 Predicted Changes in Fish Tissue Metal Concentrations in Muskeg River (M0)

Constituent	Units	Toxicological Benchmark[(a)] [mg/kg ww]	Bioaccumulation Factor	EIA Base Case		2012 Planned Development Case	
				Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
				[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	mg/kg	20	32	0.23	7.4	0.24	7.7
Antimony	mg/kg	30	25	0.00037	0.01	0.00036	0.009
Arsenic	mg/kg	6.1	103	0.00043	0.04	0.00079	0.081
Cadmium	mg/kg	0.6	95	0.00024	0.02	0.00024	0.023
Chromium	mg/kg	0.58	53	0.0022	0.12	0.0027	0.14
Copper	mg/kg	3.4	734	0.0017	1.2	0.0024	1.8
Lead	mg/kg	4	57	0.00023	0.01	0.0004	0.023
Mercury	mg/kg	5	226,509	0.0000038	0.86	0.000009	2
Nickel	mg/kg	0.82	92	0.0079	0.73	0.0091	**0.84**
Selenium	mg/kg	2.58	225	0.00055	0.12	0.00049	0.11
Vanadium	mg/kg	0.41	74	0.0038	0.28	0.0037	0.27
Zinc	mg/kg	60	747	0.011	8.2	0.013	9.7

Notes: Base Case information for this node is presented in the EIA, Volume 4A, Section 6.6.4.3, Table 6.6-10.

Bold values exceed the toxicological benchmark.

(a) Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

In Jackpine Creek, none of the water quality constituents were identified as having the potential to influence aquatic health. All constituents within Jackpine Creek received negligible ratings for environmental consequence (Table 3.3-31).

In Kearl Lake, aluminum, cadmium and selenium were predicted to have a low magnitude effect. Whereas all of the CEBs derived are conservative in that they based on tests using dissolved metals and applied to modelled concentrations of total metals, the aluminum CEB is particularly conservative when applied this way, because aluminum will be minimally bioavailable in the pH range (i.e., 7 to 8) and oxidation state (i.e., generally well-oxygenated) anticipated for LSA watercourses under all modelled scenarios. In light of the magnitude, duration and spatial extent of the predicted changes to the concentrations of aluminum, cadmium and selenium during closure and after final reclamation, it is unlikely that changes to the concentrations of these selected constituents will be sufficient to affect the resistance or resilience of the ecosystems. Therefore, a rank of "reversible" was assigned to each of these constituents, which resulted in the individual constituents receiving negligible to low ratings for environmental consequence (Table 3.3-32).

In the Muskeg River (M0 and M3), none of the water quality constituents were identified as having the potential to influence aquatic health. All constituents within the Muskeg River received negligible ratings for environmental consequence (Tables 3.3-33 and 3.3-34).

Table 3.3-31 Residual Impact Classification for Aquatic Health in Jackpine Creek

Constituent	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
All substances	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Toxic units	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Sediment quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Tissue quality	neutral	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)

Note: If magnitude was negligible, then the environmental consequence was negligible and the other measures were rated as not applicable (N/A).

Numerical scores for ranking of environmental consequences are explained in EIA, Volume 3, Section 1.3.6.

Table 3.3-32 Residual Impact Classification for Aquatic Health in Kearl Lake

Constituent	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Aluminum	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	high (+2)	low (+6)
Cadmium	negative	low (+5)	local (0)	short-term (0)	reversible (-3)	moderate (+1)	negligible (+3)
Chromium	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Cobalt	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Copper	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Manganese	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
PAH group 3	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Selenium	negative	low (+5)	local (0)	short-term (0)	reversible (-3)	moderate (+1)	negligible (+3)
All other substances	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Toxic units	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Sediment quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Tissue quality	neutral	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)

Note: If magnitude was negligible, then the environmental consequence was negligible and the other measures were rated as not applicable (N/A).

Numerical scores for ranking of environmental consequences are explained in EIA, Volume 3, Section 1.3.6.

Table 3.3-33 Residual Impact Classification for Aquatic Health in the Muskeg River (M0)

Constituent	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
All substances	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Toxic units	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Sediment quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Tissue quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)

Note: If magnitude was negligible, then the environmental consequence was negligible and the other measures were rated as not applicable (N/A).

Numerical scores for ranking of environmental consequences are explained in EIA, Volume 3, Section 1.3.6.

Table 3.3-34 Residual Impact Classification for Aquatic Health in the Muskeg River (M3)

Constituent	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
All substances	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Toxic units	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Sediment quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Tissue quality	neutral	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)

Note: If magnitude was negligible, then the environmental consequence was negligible and the other measures were rated as not applicable (N/A).
Numerical scores for ranking of environmental consequences are explained in EIA, Volume 3, Section 1.3.6.

Potential changes to aquatic health resulting from existing, approved and planned developments are expected to be negligible to low in the LSA, when all lines of evidence are considered together, including predicted acute and chronic toxicity levels, predicted changes to water quality and fish tissue metal concentrations.

Athabasca River

Activities associated with JME and PRM in combination with existing, approved and planned developments in the lower Athabasca River watershed have the potential to affect water quality in the Athabasca River. Changes to sediment quality are expected to be negligible for the reasons outlined in the EIA, Volume 4A, Section 6.5. The aquatic health assessment was, therefore, focused on assessing how the predicted changes in water quality could affect aquatic health in the Athabasca River. Two pathways for potential effects were considered: direct effects occurring as a result of predicted changes to water quality and indirect effects related to dietary consumption and possible accumulation of material within fish tissue.

Potential effects related to predicted changes to water quality were evaluated in consideration of predicted levels of whole effluent acute and chronic toxicity and predicted concentrations of individual substances. The fish tissue analysis was completed by comparing predicted body-burdens with toxicological benchmarks. The assessment methods used to complete the aquatic health assessment is consistent with that outlined in the EIA, Volume 4A, Section 6.6.2.

The environmental evaluation of surface water and sediment quality changes to the PAD (Appendix 3.4) indicated that changes due to JME and PRM in conjunction with operating, existing, approved and planned developments would be negligible. This conclusion was based on a number of lines of evidence, including a literature review of existing studies, an analysis of data from those studies and the model results for the Athabasca River described above. As effects on water and sediment quality were predicted to be negligible upstream of and within the PAD, the spatial extent of the aquatics RSA in the EIA was verified to be appropriate.

Changes in Water Quality

Whole Effluent Toxicity

Levels of chronic and acute whole effluent toxicity in the Athabasca River downstream of the Muskeg River, Pierre River, Big Creek and upstream of the Embarras River are predicted to be below the guidelines recommended by Alberta Environment and Water (AEP 1995) throughout the active life of existing, approved and planned developments and into the Far Future. These guidelines represent no effects thresholds for sensitive aquatic organisms. Compliance with acute and chronic guidelines provides a high level of confidence that aquatic health in the Athabasca River will be protected.

Individual Substances

The SOPCs that were identified in the Athabasca River are listed in Table 3.3-35.

Table 3.3-35 Summary of Substances of Potential Concern in the Athabasca River

Constituent	Watercourse
Manganese	Athabasca River upstream of Embarras River

For manganese, median and peak concentrations in the identified snapshots were less than the corresponding CEB. Negligible effects on aquatic health are, therefore, expected to result from the predicted changes in the concentrations of this constituent.

Changes to Fish Tissue Quality

Predicted median concentrations of all of the constituents considered in the fish tissue analysis were essentially unchanged between the 2012 Base Case and 2012 PDC. Therefore, changes to water quality in the Athabasca River downstream of the Muskeg River and in the Athabasca River upstream of Embarras River are projected to result in negligible changes to fish tissue quality and, by association, negligible impacts to aquatic health (Tables 3.3-36 and 3.3-37).

Residual Impact Classification

Activities associated with the existing, approved and planned developments in the Oil Sands Region are predicted to produce changes in water quality in the Athabasca River. Changes to sediment quality are expected to be negligible for the reasons outlined in the EIA, Volume 4A, Section 6.5.7. Potential effects on aquatic health were, therefore, evaluated in consideration of two potential effects pathways: direct effects occurring as a result of predicted changes to water quality and indirect effects related to dietary consumption and possible accumulation of material within fish tissue. This information was used to assign environmental consequence according to criteria specified in the EIA, Volume 4A, Section 1.3.6.1.

Whole effluent acute and chronic toxicity levels in the Athabasca River are predicted to be below guideline levels throughout the life of the existing, approved and planned developments and into the Far Future. Predicted changes to in-stream concentrations of the individual constituents considered in the analysis are either unchanged from existing conditions or the 2012 Base Case, or they remain below CEBs. In addition, changes to constituent concentrations in fish tissues are expected to remain below toxicological benchmarks. As such, activities associated with the existing, approved and planned developments are expected to result in negligible effects on aquatic health in the Athabasca River (Table 3.3-38).

Table 3.3-36 Predicted Changes in Fish Tissue Metal Concentrations in the Athabasca River Downstream of the Muskeg River

Constituent	Toxicological Benchmark [a] [mg/kg ww]	Bioaccumulation Factor	2012 Base Case		2012 Planned Development Case	
			Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
			[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	20	2	0.42	0.8	0.43	0.86
Antimony	9	49	0.00046	0.02	0.00046	0.023
Arsenic	6.1	63	0.001	0.06	0.001	0.063
Cadmium	0.6	77	0.00041	0.03	0.00041	0.032
Chromium	0.58	51	0.0032	0.2	0.0032	0.16
Copper	3.4	79	0.0027	0.2	0.0027	0.21
Lead	4	30	0.001	0.03	0.001	0.03
Mercury	5	13,344	0.000015	0.2	0.000015	0.2
Nickel	0.82	32	0.011	0.4	0.0054	0.17
Selenium	2.58	1,765	0.00023	0.4	0.00023	0.41
Vanadium	0.41	20	0.0024	0.05	0.0024	0.048
Zinc	60	404	0.014	5.7	0.014	5.7

[a] Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

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Table 3.3-37 Predicted Changes in Fish Tissue Metal Concentrations in the Athabasca River Upstream of the Embarras River

Constituent	Toxicological Benchmark [a] [mg/kg ww]	Bioaccumulation Factor	2012 Base Case		2012 Planned Development Case	
			Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration	Predicted Maximum Median Concentration in Water	Estimated Fish Tissue Concentration
			[mg/L]	[mg/kg]	[mg/L]	[mg/kg]
Aluminum	20	2	0.42	0.8	0.36	0.72
Antimony	9	49	0.00046	0.02	0.00032	0.016
Arsenic	6.1	63	0.001	0.06	0.001	0.063
Cadmium	0.6	77	0.00041	0.03	0.00042	0.032
Chromium	0.58	51	0.0032	0.2	0.003	0.15
Copper	3.4	79	0.0027	0.2	0.0026	0.21
Lead	4	30	0.001	0.03	0.0011	0.033
Mercury	5	13,344	0.000015	0.2	0.000015	0.2
Nickel	0.82	32	0.011	0.4	0.0051	0.16
Selenium	2.58	1,765	0.00023	0.4	0.00021	0.37
Vanadium	0.41	20	0.0024	0.05	0.0027	0.054
Zinc	60	404	0.014	5.7	0.013	5.3

[a] Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium. The selenium benchmark is based on data contained in U.S. EPA (2004) expressed as wet weight assuming a moisture content of 75.8%.

Table 3.3-38 Residual Impact Classification for Aquatic Health in the Athabasca River

Constituent	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Individual Substances	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Toxic Units	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Sediment Quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)
Tissue Quality	negative	negligible (0)	N/A	N/A	N/A	N/A	negligible (0)

Note: If magnitude was negligible, then the environmental consequence was negligible and the other measures were rated as not applicable (N/A).

Numerical scores for ranking of environmental consequences are explained in EIA Volume 3, Section 1.3.6.

3.3.4.2 Summary of Results

Activities associated with the existing, approved and planned developments in the Oil Sands Region are predicted to produce changes in water quality in the Jackpine Creek, Kearl Lake, Muskeg River and Athabasca River. Potential effects on aquatic health were evaluated for two potential effects pathways: direct effects occurring as a result of predicted changes to water quality and indirect effects related to dietary consumption and possible accumulation of material within fish tissue.

Whole effluent acute and chronic toxicity levels in Jackpine Creek, Kearl Lake and the Muskeg River are predicted to be below guideline levels throughout the life of JME and into the Far Future. Constituent concentrations within fish tissues are also predicted to remain below toxicological benchmarks, with the possible exception of nickel. This predicted concentration slightly exceeds the EIA Base Case concentrations which are particularly conservative; therefore, the risks to fish health from nickel are expected to be negligible.

In Jackpine Creek, none of the water quality constituents were identified as having the potential to influence aquatic health.

In Kearl Lake, aluminum, cadmium and selenium were predicted to have a low magnitude effect. All CEBs derived for JME and PRM are conservative, in that they are based on tests using dissolved metals and applied to modelled concentrations of total metals; however, the aluminum CEB is particularly conservative when applied this way, because aluminum is minimally bioavailable in the pH range and oxidation state anticipated for LSA watercourses under all modelled scenarios. In light of the magnitude, duration and spatial extent of the predicted changes to the concentrations of aluminum, cadmium and selenium during closure and after final reclamation, it is unlikely that changes to the concentrations of these constituents will be sufficient to affect the resistance or resilience of the ecosystems. Therefore, a rank of “reversible” was assigned to each of these constituents, which resulted in the individual constituents receiving negligible to low ratings for environmental consequence.

In the Muskeg River at both nodes M0 and M3, none of the water quality constituents were identified as having the potential to influence aquatic health. All constituents within the Muskeg River received negligible ratings for environmental consequence.

In the Athabasca River potential effects on aquatic health were evaluated for two potential effects pathways: direct effects occurring as a result of predicted changes to water quality and indirect effects related to dietary consumption and possible accumulation of material within fish tissue.

Whole effluent acute and chronic toxicity levels in the Athabasca River are predicted to be below guideline levels into the Far Future. Predicted changes to in-stream concentrations of the individual constituents considered in the analysis are either unchanged from existing conditions or the EIA Base Case, or they remain below CEBs. In addition, changes to constituent concentrations in fish tissues are expected to remain below toxicological benchmarks. As such, activities associated with the 2012 PDC are expected to result in negligible effects to aquatic health in the Athabasca River.

3.3.5 Fish and Fish Habitat Assessment

The Fish and Fish Habitat Assessment for JME and PRM was presented in the EIA, Volume 4, Section 6.7, and was updated in the May 2008 EIA Update and the *May 2011, Submission of Information to the Joint Review Panel* to account for changes to JME. The effects assessments in the EIA Application Case provide the assessment of all residual impacts of JME and PRM in combination with existing and approved developments. The PDC assesses these residual impacts in combination with potential impacts of additional planned developments. The developments considered for the 2012 PDC are listed in Appendix 3.1. Cumulative effects are only evaluated for potential impacts from other developments that are predicted to overlap in time and space with potential impacts from JME and PRM.

Fish and fish habitat were assessed using the assessment methods described in the EIA, Volume 4, Section 6.7. The approach used for the 2012 PDC assessment is consistent with the EIA. Mitigation and compensation measures for fish and fish habitat are the same as those described in the EIA, Volume 4, Section 6.7.

The 2012 PDC assessments for Surface Water Hydrology (Section 3.3.2), Water Quality (Section 3.3.3) and Aquatic Health (Section 3.3.4) were reviewed. Linkages in these assessments were only evaluated if there were changes from the EIA Application Case that might directly affect the Fish and Fish Habitat assessment. The 2012 PDC predictions for Water Quality and Aquatic Health do not differ for the EIA Application Case. However, there are minor changes in predicted stream flows in the 2012 PDC Surface Water Hydrology assessment for the Muskeg River and the Athabasca River, compared to flows predicted in the EIA. Therefore, the linkage associated with changes in stream flow was the only pathway carried through to the 2012 PDC Fish and Fish Habitat assessment.

3.3.5.1 Assessment Results

Jackpine Mine Expansion

The Muskeg River is the only watercourse in the JME area where potential effects on fish habitat and fish abundance under the 2012 PDC may differ from those predicted to occur under the EIA Application Case. Changes in stream flow in the Muskeg River under the EIA Application Case will be accounted for in the Draft No Net Loss Plan, and as a result, no residual impacts were predicted. The inclusion of new planned developments for the 2012 PDC will result in additional reductions to peak flow statistics at Closure. Additional incremental reductions in stream flow will require further compensation in proportion to each development's contribution to habitat alteration. Based on the compensation that will be required, the residual impacts on regional fish habitat and abundance are predicted to be negligible.

Athabasca River

Potential effects on fish habitat and fish abundance under the 2012 PDC may differ from those predicted to occur under the 2012 JME Application Case for the Athabasca River. In the 2012 JME Application Case, impacts to fish habitat that may result from changes in Athabasca River flow or water level, as a result of JME, are predicted to be negligible. The assessment of effects considers the Water Management Framework for the Lower Athabasca River. The Framework was developed to manage withdrawals from the Athabasca River and protect the aquatic ecosystem, while allowing industry to operate; this would include the planned projects in the 2012 PDC. As the Framework is adaptive, the Framework, informed by ongoing scientific study, will be modified as necessary to maintain protection of the river. Accordingly, no cumulative impacts to fish habitat, beyond those outlined in the Framework, would be expected from changes to stream flow in the Athabasca River in the 2012 PDC.

3.4 Terrestrial Resources

This section provides the results of the 2012 PDC assessments for Terrestrial Resources to inform the cumulative effects on the terrestrial environment. The 2012 PDC includes a review of the cumulative effects that could result from the existing and approved developments, JME and PRM, and the planned (publicly disclosed) developments in the Oil Sands Region, as of September 2011.

The section presents assessments of Soils and Terrain, Terrestrial Vegetation, Wetlands and Forest Resources, Wildlife and Wildlife Habitat and Biodiversity. The approaches used for the assessments are the same as the approaches used in the EIA with the following exceptions:

- Species at Risk are incorporated into the wildlife assessment as requested in JRP SIR 8, building from the work previously submitted in the *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B.
- The ALCES® model was used to simulate forest fire and harvest information. Landscape simulations were conducted using the ALCES and ALCES M*apper® computer programs. The ALCES® program was used to sim*ulate the effects of fire, timber harvest, and industrial development in the RSA over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the 2012 Base Case, 2012 JME Application Case and 2012 PDC in this appendix.
- Updated Alberta Biodiversity Monitoring Institute (ABMI), Alberta Conservation Management Information System (ACIMS), and Fisheries and Wildlife Management Information System (FWMIS) were incorporated into the updated assessment of the effects of JME.
- Forest stands at closure are considered to be 80 years old (December 2007 Jackpine Mine Expansion, Volume 5, Section 7.2.3 and *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B). Eighty years represents the estimated time required for the development of mature forest on the reclaimed landscape, and is a more appropriate time frame upon which to compare vegetation, wildlife and biodiversity values in the reclaimed landscape against the EIA Base Case values (EIA, Volume 5, Section 7.2.3). However, this represents a change from the EIA (Volume 5, Section 7.2.3) for habitat suitability modelling, in which stand ages of original wildlife KIRs were assigned using mine progression diagrams to represent stand ages at the point in time at which

closure occurs (i.e., 2070), and therefore resulted in closure landscape much younger than that used for habitat suitability modelling here. The assumptions regarding stand age at closure were changed from those used in the EIA because mature forest stands at closure represent a more appropriate time frame for the assessment of long-term JME effects. Robust ecological communities and processes will take time to develop on the closure landscape.

Detailed information on approach modifications is provided in Appendix 3.1.

3.4.1 Soils and Terrain Assessment

The effects of JME and PRM and planned developments on soils and terrain were assessed in the EIA Volume 5, Section 7.3 through 7.6 and in the May 2008 EIA Update Section 2.7.1.

Assessment Results

The 2012 soils assessment indicates 78,004 ha (3% of RSA) of mineral soils and 51,419 ha (2% of RSA) of organic soils will be lost or disturbed (Table 3.4-1). These losses and alterations are summarized in Table 3.4-2. As each of Tables 3.4-1 and 3.4-2 describe the disturbance conditions before reclamation, they do not include closure pit lakes or compensation lakes, and are grouped under reconstructed landforms. There will be a net positive increase of 22,014 ha (1% of RSA) in mineral soils after reclamation due to an increase of 147,575 ha (6% of RSA) in reconstructed landforms (Table 3.4-3), and an increased area of water of 18,878 ha (<1% of the RSA). Changes in soil types due to the 2012 PDC are presented in Table 3.4-1.

Table 3.4-1 Changes to Soil Types Due to the 2012 Planned Development Case: Before Reclamation

Soil Series	2012 Base Case		2012 PDC								
			Loss/Alteration Due to 2012 PDC[a]		Loss/Alteration Due to JME		Closure		Net Change Due to 2012 PDC[b]		
	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	% Resource[c]
Mineral Soil											
Algar Lake	42,359	2	-4,580	- <1	-3	0	37,779	2	-4,580	- <1	-11
Bitumount	38,786	2	-3,495	- <1	-275	- <1	35,291	2	-3,495	- <1	-9
Buckton	31,738	1	-16	- <1	0	0	31,722	1	-16	- <1	- <1
Dover	51,455	2	-5,687	- <1	0	0	45,768	2	-5,687	- <1	-11
Firebag	60,413	3	-1,374	- <1	-11	- <1	59,039	3	-1,374	- <1	-2
Horse River	23,558	1	-2,508	- <1	-465	0	21,050	1	-2,508	- <1	-11
Joslyn	66,313	3	-8,283	- <1	0	0	58,030	3	-8,283	- <1	-12
Kinosis	49,593	2	-1,873	- <1	0	- <1	47,720	2	-1,873	- <1	-4
Legend	126,288	6	-4,951	- <1	0	0	121,337	5	-4,951	- <1	-4
Livock	36,688	2	-1,087	- <1	-334	0	35,601	2	-1,087	- <1	-3
Marguerite	71,654	3	-973	- <1	0	- <1	70,681	3	-973	- <1	-1
McMurray	52,879	2	-3,555	- <1	0	- <1	49,324	2	-3,555	- <1	-7
Mildred	171,303	8	-9,293	- <1	-732	- <1	162,010	7	-9,293	- <1	-5
Namur	60,569	3	-22,142	- <1	-3	0	38,427	2	-22,142	- <1	-37
Steepbank	120,406	5	-4,786	- <1	0	0	115,620	5	-4,786	- <1	-4
Other Mineral Soils	35,480	2	-3,401	- <1	-1,336	- <1	32,079	1	-3,401	- <1	-10
sub-total (mineral soil)	*1,039,482*	*46*	*-78,004*	-3	-3,159	- <1	961,478	42	-78,004	-3	-8
Organic Soil											
Muskeg	228,588	10	-12,408	- <1	-1,056	- <1	216,180	9	-12,408	- <1	-5
Conklin	58,013	3	-4,817	- <1	0	- <1	53,196	2	-4,817	- <1	-8
Hartley	153,966	7	-7,979	- <1	-854	- <1	145,987	6	-7,979	- <1	-5
Mariana	139,442	6	-10,569	- <1	-460	- <1	128,873	6	-10,569	- <1	-8
McLelland	146,026	6	-9,510	- <1	-5,566	- <1	136,516	6	-9,510	- <1	-7
Mikkwa	125,267	6	-3,108	- <1	-228	0	122,159	5	-3,108	- <1	-2
Other Organic Soils	66,077	3	-3,028	- <1	-1,591	- <1	63,049	3	-3,028	- <1	-5
sub-total (organic soil)	*917,379*	*40*	-51,419	-2	-9,755	- <1	865,960	38	-51,419	-2	-6
Non Soil											
Disturbed	170,483	7	-6,657	- <1	-278	- <1	163,826	7	-6,657	- <1	-4
Indian Reserve	6,161	<1	-30	- <1	0	0	6,131	<1	-30	- <1	- <1
Reconstructed Landforms	6,494	<1	-6,169	- <1	-6,169	- <1	147,575	6	141,081	6	2,173
Rough broken/rock	82,401	4	-2,306	- <1	0	0	80,095	4	-2,306	- <1	-3
Water	54,976	2	-2,665	- <1	-1,441	- <1	52,311	2	-2,665	- <1	-5
sub-total (non-soil)	320,515	14	-17,827	- <1	-7,888	- <1	449,938	20	129,423	6	40
Total	**2,277,376**	**100**	**-147,250**	**-6**	**-20,802**	**-1**	**2,277,376**	**100**	**0**	**0**	**0**

(a) Loss/alteration combines direct effects due to JME and all existing, approved and planned developments in the RSA.

(b) Net change is calculated as the difference between Closure and the 2012 Base Case.

(c) % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The total changes in soil types before reclamation are summarized in Table 3.4-2. The net changes in soil types after reclamation are summarized in Table 3.4-3. The total changes due to the 2012 PDC account for 147,250 ha (or about 6% of the RSA). There is an increase of 18,474 ha of disturbance from the EIA PDC (EIA Volume 5, Section 7.6, Table 7.6-4) to the 2012 PDC. There is an accompanying net increase in the loss of organic soils from the EIA PDC to the 2012 PDC after reclamation, because disturbed areas are reclaimed to mineral soils.

Table 3.4-2 Summary of Changes to Soil Types Due to the 2012 Planned Development Case: Before Reclamation

Soil Type	2012 Base Case		2012 PDC Loss/Alteration		Closure		Net Change Due to the 2012 PDC[(a)]		
	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	% Resource[(b)]
Mineral soils	1,039,482	46	-78,004	-3	961,478	42	-78,004	-3	-8
Organic soils	917,379	40	-51,419	-2	865,960	38	-51,419	-2	-6
rock, rough, disturbed, reconstructed landforms, Indian Reserves	265,537	12	-15,162	-< 1	397,627	17	132,090	6	50
Water	54,976	2	-2,665	- <1	52,311	2	-2,665	- <1	-5
Total	**2,277,376**	**100**	**-147,250**	**-6**	**2,277,376**	**100**	**0**	**0**	**0**

(a) Net change is calculated as the difference between the 2012 Base Case and Closure, a value upon which the environmental consequence is assessed.

(b) % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.4-3 Summary of Changes to Soil Types Due to the 2012 Planned Development Case: After Reclamation

Soil Type	2012 Base Case		2012 PDC Loss/Alteration		Closure[(a)]		Net Change Due to the 2012 PDC[(b)(d)]		
	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	Area [ha]	% of RSA	% Resource[(e)]
Mineral soils	1,039,482	46	-78,004	-3	1,061,497	47	22,014	<1	2
Organic soils	917,379	40	-51,419	-2	891,972	39	-25,407	-1	-3
rock, rough, disturbed, reconstructed landforms, Indian Reserves	265,537	12	-15,162	- <1	250,052	11	-15,485	- <1	-6
Water[(c)]	54,976	2	-2,665	- <1	73,854	3	18,878	< 1	34
Total	**2,277,376**	**100**	**-147,250**	**-6**	**2,277,376**	**100**	**0**	**0**	**0**

(a) After reclamation closure assumes all disturbed minerals soils are reclaimed and some organic soils are recreated. -Closure landscape scenario conceptualized for land cover is used to predict the after reclamation scenario.

(b) Total net change due to 2012 PDC is set to zero for presentation purposes only. The residual environmental consequence rating is based on the loss of organic soils.

(c) Includes reclaimed pit lakes and compensation lakes.

(d) Net change is calculated as the difference between the 2012 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

(e) % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Residual Impact Classification for Soils in the Regional Study Area

The 2012 PDC residual impact classification for soils in the RSA is shown in Table 3.4-4. The environmental consequences for the loss/alteration of soils in the RSA were rated as moderate both before and after reclamation.

Table 3.4-4 Residual Impact Classification for Soils in the Regional Study Area: 2012 Planned Development Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (RSA)
Loss/Alteration of Soils - Before and After Reclamation							
permanent loss	negative	low (+5)	regional (+1)	long-term (+2)	irreversible (+3)	low (0)	moderate (+11)

Note: Numerical score for ranking of environmental consequence is explained in EIA, Volume 3, Section 1.3.6.

3.4.1.1 Summary of Results

The 2012 PDC assessment shows an increase of in planned development disturbances. The area of soil disturbance in the 2012 PDC was 147,250 ha (6% of RSA), compared to the EIA prediction of 128,842 ha (6% of RSA). After reclamation, there will be a net increase of mineral soils (22,014 ha or less than 1% of RSA) at closure, compared to the 2012 Base Case. A net loss of 25,407 ha (1% of RSA) organic soils is predicted after reclamation based on the conceptualized landscape. The environmental consequence rating for the 2012 PDC is increased from low to moderate compared to the EIA.

3.4.2 Terrestrial Vegetation, Wetlands and Forest Resources Assessment

The effects of JME and PRM and planned developments on terrestrial vegetation, wetlands and forest resources were assessed in EIA Volume 5, Section 7. The 2012 PDC was completed for those components that had a low, moderate or high negative environmental consequence in the LSA in the 2012 JME Application Case assessment at Closure (Appendix 1). Greater than negligible negative environmental consequences were predicted in the LSA for the following Key Indicator Resources (KIRs):

- wetlands (including peatlands and patterned fens);
- old growth forests; and
- rare plants, rare and special plant communities, and rare plant potential.

For a PDC assessment, only rare plant potential can be assessed as rare plant occurrences and rare plant community data for planned development areas are not typically available.

The remaining KIRs were assessed to have a positive, neutral or negative negligible environmental consequence in the LSA and a negligible environmental consequence in the RSA for the 2012 JME Application Case at Closure (Appendix 1) and therefore were not analyzed in the 2012 PDC. Effects of JME on these KIRs in terms of magnitude, extent, duration, frequency and reversibility at the 2012 JME Application Case are summarized in Appendix 1. The results of the 2012 PDC assessment both during construction and operations and at 2012 PDC Closure (i.e., 80 years following final reclamation) are presented below.

3.4.2.1 Assessment Results

Change to Regional Land Cover Classes

The combined developments in the 2012 PDC will result in the direct and indirect loss or alteration to the 2012 Base Case terrestrial and wetlands resources as summarized in Table 3.4-5. A total of 56,137 ha (2% of the RSA) of the 2012 Base Case terrestrial Regional Land Cover Classes (RLCCs) will be disturbed in the 2012 PDC. Although terrestrial vegetation will be lost during construction and operations, there will be an overall increase in terrestrial vegetation by 8% of the RSA over the 2012 Base Case. During construction and operations, there will be a loss of 76,618 ha (3% of RSA) of wetlands within the RSA. Following reclamation, the net decrease is reduced to 14,044 ha of wetlands (less than 1% of the RSA). From 2012 Base Case to Closure, the largest portion of terrestrial vegetation gained will be in the deciduous aspen-balsam poplar RLCC, while wetlands area loss will be in the treed bog/poor fen and treed fen RLCCs.

Change in Wetlands Including Peatlands

Peatlands are included in the wetlands class in the 2012 PDC. Peatlands cannot be assessed separately because they are indistinguishable from other wetlands classes in the RSA at the scale of the mapping units used to classify RLCCs. Peatlands and patterned fens are discussed in JRP SIR Responses 8 and 12 for the LSA.

Wetlands in the RSA are represented by the following RLCCs:

- non-treed wetlands;
- treed bog/poor fen; and
- treed fen.

A total of 76,618 ha (3% of RSA) of wetlands will be lost or altered in the 2012 PDC (Table 3.4-5). Following reclamation and regeneration, the effect of planned developments on 2012 Base Case wetlands is a net decrease of 14,044 ha (less than 1% of the RSA). Based on this, at Closure, non-treed wetlands are predicted to increase by 34,394 ha (2% of the RSA) over the 2012 Base Case. The natural regeneration of wetlands on linear disturbances (i.e., seismic lines, pipelines and trails) to non-treed wetlands is included in this net gain. From 2012 Base Case to the 2012 PDC at Closure, the treed bog/poor fen RLCC is predicted to decrease by 24,099 ha (1% of the RSA), while the treed fen RLCC is predicted to decrease by 24,340 ha (1% of the RSA).

Due to the scale of mapping used at the RSA, the treed bog/poor fen, treed fen and non-treed wetlands RLCCs likely include a proportion of non-peatland wetlands types. Based on a review of nine oil sands projects within the RSA, peatlands are estimated to represent 67% of all the wetlands mapped at the regional scale (EIA, Volume 5, Section 7.6.2). Using this proportion as a guide, approximately 9,410 ha of peatlands will be lost (less than 1% of the RSA) from 2012 Base Case to 2012 PDC at Closure. During construction and operations, a negative moderate environmental consequence has been assigned to wetlands (including peatlands).

Table 3.4-5 Regional Land Cover Classes in the Regional Study Area: 2012 Base Case to the 2012 Planned Development Case

Land Cover Classes	2012 Base Case[a]		Loss/Alteration to 2012 Base Case Due to JME and Jackpine Mine - Phase 1[a][b]			Loss/Alteration to 2012 Base Case Due to 2012 Planned Developments[a][d]			Closure[a]		Net Change to 2012 Base Case Due to 2012 Planned Developments[e]		
	Area [ha]	% of RSA	Area [ha]	% of RSA	% of Resource[c]	Area [ha]	% of RSA	% of Resource[c]	Area [ha]	% of RSA	Area [ha]	% of RSA	% of Resource[c]
Terrestrial Vegetation													
coniferous jack pine	167,268	7	-785	-<1	-<1	-4,715	-<1	-3	179,186	8	11,918	<1	7
coniferous jack pine-black spruce	40,429	2	-146	-<1	-<1	-1,524	-<1	-4	64,100	3	23,670	1	59
coniferous white spruce	53,351	2	-966	-<1	-2	-6,043	-<1	-11	90,385	4	37,033	2	69
deciduous aspen-balsam poplar	182,315	8	-1,711	-<1	-<1	-23,006	-1	-13	232,463	10	50,148	2	28
mixedwood aspen-jack pine	39,462	2	-291	-<1	-<1	-2,201	-<1	-6	59,510	3	20,048	<1	51
mixedwood aspen-white spruce	147,918	6	-2,782	-<1	-2	-18,648	-<1	-13	186,820	8	38,902	2	26
terrestrial vegetation subtotal	*630,743*	*28*	*-6,680*	*-<1*	*-1*	*-56,137*	*-2*	*-9*	*812,464*	*36*	*181,721*	*8*	*29*
Wetlands (Peatlands)													
non-treed wetlands	245,047	11	-7,906	-<1	-3	-23,239	-1	-9	279,441	12	34,394	1	14
treed bog/poor fen	427,623	19	-4,181	-<1	-<1	-24,759	-1	-6	403,524	18	-24,099	-1	-6
treed fen	233,346	10	-5,190	-<1	-2	-28,620	-1	-12	209,007	9	-24,340	-1	-10
wetlands subtotal	*906,016*	*40*	*-17,277*	*-<1*	*-2*	*-76,618*	*-3*	*-8*	*891,972*	*39*	*-14,044*	*-<1*	*-2*
Miscellaneous													
burn	395,857	17	-106	-<1	-<1	-7,892	-<1	-2	388,070	17	-7,787	-<1	-2
water	54,244	2	-1,425	-<1	-3	-2,661	-<1	-5	73,854	3	19,610	<1	36
miscellaneous subtotal	*450,101*	*20*	*-1,531*	*-<1*	*-<1*	*-10,553*	*-<1*	*-2*	*461,925*	*20*	*11,823*	*<1*	*3*
Disturbances													
cutblock	100,391	4	0	0	0	-771	-<1	-<1	99,620	4	-771	-<1	-<1
disturbance	190,124	8	-474	-<1	-<1	-8,331	-<1	-4	11,396	<1	-178,729	-8	-94
disturbances subtotal	*290,515*	*13*	*-474*	*-<1*	*-<1*	*-9,102*	*-<1*	*-3*	*111,015*	*5*	*-179,500*	*-8*	*-62*
Total	**2,277,376**	**100**	**-25,963**	**-1**	**-1**	**-152,410**	**-7**	**-7**	**2,277,376**	**100**	**n/a**	**n/a**	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration combines direct effects due to site clearing (Project footprint) and indirect Project effects due to groundwater drawdown within the RSA. Excluding indirect effects due to groundwater drawdown there is a total loss/alteration of -20,802 ha, within the RSA.

(c) % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

(d) Loss/alteration combines direct effects due to site clearing (Project footprint) and indirect Project effects due to groundwater drawdown within the RSA, plus existing, approved and planned developments in the RSA. Excluding indirect effects due to groundwater drawdown the total loss/alteration is -147,249 ha, within the RSA.

(e) Net change is calculated as the difference between the 2012 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

n/a = Not applicable.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Wetlands are predicted to account for 891,972 ha or 39% of the RSA following reclamation. Wetlands (including peatlands) have been assigned a negative and low environmental consequence ranking during construction and operations, which has not changed from negative and low in the PDC EIA (Table 3.4-9). At Closure, wetlands (including peatlands) have been assigned a negative and negligible environmental consequence ranking. Although the peatlands (i.e., fens) in the RSA cannot be reclaimed with current technologies, the non-treed wetlands can be reclaimed. For this reason, reversible/irreversible was used. Reclamation programs will be adaptively managed to incorporate the results and recommendations from ongoing research regarding establishment of bogs and fens on the closure landscape (May 2008 EIA Update, Appendix 2, Section 1.5).

Change to Old Growth Forest

The estimated effect that JME and combined developments within the RSA will have on old growth forests is outlined in Table 3.4-6. Due to the combined effects of the 2012 PDC developments, up to 25,294 ha of potential 2012 Base Case old growth forest area may be cleared in the RSA; JME will contribute to less than 1% of this total. Old growth is not expected to be re-established within the 80-year period defined for the Closure scenario. Over time, the proportion of old growth in the RSA may return to their pre-disturbance proportions. The overall environmental consequence for old growth forests in the RSA is low both before and after reclamation (Table 3.4-9). There has been no change in the old growth environmental consequence ranking from the EIA PDC.

Change to Rare Plant Potential

The predicted changes to high rare plant potential habitat under the 2012 PDC are presented in Table 3.4-7. An estimated 51,859 ha of high rare plant potential will be lost from 2012 Base Case to the 2012 PDC (2% of the RSA). Post reclamation, high rare plant potential habitat is predicted to increase by 10,055 ha (less than 1% of the RSA; 2% of high rare plant potential) over 2012 Base Case. This predicted increase in high rare plant potential in the Closure is mainly a result of non-treed wetlands reclamation and natural wetlands regeneration on existing and future linear disturbances.

During construction and operations, a negative moderate environmental consequence has been assigned to wetlands (including peatlands). At Closure, the high rare plant potential environmental consequence ranking has changed from positive and low in the EIA PDC to positive and negligible within the RSA (Table 3.4-9).

Residual Impact Classification

During Project operations, a total of 56,137 ha (2% of the RSA) of the terrestrial vegetation and 76,618 ha (3% of the RSA) of wetlands in the RSA will be lost/altered by disturbances in the 2012 PDC (Table 3.4-5). Table 3.4-8 summarizes the environmental consequences of the 2012 PDC during construction and operations.

Following reclamation, terrestrial vegetation is expected to increase by 181,721 ha (8% of the RSA) and wetlands are expected to decrease by 14,044 ha (less than 1% of the RSA). The effects description and environmental consequences associated with the 2012 PDC at Closure are summarized in Table 3.4-9.

Table 3.4-6 Old Growth Forest in the Regional Study Area: 2012 Base Case to 2012 Planned Development Case

Regional Land Cover Classes	Forest Type (Old Growth Range)	Mid-Point Estimated Occurrence of Old Growth in the RSA[a]	Estimated 2012 Base Case Old Growth in the RSA[b][c]		Loss/Alteration of 2012 Base Case Old Growth Due to JME and Jackpine Mine - Phase 1[b][d]			Estimated Loss/Alteration of 2012 Base Case Old Growth Due to 2012 Planned Developments[b][c]		
		[% of Land Cover] Class	Area [ha]	% of RSA	Area [ha]	% of RSA	% of Resource[d] [e]	Area [ha]	% of RSA	% of Resource[d][e]
Terrestrial Vegetation										
coniferous jack pine	pine dominant (16% to 36%)	26	43,490	2	0	0	0	-1,226	-<1	-3
coniferous jack pine-black spruce	pine dominant (16% to 36%)	26	10,512	<1	0	0	0	-396	-<1	-4
coniferous white spruce	white spruce dominant (10% to 34%)	22	11,737	1	-13	-<1	-<1	-1,330	-<1	-11
deciduous aspen-balsam poplar	hardwood dominant (14% to 42%)	28	51,048	2	-115	-<1	-<1	-6,442	-<1	-13
mixedwood aspen-jack pine	mixedwood dominant (16% to 38%)	27	10,655	<1	-88	-<1	-1	-594	-<1	-6
mixedwood aspen-white spruce	mixedwood dominant (16% to 38%)	27	39,938	2	-173	-<1	-<1	-5,035	-<1	-13
treed bog/poor fen	black spruce dominant (12% to 28%)	20	85,525	4	0	0	0	-4,820	-<1	-6
treed fen	black spruce dominant (12% to 28%)	20	46,669	2	0	0	0	-5,451	-<1	-12
Total		**n/a**	**299,573**	**13**	**-390**	**-<1**	**-<1**	**-25,294**	**-1**	**-8**

[a] Based on overmature age class range values in Andison (2003).

[b] Includes burns and cutblocks as modelled by ALCES.

[c] Estimations are calculated by multiplying the total area of each land cover class by the mid-point estimated occurrence of old growth.

[d] Values generated by correlating the amount of loss/alteration of old growth in each LSA vegetation type to the corresponding regional land cover class.

[e] % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

n/a = Not applicable.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Table 3.4-7 Rare Plant Potential in the Regional Study Area: 2012 Base Case to 2012 Planned Development Case

Rare Plant Potential	2012 Base Case[a]		Loss/Alteration to 2012 Base Case Due to JME and Jackpine Mine - Phase 1[a][b]			Loss/Alteration to 2012 Base Case Due to Planned Developments[a][d]			Closure[a]		Net Change to 2012 Base Case Due to Planned Developments[e]		
	Area [ha]	% of RSA	Area [ha]	% of RSA	% of Resource[c]	Area [ha]	% of RSA	% of Resource[c]	Area [ha]	% of RSA	Area [ha]	% of RSA	% of Resource[c]
high	478,393	21	-13,095	-1	-3	-51,859	-2	-11	488,448	21	10,055	<1	2
moderate	1,171,031	51	-5,509	-<1	-<1	-41,862	-2	-4	1,194,010	52	22,979	1	2
low	627,952	28	-7,358	-<1	-1	-58,689	-3	-9	594,918	26	-33,034	-1	-5
Total	**2,277,376**	**100**	**-25,963**	**-1**	**-1**	**-152,410**	**-7**	**-7**	**2,277,376**	**100**	**n/a**	**n/a**	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration combines direct effects due to site clearing (Project footprint) and indirect Project effects due to groundwater drawdown within the RSA. Excluding indirect effects due to groundwater drawdown there is a total loss/alteration of -20,802 ha, within the RSA.

(c) % of Resource is calculated as a percentage of 2012 Base Case area; the areas of this column are not additive.

(d) Loss/alteration combines direct effects due to site clearing (Project footprint) and indirect Project effects due to groundwater drawdown within the RSA, plus existing, approved and planned developments in the RSA. Excluding indirect effects due to groundwater drawdown the total loss/alteration is -147,249 ha, within the RSA.

(e) Net change is calculated as the difference between the 2012 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

n/a = Not applicable.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Table 3.4-8 Residual Impact Classification for Terrestrial Vegetation, Wetlands and Forest Resources in the Regional Study Area: 2012 Base Case to 2012 Planned Development Case During Construction and Operations

Component Criteria	Direction	Magnitude[(a)]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
wetlands including peatlands	negative	low (+5)	regional (+1)	long term (+2)	irreversible/ reversible (0)	high (+2)	low (+10)
old growth forests	negative	low (+5)	regional (+1)	long term (+2)	irreversible/ reversible (0)	high (+2)	low (+10)
rare plant potential (high)	negative	low (+5)	regional (+1)	long term (+2)	n/a	high (+2)	low (+10)

(a) Residual impact magnitude is based on percent of the RSA.

Note: Numerical scores for ranking of environmental consequence are explained in EIA Volume 3, Section 1.3.6.

n/a = Not applicable.

Table 3.4-9 Residual Impact Classification for Terrestrial Vegetation, Wetlands and Forest Resources in the Regional Study Area: 2012 Base Case to the 2012 Planned Development Case Closure

Component Criteria	Direction	Magnitude[(a)]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
wetlands including peatlands	negative	negligible (0)	regional (+1)	long term (+2)	irreversible/ reversible (0)	high (+2)	negligible (+5)
old growth forests	negative	low (+5)	regional (+1)	long term (+2)	irreversible/ reversible (0)	high (+2)	low (+10)
rare plant potential (high)	positive	negligible (0)	regional (+1)	long term (+2)	n/a	high (+2)	negligible (+5)

(a) Residual impact magnitude is based on percent of the RSA.

Note: Numerical scores for ranking of environmental consequence are explained in EIA Volume 3, Section 1.3.6.

n/a = Not applicable.

3.4.2.2 Summary of Results

As assessed in Appendix 1, greater than negligible negative environmental consequences were predicted in the LSA for the 2012 JME Application Case at Closure for the following KIRs: old growth forests, wetlands including peatlands, and rare plants, rare and special plant communities and rare plant potential.

The results of the 2012 PDC assessment during construction and operations indicate a negative, low environmental consequence for old growth forests and high rare plant potential. A negative moderate environmental consequence is assigned to wetlands (including peatlands).

The results of the 2012 PDC assessment indicate that there has been no change to the old growth forest environmental consequence rankings from the EIA PDC, within the RSA at Closure. The wetlands (including peatlands) environmental consequence ranking at Closure was reduced to negligible from low in the EIA PDC. Although the peatlands (i.e., fens) in the RSA cannot be reclaimed with current technologies if the soil has been disturbed, the non-treed wetlands can be reclaimed, resulting in the reduction in environmental consequence.

The high rare plant potential environmental consequence ranking has changed from positive and low in the EIA to positive and negligible within the RSA.

3.4.3 Wildlife Assessment

The effects of JME and PRM, and planned developments on wildlife were assessed in the EIA Volume 5, Section 7.3.4 through 7.6. The EIA as amended assessed the effects of JME and PRM on the abundance, habitat and movement of wildlife Key Indicator Resources (KIRs), which were selected based on robust selection rationale. Estimated effects on those species were extrapolated to assess the effects of JME and PRM on other wildlife species, including federally-listed species at risk. A list of species considered in this assessment is presented in Table 1.3-2 of the *May 2011 Submission of Information to the Joint Review Panel.* The effects of JME and PRM on wildlife abundance, habitat and movement for selected wildlife KIRs in the EIA and for federally listed species at risk that may be affected by JME and PRM were assessed in the *May 2011 Submission of Information to the Joint Review Panel*. The effects of JME and PRM and planned developments on the abundance of the wildlife KIRs Canadian toad, barred owl, beaver, Canada lynx, fisher and black-throated green warbler were not previously explicitly assessed in the EIA for the RSA, but are assessed here to increase the clarity of the assessment (Section 3.4.4.1). The effects of JME and planned developments on wood bison abundance were previously assessed (May 2011, Submission of Information to the Joint Review Panel), but are not assessed here because bison in Alberta are not found east of the Athabasca River. Therefore, effects on wood bison abundance are not a valid linkage for JME. Effects on woodland caribou habitat were not previously assessed, because woodland caribou are virtually absent in the LSA and are, therefore, unlikely to be affected by habitat changes there. However, the effects on wood bison and woodland caribou habitat are assessed in the response to JRP SIR 19a and 21b (May 2012, JME JRP SIRs) because these species occurred in the LSA in the past.

The effects of JME and planned developments on wildlife movement were not explicitly assessed in the 2007 EIA PDC for Canadian toad, barred owl, beaver, black-throated green warbler and western toad but have been assessed in this update to increase the clarity of the assessment (Section 3.4.4.3). In the EIA, the effects of habitat fragmentation were combined with the results of the Linkage Zone Analysis to assess the environmental consequence of the EIA PDC on wildlife movement. Fragmentation metrics may be useful indicators of effects on wildlife movement, but should not be considered in isolation because wildlife are often able to move around disturbances. In addition, areas of suboptimal habitat may facilitate movement rather than inhibiting it (Andreassen et al. 1996). Environmental consequences for the effects of landscape change on wildlife movement were assessed in the EIA using fragmentation metrics and Linkage Zone Analysis results separately. For the 2012 PDC, the outputs of these quantitative tools are combined with professional judgement to result in one environmental consequence for each wildlife KIR and Species at Risk (SAR) for which movement may be affected.

3.4.3.1 Assessment Results

Wildlife Abundance

The effects of JME and PRM and planned developments on wildlife abundance were assessed in the EIA and the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel). For wildlife KIRs, abundance was previously assessed explicitly for black bear and moose through the use of a Population Viability Analysis. A Population Viability Analysis was also conducted for the 2012 PDC (Appendix 3.7). A low magnitude reduction in the carrying capacity of the RSA was predicted for both the EIA PDC and the 2012 PDC.

However, as these species are likely below carrying capacity in the region, changes in carrying capacity are unlikely to relate directly to changes in abundance. The environmental consequences of the 2012 PDC on the abundance of black bear and moose are, therefore, predicted to be negligible, as in the EIA. The assessed environmental consequences of the effects of the EIA PDC on moose and black bear abundance were assessed as neutral and negligible in the EIA (Volume 5, Section 7.6.3) due to projections of increasing populations of these species despite reductions in carrying capacity (EIA, Volume 5, Appendix 5-4, Section 3). To be conservative, the environmental consequence is changed to negative and negligible for these species, due to the decreased carrying capacity in the RSA in the 2012 PDC, and the effects of development on mortality (Table 3.4-10).

The effects of JME and planned developments on the remaining EIA wildlife KIRs were not explicitly assessed in the RSA, but are assessed for the 2012 PDC using professional judgment to be negligible for Canadian toad, barred owl, beaver, Canada lynx, fisher and black-throated green warbler (Table 3.4-10).

The assessed environmental consequences of the 2012 PDC on the abundance of wildlife SAR are similar to those previously assessed (May 2011, Submission of Information to the Joint Review Panel). Impacts affecting the abundance of Eskimo curlew and northern leopard frog are not predicted because these species have not been recorded in the RSA. Impacts affecting the abundance of wood bison and woodland caribou are also not predicted, because wood bison in Alberta are not found east of the Athabasca River, and woodland caribou are virtually absent from the LSA.

The available evidence suggests the regional abundances of Canada warbler, common nighthawk, peregrine falcon, red knot, western toad, whooping crane and wood bison are not limited by habitat in the RSA (May 2011, Submission of Information to the Joint Review Panel). As such, the abundances of these species are unlikely to be affected by habitat changes due to JME and other planned developments in the RSA. It is probable that the abundances of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are also not limited by habitat within the RSA. However, for these species, sufficient uncertainty exists that the potential effects of habitat loss on abundance were considered (May 2011, Submission of Information to the Joint Review Panel). To be conservative, the magnitude of effects on regional populations of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are estimated as equivalent to the magnitude of the habitat loss effects within the RSA for the 2012 PDC. As a result, the environmental consequences of the 2012 PDC on the abundance of horned grebe, rusty blackbird and yellow rail increase from low (May 2011, Submission of Information to the Joint Review Panel) to moderate (Table 3.4-10).

Table 3.4-10 Residual Effects Classification for Effects on Wildlife in the Regional Study Area – 2012 Planned Development Case Before Closure

Potential Effects and Key Indicator Resources	Direction	Magnitude[a]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Wildlife Abundance							
Canadian toad, barred owl	negative	negligible (0)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	negligible (0)
beaver, black bear, Canada lynx, fisher, moose	negative	negligible (0)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+1)
black-throated green warbler	negative	negligible (0)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+2)
Canada warbler, common nighthawk, peregrine falcon, red knot, western (boreal) toad, whooping crane	negative	negligible (0)	local to beyond regional (0 to +2)	medium-term (+1)	reversible (-3)	high (+2)	negligible (0 to +2)
short-eared owl	negative	negligible (0)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+2)
olive-sided flycatcher, wolverine	negative	low (+5)	regional to beyond regional (+1 to +2)	medium-term (+1)	reversible (-3)	high (+2)	low (+6 to +7)
horned grebe, rusty blackbird, yellow rail	negative	moderate (+10)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	moderate (+12)
Wildlife Habitat (Including Fragmentation)							
Canadian toad	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	low (+5)
beaver, black bear	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	low (+6)
barred owl	negative	moderate (+10)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	low (+10)
Canada lynx, fisher, moose	negative	moderate (+10)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	moderate (+11)
black-throated green warbler	negative	moderate (+10)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	moderate (+12)
common nighthawk, olive-sided flycatcher, short-eared owl	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	low (+7)
wolverine	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	low (+6)
western (boreal) toad	negative	moderate (+10)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	low (+10)
wood bison	negative	moderate (+10)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	moderate (+11)
woodland caribou	negative	moderate (+10)	regional (+1)	medium-term (+1)	reversible/ irreversible (0)	high (+2)	moderate (+14)
horned grebe	negative	moderate (+10)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	moderate (+12)
rusty blackbird, yellow rail	negative	moderate (+10)	beyond regional (+2)	medium-term (+1)	reversible/ irreversible (0)	high (+2)	moderate (+15)

Table 3.4-10 Residual Effects Classification for Effects to Wildlife in the Regional Study Area – 2012 Planned Development Case Before Closure (continued)

Potential Effects and Key Indicator Resources	Direction	Magnitude[a]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Canada warbler	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)
Wildlife Movement							
Canadian toad	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+5)
barred owl	negative	negligible (0)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+1)
beaver, black bear, Canada lynx, fisher, moose	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	low (+6)
black-throated green warbler	negative	negligible (0)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+2)
western toad	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+5)
Canada warbler, common nighthawk, horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	negative	negligible (0)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	negligible (+2)
wolverine	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	low (+6)

[a] Magnitude is defined through habitat suitability modelling (Appendix 3.7).

Note: Numerical scores for ranking of environmental consequence are explained in Volume 3, Section 1.3.6.

Wildlife Habitat

The effects of JME and PRM and planned developments on wildlife habitat were assessed in the EIA and the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel). The assessed environmental consequences of the 2012 PDC on wildlife habitat are similar to those previously assessed (May 2011, Submission of Information to the Joint Review Panel). However, the 2012 PDC results in changes to the environmental consequences for the effect on habitat for some wildlife species (Table 3.4-10). Specifically, the predicted decline in high suitability habitat due to the 2012 PDC include:

- a change from a negligible environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to low for western toad habitat;
- a change from a low environmental consequence in the EIA (Volume 5, Section 7.6.3) to moderate for black-throated green warbler habitat;
- a change from a low environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to moderate for wood bison, horned grebe, rusty blackbird and yellow rail habitat; and
- a change from a low environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to high for Canada warbler.

These changes in predicted environmental consequences are due to the simulation of forest fires and forest harvest outside of 2012 PDC development footprints, and the increased disturbance footprints of planned

developments in the 2012 PDC relative to the 2012 Base Case. The simulation of forest fires and forest harvest increased from 10% of the RSA (about 220,000 ha) in the EIA (Volume 5, Section 7.6.2) to 22% of the RSA (about 500,000 ha) in the 2012 PDC, reducing the amount of high suitability habitat in the 2012 Base Case, particularly for forest-dependent species such as the black-throated green warbler and Canada warbler. In addition, the 2012 PDC represents an increase in industrial disturbance of about 50,000 ha (2% of the RSA) relative to the EIA PDC.

The regional abundance of black-throated green warbler, Canada warbler and wood bison are unlikely to be affected by habitat changes due to JME and other planned developments in the RSA. Despite development within their range, populations of black-throated green warbler in Canada do not seem to have declined from 1970 to 2009, suggesting that they are not currently limited by habitat availability (Environment Canada 2010). Available data on Canada warbler populations suggest that although declines in abundance are apparent in eastern Canada, there appears to have been a statistically significant increase in the Alberta population from 1970 to 2009, despite habitat loss due to development (Environment Canada 2010). Wood bison in Alberta do not occur east of the Athabasca River, and will not be affected by habitat loss in the LSA.

Although it is probable that populations of horned grebe, rusty blackbird and yellow rail are also not limited by habitat within the RSA, sufficient uncertainty exists regarding the causes of their decline that there is the potential that the effects of habitat loss will affect the abundance of these species (May 2011, Submission of Information to the Joint Review Panel).

The environmental consequences of the 2012 PDC on potential wood bison habitat are unchanged from the Species at Risk Assessment (i.e., negative and moderate, May 2011, Submission of Information to the Joint Review Panel). The effects on potential woodland caribou habitat are assessed as having a negative moderate environmental consequence prior to reclamation (Table 3.4-10). However, both species are unlikely to be affected by JME as they are either absent (bison) or virtually absent (woodland caribou) from the JME LSA. A single Caribou track was found near the LSA as presented in Appendix V, Table V-7 of the *Wildlife and Wildlife Habitat Environmental Setting for Jackpine Mine Expansion & Pierre River Mine Project* (Golder 2007)

Some wildlife species are dependent upon wetlands, including peatlands. For example, rusty blackbird, yellow rail, and woodland caribou are all associated with peatlands. However, rusty blackbird (COSEWIC 2006) and yellow rail (COSEWIC 2009) are also associated with non-peatland wetlands types, and woodland caribou will utilize upland stands rich in lichen (COSEWIC 2002; Jones 2007). Therefore, the partial reversibility of the effects of habitat change for these species are classified as “reversible/irreversible”.

The predicted effects of the 2012 PDC represent a reasonable worst-case scenario, because habitat suitability modelling in the 2012 PDC assumes that disturbances from construction occur simultaneously and no reclamation will occur. The actual loss of habitat at any point in time will be less, due to the phased nature of developments and reclamation. Reclamation is not represented because the precise locations and size of some planned projects and the associated reclamation and revegetation plans are unknown. However, there is a regulatory requirement to reclaim habitats at completion. Therefore, predicted environmental consequences are likely more conservative than what may actually take place. There will be a reduction in environmental consequence as wildlife habitat redevelops and wildlife populations return to the reclaimed landscape from neighbouring source populations.

In addition, the estimated effects of the 2012 PDC on wildlife species at risk are largely due to the use of setback distances recommended by Environment Canada (2009) as disturbance zones of influence for estimating the effects of sensory disturbance on habitat suitability (May 2011, Submission of Information to the Joint Review Panel, Appendix 2, Part A, Appendix B). However, the effects of sensory disturbance on these species are relatively unknown (Environment Canada 2009). Therefore, sensory disturbance and habitat fragmentation effects of this 2012 PDC are likely conservative.

Wildlife Movement

The effects of JME and PRM, and planned developments on wildlife movement were assessed in the EIA and the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel). The effects of the EIA PDC on wildlife movement were not previously explicitly assessed for Canadian toad, barred owl, beaver, black-throated green warbler and western toad, but are assessed for the 2012 PDC. The effects on woodland caribou and bison movement are not assessed because both species are unlikely to be affected by JME, given that they are either absent (bison) or virtually absent (woodland caribou) from the JME LSA.

The assessed environmental consequences of the 2012 PDC on wildlife movement are low for beaver, black bear, Canada lynx, fisher, moose and wolverine, and negligible for all remaining wildlife KIRs and SAR (Table 3.4-10). The 2012 PDC results in a change in the environmental consequence for the effects on movement for fisher, which was previously assessed as moderate. The effects of the 2012 PDC on fisher movement are predicted to be low, because although habitat fragmentation and loss will affect movement in the RSA, fisher are highly mobile and landscape connectivity will be maintained.

3.4.3.2 Summary of Results

The effects of JME and PRM and planned developments on wildlife abundance, habitat and movement were previously assessed in the EIA and the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel).

For black bear and moose, a low magnitude reduction in the carrying capacity of the RSA was predicted using a Population Viability Analysis for both the EIA PDC and the 2012 PDC. However, as these species are likely to be currently below carrying capacity in the region, changes in carrying capacity are unlikely to relate directly to changes in abundance. The environmental consequences of the 2012 PDC on the abundance of black bear and moose are, therefore, predicted to be negligible, as in the EIA. The effects of JME and PRM and planned developments were assessed for the 2012 PDC to be negligible for Canadian toad, barred owl, beaver, Canada lynx, fisher and black-throated green warbler.

The assessed environmental consequences of the 2012 PDC on wildlife SAR are similar to those previously assessed (May 2011, Submission of Information to the Joint Review Panel). Impacts affecting the abundance of Eskimo curlew and northern leopard frog are not predicted because these species have not been recorded in the RSA. Impacts affecting the abundance of wood bison and woodland caribou are also not predicted, because wood bison in Alberta are not found east of the Athabasca River, and woodland caribou are virtually absent from the LSA. The available evidence suggests the regional abundances of Canada warbler, common nighthawk, peregrine falcon, red knot, western toad, whooping crane and wood bison are not limited by habitat in the RSA. It is probable that the abundances of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are also not limited by habitat within the RSA. However, for these species sufficient uncertainty exists that the potential effects of habitat loss on abundance were considered (May 2011,

Submission of Information to the Joint Review Panel). To be conservative, the magnitude of effects on regional populations of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail were estimated as equivalent to the magnitude of the habitat loss effects within the RSA for the 2012 PDC. As a result, the environmental consequences of the 2012 PDC on the abundance of horned grebe, rusty blackbird and yellow rail increase from low (May 2011, Submission of Information to the Joint Review Panel) to moderate.

The assessed environmental consequences of the 2012 PDC on wildlife habitat are similar to those previously assessed (May 2011, Submission of Information to the Joint Review Panel). However, the 2012 PDC results in changes in the environmental consequences for the effects on habitat for some wildlife species (Table 3.4-10). Specifically, the predicted decline in high suitability habitat due to the 2012 PDC include:

- a change from a negligible environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to low for western toad habitat;
- a change from a low environmental consequence in the EIA to moderate for black-throated green warbler habitat;
- a change from a low environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to moderate for wood bison, horned grebe, rusty blackbird and yellow rail habitat; and
- a change from a low environmental consequence in the Species at Risk Assessment (May 2011, Submission of Information to the Joint Review Panel) to high for Canada warbler habitat.

These changes in environmental consequences are due to the simulation of forest fires and forest harvest outside of 2012 PDC development footprints, and the increased disturbance footprints of planned developments in the 2012 PDC relative to the 2012 Base Case. The simulation of forest fires and forest harvest increased from 10% of the RSA (about 220,000 ha) in the EIA (Volume 5, Section 7.6.2) to 22% of the RSA (about 500,000 ha) in the 2012 PDC, greatly reducing the amount of high suitability habitat at the 2012 Base Case, particularly for forest-dependent species such as the black-throated green warbler and Canada warbler, In addition, the 2012 PDC represents an increase in industrial disturbance of about 50,000 ha (2% of the RSA) relative to the EIA PDC.

Although wood bison are not found east of the Athabasca River, and woodland caribou are virtually absent from the LSA, effects on habitat of these species are assessed at the request of the JRP (SIR 19a, SIR 21b) because these species occurred in the LSA in the past. The environmental consequences of the 2012 PDC on potential wood bison habitat are unchanged from the Species at Risk Assessment (i.e., negative and moderate, May 2011, Submission of Information to the Joint Review Panel). The effects on potential woodland caribou habitat are assessed as having a negative moderate environmental consequence prior to reclamation.

The predicted effects of the 2012 PDC represent a reasonable worst-case scenario, because habitat suitability modelling in the 2012 PDC assume that disturbances from construction occur simultaneously and no reclamation will occur. The actual loss of habitat at any point in time will be less, due to the phased nature of developments and reclamation. Reclamation is not represented because the precise locations and size of some planned projects and the associated reclamation and revegetation plans are unknown. However, there is a regulatory requirement to reclaim habitats at completion. Thus, predicted environmental consequences are,

therefore, likely more conservative than what may actually take place. There will be a reduction in environmental consequence as wildlife habitat redevelops and wildlife populations return into the reclaimed landscape from neighbouring source populations.

In addition, the estimated effects of the 2012 PDC on wildlife species at risk are largely due to the use of setback distances recommended by Environment Canada (2009) as disturbance zones of influence for estimating the effects of sensory disturbance on habitat suitability (May 2011, Submission of Information to the Joint Review Panel, Appendix 2, Part A, Appendix B). However, the effects of sensory disturbance on these species are relatively unknown (Environment Canada 2009). Therefore, sensory disturbance and habitat fragmentation effects of this 2012 PDC are likely conservative.

The assessed environmental consequences of the 2012 PDC on wildlife movement are low for beaver, black bear, Canada lynx, fisher, moose and wolverine, and negligible for all remaining wildlife KIRs and SAR. The 2012 PDC results in a change in the environmental consequence for the effects on movement for fisher, which was previously assessed as moderate. The effects of the 2012 PDC on fisher movement are predicted to be low, because although habitat fragmentation and loss will affect movement in the RSA, fisher are highly mobile and landscape connectivity will be maintained. The effects on woodland caribou and bison movement are not assessed because both species are unlikely to be affected by JME, given that they are either absent (bison) or virtually absent (woodland caribou) from the JME LSA.

3.4.4 Biodiversity Assessment

Biodiversity has been assessed for the 2012 PDC using the same assessment methods described in EIA Volume 5, Section 7.6.4 of the EIA, where appropriate. One notable change is the use of A Landscape Cumulative Effects Simulator (ALCES) model to predict burns and cutblocks in the year 2070. Refer to Appendix 3.1 for details on the modelling of burns and cutblocks.

The 2012 PDC assessment is completed for those components that had a low, moderate or high negative environmental consequence in the 2012 JME Application Case assessment (Appendix 1). Greater than negligible negative environmental consequences were predicted for all levels of biodiversity in the 2012 JME Application Case.

3.4.4.1 Assessment Results

Species-Level Biodiversity Impact Analysis

Results at the species level of biodiversity for the 2012 PDC are summarized for fish, plants and wildlife as follows:

- Residual effects were predicted to have no environmental consequence on fish habitat and fish abundance (EIA Volume 4A, Tables 6.7-17 and 6.7-22) and fish and fish habitat diversity (EIA Volume 4A, Table 6.7-18); therefore, no fish KIRs were analyzed in the EIA PDC.
- High rare plant potential is predicted to experience a negative residual effect with low environmental consequence before reclamation in the 2012 PDC (Table 3.4-7). After reclamation, the environmental consequence becomes negligible and is positive in direction (Table 3.4-8).
- Before reclamation, the predicted residual effects on abundance, habitat and movement in the 2012 PDC are negative in direction for all wildlife KIRs, with environmental consequences evenly split between

negligible and low or moderate (Table 3.4-10). Only one KIR, Canada warbler habitat, is predicted to experience a high environmental consequence as a result of the 2012 PDC before reclamation. The wildlife assessment does not consider reclamation in the 2012 PDC because the precise locations and size of some planned projects and the associated reclamation and revegetation plans are unknown.

Ecosystem-Level Biodiversity Impact Analysis

Effects of the 2012 PDC on RLCCs in the RSA are presented according to biodiversity potential in Table 3.4-11 and are summarized according to rank below:

- Before reclamation, high biodiversity potential areas will decrease by 51,859 ha (2% of the RSA). Non-treed wetlands and treed fen RLCCs will each decrease by 1%. After reclamation, there will be an overall net increase in high biodiversity potential areas of 9,843 ha (less than 1% of the RSA), which is mainly a consequence of an increased abundance of non-treed wetlands, specifically shrubland and littoral zone reclamation types. The treed fen RLCC will experience a negative net change due to the 2012 PDC because peatland wetlands currently cannot be reclaimed in areas where the soil has been disturbed (e.g., open-pit mines).
- Moderate biodiversity potential areas will decrease by 54,312 ha (2% of the RSA) before reclamation. Each RLCC is affected by 1% or less of the RSA compared to 2012 Base Case conditions. After reclamation, there will be an overall net increase in moderate biodiversity potential areas of 92,092 (4% of the RSA). Treed bog/poor fen is the only moderate-ranked RLCC that will experience a net decrease after reclamation relative to 2012 Base Case in the 2012 PDC. As previously stated, peatlands currently cannot be reclaimed where soil has been disturbed.
- Before reclamation, low biodiversity potential areas will decrease by 46,239 ha (2% of the RSA). Each RLCC is affected by 1% or less of the RSA compared to 2012 Base Case conditions. The majority of the effect on low biodiversity potential RLCCs is experienced by deciduous aspen-balsam poplar, followed by disturbances and burns. There will be a net decrease of 101,935 ha (4% of the RSA) in low-ranked areas after reclamation. Disturbances comprise the majority of this loss because project infrastructure, as well as much of the existing disturbances, will be reclaimed to natural land cover classes.

Landscape-Level Biodiversity Impact Analysis

Results at the landscape level of biodiversity for the 2012 PDC are summarized as follows:

- Wetlands (including peatlands) are predicted to experience a negative residual effect with moderate environmental consequence before reclamation in the 2012 PDC (Table 3.4-5). After reclamation, the negative residual effect remains a moderate environmental consequence for this KIR (Table 3.4-9).

Before reclamation, old growth forests are predicted to experience a negative residual effect with low environmental consequence (Table 3.4-6). After reclamation, the negative residual effect remains a low environmental consequence for this KIR (Table 3.4-9).

Table 3.4-11 Change in Biodiversity Potential in the Regional Study Area – 2012 Planned Development Case

Regional Land Cover Class	2012 Base Case [ha]	Loss/Alteration due to 2012 PDC			Loss/Alteration due to JME and Jackpine Mine Phase-1 [a]			Project Contribution to 2012 PDC [%][b]	2012 PDC Closure [ha]	Net Change due to Planned Developments[c]		
		[ha]	% Resource[b]	% RSA	[ha]	% Resource[b]	% RSA			[ha]	% Resource[b]	% RSA
High Biodiversity Potential												
non-treed wetlands	245,047	-23,239	-9	-1	-7,906	-3	-<1	34	279,441	34,394	14	2
treed fen	233,346	-28,620	-12	-1	-5,190	-2	-<1	18	209,007	-24,340	-10	-1
subtotal	*478,393*	*-51,859*	*-11*	*-2*	*-13,095*	*-3*	-<1	*25*	*488,448*	*10,055*	*2*	*<1*
Moderate Biodiversity Potential												
coniferous white spruce	53,351	-6,043	-11	-<1	-966	-2	-<1	16	90,385	37,033	69	2
mixedwood aspen−jack pine	39,462	-2,201	-6	-<1	-291	-<1	-<1	13	59,510	20,048	51	*<1*
mixedwood aspen−white spruce	147,918	-18,648	-13	-<1	-2,782	-2	-<1	15	186,820	38,902	26	2
treed bog/poor fen	427,623	-24,759	-6	-1	-4,181	-<1	-<1	17	403,524	-24,099	-6	-1
water	54,244	-2,661	-5	-<1	-1,425	-3	-<1	54	73,854	19,610	36	*<1*
subtotal	*722,598*	*-54,312*	*-8*	*-2*	*-9,645*	*-1*	*-<1*	*18*	*814,094*	*91,496*	*13*	*4*
Low Biodiversity Potential												
burn	395,857	-7,892	-2	-<1	-106	-<1	-<1	1	388,070	-7,787	-2	-<1
coniferous jack pine	167,268	-4,715	-3	-<1	-785	-<1	-<1	17	179,186	11,918	7	*<1*
coniferous jack pine−black spruce	40,429	-1,524	-4	-<1	-146	-<1	-<1	10	64,100	23,670	59	1
deciduous aspen−balsam poplar	182,315	-23,006	-13	-1	-1,711	-<1	-<1	7	232,463	50,148	28	2
cutblock	100,391	-771	-<1	-<1	0	0	0	0	99,620	-771	-<1	-<1
disturbance	190,124	-8,331	-4	-<1	-474	-<1	-<1	6	11,396	-178,729	-94	-8
subtotal	*1,076,385*	*-46,239*	*-4*	*-2*	*-3,222*	*-<1*	*-<1*	*7*	*974,834*	*-101,550*	*-9*	*-4*
Total	**2,277,376**	**-152,410**	**-7**	**-7**	**-25,963**	**-1**	**-1**	**17**	**2,277,376**	**n/a**	**n/a**	**n/a**

(a) Loss/alteration is calculated as the difference between the 2012 Base Case and 2012 JME Application Case, a value upon which the environmental consequence before reclamation is assessed.

(b) Column is calculated as a percentage of 2012 Base Case area; the areas are not additive.

(c) Net change is calculated as the difference between the 2012 Base Case and closure, a value upon which the environmental consequence after reclamation is assessed.

n/a = Not applicable.

Note: Calculations are performed on non-rounded values and some values are then rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Residual Impact Classification

Before reclamation, the scores of the individual impact description criteria (discussed below) result in an overall low environmental consequence at all levels of biodiversity in the 2012 PDC (Table 3.4-12).

The residual effects of the 2012 PDC on plant and wildlife KIRs are negative. The overall magnitude of the residual effect at the species-level of biodiversity is considered low because the residual effects on KIRs range from negligible to moderate. Most residual effects range from regional to beyond regional (wildlife KIRs only). With the exception of the residual effects on high rare plant potential and Canada warbler habitat, which are long-term in duration, all effects are considered to be medium-term. The residual effects on most species-level KIRs are considered reversible. All residual effects on plant and wildlife KIRs occur with high frequency.

The overall magnitude of the residual effect of the 2012 PDC on the ecosystem level of biodiversity is considered low because the changes in high, moderate and low biodiversity potential areas are all less than 10% (Table 3.4-11). The residual effect is considered to be regional, because the scale of assessment is the RSA. Although the peatlands (i.e., fens) that make up approximately half of the high biodiversity potential category in the RSA cannot be reclaimed with current technologies if the soil has been disturbed, the RLCC that comprises the remainder of the high biodiversity potential category (non-treed wetlands) can be reclaimed. For this reason, the overall residual effect was scored as reversible/irreversible. The residual effect is also considered to be long-term in duration and low in frequency. The effect occurs with low frequency because continual losses to ecosystem-level biodiversity potential will be balanced by continual gains due to reclamation of disturbances.

At the landscape level, the residual effect of the 2012 PDC on both wetlands (including peatlands) and old growth forests is considered low, regional, long-term and high in frequency. Due to the uncertainty surrounding peatlands reclamation, the residual effect is considered irreversible for the wetlands. Old growth forests will continue to develop beyond Closure; therefore, the residual effect is considered reversible/irreversible due to the extended time frame.

Table 3.4-12 Residual Effects on Biodiversity in the Regional Study Areas — 2012 Planned Development Case

Biodiversity Criteria	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Before Reclamation							
species-level effects	negative	low (+5)	regional to beyond regional (+1 to +2)	medium-term (+1)	reversible (-3)	high (+2)	low (+6 to +7)
ecosystem-level effects	negative	low (+5)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	low (0)	low (+8)
landscape-level effects	negative	low (+5)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	high (+2)	low (+10)
After Reclamation							
species-level effects	positive	low (+5)	regional (+1)	long-term (+2)	n/a	high (+2)	low (+10)
ecosystem-level effects	negative	low (+5)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	low (0)	low (+8)
landscape-level effects	negative	negligible or low (0 to +5)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	high (+2)	negligible to low (+5 to +10)

n/a = Not applicable.

Note: Numerical scores for ranking of environmental consequence are explained in EIA, Volume 3, Section 1.3.6.

After reclamation, there is an overall low environmental consequence at all levels of biodiversity in the 2012 PDC (Table 3.4-12) unchanged from the EIA PDC assessment (EIA, Table 7.6-11, Section 7.6, Volume 5).

The residual effect of the 2012 PDC on high rare plant potential is positive. After reclamation, high rare plant potential is predicted to increase by less than 1% of the RSA; therefore, the residual effect is negligible. The 2012 PDC assessment is conducted at the RSA scale; therefore, the geographic extent is regional. The duration of the residual effect is long-term and the reversibility is considered "not applicable" because the environmental consequence is positive. Because clearing of vegetation will occur into the future, the frequency is considered to be high.

The overall magnitude of the residual effect of the 2012 PDC on the ecosystem level of biodiversity is considered low because the changes in high, moderate and low biodiversity potential areas are all less than 10% (Table 3.4-11). The residual effect is also considered to be regional, long-term, reversible/irreversible, and low in frequency.

At the landscape level, the residual effects of the 2012 PDC on wetlands (including peatlands) and old growth forests are considered low. Residual effects on these KIRs are also considered to be regional, long-term, high in frequency, and irreversible or reversible/irreversible.

3.4.4.2 Summary of Results

Greater than negligible negative environmental consequences are predicted in the 2012 JME Application Case for all levels of biodiversity (Appendix 1). In the 2012 PDC, both the before-reclamation and after-reclamation assessments result in an overall low environmental consequence on all levels of biodiversity. This result is the same as previously determined in the EIA PDC (EIA, Volume 5, Section 7.6, Table 7.6-11).

3.5 Human Environment

This section provides the results of the 2012 PDC assessments for Human Environment to inform the cumulative effects on traditional knowledge and land use, resource use and socio-economics. Historical resources and visual aesthetics were not assessed in the EIA PDC. The 2012 PDC includes a review of the cumulative effects that could result from the existing and approved developments, JME and PRM, and the planned (publicly disclosed) developments in the Oil Sands Region, as of September 2011.

The approaches used for these assessments are the same as those used in the EIA with the following exceptions:

- The ALCES® model was used to simulate forest fire and harvest disturbance information. These areas are assumed to be unusable disturbances for traditional uses. Landscape simulations were conducted using the ALCES and ALCES Mapper® computer programs. The ALCES® program was used to simulate the effects of fire, timber harvest, and industrial development in the RSA over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the Pre-Industrial Case, 2012 Base Case, 2012 JME Application Case and 2012 PDC in this submission.
- The Traditional Knowledge and Land Use assessment assessed updated traditional territories for Fort McKay First Nations based on feedback received during consultation.

- The Socio-Economic Assessment for the 2012 PDC is informed by the following:
  - Shell's ongoing consultation in the region;
  - analysis of recent Socio-Economic Impact Assessments (SEIAs) for other oil sands projects;
  - responses by the Alberta Energy Resources Conservation Board (ERCB), other stakeholders, and interveners to recent oil sands SEIAs in the course of the regulatory review process; and
  - socio-economic studies and reports prepared by government, industry or regional service providers since the filing of the EIA

3.5.1 Traditional Knowledge and Land Use Assessment

The 2012 PDC assessment was completed to evaluate the potential for effects on TLU as a result of JME in combination with existing and planned developments within the Oil Sands Region. The 2012 PDC assessment compares the amount of PDC disturbance within the Terrestrial RSA to the total area of First Nations' traditional territories, and the FMFN CSEs. The approach taken in this assessment is generally the same as the approach taken in the EIA except this assessment uses the Traditional Territory of the FMFN that is identified in the Fort McKay IRC (2010). The disturbance calculations for the 2012 update are based on the disturbances within the Terrestrial Resources assessment.

3.5.1.1 Assessment Results

Quantitative Analysis

Local Registered Fur Management Areas

The amount of land that is or will be unavailable for use by RFMA holders due to developments in the 2012 Base Case, 2012 JME Application Case and 2012 PDC cases is shown in Table 3.5-1. No change is expected from planned development in RFMAs 1714, 1716, 2137 or 2172.

Under the 2012 PDC, there will be no additional disturbance to the directly affected RFMAs (Table 3.5-1).

Table 3.5-1 Disturbance Areas Within Local Registered Fur Management Areas for All Cases

RFMA	Area of RFMA [ha]	2012 Base Case Total Disturbance Area		2012 JME Application Case Total Disturbance Area		2012 Planned Development Case Total Disturbance Area	
		[ha]	% of RFMA[(a)]	[ha]	% of RFMA[(a)]	[ha]	% of RFMA[(a)]
#1714	38,573	17,257	45	25,636	67	25,636	67
#1716	23,657	10,324	44	13,527	57	13,527	57
#2137	27,097	12,822	47	14,369	53	14,369	53
#2172	37,071	16,179	44	23,318	63	23,318	63

(a) The percentage indicated is the contribution of the area of disturbance to the total area of the RFMA and has been rounded to the nearest whole percent.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Regional Study Areas

The amount of land within the FMFN CSE for All Traditional Uses that is or will be unavailable for TLU for the 2012 PDC is shown in Table 3.5-2. Under the 2012 PDC, disturbances to the All Traditional Uses CSE generally occur throughout the CSE, but are more focused on the intense and moderate use areas.

Table 3.5-2 Disturbance Within the Terrestrial Regional Study Area Portion of the Fort McKay First Nation Culturally Significant Ecosystems for All Cases – All Traditional Uses

CSE	Total Area of CSE [ha]	2012 Base Case Total Disturbance Area		2012 JME Application Case Total Disturbance Area		2012 Planned Development Case Total Disturbance Area	
		[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]
low use	2,142,679	311,203	15	311,203	15	356,536	17
moderate use	861,563	248,841	29	269,169	31	315,191	37
intense use	309,215	94,401	31	94,401	31	110,567	36
Total	**3,313457**	**654,445**	**20**	**674,773**	**20**	**782,294**	**24**

(a) The percentage indicated is the contribution of the area of disturbance to the total area of the CSE and is rounded to the nearest whole percent.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The amount of land within the FMFN CSE for large game harvesting that is or will be unavailable for TLU for the 2012 PDC is shown in Table 3.5-3. Under the 2012 PDC, the disturbances are focused within the intense use area, but also occur throughout the CSE.

Table 3.5-3 Disturbance Within the Terrestrial Regional Study Area Portion of the Fort McKay First Nation Culturally Significant Ecosystems for All Cases – Large Game Harvesting

CSE	Total Area of CSE [ha]	2012 Base Case Total Disturbance Area		2012 JME Application Case Total Disturbance Area		2012 Planned Development Case Total Disturbance Area	
		[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]
low use	1,347,998	46,019	3	46,019	3	53,300	4
moderate use	1,723,226	325,961	19	325,961	19	358,067	21
intense use	1,018,146	302,988	30	323,316	32	393,962	39
Total	**4,089,370**	**674,968**	**17**	**695,296**	**17**	**805,329**	**20**

(a) The percentage indicated is the contribution of the area of disturbance to the total area of the CSE and is rounded to the nearest whole percent.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

The amount of land within the FMFN CSE for traditional plant harvesting that is or will be unavailable for TLU for the 2012 PDC is shown in Table 3.5-4. Table 3.5-5 shows the disturbances within the traditional territories of the Athabasca Chipewyan First Nation, Fort McKay First Nation and Mikisew Cree First Nation. The 2012 PDC disturbances within the Traditional Plant Harvesting CSE are focused on the intense and moderate use areas.

Table 3.5-4 Disturbances Within the Terrestrial Regional Study Area Portion of the Fort McKay First Nation Culturally Significant Ecosystems for All Cases – Traditional Plant Harvesting

CSE	Total Area of CSE [ha]	2012 Base Case Total Disturbance Area		2012 JME Application Case Total Disturbance Area		2012 Planned Development Case Total Disturbance Area	
		[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]	[ha]	% of CSE[(a)]
low use	1,396,491	322,516	23	330,620	24	391,989	28
moderate use	396,759	123,063	31	135,286	34	168,537	42
intense use	74,917	35,268	47	35,268	47	41,498	55
Total	**1,868,167**	**480,846**	**26**	**501,174**	**27**	**602,024**	**32**

(a) The percentage indicated is the contribution of the area of disturbance to the total area of the CSE and is rounded to the nearest whole percent.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Table 3.5-5 Disturbances Within the Terrestrial Regional Study Area Portion of the Athabasca Chipewyan First Nation, Fort McKay First Nation and Mikisew Cree First Nation Traditional Territories for All Cases

Traditional Territory	Total Area of Traditional Territory	Area of Traditional Territory Within Terrestrial RSA	2012 Base Case Total Disturbance Area Within Terrestrial RSA Portion of Traditional Territory (TT)		2012 JME Application Case Total Disturbance Area Within Terrestrial RSA Portion of Traditional Territory (TT)		2012 Planned Development Case Total Disturbance Area Within Terrestrial RSA Portion of Traditional Territory (TT)	
Units	**[ha]**	**[ha]**	**[ha]**	**% of TT[(a)]**	**[ha]**	**% of TT[(a)]**	**[ha]**	**% of TT[(a)]**
Athabasca Chipewyan First Nation	4,383,440	1,401,026	474,280	11	494,608	11	568,418	13
Fort McKay First Nation	3,525,101	2,130,001	650,454	18	670,782	19	779,778	22
Mikisew Cree First Nation	8,641,549	1,673,308	523,501	6	543,829	6	646,250	7

(a) The percentage indicated is the contribution of the area of disturbance to the total area of the Traditional Territory and is rounded to the nearest whole percent.

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

Qualitative Assessment

Effects on traditional resources used for harvesting also have the potential to affect traditional land use. As a result, the potential effects of the 2012 PDC on wildlife, fish, and vegetation may also affect the ability to undertake traditional harvesting activities. The potential effects of JME on wildlife under the 2012 PDC are assessed in Section 3.4.3. The potential effects of the 2012 PDC on fish are assessed in Section 3.3.5, and the potential effects of the 2012 PDC on vegetation under the 2012 PDC are found in Section 3.4.2.

3.5.1.2 Summary of Results

Under the 2012 PDC, disturbances will represent between 53% and 67% of the total area for each of the directly affected RFMAs. Disturbances to the FMFN CSEs under the 2012 PDC will represent 24% of the area of the All Traditional Uses CSE, 20% of the area of the Large Game Harvesting CSE, and 32% of the area of the Traditional Plant Harvesting CSE. Disturbances under the 2012 PDC are calculated to represent 13% of the area of the total area of the ACFN RSA, 22% of the total area of the FMFN RSA, and 7% of the total area of the MCFN RSA.

3.5.2 Resource Use Assessment

The assessment considers the capability for use of resources and the extent of use by non-traditional resource users. Site clearing for the Project will reduce the availability of and access to certain resources, while changes to the local road system may increase or decrease access to resources in various areas. The assessment also considers the increase in the local area workforce and how it may affect resource use. The Planned Development Case predicts the effects of the Project in combination with other developments on resource use by non-traditional users in the RSA.

All residual impacts of JME identified as having low, moderate or high environmental consequences may contribute to additive effects with future projects in the region. Where consequences are considered negligible, effects are not assessed for the 2012 PDC. Under the 2012 JME Application Case the consequences that were considered above negligible were effects on forestry, aggregate resources, and the effects of an increased regional population on public resource use. The effects are either local or regional in extent and long-term. The effects on forestry and public resource use are reversible and the effect on aggregate resources is not reversible as the resource is non-renewable.

Effects on forestry under the 2012 PDC assessment will be minimal based on the understanding that compensation will be provided to FMA holders. The majority of the impacts will be short-term effects to Northland Forest Products, which is more vulnerable to loss of lands from annual allowable cut calculations. The magnitude of the impact will be low, the geographic extent will be regional, the duration is long-term, the frequency is moderate and the impacts are reversible with reclamation. The overall environmental consequence is low.

Effects on aggregate resources under the 2012 PDC assessment are difficult to measure, as few projects have described their aggregate requirements. In 2005, the overall status of aggregate in the RMWB increased with the opening of the 255 ha Muskeg Valley Quarry north of Fort McMurray. In June 2010, this quarry was granted approval to expand to 1,265 ha as part of the Hammerstone Project (NRCB 2010). These quarries contribute to the overall aggregate sourcing in the RMWB, thereby extending the lifespan of aggregate resources in the RMWB by several decades. Making the assumption that future discoveries of aggregate resources, or the use

of alternatives such as crushed limestone, will occur in a market-driven fashion to replace a large proportion of that used, the magnitude of long-term cumulative aggregate extraction impacts is expected to be low and beyond regional. These impacts will be irreversible. The environmental consequence is low.

Planned projects, including JME and PRM, will result in a higher RSA population. The socio-economic assessment in the originally filed EIA offers the regulatory board a more conservative forecast of population and subsequent community effects in the near term (2012 to 2015) and medium term (2016 to 2018). Over the longer term (beyond 2019), the 2012 PDC projections are higher than provided in the EIA socio-economic assessment because the most recent 2012 PDC projections are based on a high production curve and the assumptions built into the RMWB population model. The population increase is expected to result in an increased use of environmentally significant areas (ESAs) and public use resources including hunting, berry picking, fishing and recreation. The impact is moderate in magnitude, regional in geographic extent, long-term in duration and high in frequency due to the high frequency of the population's engagement in resource use activities. The impact is reversible. The environmental consequence is moderate.

A moderate rating is not considered to be predictive of negative effects to ESAs in the region for a number of reasons. First, an increase in population does not directly result in an equal increase in visits to ESAs. Second, public visits to ESAs will not necessarily be destructive to them, and people tend to use other designated areas for recreation such as municipal or provincial parks. Other activities such as hunting and fishing will take place in accessible areas on public land that may or may not be considered ESAs. An increase in the population is more likely to result in changes to resources, or the outdoor recreation experience due to increased competition. The types of recreational activities (e.g., backcountry recreation) likely to be displaced by 2012 PDC developments throughout the RSA are relatively flexible as to location. Activities such as ATV use, snowmobiling, camping and backcountry hiking can occur in other locations, without an impact on the overall regional capacity for such recreation. Over time, increases in recreational facilities or recreational use areas in the RMWB will maintain or increase regional capacity.

3.5.3 Socio Economic Assessment

3.5.3.1 Introduction

This section presents the population and community effects on the Study Area under 2012 PDC assumptions. Study area selection is discussed in the EIA, Volume 5, Section 8.7.1. Determination of the project inclusion list for the 2012 PDC assessment scenario is discussed in Appendix 3.1.

3.5.3.2 Approach

Population Effects

The EIA as amended provided population estimates under PDC assumptions by using the Oil Sands Developers Group (OSDG) Urban Population Impact Model.

The PDC population projections presented below use the population model developed by the RMWB in 2010 (RMWB 2011). The RMWB model has been used to develop population estimates for the 2011 RMWB Municipal Development Plan and the 2011 Athabasca Oil Sands Area Comprehensive Regional Infrastructure Sustainability Plan (AOSA CRISP). Differences between the two models notwithstanding, both indicate substantial population growth in the near to medium term. Some aspects of the RMWB population model include the following:

- It forecasts employment growth in oil sands and related industries, based on specified bitumen production forecasts and a listing of anticipated oil sands projects that captures construction and operating employment.
- It assumes net migration into the region to be equal to the number of new jobs created minus the natural growth of the resident labour force.
- It delineates population projections by permanent, non-permanent and project accommodations (rural) to account for the particularity of the population in the region.
- It uses the standard component method (i.e., accounting for births, deaths and migration) to project and age the permanent population.

The RMWB model forecasts population for urban and rural residents and for non-residents who reside primarily in project accommodation (i.e., work camps or lodges).

Population projections are open to considerable uncertainty and, therefore, should be treated as estimates only and not as certain outcomes. Variables that could alter regional population growth include:

- changes in the timing and size of individual oil sands projects considered in the assessment;
- additional projects being brought forward that are currently not included in the assessment;
- future technological advances in oil sands construction and operation that affect a project's employment-related needs and, therefore, its population effect;
- emergence of a new northern community in the region;
- the speed with which residential and infrastructure development occurs in the region;
- possible environmental thresholds that might serve to limit future oil sands development; and
- the impact of planning initiatives, such as the AOSA CRISP or Lower Athabasca Regional Plan (LARP), on future development (Government of Alberta 2011a,b).

Community Effects

Population growth is the primary driver of community effects in the region. As such, Section 3.5.5.3, along with Attachment A, discusses the effect of the PDC population estimates on the community as compared to the effects estimated in the EIA.

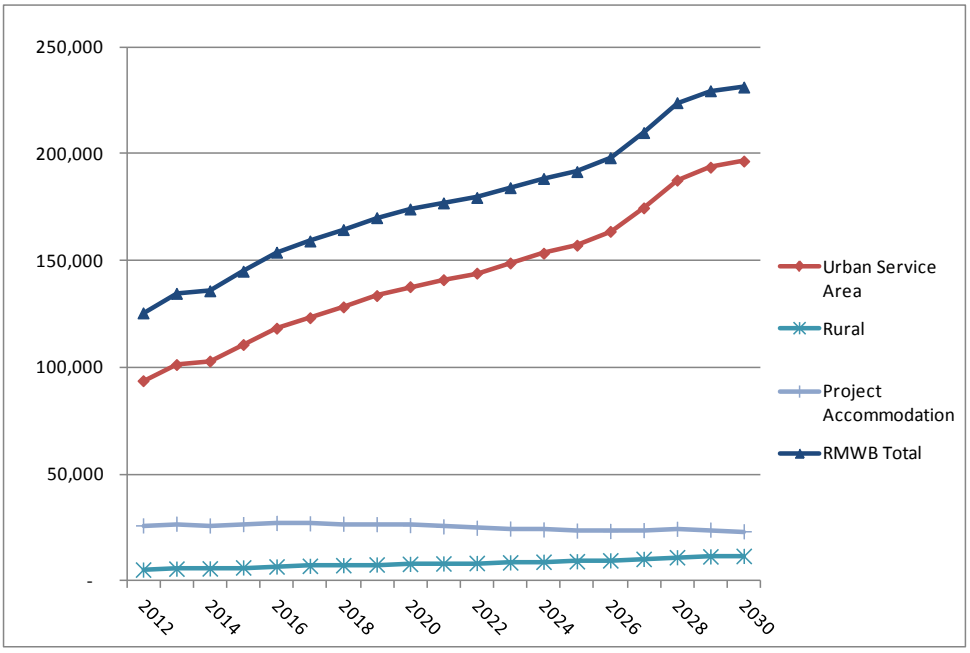
3.5.3.3 Population Effects

Planned Development Case Population Projections

The long-range regional population growth trend is expected to be over 3% per year, reaching over 230,000 by 2030, based on projections from the RMWB Population and Employment Projection Model. This projection includes both permanent and non-permanent residents.

A breakdown of the region's projected population by year for the urban service area, rural communities, and project accommodation is provided in Figure 3.5-1.

Figure 3.5-1 Projected Regional Population (2012 to 2030)



Source: RMWB Population and Employment Projection Model, (RMWB 2011).

The RMWB Population and Employment Projection Model results (RMWB 2011) project the following:

- annual regional population growth to be highest in the near-term (4.9% between 2012 to 2015);
- growth in the urban service area and rural communities, as the population in both areas more than doubles by 2030; and
- population growth in project accommodations to remain fairly static over the forecast period.

These population projections represent a very conservative forecast based on:

- a high production curve of 6.9 million barrels per day (bpd) by 2030; and
- a high number of oil sands operations workers choosing to relocate with their families to Fort McMurray, as opposed to remaining in their home communities and staying in project accommodations in the region when working on-site.

Population Projection Comparisons

To provide up-to-date information, population projections for the urban service area have been updated since the EIA was filed, specifically:

- In the May 2008 EIA Update, Base Case and PDC, population projections were updated to reflect new municipal census information, new project information, and new information on worker needs and shortages.
- In the May 2009 Pierre River Mine, Project Update, Base Case and PDC population projections were updated to reflect more recent experiences at the time with labour productivity for several oil sands projects in the region.
- In the May 2009 Pierre River Mine, Project Update and December 2009 Jackpine Mine Expansion Project Update, the respective Application Case population projections were updated to reflect updated construction labour force estimates from Shell, based on recent experiences with inflationary pressures and decreased labour productivity by oil sands developers.

The 2012 PDC population for the urban service area was compared to the most recent 2012 Base Case and 2012 JME Application Case Projections. The comparison shows the following:

- The additional PDC population over and above the Base Case forecast is 35% in 2017 and 56% in 2022.
- The JME project accounts for 16% of the PDC population effect at peak project construction and approximately 7.5% after full operations.

A limitation of these comparisons is that the OSDG Urban Population Impact Model was used for the Base Case and JME Application Case projections, while the RMWB Population and Employment Projection Model was used for the most recent PDC projections.

While population projections are open to considerable uncertainty (using either model, a common theme among projections is that sizeable growth is forecasted for the region.

3.5.3.4 Community Effects

Community effects will largely follow population effects. As such, community effects under PDC assumptions, in comparison to community effects provided in the EIA, will be:

- lower in the near term (2012 to 2015);
- medium in the medium term (2016 to 2018); and
- higher in the longer-term (2019 to 2021).

Given that community effects are expected to be either lower or comparable in the near and medium term, the socio-economic assessment in the EIA offers the regulatory board a more conservative forecast during this timeframe than under PDC assumptions. With respect to the longer-term forecast (2019 and beyond), infrastructure and service providers have additional time to plan and act in addressing this growth, and are in a much better position to deal with increased growth than outlined in the filed SEIA, largely as a result of:

- **Additional funding that has been provided:** Resourcing challenges faced by regional service providers has been well documented over the years through government and industry-sponsored reports, including the, Wood Buffalo Business Case 2005 Update (RIWG 2005), Sustainable Community Indicators Report (Nichols 2006) and the Radke Report (Radke 2006). In response, government funding has increased significantly in recent years to address growth pressures in the region. For example, since 2007 the Government of Alberta has committed $2.25 billion to infrastructure and services in the Wood Buffalo region, and the RMWB has also invested in major infrastructure developments, including RCMP detachment buildings and regional fire halls.
- **New agencies and structures that have been put in place, and new planning initiatives that have carried out:** In response to the challenges posed by growth in the region, a number of short- and long-term planning initiatives have been carried out by both the provincial and municipal governments. Specifically, in 2007 the provincial government established the Oil Sands Sustainable Development Secretariat to coordinate and improve planning, communications and service delivery to Alberta's oil sands regions, including the Wood Buffalo region. Among the Secretariat's initiatives are *Responsible Actions: A Plan for Alberta's Oil Sands* (Government of Alberta 2009) and the AOSA CRISP process (Government of Alberta 2011a). The municipality has also been carrying out planning initiatives to accommodate future demands for infrastructure and services, including the 2011 Municipal Development Plan.
- **Service providers being afforded additional time to plan and act:** The global financial crisis of 2008/2009 led to a period of relatively moderate growth in the region, giving service providers additional time to plan and act. As of mid-2011, service delivery outcomes have improved in several social infrastructure areas, including health and emergency services (e.g., reduced emergency department wait times, targeted emergency response times being met).

Although infrastructure and service providers in the region are now in a better position to address growth than in 2007, they continue to face several issues, including:

- the demands of non-permanent residents, which have grown considerably over the past decade;
- social stressors in the region, including social isolation, reduced community cohesion, increased homelessness, crime and traffic;
- difficulty in attracting and retaining appropriately skilled workers as a result of relatively high housing costs and the region's remote location; and
- the need for stable, predictable funding that also recognizes the particular challenges of service delivery in the region (e.g., rural, remote location).

An overview of current socio-economic issues, along with responses from both government and industry to these issues, can be found in Attachment A.

3.5.3.5 Summary

The socio-economic assessment in the EIA offers the regulatory board a more conservative forecast of population and subsequent community effects in the near term (2012 to 2015) and medium term (2016 to 2018). Over the longer term (beyond 2019), PDC projections presented here are higher than provided in the 2007 SEIA. The most recent PDC projections are based on a high production curve and the assumption built into the RMWB population model that a large number of oil sands operations workers will choose to relocate with their families to Fort McMurray as opposed to remaining in their home communities and staying in project accommodations in the region when working on-site. While population projections vary, a common theme among projections is that sizeable growth is forecasted for the region.

Responsible authorities are in a better position to deal with this potential future growth than in previous years as a result of increased revenue from property taxes (as a result of population growth), new funding initiatives, and policy and planning mechanisms put in place by government and industry. These initiatives have helped alleviate a number of socio-economic pressures and enhance the quality of life for local residents. The outcome of ongoing or contemplated planning exercises may also substantially alter effects in the region. Avoiding future socio-economic pressures will depend upon current planning initiatives being properly resourced and carried out in a timely manner.

The amount of land that will be unavailable for TLU in the portions of the RSAs for the ACFN, FMFN and MCFN which overlap the Terrestrial RSA, for the 2012 PDC is shown in Table 3.5-5. The total amount of 2012 PDC disturbance represents 9%, 22% and 6% of the total area of the ACFN, FMFN and MCFN RSAs, respectively.

3.6 Planned Development Case Summary

Appendix 2, Section 3 presents the updated PDC assessment requested in JRP SIR 11. The revised assessment, referred to as the 2012 PDC, concluded that environmental effects for Air Quality, Environmental Health and Aquatic Resources are generally the same as the EIA PDC while effects on Terrestrial Resources and the Human Environment components have generally increased under the 2012 PDC.

The following sections provide conclusions by component for the 2012 PDC.

Air Quality

For the 2012 PDC, only H_2S and select VOCs were assessed because other air quality parameters were predicted to be negligible in the 2012 JME Application Case. There are some predicted air quality exceedances for these parameters in the 2012 PDC at cabins near planned projects as well as in Fort McMurray primarily due to the estimated increase in emissions from future population growth. Of the nine ambient air quality parameters assessed for the 2012 PDC, five are rated as having a low environmental consequence and four are rated as having a high environmental consequence.

Environmental Health

Overall, the changes between the 2012 Base Case and 2012 PDC risks are generally small in the HHRA. Cumulative environmental risks associated with the additional projects and activities planned for the region are not expected to result in adverse health effects. The 2012 PDC does not alter the assessment results or the conclusions presented in the HHRA of the EIA.

The results of the WHRA indicate that the overall risks posed to wildlife health will be low. Therefore, no impacts to wildlife populations are expected based on estimated wildlife exposures to predicted maximum acute and chronic air concentrations or predicted soil and surface water concentrations. These conclusions are consistent with those presented in the WHRA of the EIA.

Hydrogeology

Net groundwater inflows to the JME LSA do not change between the EIA and the 2012 PDC The Athabasca River assessment concluded no additional effects from planned developments are expected in the 2012 PDC. This result is consistent with the limited additional drawdown predicted in the Basal Aquifer in the immediate vicinity of the Athabasca River.

Hydrology

The magnitude of predicted changes in flow parameters for the Muskeg River due to the 2012 PDC are slightly less for all nodes than in the EIA Application Case for the operational snapshots. The incremental changes to the annual average flow depth and annual maximum flow depth in the Muskeg River for the 2012 PDC are very small compared to the EIA Application Case. The incremental changes in Kearl Lake water levels for 2012 PDC are negligible compared to the EIA Application Case.

The total projected net water allocations to existing, approved and planned oil sands mining projects represents about 76% of the total net water allocation for the Athabasca River basin under the Water Management Framework for the Lower Athabasca River The incremental water level reductions due to planned developments in the Athabasca River are less than 1 cm for the mean seasonal flow depths.

Water Quality

Within the Muskeg River watershed, acute and chronic toxicity and tainting potential levels are predicted to be appreciably lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2012 PDC at all assessment nodes.

For the Athabasca River, key water quality constituents, including tainting potential and chronic and acute toxicity in the 2012 PDC are predicted to be appreciably lower than the corresponding guideline or threshold values at all nodes and snapshots. Concentrations of all constituents at all assessment nodes are predicted to be similar to those under the EIA PDC, which show few changes and no additional guideline exceedances compared to EIA Base Case conditions.

Aquatic Health

Whole effluent acute and chronic toxicity levels in Jackpine Creek, Kearl Lake and the Muskeg River are predicted to be below guideline levels throughout the life of JME and into the Far Future. Constituent concentrations within fish tissues are also predicted to remain below toxicological benchmarks, with the possible exception of nickel. However, predicted concentration only slightly exceeds EIA Base Case concentrations, and the benchmark concentration is particularly conservative; therefore, the risks to fish health from nickel are expected to be negligible.

In Jackpine Creek, none of the water quality constituents were identified as having the potential to influence aquatic health. All constituents within Jackpine Creek received negligible ratings for environmental consequence.

In Kearl Lake, aluminum, cadmium and selenium were predicted to have a low magnitude effect and negligible to low environmental consequence ratings.

In the Muskeg River at Node M0, aluminum, manganese and zinc were predicted to have a low magnitude effect and negligible environmental consequence ratings. None of the water quality constituents were identified as having the potential to influence aquatic health and all received negligible environmental consequence ratings in the Muskeg River at Node M3.

Whole effluent acute and chronic toxicity levels in the Athabasca River are predicted to be below guideline levels throughout the life of the existing, approved and planned developments and into the Far Future. Predicted changes to in-stream concentrations of the individual constituents considered in the analysis are either unchanged from existing conditions or the 2012 Base Case, or they remain below CEBs. In addition, changes to constituent concentrations in fish tissues are expected to remain below toxicological benchmarks. As such, activities associated with the existing, approved and planned developments are expected to result in negligible effects to aquatic health in the Athabasca River.

Fish and Fish Habitat

For the Muskeg River, additional incremental reductions in stream flow due to the 2012 PDC could require further compensation in proportion to each development's contribution to habitat alteration. Based on the compensation that will be required, the residual impacts on regional fish habitat and abundance are predicted to be negligible.

For the Athabasca River, the assessment of effects considers the Water Management Framework for the Lower Athabasca River. The Framework was developed to manage withdrawals from the Athabasca River and protect the aquatic ecosystem, while allowing industry to operate; this would include the planned projects in the 2012 PDC. As the Framework is adaptive, the Framework, informed by ongoing scientific study, will be modified as necessary to maintain protection of the river. Accordingly, no cumulative impacts to fish habitat, beyond those outlined in the Framework, would be expected from changes to stream flow in the Athabasca River in the 2012 PDC.

Soils and Terrain

The 2012 PDC assessment shows an increase of total planned development disturbances. After reclamation, there will be a net increase of mineral soils at Closure, compared to the 2012 Base Case. A net loss of organic soils in the RSA is predicted after reclamation based on the conceptualized landscape. The environmental consequence rating for the 2012 PDC for permanent soil loss is moderate, an increased compared to the EIA PDC.

Terrestrial Vegetation, Wetlands and Forest Resources

The 2012 PDC assessment assessed the following KIRs in the RSA: old growth forests, wetlands including peatlands, and rare plants, rare and special plant communities and rare plant potential, as these had greater than negligible environmental consequences in the 2102 JME Application Case.

During construction and operations, negative low environmental consequences were predicted for old growth forests and high rare plant potential. A negative moderate environmental consequence is assigned to wetlands (including peatlands).

At Closure, the environmental consequence rating for old growth forest is negative low, the same as the EIA PDC. The wetlands (including peatlands) environmental consequence rating has changed from negative and low in the EIA PDC to negative and moderate in the 2012 PDC. The change from low to moderate is the result of increased planned developments within the RSA and a shift to a drier landscape based on current reclamation plans. The high rare plant potential environmental consequence rating has changed from positive and low in the EIA PDC to positive and negligible in the 2012 PDC.

Wildlife and Wildlife Habitat

For black bear and moose, a low magnitude reduction in the carrying capacity of the RSA was predicted using a Population Viability Analysis for both the EIA PDC and the 2012 PDC. However, as these species are likely to be currently below carrying capacity in the region, changes in carrying capacity are unlikely to relate directly to changes in abundance. The environmental consequences of the 2012 PDC on the abundance of black bear and moose are, therefore, predicted to be negligible, as in the EIA. The effects for the 2012 PDC were predicted to be negligible for Canadian toad, barred owl, beaver, Canada lynx, fisher and black-throated green warbler.

The assessed environmental consequences of the 2012 PDC on wildlife habitat are similar to those previously assessed (May 2011, Submission of Information to the Joint Review Panel). However, the 2012 PDC results in changes in the environmental consequences for the effects on habitat for some wildlife species. Specifically, the predicted decline in high suitability habitat due to the 2012 PDC include:

- a change from a negligible environmental consequence in the Species at Risk assessment (May 2011, Submission of Information to the Joint Review Panel) to low for western toad habitat;
- a change from a low environmental consequence in the EIA to moderate for black-throated green warbler habitat;
- a change from a low environmental consequence in the Species at Risk assessment (May 2011, Submission of Information to the Joint Review Panel) to moderate for wood bison, horned grebe, rusty blackbird and yellow rail habitat; and
- a change from a low environmental consequence in the Species at Risk assessment (May 2011, Submission of Information to the Joint Review Panel) to high for Canada warbler.

Although wood bison are not found east of the Athabasca River, and woodland caribou are virtually absent from the LSA, effects on habitat of these species are assessed at the request of the JRP (SIR 19a, SIR 21b) because these species occurred in the LSA in the past. The environmental consequences of the 2012 PDC on potential wood bison habitat are unchanged from the Species at Risk assessment (i.e., negative and moderate, May 2011, Submission of Information to the Joint Review Panel). The effects on potential woodland caribou habitat are assessed as having a negative moderate environmental consequence prior to reclamation.

The predicted effects of the 2012 PDC represent a reasonable worst-case scenario, because habitat suitability modelling in the 2012 PDC assume that disturbances from construction occur simultaneously and no reclamation will occur. The actual loss of habitat at any point in time will be less, due to the phased nature of developments and reclamation. Reclamation is not represented because the precise locations and size of some planned projects and the associated reclamation and revegetation plans are unknown. However, there is a regulatory requirement to reclaim habitats at completion. Thus, predicted environmental consequences are,

therefore, likely more conservative than what may actually take place. There will be a reduction in environmental consequence as wildlife habitat redevelops and wildlife populations return into the reclaimed landscape from neighbouring source populations.

The assessed environmental consequences of the 2012 PDC on wildlife movement are low for beaver, black bear, Canada lynx, fisher, moose and wolverine, and negligible for all remaining wildlife KIRs and Species at Risk. The 2012 PDC results in a change in the environmental consequence for the effects on movement for fisher, which was previously assessed as moderate. The effects of the 2012 PDC on fisher movement are predicted to be low, because although habitat fragmentation and loss will affect movement in the RSA, fisher are highly mobile and landscape connectivity will be maintained.

Biodiversity

In the 2012 PDC, both the before-reclamation and after-reclamation assessments result in an overall low environmental consequence on all levels of biodiversity at the RSA. This result is the same as that determined in the EIA PDC.

Traditional Knowledge and Land Use

Under the 2012 PDC, disturbances will represent between 53% and 67% of the total area for each of the directly affected RFMAs. Disturbances to the FMFN CSEs under the 2012 PDC will represent 24% of the area of the All Traditional Uses CSE, 20% of the area of the Large Game Harvesting CSE, and 32% of the area of the Traditional Plant Harvesting CSE. Disturbances under the 2012 PDC are calculated to represent 13% of the area of the total area of the ACFN traditional territories, 22% of the total area of the FMFN traditional territories, and 7% of the total area of the MCFN traditional territories.

Resource Use

The overall environmental consequences to the resource uses considered under the 2012 PDC are unchanged from the EIA. The environmental consequences for forestry and aggregates are considered low. The environmental consequence of changes in the regional population leading to increased land and resource use is considered moderate. These environmental consequences are the same as in EIA.

Socio-Economics

The most recent PDC projections are based on a high production curve and the assumption built into the RMWB population model that a large number of oil sands operations workers will choose to relocate with their families to Fort McMurray as opposed to remaining in their home communities and staying in project accommodations in the region when working on-site. While population projections vary, a common theme among projections is that sizeable growth is forecasted for the region.

Responsible authorities are in a better position to deal with this potential future growth than in previous years as a result of increased revenue from property taxes (as a result of population growth), new funding initiatives, and policy and planning mechanisms put in place by government and industry. These initiatives have helped alleviate a number of socio-economic pressures and enhance the quality of life for local residents. The outcome of ongoing or contemplated planning exercises may also substantially alter effects in the region. Avoiding future socio-economic pressures will depend upon current planning initiatives being properly resourced and carried out in a timely manner.

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ATTACHMENT A

Current Socio-Economic Issues and Responses

Table 1 Current Socio-Economic Issues and Responses

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Policing	• Recruitment and retention issues have historically made it a challenge to fill all allocated positions, but the Wood Buffalo RCMP detachment reports full complement as of June 2011 (Bane 2011, pers. comm.). While staff recruitment has improved in recent years, the relatively high cost of housing remains a challenge. • Traffic safety remains a top priority for the detachment. • Community concerns include traffic safety, drug, and alcohol-related offences. • Statistics Canada reports that criminal code offences per 100,000 people in the urban service area were well above the provincial average in 2010, but comparable to Grande Prairie, a comparator community: 15,837 offences in Fort McMurray compared with 15,602 in Grande Prairie and a provincial average of 8,624 (STATSCAN 2011). However, the rates from Statistics Canada are based on federal census numbers, which understate the actual population in Fort McMurray and thus, overstate the rates of criminal code offences. Using municipal census numbers, the criminal code offences per 100,000 people in the urban service area was over 12,705, still above the provincial average but below Grande Prairie.	• Regional policing has benefited in recent years from increases in staffing and improvements in infrastructure, including: - a 92% increase in allocated staff positions between 2004 and 2011 for the Wood Buffalo RCMP detachment (from 97 officers in 2004 to 186 in 2011); and - a new RCMP detachment building that has been built in Fort McMurray. It is a state of the art, Leadership in Energy and Environmental Design (LEEDS) award-winning building, featuring a forensic lab and a fully equipped gym. • RCMP employees receive a cost-of-living allowance (introduced in 2007). • Industrial operators in the region often have in place: - explicit and enforced lodge, workplace, and flight policies with regards to the use of alcohol, drugs, and illegal activities; - in-lodge security, which will assist the RCMP within, and sometimes outside, their individual lease boundaries (e.g., securing accident scenes, assisting with highway closures); and - limits on private vehicles brought to the project sites, reducing commuter traffic on Highway 63, thus decreasing the need for traffic enforcement. • Industry has also provided financial contributions towards additional police officer positions in the region.
Emergency Services	• Recruitment and retention challenges have eased for the Regional Emergency Services department in recent years. As of early 2011, the urban component of emergency personnel is fully staffed. However, volunteer recruitment has been a problem in selected communities. Recruitment and retention remains a top priority for the Regional Emergency Services department. • As of early 2011, the Regional Emergency Services department is meeting its target response times for both fire and ambulance. However, providing comprehensive emergency response coverage to the region remains a challenge because of the large geographic area being covered. Improved coordination of provincially supported (i.e., Alberta Health Services [AHS]) and industrial site-based emergency services is a priority for the Regional Emergency Services department (MacMillan 2011, pers. comm.). • The department has previously raised concerns regarding the transportation of hazardous goods on Highway 63 through Fort McMurray and the response time/coverage implications with respect to traffic incidents on Highway 63. • Concerns have also been raised about the increased likelihood of a major industrial accident.	• Regional emergency service providers have benefited in recent years from increases in staffing and improvements in infrastructure, including: - in early 2011 there were 124 fire and ambulance personnel and 45 support and administration positions, up from 116 fire and ambulance personnel and 34 support positions in 2007; and - a fifth fire hall station is expected to open in late 2011 and a sixth station is in the planning stages (MacMillan 2011, pers. comm.). • The Emergency Services Department has launched its new mobile training unit to improve access to firefighter training in rural areas. • A new approach to recruiting has been implemented, which allows the department to proactively hire new emergency personnel intended to cover positions lost through attrition (MacMillan 2011, pers. comm.). • Industrial operators in the region often have in place: - emergency response plans, including integrated incident/crisis management teams, full-time certified emergency responders, and auxiliary emergency response teams; and - mutual aid agreements with the RMWB and other oil sands companies that include: responding to motor vehicle accidents on Highway 63; advanced life support and ambulance support to rural residents, including transfers to the Fort McMurray hospital; responding to forest fire threats; responding to regional oil spills, and participating in the management of regional emergencies at the RMWB's Regional Emergency Operations Centre. • In 2010, the RMWB completed a review of 21 municipal service functions, including fire response services, in rural communities in the region. The Rural Service Delivery Review Report is intended to serve as a guiding document for the municipality to strategically direct and coordinate rural service delivery (RMWB 2010a).
Health Services	• Difficulty in recruiting and retaining health care professionals and support staff, a national challenge that is intensified by difficulties in attracting staff because of the region's remote location, lack of affordable housing, higher cost of living, and significant wage competition. • Provincial funding approaches that have not adequately addressed the population growth rates of the RMWB and the health services demands of out-of-region residents. • A concern in the region, as it is in many rural areas of the province, is adequate access to appropriate health services that is comparable to other parts of the province (Kirschner 2011, pers. comm.). • Fort McKay and Fort Chipewyan community members are reliant on the Fort McMurray hospital for many medical services and are concerned about long wait times at, for example, the emergency department. Other health concerns include alcohol and drug use and elder care. Residents of Fort Chipewyan are concerned with drug and alcohol abuse as well as cancer rates.	**Recruitment of additional physicians and other health providers** While health staffing issues remain a concern in the Wood Buffalo region, improvements have been made in recent years: • Between 2006 and 2008, the number of physicians in the former Northern Lights Health Region increased by 30%, from 60 to 78 physicians (CPSA 2008). • A 2009 survey of patients visiting the Northern Lights Regional Health Centre's emergency department found that 83% of respondents reported having a regular family doctor or specialist, as compared to only 73% in 2007 (HQCA 2010). • According to the Wood Buffalo Primary Care Network website, "There is a myth in Fort McMurray that it is difficult to find a local family physician because they are not accepting new patients. While this was true close to three years ago the situation has changed. With recruitment of physicians to the area there are now 9 physicians accepting new patients." (WBPCN 2011). • Provincial funding has been provided for a northern living allowance to health workers in the former Northern Lights Health Region. • Many of the challenges in recruiting health service providers to Wood Buffalo are the same challenges faced by all sectors of the regional economy looking to recruit and retain workers (e.g., remote location, high cost of living). The recent economic slowdown has provided some additional time for these service providers to plan and act in addressing these challenges.

Table 1 Current Socio-Economic Issues and Responses (continued)

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Health Services (continued)	• Some physicians in the region are requesting payment up-front from residents with out-of-region health cards because of uncertainty that these residents are covered, or additional barriers incurred in attempting to receive remuneration from other provincial health plans (FMT 2010). • The lack of available commercial office space in the region has been creating challenges for local physicians (Kirschner 2011, pers. comm.). • Additional regional health infrastructure is needed, including a continuing care facility and a health and wellness centre in the northern part of the urban service area.	**Additional funding to address health-related growth pressures** In response to the Radke Report, the Government of Alberta committed an additional $177 million between 2007 and 2010 to "address health-related growth pressures" in the region (Government of Alberta 2007a). More recently, in 2010 the Government of Alberta introduced a five-year funding plan for AHS which commits to providing 6% operating funding increases in each of the first three years and 4.5% increases in each of the final two years (Government of Alberta 2010a). The government continued carrying through on this commitment in its 2011 budget with a $545 million, or 6%, increase in funding for AHS over the previous fiscal year (Government of Alberta 2011a). **Additional investments in regional health infrastructure** Since 2006, the provincial government has announced plans for and moved forward with several infrastructure improvements to the Northern Lights Regional Health Centre, including: • renovation to the ambulatory and emergency departments ($6.0 million); • replacement of sewer line and domestic hot water circulation piping ($4.5 million); • renovation to the intensive care unit (ICU) ($2.0 million); and • renovations to the hospital's pediatric unit including more rooms, new beds, new equipment and a new nursing station. Funding has also been provided and planning underway for two new community health centres in the Fort McMurray communities of Thickwood and Timberlea ($28.2 million, in planning phase) (Government of Alberta 2010b) to improve access by residents to primary care services. As well, the province has been moving forward with plans to build a new long-term care facility in Fort McMurray, helping to relieve bed pressures at the Northern Lights Regional Health Centre (FMT 2011a). **Reduction in emergency wait times** • According to Alberta Health Services 2009/10 Annual Report, a series of measures implemented by staff at the Northern Lights Regional Health Centre has reduced emergency department length of stay and ensured visitors see physicians and nurses sooner. For example, the number of patients waiting more than 15 minutes to have their condition assessed by a triage nurse has been reduced by 30% between 2007 and 2009, and the number of patients waiting more than two hours to see a physician has been reduced by 15% over the same period (AHS 2010a). • For the past three years (2008/09, 2009/10, 2010/11), the Northern Lights Regional Health Centre emergency department discharged a higher percentage of patients within the targeted timeframe (less than 4 hours) than emergency departments in Edmonton, Grande Prairie, and Lethbridge (AHS 2010b, 2011a). • Looking forward, the development of new primary care capacity and plans for 100 new continuing care spaces will also help to reduce pressure on the emergency department by enhancing primary care capacity in the region and freeing up hospital beds. **Development of a new activity-based funding formula** • In 2010, AHS began implementing a phased approach to activity-based funding in long-term care (AHS 2011b). • In 2011, AHS was developing approaches to introduce activity-based funding for acute care services (AHS 2011b). [(a)] • One advantage of such a system is that funding would be more closely tied to actual activity levels, something which the former Northern Lights Health Region has called for in health funding. However, there are also concerns that such a funding formula could penalize rural hospitals with low utilization rates by making them compete with larger urban facilities. The details regarding this funding design for acute care and other services are still under consideration and it is not yet clear how this funding formula might ultimately affect services in the RMWB. **Commitment to Fort McKay Health Study** In September 2011, the Government of Alberta signed a Letter of Intent to develop a comprehensive community health assessment for Fort McKay. The study is expected to involve Fort McKay First Nation, Fort McKay Métis Community, Alberta Health and Wellness and Alberta Aboriginal Relations working together to identify community health issues, determine from residents what their health care priorities are, and design and deliver new programs to address those priorities. **Assistance from the oil sands industry** The oil sands industry has also supported efforts aimed at addressing health service delivery challenges in the region. For example: • Oil sands companies have donated funds to the Northern Lights Regional Health Foundation – a not-for-profit charitable organization established to strengthen health care for residents in the RMWB. • Several industry proponents have signed separate Memoranda of Understanding (MOUs) with the Northern Lights Health Region to provide increased health services to oil sands workers in lodges in the region.

Table 1 Current Socio-Economic Issues and Responses (continued)

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Education	• According to Accountability Pillar Survey results from Alberta Education (AE 2011), between 86% and 89% of teachers, parents and students surveyed in 2011 were satisfied with the overall quality of basic education in the Fort McMurray public and separate school systems. This is comparable to the provincial average of 89%. In comparison, 80% of teachers, parents and students surveyed in the Northlands School Division were satisfied with the overall quality of basic education (AE 2011). • Schools in high-growth neighbourhoods are experiencing enrolment pressures. In many cases, growth is managed through modular classrooms. • Services need to be expanded, in part to accommodate new students whose first language is other than English or French (FMCSD 2011). • School boards regularly lose support staff to the private sector. Staff turnover, while still an issue, has decreased from levels experienced in previous years (FMPSD 2010; FMCSD 2011). • School boards have raised concerns about the difficulty of getting contractors to do work and the cost of building maintenance and repair. • Cost of housing remains an issue in attempting to attract and retain staff. Teachers have difficulty finding suitable accommodation even with the provincial Cost of Living Allowance (FMPSD 2010). • In 2011, high school completion rates (three-year rate) were 74.9% and 70.6% for Fort McMurray's separate and public school systems respectively. The provincial average was 72.6% (AE 2011). • The Northlands School Division, whose student population is primarily First Nations, Métis, or Inuit (FNMI), had a high school completion rate of only 13.5% (AE 2011). Concerns have been raised about persistently weak student learning outcomes in the Northlands School Division and other matters relating to the governance of the jurisdiction. • Education concerns among rural communities also include difficulty for students transitioning to high schools in Fort McMurray and challenges in facilitating the transfer of traditional knowledge, including language, from Elders to young people. • Keyano College has experienced increasing enrolment in recent years. However, the economic recession created resourcing challenges for the college as grant funding from Alberta Advanced Education and Technology was reduced and corporate training opportunities were cut back.	**New schools and school infrastructure** • Ecole McTavish Junior High School opened in September 2011. Initial capacity is 800 students but is set to increase to 1,100 students when 12 portable classrooms are added (FMPSD 2011). • Holy Trinity Catholic High School, which includes a locally funded performing arts centre, opened in September 2011. • In May 2011, the Government of Alberta announced funding for two new Kindergarten to Grade 6 schools in Fort McMurray's Timberlea area. Both schools are expected to be open by 2014 (Government of Alberta 2011b). • Aside from new schools, the provincial government has also committed funds in recent years to other capital projects which can help increase existing capacity, including additional modular classrooms and school modernization projects. **Attraction and retention of teaching staff** • Both divisions have housing allowances in place, which have been helpful in addressing high staff turnover rates. • Both divisions have New Teacher Induction Programs which provide structured training and support programs for new teachers to the region. **Northlands inquiry** • In January 2010 the Minister of Education dismissed the Corporate Board of Northland School Division and convened the Northland School Division Inquiry to gather information and develop recommendations for improving the situation. The Northland School Division Inquiry Team provided its 48 recommendations to the Minister in November 2010 (NSD 2010). In early 2011, the Minister appointed a Community Engagement Team to provide feedback on the Inquiry Report recommendations and offer strategic advice, direction and leadership in the development of a community engagement blueprint (NSD 2011).
Social Services	• Social/community service providers flag several issues linked to population growth and economic expansion, including: - growing numbers of homeless looking for shelter and other support services; - displaced/terminated lodge-based workers placing additional demands on the homeless serving agencies in the region (Evasiuk 2011, pers. comm.); - high demand for affordable child care spaces; - work demands taking time away from family and community life; - reduced community cohesion and a sense of transience among residents; - alcohol and drug use and gambling; and - changes experienced in Aboriginal communities as members move away from traditional cultural practices. • In line with many social service providers in the province, the agencies in outlying communities are challenged by the sometimes ad hoc and project-specific funding, and the difficulty of recruiting and retaining staff. • Many social and community agencies are also experiencing difficulties in attracting and retaining personnel and volunteers.	• Additional support has been provided for social and affordable housing in the region in recent years. See "Housing" section below. • The RMWB has developed its own 10-year plan to end homelessness which aligns with the provincial plan to end homelessness and outlines actions to build community support for Housing First (RMWB 2010b). • The Government of Alberta extended its cost-of-living allowance to employees of all provincially funded organizations in Fort McMurray (Government of Alberta 2007b). • Several broader-based programs run by the provincial government in recent years have benefited the RMWB, such as Alberta's 10-year provincial strategy to end homelessness and Alberta's Making Space for Children: Child Care Space Creation Innovation Fund (ACYS 2009, 2011; AHUA 2009a). • The new Fort McKay Elder and Day Care Centre opened in January 2010, replacing the original building that was destroyed by fire in 2007. • In 2010 the RMWB completed a review of 21 municipal service functions, including family and community support services, in rural communities in the region. The Rural Service Delivery Review Report is intended to serve as a guiding document for the municipality to strategically direct and coordinate rural service delivery (RMWB 2010a).
Recreation Infrastructure and Services	• The RMWB and residents of the Wood Buffalo region have previously expressed concern regarding the limited number of recreation facilities. A number of new recreation facilities and amenities have been built in recent years in response to these concerns. • Similar to other sectors in the area, recreation service providers have experienced staff recruitment and retention challenges. • With increasing industrial development and a growing regional population, access to previously hard-to-get-to places is increasing, thus increasing the competition with traditional land use. • Many campgrounds are being used as semi-permanent accommodations by mobile workers, thus reducing their use for recreation purposes.	**Additional recreation facilities and amenities** Recognizing the need for more recreation facilities, the RMWB, the Province of Alberta, industry and other stakeholders have added new recreation facilities and amenities in recent years. Along with the Syncrude Sports and Wellness Centre (2007) and the expanded Syncrude Timberlea Athletic Park (2008), there has been a $170 million redevelopment of MacDonald Island Park. Highlights of the renovated 450,000 ft^2 multiuse recreation space, touted as Canada's largest recreation centre, include: • a 56,000 ft^2 public library; • two NHL-sized arenas; • an Olympic-sized pool; • an eight-sheet curling rink; • field houses and running track; • an 8,000 ft^2 fitness centre; • squash and racquetball courts; • indoor playground and child-minding area; and • baseball diamonds, basketball, and tennis courts (MacDonald Island Park 2010). In addition, community consultation is currently underway on plans for a sizeable expansion to MacDonald Island Park, including an outdoor stadium. Outside the urban service area, the Archie Simpson Arena, a new 4,500 m^2 facility, recently opened in Fort Chipewyan. The new facility (replacing the original building whose roof collapsed in 2005) features an ice surface, computer lab, fitness centre, youth area with games like pool and foosball, a basketball court, and playground (FMT 2009).

Table 1 Current Socio-Economic Issues and Responses (continued)

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Recreation Infrastructure and Services (continued)		**Rural service delivery review** In 2010 the RMWB completed a review of 21 municipal service functions, including recreation programs, in rural communities in the region. The Rural Service Delivery Review Report is intended to serve as a guiding document for the municipality to strategically direct and coordinate rural service delivery (RMWB 2010a). **Industry response** Industry has also responded by: • providing workers with recreation opportunities in-camp, including exercise and games rooms; • providing the RMWB with data in support of its recreation planning and development; and • playing a key role in providing financing for new major recreation centres in the region. **Draft Lower Athabasca Regional Plan (LARP)** One of the Draft LARP objectives is to "provide a wide range of recreation and tourism opportunities that meet the preferences of regional residents and visitors" (Government of Alberta 2011c). Among the strategies identified for achieving this objective are: • designate new provincial recreation areas to address growing demand for recreational opportunities in the region and provide a secure land base to support tourism development; • create new public land areas for recreation and tourism in the region that contain unique features or settings; • develop the regional parks plan for the Lower Athabasca; • collect regional data in the form of a recreation and tourism resource inventory that includes the completion of a scenic resource assessment inventory and a regional recreational demand and satisfaction survey; and • in collaboration with Aboriginal and other community stakeholders and partners, coordinate the development of the Lower Athabasca Regional Trail System Plan.
Housing	• Strong population growth in Fort McMurray combined with a lack of available land and high costs of development have contributed to a housing shortage in Fort McMurray. • Housing costs are the principal contributor to the high cost of living in Fort McMurray. The average price for single family dwellings more than doubled between 2003 and 2008 before dropping in 2009 in response to the economic recession. House prices began increasing again in 2010, rising to levels comparable with 2008. In 2011 house prices continued climbing in Fort McMurray, with an average selling price of over $730,000 (FMREB 2012). • Between 2003 and 2008 rental rates roughly doubled, and vacancy dropped to near-zero. Despite moderating in recent years, average rental rates in the Wood Buffalo region remain the highest in Alberta. Vacancy rates, however, have increased from 5.5% in 2010 to over 9% in 2011 (CMHC 2011a). • The price of housing makes it hard to recruit and retain staff, especially in those sectors where wage rates are relatively low, such as social services and the service sector. • High housing costs and lack of affordable housing has given rise to homeowners renting out rooms on the formal or informal rental market. • Despite a slowdown in housing starts in recent years, the market has shown resiliency in the past by quickly increasing housing starts in response to strong demand. Housing starts in the region increased rapidly, from 861 in 2004 to 2,175 in 2007, before dropping to 769 in 2010 (CMHC 2005, 2008, 2011b). • The effect of high housing costs on the residents of Fort McMurray is dependent upon income levels. For many residents, particularly those working in the oil sands sector, higher wages relative to other communities in the province, as well as housing allowances, help to offset high housing prices. However, not all residents can benefit from high earning opportunities. With rising house prices, low-income residents in particular (e.g., workers employed in the service sector, lone-parent and single-income households), are put under increased pressure to find affordable accommodation. • Many rural communities in the RMWB are also experiencing housing pressures as a result of: community members returning, often from Fort McMurray, to avoid high housing prices there; a young population and early family formation; and housing policies and funding allocations by Aboriginal Affairs and Northern Development Canada (AANDC) that do not tend to respond quickly to changing situations.	**Ongoing Planning and Development** Several planning initiatives have been completed or are underway to make sufficient land available for residential and other uses in the various communities in the region: • signing of an MOU between the municipal and provincial governments for the creation of an Urban Development Sub-Region (UDSR) (RMWB 2011a); • adoption of the Lower Town Site Area Redevelopment Plan (adopted May 2009); • development of the Parsons Creek Design and Outline Plan (June 2009); • extension of the urban services area to include the Parsons Creek Area (adopted August 2009); • commitment of more than $241 million by the Government of Alberta to develop lands in the Parsons Creek and Saline Creek Plateau areas (AHUA 2009b); • development of new planning frameworks for rural communities; and • carrying out of a market demand study in early 2011 for residential lot development in Fort Chipewyan to help inform the Area Structure Plan (ASP) and any potential land releases from the municipality. The development of communities in the RMWB will also be influenced by other planning initiatives currently underway, most notably LARP, AOSA CRISP, and the RMWB Municipal Development Plan. Among the elements of the AOSA CRISP that would directly affect the level and type of future housing requirements is the: • designation of selected areas as planned camp communities which may or may not develop into permanent settlements; and • designation of one consolidated camp location north of Fort McMurray and Fort McKay to serve as a residential community for mostly operations workers of mines around Fort McKay. **Support for Social and Affordable Housing** The Wood Buffalo Housing and Development Corporation (WBHDC) currently has projects underway to increase the supply of affordable housing in the region. Between November 2006 and June 2011, the WBHDC added over 680 affordable housing units, reducing their waiting list from approximately 430 to 250 individuals and families (Lutes 2011, pers. comm.). Additional support has also been provided in recent years for social and affordable housing in the region, including: • $11.7 million from the Government of Alberta for the Fort McMurray Family Crisis Society to develop a 78-unit apartment (FMT 2011b); • a commitment that 20% of the 2,000 new homes associated with the first phase of Parsons Creek development will be designated as affordable housing, with rents to be set below market rate (AHUA 2009b); • $45 million from the Government of Alberta to develop 300 affordable housing units in the RMWB (Government of Alberta 2007a); and • northern (or housing) allowances paid to public sector workers (Government of Alberta 2007b). **Project Accommodations** • Oil sands facilities are routinely supported by a construction camp. As well, several oil sands developments have, or plan to have, operations camps. Driven mostly by health and safety considerations linked to long commutes, operations camps limit the near-term effects that these developments would otherwise have had on the local housing market.

Table 1 Current Socio-Economic Issues and Responses (continued)

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Municipal Infrastructure and Services	• As the population grows, the RMWB has been experiencing high demand for both municipal infrastructure and services. The municipality has some concerns with meeting infrastructure and service demands, including: - the relatively higher costs of providing infrastructure in the RMWB as compared to municipalities in the southern half of the province; and - reduced management capacity within the municipality as a result of staff attraction and retention difficulties. • Planned oil sands developments will drive further population growth and demand for municipal infrastructure and services.	**Increased Investment** • The RMWB has invested in major infrastructure developments, including RCMP force and detachment buildings; and regional emergency service providers and fire halls. Under the RMWB's *2011-2014 Fiscal Management Strategy*, the municipality is set to invest a further $2.1 billion in capital projects between 2012 and 2017, in addition to the $1 billion in committed projects in the 2011 and pre 2011 capital budgets. • The RMWB has received assistance from the provincial government in recent years, including: - $3.6 million over 3 years (2007 to 2010) to provide strategic municipal planning support to the RMWB; - $103 million in funding, in addition to a $136 million four-year interest-free loan, to build a replacement sewage treatment facility and an upgraded water treatment plant in Fort McMurray; - $30 million to support the lower town site water collection system upgrader; and - $15 million for regional landfill development. **Increased Planning** • The municipality has recently updated their Municipal Development Plan (MDP; RMWB 2011b). The RMWB has also invested significant time and resources in updating their municipal infrastructure master plans to accommodate future population growth. • A population forecasting tool and long-term municipal fiscal model for the RMWB have also been developed. • Planning and investment currently underway assumes population levels in line with the population estimate associated with the PDC. **Increased Resources** • The RMWB has a number of initiatives in place to address staff recruitment and retention, including a housing allowance, relocation assistance and house equity protection. • Oil sands development growth has increased demands on the municipality, but it has also provided the RMWB with increased financial ability to respond to these demands. Property assessment in the Rural Service Area of the RMWB, which consists mostly of oil sands industry facilities, grew on average by 24% per year from $6.6 billion in 2005 to $24.1 billion in 2011. • As planned oil sands development proceeds, non-residential assessment will also grow, thus expanding the RMWB's ability to pay for municipal services and infrastructure.
Transportation	• Oil sands expansion in the RMWB has led to increased traffic throughout the region and beyond. Traffic volumes over the last five years have increased by about 12% per year on highway segments north of Fort McMurray. • Traffic volumes outside of Fort McMurray are higher to the north than the south, reflecting the daily traffic generated between the urban service area and the oil sands facilities to the north. • While traffic safety is a concern for many residents, both Highway 63 and Highway 881 continue to have collision rates below the provincial average for comparable roadways. • Industrial activity has resulted in an increased volume of larger vehicles and the transportation of hazardous materials in the region, including through the urban service area of Fort McMurray, creating safety concerns among residents. • Daily and weekly shift change peaks result in traffic congestion within Fort McMurray and along Highway 63, as well as segments of Highway 881.	**Road Infrastructure Improvements** Road infrastructure in the study area continues to undergo changes and improvements. A key component is the twinning of Highway 63, the primary roadway in the region, connecting southward with the wider provincial road network. Twinning work completed, as well as planned, includes the following segments: • Fort McMurray to Suncor, completed in 2002; • Suncor to Syncrude, completed in 2008; • Highway 69 to Highway 881/Anzac turnoff, completed in 2008; • 16-km-segment north of Wandering River; and • North of Highway 55/Grassland to Highway 881/Anzac turnoff, a 225-km segment, planned and under construction. The latter represents a major project by the provincial and federal governments. Early estimates predict a cost of $940 million, with the Federal government committing $150 million to date. Several other major road infrastructure projects have also either recently completed or are underway including: • construction of a five-lane bridge across the Athabasca River in Fort McMurray (completed in 2011); • construction of interchanges at the intersections of Thickwood Boulevard and Confederation Way with Highway 63 (completed in 2011) Industry has also supported a number of road improvements including: • construction of the Suncor interchange over Highway 63; and • improvement to the Fort McKay turnoff along Highway 63. **Planning** • The Alberta Oil Sands Sustainable Development Secretariat, in co-operation with several Alberta government departments and local area municipalities, has developed the Athabasca Oil Sands Area (AOSA) Comprehensive Regional Infrastructure Sustainability Plan (CRISP) which lays out the infrastructure requirements, including highways, required for a future scenario in which the Athabasca Oil Sands Region (Wood Buffalo region, plus the Wabasca Desmarais region) produces 6 million barrels per day (bpd) (Government of Alberta 2011d). • In early 2012 the Government of Alberta announced the creation of the Athabasca Oil Sands Area Transportation Coordinating Committee, a new advisory committee comprised of municipal, provincial and industry representatives who will review and make recommendations on current and future transportation needs in the region (Government of Alberta 2012).

Table 1 Current Socio-Economic Issues and Responses (continued)

Socio-Economic Area	Issues	Public/Private Sector Response(s)
Traditional Land Use and Culture	• Aboriginal peoples in the region have been engaged in traditional activities such as hunting, fishing, and gathering for thousands of years. • The traditional culture of Aboriginal communities in the RSA is affected by multiple external influences, similar to those impacting Aboriginal communities elsewhere in Canada, including: increased use of traditional lands for non-traditional purposes; education initiatives that limit the learning of traditional knowledge values and practices; and increased access to other cultural influences through advancements in technology (e.g., satellite, internet, cell phones). • From the perspective of many Aboriginal peoples in the region, industrial development has had an effect on traditional culture, largely because of the scale of oil sands development and its direct effect on the biophysical environment that supports traditional land use. • Oil sands development is placing pressure on the traditional lands and culture of Aboriginal peoples in the region in several different ways, including: - making portions of land unavailable for traditional pursuits for a sizeable period of time, thereby reducing opportunities to carry out traditional activities on oil sands industry affected lands and to transmit traditional culture and oral history while on the land; - raising concerns among Aboriginal persons regarding the effect of pollutants on traditional lands and resources, thereby affecting how and where traditional practices are carried out; - using local waterways which in turn has led to concerns about the quantity of water in the region which is relied upon for carrying out traditional activities (e.g., fishing, means of accessing traditional lands); - offering opportunities for increased engagement in the wage economy which can limit opportunities for carrying out traditional pursuits and transferring traditional knowledge to Aboriginal youth while on the land; and - increasing the non-Aboriginal population in the region, thus increasing the competition for traditional resources from non-Aboriginal community members and increasing the exposure of Aboriginal persons to outside cultural values that might run contrary to the values associated with Aboriginal use and stewardship of traditional lands. • Along with these pressures, oil sands development has also had positive effects on Aboriginal peoples, including: - increased participation of local Aboriginal persons in the wage economy, leading to greater household spending power, lower need for government transfer payments, and an improved sense of self-worth for some; - support for traditional land use (TLU) and traditional ecological knowledge (TEK) studies, oral history projects, and other initiatives; - support for Aboriginal community projects, cultural retention programs, and historical preservation initiatives; and - support for Aboriginal community consultation offices (e.g., Industry Relations Corporations, Government and Industry Relations, Sustainability Department). • These positive effects have provided Aboriginal communities with additional resources with which to manage social and cultural change.	The effects of development on local Aboriginal peoples depends significantly on the approaches taken by industry to engage local Aboriginal peoples in order to mitigate the negative effects and enhance the benefits of development. **Increased employment, training and business opportunities for local Aboriginal workers and businesses** • Wood Buffalo Aboriginal companies performed over $1.3 billion in contract work with OSDG member companies in 2010. Over the past 12 years Aboriginal companies have earned over $5 billion in revenue. • Nearby oil sands operations are offering local Aboriginal workers opportunities to find wage employment while continuing to live in their home communities and pursue traditional lifestyles. According to Sonny Flett, former President of the Fort Chipewyan Métis Local, Syncrude's fly-in rotational program, "*is very beneficial because people are able to still maintain contact with their family and uphold a traditional lifestyle*." (CBSR 2005). • Industry supported the construction of a new Keyano College Campus in Fort Chipewyan, allowing residents to attend classes in their own community. **Institutional capacity-building among local First Nations and ongoing industry consultation** • First Nations in the region currently operate Industry Relations Corporation (IRC) or Government and Industry Relations (GIR) organizations. The IRCs/GIRs facilitate and support ongoing communication with industry and government on existing and planned oil sands development. • Between 2007 to 2009, industry provided approximately $22 million in funding for IRCs/GIRs, including funding paid by project proponents for project-specific reviews. • With the expiration of the All Parties Core Agreement which established and maintained funding for the GIR Corporations, individual arrangements between proponents and First Nations are being developed or renewed through memorandums of understanding and benefits agreements. In 2010, industry provided over $12 million in funding for Aboriginal and Métis/non-status consultation funding (OSDG 2011). • There are concerns that without the All Parties Core Agreement, the long-term viability of the consultation office model could be in jeopardy. **Support for the collection of traditional ecological knowledge** • Traditional Land Use Studies are required by the Government of Alberta as part of the EIA process. Oil sands companies have provided funding for in-depth traditional land use studies for local First Nations and Métis Locals. • Traditional cultural and environmental knowledge is changing, moving from a mostly oral and activity-based tradition of preservation to a greater emphasis on systematic documentation. **Support for cultural retention programs and historical preservation initiatives** • Oil sands companies have contributed over $35 million in the past ten years to Aboriginal communities in the region for school and youth programs, celebrations, cultural events, literacy, community projects and other programs (OSDG 2011). **The establishment of regional multi-stakeholder groups and research initiatives** • Local First Nations participate in a number of regional multi-stakeholder issues management organizations, including the Cumulative Environmental Management Association (CEMA), the Wood Buffalo Environmental Association (WBEA), and the Regional Aquatics Monitoring Program (RAMP). **The negotiation of benefit agreements with First Nation communities** • Many existing operators have benefit agreements in place with local First Nations. These agreements are often confidential, but may contain provisions with respect to: training, employment and business opportunities; support for social, cultural and community initiatives; and financial provisions and cash payments. • Further agreements are in the process of being negotiated with proponents bringing forward new projects in the region.

(a) Activity-based funding model is essentially a fee-for-service payment for hospital care where hospitals are paid a set price by the provincial government for the services they provide to each patient.

Note: References for this attachment are presented in Appendix 2.