Frontier Oil Sands Mine Project
Integrated Application

Project Directory

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1 Introduction

The people and places volume of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project) assesses potential effects of the Project on palaeontology, historical resources, resource use, visual aesthetics and traditional land use. The potential cumulative effects of the Project as they relate to the Peace-Athabasca Delta (PAD) are also considered as a separate topic.

The EIA was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by input from regulatory sources, potentially affected Aboriginal communities and public stakeholders. An evaluation of Project effects on the PAD is not required as part of the TOR but has been included to address federal agencies' input (see Canadian Environmental Assessment Agency 2009a and 2009b).

The EIA forms part of the Application made to the Energy Resources Conservation Board (ERCB) pursuant to the *Oil Sands Conservation Act*. Provincial (AENV 2011) and federal (Government of Canada 2011) guidance for the preparation of EIAs.

For a concordance table of the provincial TOR with EIA discipline sections, see Volume 3, Section 1, Appendix 1A. For a concordance table of federal requests with EIA discipline sections, see Volume 3, Section 1, Appendix 1B.

1.1 Approach

1.1.1 Key Issues and Key Questions

Based on input gathered from regulatory meetings and consultations with potentially affected Aboriginal communities and public stakeholders, a series of key issues were defined for the assessment of palaeontology, historical resources, resource use, visual aesthetics and traditional land use. A summary of the key issues for each phase of the Frontier Project and their relevance to the Frontier Project are summarized in Table 1-1.

Key questions were identified to:

- provide a framework for examining key issues identified by regulators, potentially affected Aboriginal communities and public stakeholders
- reflect the Frontier Project TOR
- provide a focus for the assessment

Issues over and above those captured in the key questions are also implicitly addressed. Key questions examined by the palaeontology, historical resources, resource use, visual aesthetics and traditional land use sections are provided in Table 1-1.

For the PAD, relevant key issues in the EIA were identified and examined relative to available baseline information. For a list of key issues identified, see Table 1-2.

Table 1-1 Key Issues and Key Questions

Project Phase	Key Issue	Relevance to Project	Key Questions
Palaeontology			
Construction and operation	Loss of palaeontological resources, loss of interpretive value, or both	• Project activities will disturb strata with high palaeontological potential	• P1: Could the Frontier Project result in the loss of contents or disrupt the interpretive context of palaeontological sites?
Historical Resources			
Construction	Loss of historical resources site contents and context and associated interpretive value	• Project construction activities will disturb historical resources site contents and site context, and will thus affect the interpretive value of historical resources sites.	• HR1: Could the Frontier Project result in the loss of contents and site context of historical resource sites, thereby affecting the interpretive value of sites?
Resource Use			
All phases	Consistency with land and resource use goals, objectives and policies	• The Project is located on Alberta Crown lands and in the planning area boundaries of certain provincial land use planning policy documents (*LARP*[1] and *the Fort McMurray Athabasca Oil Sands Subregional IRP*[2]). The goals, objectives and policies of these documents are applicable to all phases of the Project.	• R1: Is the Frontier Project consistent with regional management goals of the draft *Lower Athabasca Regional Plan*? • R2: Is the Frontier Project consistent with regional management goals of the *Fort McMurray Athabasca Oil Sands Subregional IRP*?
Construction and operation	Changes in land use capability and resource use.	• Project development will result in vegetation clearing, terrain alteration and disturbance and noise during construction and operation. This will result in change to certain land uses and capabilities and changes to the availability of resources in the Project assessment area (PAA).	• R3: Could the Frontier Project affect aggregate and mineral resources? • R4: Could the Frontier Project affect forestry? • R5: Could the Frontier Project affect hunting and trapping? • R6: Could the Frontier Project affect sports-fishing? • R7: Could the Frontier Project affect designated parks and protected areas? • R8: Could the Frontier Project affect environmentally significant areas? • R9: Could the Frontier Project affect recreation and tourism?
Construction	Disturbance to existing land and resource use activities	• Construction of the Project can result in restricted access and increased noise in the PAA which can interfere with existing land and resource use activities.	
Closure	Change in land use capability and resource use.	• At closure, the landscape will have topographic, vegetation and drainage characteristics that differ from pre-disturbance conditions. This may result in changes in land use capabilities and changes in the availability of resources in the PAA.	

Table 1-1 Key Issues and Key Questions (cont'd)

Project Phase	Key Issue	Relevance to Project	Key Questions
Resource Use (cont'd)			
Closure	Disturbance to existing land and resource use activities	• Closure of the Project can result in restricted access in the PAA which can interfere with existing land and resource use activities.	
Visual Aesthetics			
Construction and operation	Changes in visual aesthetics	• Elevated Project components could be visible at certain receptor locations and could affect visual characteristics	• V1: Could the Frontier Project affect visual aesthetics?
Closure	Changes in visual aesthetics	• Changes in topography associated with the closure landscape will be visible from a number of receptor locations and will affect visual characteristics	
Traditional Land Use			
Construction, operation and closure	Changes to wildlife habitat that may affect traditional hunting and trapping.	• Project activities may affect wildlife habitat	• TLU1: Could the Frontier Project in combination with other developments cumulatively affect traditional land uses? • TLU2: Could the Frontier Project in combination with other developments cumulatively affect the potential for traditional land uses?
	Changes to fish or fish habitat	• Project activities, such as runoff water and Project-related dust, may affect fish habitat	
	Potential effects on traditional use plants used for consumption, medicinal or spiritual purposes	• Additional areas with traditional use plant potential may be disturbed due to the Project	
	Potential effects on culturally important sites or areas	• Project activities may cause disturbance to culturally important areas, or affect the use of the areas	

NOTES:
[1] LARP = Draft *Lower Athabasca Regional Plan*
[2] IRP = Integrated Resource Plan

Table 1-2 EIA Key Issues Relevant to the PAD

Discipline	Key Issue[1]
Air	Potential for changes in ambient air quality
Groundwater	Potential for changes in groundwater quantity and quality
Hydrology	Potential for changes in surface water flows levels
Surface water quality	Potential for changes in water quality, thermal regime, dissolved oxygen and sediment quality
Fish and fish habitat	Potential for changes in fish habitat and fish abundance
Terrain and soils	Potential for changes in soil series diversity
Vegetation	Potential for changes in community and species diversity
Wildlife	Potential for changes in wildlife habitat availability and populations
Human health	Potential for changes to human health

NOTE:
[1] Key issue included to address federal input (Canadian Environmental Assessment Agency 2009a and 2009b).

1.1.2 Study Areas

The Project is located approximately 110 km north of Fort McMurray on the west side of the Athabasca River near the Birch Mountains, in Townships (Twps) 98 to 102, Ranges (Rges) 10 and 11, West of the Fourth Meridian (W4M) (see Figure 1-1).

Study areas were individually defined for the palaeontology, historical resources, resource use, visual aesthetics and traditional land use assessments to evaluate potential effects from the Project. These study areas are described in each section. The study area for the PAD is the delta (see Figure 1-1).

1.1.3 Assessment Cases

The palaeontology, historical resources, resource use, visual aesthetics and traditional land use assessments were evaluated in the context of the following development scenarios:

- Base Case, which includes developments that are currently operating or under construction, and activities approved but not yet constructed or those likely to be approved in the near future
- Application Case, which includes developments and activities in the Base Case, with the Frontier Project added
- Planned Development Case (PDC), which includes developments and activities included in the Application Case with other planned developments that are reasonably foreseeable added

For more details on the assessment cases, the related developments and activities included in each case and considered relevant to the palaeontology, historical resources, resource use, visual aesthetics and traditional land use assessments, see Volume 3, Section 1, Appendix 1C.

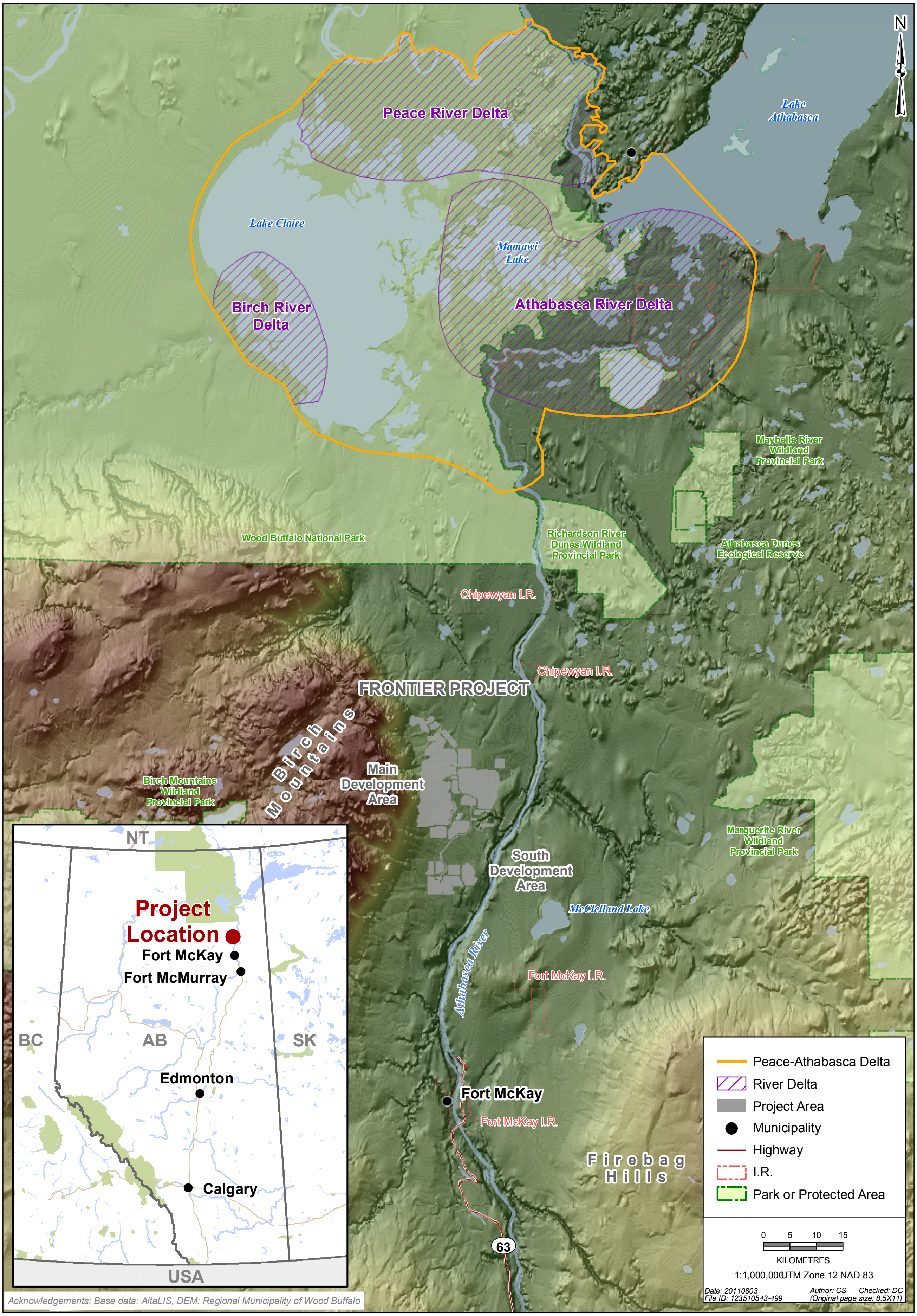

Figure 1-1: Project Location Map

1.1.4 Temporal Considerations

1.1.4.1 Reference Conditions

To provide a reference for the assessment of palaeontology, historical resources, visual aesthetics and traditional land use key issues and associated key indicators, reference conditions or reference snapshots were evaluated at two specific points in time including:

- predevelopment (pre-1965)
- existing (2010)

1.1.4.2 Snapshots

In addition to the reference condition snapshots, the following temporal snapshots were used to evaluate changes from the Frontier Project, in combination with other developments, as applicable:

- maximum build-out (2057)
- closure (2068)

Disturbances associated with projects other than the Frontier Project were always included as unreclaimed, except for the Pierre River Mine (PRM) fish habitat compensation lake, which is defined as water. As a result, any predicted cumulative effects are conservative (i.e., the assessments overpredict cumulative effects associated with vegetation disturbance).

1.1.5 Key Indicators

Key indicators have been selected for each key question. Sometimes one key indicator was selected for a key question; in other cases, several key indicators were used.

In general, key indicators were chosen based on ecological importance and vulnerability or value, including value for resource use, traditional use, monitoring or social importance. Selection of key indicators is explained in each EIA section.

Where possible, changes to key indicators are described quantitatively or semi-quantitatively. Where changes cannot be expressed quantitatively, they are described in qualitative terms.

1.1.6 Mitigation

Mitigation measures for limiting Project effects were discussed for each EIA discipline. Project-specific design and mitigation measures and cooperative regional initiatives were both discussed as relevant. The effects of the Project were assessed with mitigation considered.

1.1.7 Effects Analysis

An analysis of effects was completed for each key question and for each assessment case if a valid linkage was identified between the Project and an effect. Validation of the link included consideration of mitigation measures.

In some cases, the PDC was not analyzed because:

- the linkage was specific to the Frontier Project
- no planned developments were present in the study area
- the linkage between Project activities and potential environmental effects was broken at the Application Case

When possible, a quantitative approach was used to complete the effects analysis for each key question, including the use of predictive models. The approach and methods used to complete the effects analysis for each key question are described in the EIA discipline sections.

Effects were evaluated relative to applicable guidelines, standards, thresholds and criteria, as discussed for each discipline, or the degree of change was quantified or qualitatively discussed.

1.1.8 Prediction Confidence

Assessment of Project effects has some inherent uncertainty associated with data, methods and the predictive nature of the assessment. In addition, changes in future environmental conditions could also result in added uncertainty. Assessment confidence was determined by considering:

- quality and quantity of baseline data used in the assessment
- confidence in measurements and analytical techniques
- confidence in the success of mitigation
- potential changes in future environmental conditions (as appropriate)

The effects of climate change are included under prediction confidence discussions because of the uncertainty that climate change may have on predictions as well as the uncertainty associated with what specific climate changes may occur. Discussion is limited to the effects of climate change on the Project.

In addition, Project design and mitigation measures have been developed with the recognition of climate change.

1.1.9 Management and Monitoring

Management and monitoring are proposed to:

- confirm, where appropriate, that mitigation measures are functioning as predicted
- detect changes and trends in the environment
- identify cause-effect relationships for detected changes and trends in the environment

Management and monitoring may be project-specific or require participation in cooperative initiatives among other operators, stakeholders and Aboriginal communities.

1.2 Volume Content

The following information is provided in the people and places volume of this EIA:

- Introduction (Section 1)
- Palaeontology (Section 2)
- Historical Resources (Section 3)
- Resource Use (Section 4)
- Visual Aesthetics (Section 5)
- Traditional Land Use (Section 6)
- Peace-Athabasca Delta (Section 7)
- Appendices (on DVD)
    - FMFN Traditional Land Use Study (Appendix 6A)
    - Hydrological Baseline Information (Appendix 7A)
    - Summary of Water Quality (Appendix 7B)
    - Summary of Sediment Quality (Appendix 7C)
    - Temporal Trends for Selected PAH Species (Appendix 7D)

1.3 References

1.3.1 Literature Cited

AENV (Alberta Environment). 2009. *Final Terms of Reference Environmental Impact Assessment for the Proposed UTS Energy Corporation/Teck Cominco Limited Frontier Oil Sands Mine Project*. Alberta Environment. Edmonton, Alberta.

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Government of Canada. 2011. *Guidelines for the Preparation of an Environmental Impact Statement for the Comprehensive Study Process Pursuant to the Canadian Environmental Assessment Act.* Ottawa, Ontario.

2 Palaeontology

2.1 Introduction

This section of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project):

- recommends mitigation measures to reduce Project effects on palaeontology (in addition to mitigation required under the Alberta *Historical Resource Act* and associated permits)
- assesses the potential effects of the Project on paleontological resources during construction and operation phases of the development

Palaeontology provides information on ancient forms of animals and plants, past ecosystems, evolution, natural climate change and extinction. Palaeontological resources (fossils) are evidence of past multicellular life, including body fossils (e.g., bones, shells and plant stems), impressions (e.g., leaf imprints) and trace fossils (e.g., dinosaur trackways). They are thousands to hundreds of millions of years old and are often the remains of extinct species.

Palaeontological sites are non-renewable and are susceptible to alteration, damage and destruction by developments. The value of these resources cannot be measured in terms of individual fossils. Rather, the value of palaeontological resources lies in the integrated information derived from the interrelationships of the individual specimens, associated features, spatial relationships (distribution) and context. Interpretation of fossil material is based on an understanding of the nature of the relationship between fossils and the sediments and surrounding strata. Removal or mixing of these strata results in the permanent loss of information basic to the understanding of these resources. As a result, palaeontological resources are easily damaged or destroyed through disturbance.

A description of the Frontier Project is provided in Volume 1.

2.2 Scoping the Assessment

The scope of the palaeontology assessment was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by specific regulatory and public stakeholder inputs and concerns from potentially affected Aboriginal communities. Preservation of palaeontological sites was also identified as an important concern through the Alberta *Historical Resources Act.* These inputs helped identify the key issues of concern and define the key questions that are the focus of this assessment.

2.2.1 Terms of Reference

The requirements of the TOR relevant to palaeontology include:

- *Describe consultation with Alberta Culture and Community Spirit (ACCS) concerning the need for a Historic Resource Impact Assessment (HRIA) for the Project and:*
- *Provide an overview of the results of any previous historic resource studies that have been conducted in the Study Area, including archaeological resources, palaeontological resources, historic period sites and any other historic resources as defined within the* Historical Resources Act;
- *Summarize the results from the field program performed to assess archaeological, palaeontological and historic significance of the Local Study Area;*
- *Summarize the results of the HRIA conducted to assess the potential impact of the Project on archaeological, palaeontological and historic resources;*
- *provide an outline of the program and schedule of field investigations that ACCS may require UTS/Teck* [now SilverBirch/Teck] *to undertake to further assess and mitigate the effects of the Project on historic resources.*

For a concordance table of the TOR and palaeontology, see Volume 3, Section 1, Appendix 1A.

2.2.2 Regulatory Setting

Palaeontological resources are protected under the Alberta *Historical Resources Act,* which is administered by the Historic Resources Management Branch (HRMB) of ACCS. Under ACCS, the Royal Tyrrell Museum of Palaeontology (RTMP) issues permits, reviews permit reports and determines any additional work or mitigation measures needed for a development.

Final *Historical Resources Act* clearance and requirements for palaeontology are issued through the HRMB. Approval from the Minister of ACCS is required before a palaeontological site is disturbed.

2.2.3 Regulatory, Public and Aboriginal Community Input

Input from a variety of potentially affected Aboriginal communities, public stakeholders and regulatory sources informed the palaeontology assessment. Potential sources included meetings with regulators and Aboriginal community and public stakeholder consultations.

2.2.3.1 Regulatory and Public Stakeholder Input

Since 2006, the Owners (Teck Resources Limited [Teck] and SilverBirch Energy Corporation [SilverBirch]) have consulted with industry members, adjacent leaseholders and public stakeholders. Teck is the Operator of the Project and Applicant on behalf of the Owners.

Field program methods and scopes were reviewed and approved by the RTMP during the palaeontological permit application process (permit numbers Bohach-2007-06 and Bohach-2008-002). On June 6, 2008, Dean Wetzel (Land Use Planner, Oil Sands, ACCS) met with members of the Project team regarding the historical resources study area. To date, ACCS has not issued any requirement letters for the Frontier Project.

2.2.3.2 Aboriginal Community Concerns

Palaeontological information was presented at open houses held in Fort Chipewyan from 2008 to 2010 (see Volume 1, Section 17); the results of studies were displayed on maps and fossil material from the Birch Mountains was on display. A palaeontologist participated in these open houses to encourage discussion, answer questions from attendees and respond to and record issues and concerns raised with respect to palaeontological studies for the Frontier Project.

General concerns were raised about the Project affecting historical resources at a workshop held in Calgary (January 26 and 27, 2010) with the Athabasca Chipewyan First Nation and Mikisew Cree First Nation, and their technical specialists (Management and Solutions in Environmental Sciences [MSES]). In addition to general concerns, participants requested Aboriginal community participation in fieldwork.

Although only general concerns related to palaeontology have been raised in consultation undertaken to date, it is recognized that some palaeontological sites may also be considered traditional land use sites.

The results of the palaeontological studies will be presented to Aboriginal communities during consultation to ensure that any palaeontological sites recorded can also be evaluated from a traditional land use perspective.

Responses to concerns expressed by Aboriginal communities are provided following the assessment of each key issue. For a summary of the responses to Aboriginal community concerns, see Volume 1, Section 17.

2.2.4 Key Issue

Based on input gathered from regulatory sources and consultations with potentially affected Aboriginal communities and public stakeholders, one key issue was defined for the palaeontology assessment (see Table 2-1).

Table 2-1 Key Issue – Palaeontology

Project Phase	Key Issue	Relevance to Project
Construction and operation	Loss of palaeontological resources, loss of interpretive value, or both	Project activities will disturb strata with high palaeontological potential

2.2.5 Key Question

One key question was developed to address the key issue and focus the assessment:

- P1: Could the Frontier Project result in the loss of contents or disrupt the interpretive context of palaeontological sites?

2.3 Approach

2.3.1 Study Areas

The Project disturbance area (PDA) is 29,335 ha in extent and reflects the anticipated limit of disturbance at the completion of operations in 2057 (see Figure 2-1). The PDA is the area where potential Project effects on palaeontology were assessed.

The palaeontology survey area (see Figure 2-1) is the area where baseline data were collected. It includes land around the PDA where bedrock exposures occur. Geological and palaeontological data collected within the survey area is extrapolated to characterize subsurface conditions in the PDA.

2.3.2 Temporal Considerations

Palaeontological resources might be affected during Project construction and operation activities that cause ground disturbance in strata with high palaeontological potential. For assessment purposes, the area is considered to be equivalent to the maximum build-out snapshot (2057).

2.3.3 Effects Consequence

An adverse effect on palaeontological resources involves the destruction or disturbance of all or part of a palaeontological site. This effect, if not controlled through mitigation (investigation and documentation), results in the permanent loss of part of the non-renewable palaeontological record. Depending on the heritage value of the specific palaeontological site, a significant adverse effect could occur. A positive effect on palaeontological resources increases the knowledge of palaeontology through inventory, documentation, protection, interpretation or other means.

Loss of palaeontological resources and loss of site context are closely linked. As these effects are difficult to separate, they will be discussed together as a single effect.

As palaeontological resources are protected and regulated under the Alberta *Historical Resources Act*, any disturbances to palaeontological sites must be approved by the Minister of ACCS. The Minister determines the significance of the effect and any required mitigation. After any required project mitigation is completed, the Minister of ACCS gives approval for a project and no residual project effects or cumulative effects are recognized.

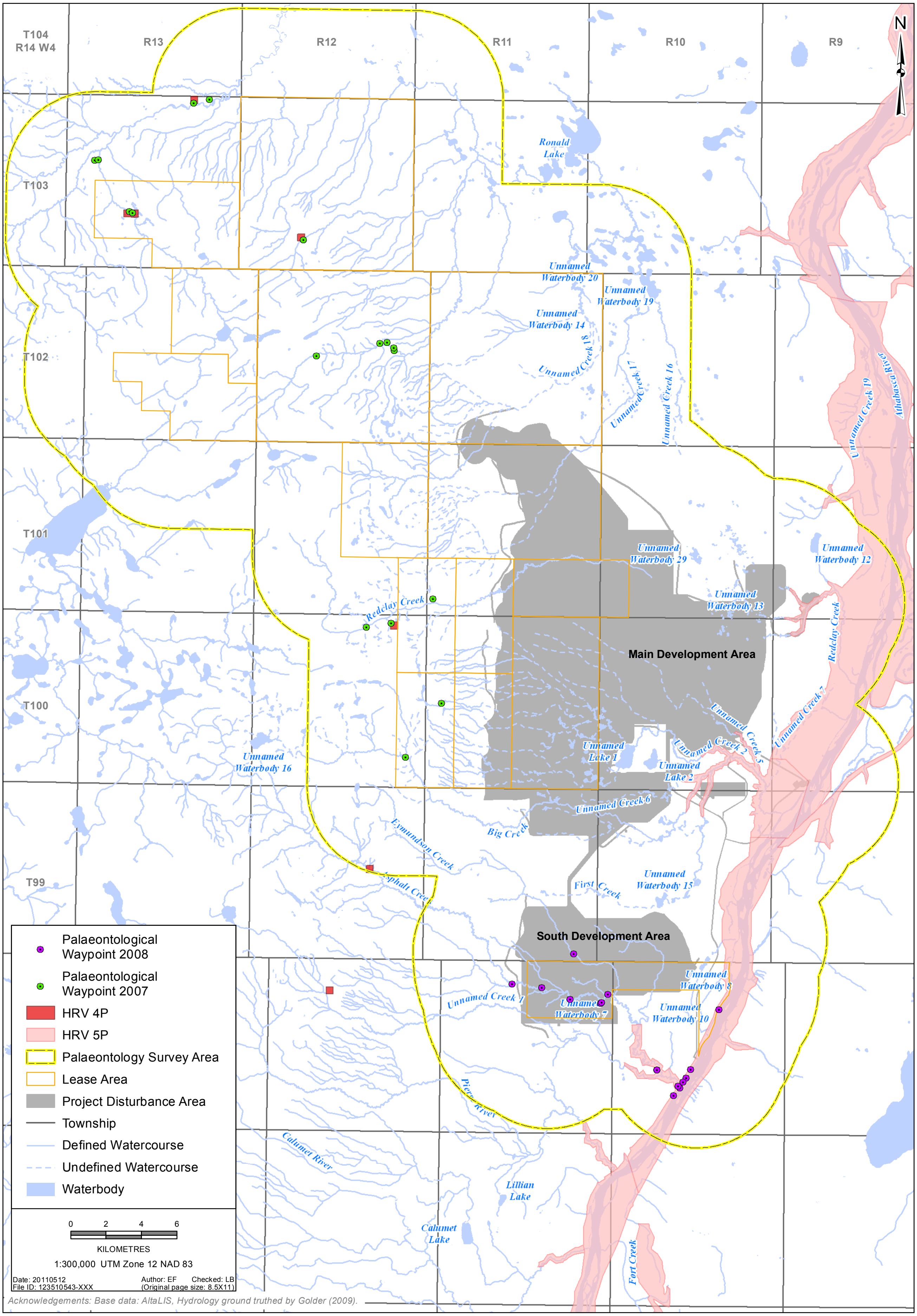

Figure 2-1: Palaeontology Survey Area

2.4 Overview of Baseline Conditions

Bedrock in the palaeontology survey area consists of a Lower to Upper Cretaceous succession of clastic strata sitting on a Devonian carbonate basement. The geology and palaeontology of the bedrock are summarized in Table 2-2.

Palaeontology field studies for the Project were conducted in 2007 and 2008 (Bohach and Frampton 2008; Bohach 2009). Five fossil sites were recorded within the Clearwater and Shaftesbury formations. The sites range from medium to high heritage value and document:

- a diverse invertebrate fauna, including ammonites, from the Clearwater Formation
- an ammonite and bivalve fauna in siltstone deposits of the Shaftesbury Formation
- a fish and marine reptile fauna in the fish scale marker bed of the Shaftesbury Formation

Table 2-2 Geology and Palaeontology of the Palaeontology Survey Area

Age	Formation	Lithology and Environment	Fossils	Palaeontological Potential
Lower to Upper Cretaceous	Shaftesbury	Marine shale	Ammonites, bivalves, fish, reptiles, plants	High
Lower Cretaceous	Pelican	Brackish to estuarine clastic deposits	Dinosaurs, reptiles, fish, plants and bivalves	High
	Joli Fou	Marine shale	Bony fish, sharks	High
	Grand Rapids[1]	Marginal marine sandstone	Ammonites, shark teeth, fish, reptile and dinosaur bones	High
	Clearwater	Marine shale over basal glauconitic sandstone	Ammonites, marine reptiles	High
	McMurray	Fluvial to brackish clastic deposits	Plants, molluscs, fish teeth, rare dinosaur bone	Low
Devonian	Waterways	Marine limestone and shale	Stromatoporoids, brachiopods, corals, bivalves, gastropods, conodonts, nautiloids, crinoids, fish	High
SOURCES: Compiled from Glass (1997) and Hamilton et al. (1999)				

In addition to the above fossil sites, ACCS (2011) also lists a sixth site of vertebrate material from the Pelican Formation within the palaeontology survey area (Bohach and Frampton 2007). Land within the survey area with high palaeontological potential that is currently listed as 5p by ACCS (2011) is restricted to areas along the Athabasca River and upstream along several of the tributaries.

Based on the literature review, field studies and ACCS (2011) *Listing of Historic Resources*, the Waterways, Clearwater, Grand Rapids, Joli Fou, Pelican and Shaftesbury formations are strata with high palaeontological potential that occur in the palaeontology survey area.

For more information on palaeontology baseline conditions, see Volume 2, Section 10.

2.5 Palaeontology

2.5.1 Introduction

This section addresses key question P1: Could the Frontier Project result in the loss of contents or disrupt the interpretive contexts of palaeontology sites?

2.5.2 Methods

The effects assessment for palaeontology uses the baseline data (see Volume 2, Section 10) and Project disturbance information to evaluate where strata with high palaeontological potential will be disturbed. As palaeontological sites can be deeply buried, it is not possible to determine where they are prior to disturbance. Rather, if a stratum has high palaeontological potential, as documented by nearby fossil sites, the likelihood of effects on palaeontological resources is considered high if the stratum will be disturbed.

2.5.2.1 Data Sources

The following data sources were used in the palaeontology assessment:

- published literature on the geology and palaeontology (see Volume 2, Section 10)
- 2007 and 2008 field data (Bohach and Frampton 2008, Bohach 2009)
- 1:1,000,000 bedrock geology map (Hamilton et al. 1999)
- 1:250,000 surficial geology map (Bayrock 1971)
- ACCS (2011) *Listing of Historic Resources*
- Royal Tyrrell Museum of Palaeontology database (RTMP 2007, Internet site; Bancescu 2011, pers. comm.)

2.5.3 Effects Assessment

The Frontier Project will result in disturbance of only one stratum with high palaeontological potential: the Clearwater Formation. Although the Waterways Formation, another stratigraphic unit with high palaeontological potential, also occurs in the PDA, it is covered to sufficient depth with surficial materials or the McMurray Formation that it will not be disturbed.

The bitumen-saturated McMurray Formation, which is the target of the mining operation, is overlain by the Clearwater Formation. Overburden removal in the mine pits, and possibly excavation of the drainage ditches, will disturb the Clearwater Formation. Eight skeletons of marine reptiles (ichthyosaurs, pliosaurs and elasmosaurs) were recovered during overburden removal of the Clearwater Formation in Syncrude Canada’s Mildred Lake open-pit oil sands mine (Druckenmiller and Russell 2003). More than 200 invertebrate specimens, mostly ammonites, were also recovered from the Clearwater Formation during excavation of the water intake for the Fort Hills Oil Sands Project (Frampton and Bohach 2009). Similarly, it is likely that disturbance of the Clearwater

Formation during Project activities will affect palaeontological resources of high heritage value.

2.5.4 Mitigation

The following mitigation measures were recommended by the palaeontological consultant (Bohach and Frampton 2008; Bohach 2009):

- development of a *Palaeontological Monitoring Plan*, detailing how a professional palaeontologist will monitor excavation through those horizons with the greatest palaeontological potential, where safe to do so
- formulation of a *Discovery Protocol* to deal with discovery and recovery of fossils of high heritage value found during mining
- development of a *Palaeontological Education Program*, to teach mine workers what to watch for and how to implement the *Discovery Protocol*
- evaluation of final mine plans and their intersection with strata of high palaeontological potential

Any required mitigation measures for palaeontological resources will be determined by the RTMP and ACCS, subsequent to review of the palaeontological assessment documents. Palaeontological resources will be protected and any issued mitigation requirements will be addressed.

2.5.5 Responses to Aboriginal Community Concerns

Historical resources baseline studies included participation of Aboriginal community members as part of field studies when logistics allowed. Effects to palaeontological resources will be mitigated following direction from RTMP and ACCS.

2.5.6 Management and Monitoring

No management or compliance monitoring programs are planned for palaeontology. See Section 2.5.4 for palaeontological construction monitoring.

2.5.7 Summary

The Frontier Project will result in disturbance of the Clearwater Formation during overburden removal in the mine pits and possibly during excavation of the drainage ditches. The Clearwater Formation has high palaeontological potential and has yielded marine reptiles and ammonites at other sites, which are fossils of high heritage value. There is a high likelihood that the Project will affect palaeontological resources of high heritage value.

The RTMP and ACCS will determine what mitigation measures are necessary to address Project effects on palaeontology. After any required mitigation is completed, the Minister of ACCS gives approval for the Project and no residual Project effects or cumulative effects are recognized.

2.6 References

2.6.1 Literature Cited

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2.6.2 Personal Communications

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2.6.3 Internet Sites

RTMP (Royal Tyrrell Museum of Palaeontology). 2007. *Heritage Resources Management Information System Internet Site.* Alberta Tourism, Parks, Recreation and Culture and Government of Alberta. Available at: http://hermis.cd.gov.ab.ca/rtmp/Default.aspx. Accessed June 1, 2007.

3 Historical Resources

3.1 Introduction

This section of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project):

- describes mitigation to reduce Project effects on archaeological sites
- summarizes the results of archaeological Historical Resources Impact Assessments (HRIAs) submitted for the Project
- assesses effects of the Project on the site contents, site context, and interpretive value of the archaeological sites in the Project disturbance area

Historical resources comprise residues of past cultures or societies, and are non-renewable resources. Although the cultures responsible for depositing archaeological material cannot be observed, the preserved context and associations related to the remains can reveal much about past human behaviour, adaptations and relationships. Patterns of cultural deposition are fragile, ephemeral and the product of unique processes and conditions of preservation. Therefore, site integrity is important for interpreting archaeological remains. Once a site is disturbed, context cannot be replaced, recreated or restored.

3.2 Scoping the Assessment

The scope of the assessment for historical resources was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by specific regulatory and public stakeholder inputs including the Alberta *Historical Resources Act*. Concerns from potentially affected Aboriginal communities were also considered in scoping the assessment. These inputs helped identify the key issues of concern and define the key questions that are the focus of this assessment.

3.2.1 Terms of Reference

The requirements of the TOR relevant to historical resources include:

- *Describe consultation with Alberta Culture and Community Spirit (ACCS) concerning the need for a Historic Resource Impact Assessment (HRIA) for the Project, and:*
- *Provide a general overview of the results of any previous historic resource studies that have been conducted in the Study Area, including archaeological resources, palaeontological resources, historic period sites, and any other historic resources as defined within the* Historical Resources Act;
- *summarize the results from the field program performed to assess archaeological, palaeontological and historic significance of the Local Study Area [LSA];*

- *summarize the results of the HRIA conducted to assess the potential impact of the Project on archaeological, palaeontological and historic resources;*
- *provide an outline of the program and schedule of field investigations that ACCS may require UTS/Teck* [now SilverBirch/Teck] *to undertake to further assess and mitigate the effects of the Project on historic resources;*
- *document any stakeholder concerns with respect to the development of the Project based on the historic significance of the Study Area; and,*
- *consult with aboriginal communities and groups regarding historical resources in the Study Area(s) including but not limited to their knowledge of existing historical resources, their concerns and recommendations regarding these and opportunities for participation (e.g., blessing ceremony on known burial grounds, participation in HHRA field studies). Document any concerns and proposed mitigative actions.*

For a concordance table of the TOR and historical resources, see Volume 3, Section 1, Appendix 1A. Note that palaeontological resources are considered in Section 2.

3.2.2 Regulatory Setting

Historical resources are protected under the Alberta *Historical Resources Act*, which is administered by the Historic Resources Management Branch (HRMB) of Alberta Culture and Community Spirit (ACCS). Alberta Culture and Community Spirit issues requirements for project-related historical resources studies, and issues *Historical Resources Act* clearance for a project to proceed. Under the Act, no effect can occur to any historical resource site without approval of the Minister of ACCS.

3.2.3 Regulatory, Public and Aboriginal Community Input

Input from a variety of potentially affected Aboriginal communities, public stakeholders and regulatory sources informed the historical resources assessment. These sources included meetings with regulators and Aboriginal community and public stakeholder consultations.

3.2.3.1 Regulatory and Public Stakeholder Input

Since 2006, the Owners (Teck Resources Limited [Teck] and SilverBirch Energy Corporation [SilverBirch]) have consulted with industry members, adjacent leaseholders and public stakeholders. Teck is the Operator of the Project and Applicant on behalf of the Owners.

Four permit applications to conduct field studies have been reviewed by ACCS (Permit 2006-576 [Youell 2007]; Permit 2008-265 [Gryba and Tischer 2009a]; Permit 2008-192 [Gryba and Tischer 2009b]; Permit 2010-123 [Roskowski et al. 2011]).

A meeting was held on June 6, 2008, between the proponent, Stantec, and Dean Wetzel of ACCS to discuss the Project and the appropriate approaches to addressing historical resources concerns. In addition, Robin Woywitka of ACCS visited the Frontier Project during the historical resources field studies on September 23, 2010. To date, ACCS has not issued any *Historical Resources Act* requirement letters for the Frontier Project.

3.2.3.2 Aboriginal Community Concerns

Historical resources information was presented at open houses held in Fort Chipewyan and Fort McKay from 2008 to 2010 (see Volume 1, Section 17); the results of studies were displayed on maps and some artifacts were on display. An archaeologist participated in these open houses to encourage discussion, answer questions from attendees and record and respond to issues and concerns raised about historic resources studies for the Frontier Project.

Issues and concerns related to historical resources expressed during consultations with potentially affected Aboriginal communities included:

- concerns about trails, burials and spiritual sites

It is recognized that some traditional use sites are also considered historical resources. As such, any traditional use sites identified during the historical resources studies or other Project-related studies (such as the traditional land use assessment) will be reviewed to ensure that all historical resource sites are documented, and to ensure that any traditional knowledge related to historical resources is considered.

In addition to specific concerns, a request for Aboriginal community participation in fieldwork was raised at a workshop held in Calgary (January 26 and 27, 2010) with the Athabasca Chipewyan First Nation and Mikisew Cree First Nation, and their technical specialists (Management and Solutions in Environmental Sciences [MSES]).

Responses to concerns expressed by Aboriginal communities are provided following the assessment of each key issue. For a summary of the responses to Aboriginal community concerns raised during consultation activities for the Frontier Project, see Volume 1, Section 17.

3.2.4 Key Issue

Based on input gathered from regulatory sources and consultations with potentially affected Aboriginal communities and public stakeholders, one key issue was defined for the historical resources assessment (see Table 3-1).

Table 3-1 Key Issue – Historical Resources

Project Phase	Key Issue	Relevance to Project
Construction	Loss of historical resources site contents and context and associated interpretive value	Project construction activities will disturb historical resources site contents and site context, and will thus affect the interpretive value of historical resources sites.

3.2.5 Key Question

One key question was developed to address the key issue and focus the assessment on the issue of concern. The key question for the historical resources assessment is:

- HR1: Could the Frontier Project result in the loss of contents and site context of historical resource sites, thereby affecting the interpretive value of sites?

3.3 Approach

3.3.1 Study Area

Vegetation clearing and construction of project components affects historical resources by disrupting the sediments that contain archaeological and historic sites, which are discrete and immovable, thereby affecting the site contents and context. As such, the Project disturbance area (PDA) is the relevant study area for historical resources sites. The Project disturbance area (PDA) is 29,335 ha in extent and reflects the anticipated limit of disturbance at the completion of operations in 2057 (see Figure 3-1). It is assumed that the PDA represents the entire area that will be subjected to surface impacts, including impacts from vegetation clearing.

3.3.2 Temporal Considerations

Effects from the Project on historical resources are most likely to occur during the construction and commissioning phase, when site clearing and preparation and construction of facilities and infrastructure takes place. For assessment purposes, this is considered to be equivalent to the maximum build-out snapshot, which corresponds to 2057 (or Year 37). It is expected that all effects on historical resources will be mitigated before operation. Assuming that no additional land is acquired for the operation, decommissioning and closure phases, no additional effects on historical resources are anticipated.

3.3.3 Effects Consequence

Adverse effects on historical resources occur as a result of destruction or disturbance of historical resources site contents and context. This effect, if not controlled through mitigation (site documentation and investigation), results in the permanent loss of part of the non-renewable historical resources record. Depending on the heritage value of the specific historical resources site, a significant adverse effect could occur.

Historical resources are protected and regulated under the Alberta *Historical Resources Act*, and any effects on historical resources sites must be approved by the Minister of ACCS. The Minister determines the significance of the effect and any required mitigation. Once mitigation is completed, the Minister of ACCS gives approval for the project and no residual project effects or cumulative effects are recognized.

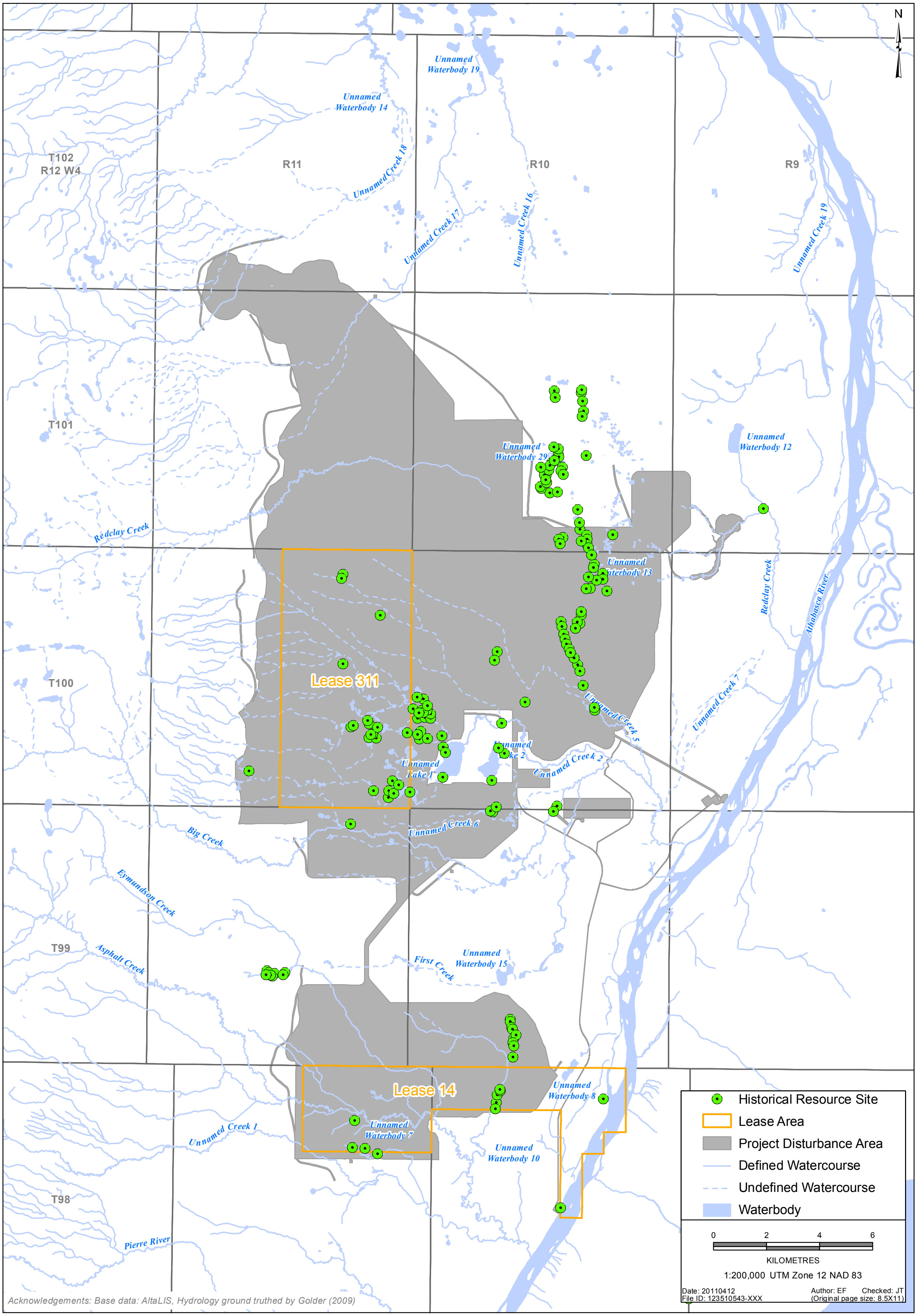

Figure 3-1: Historical Resources Sites

3.4 Overview of Baseline Conditions

Four HRIA studies conducted for the Frontier Project (Youell 2007; Gryba and Tischer 2009a, 2009b; Roskowski et al. 2011) suggest that overall archaeological potential near the Project is high, although the potential ranges from low to very high across the PDA.

In total, 153 archaeological and historic period sites were investigated during studies conducted for the Project: 151 precontact archaeological sites (isolated finds, artifact scatters, campsites) and 2 historic period sites (cabin and historic camp). Further study (additional assessment or mitigation studies) has been recommended at 140 of these sites prior to any impact, based on their perceived high value and interpretive potential. Interpretive potential at these sites is considered to be high because the known site contents and context indicate that additional investigation will contribute to the archaeological knowledge of Alberta.

3.5 Change in Historical Resources

3.5.1 Introduction

This section addresses key question HR1: Could the Frontier Project result in the loss of contents and site context of historical resource sites, thereby affecting the interpretive value of sites?

3.5.2 Methods

The effects assessment for historical resources included field studies designed to identify historical resources sites that could be affected by the Frontier Project. Those sites are assessed during field studies and during subsequent analysis, and a heritage value is assigned to each site based on a set of criteria that reflect the interpretive potential. Potential impacts to each site are determined by comparing the PDA with known historical resources sites.

Full HRIA studies have not yet been completed. Field assessment and desktop exercises identified areas that have not been fully assessed that have potential to contain historical resources. Although specific effects on these sites cannot be determined without knowing what resources they contain, some general effects can be predicted based on the archaeological potential of the area.

3.5.3 Effects Analysis

Of the 153 historical resources sites investigated for the Frontier Project, 103 are within the PDA and are expected to be disturbed during construction. Once the Project is approved, any sites with moderate to high heritage value will be subject to mitigation studies as formulated in each of the HRIA reports submitted to ACCS. Of the 103 sites in the PDA, 9 have low heritage value, and no further study has been recommended. The remaining 94 sites have been recommended for further study prior to any disturbance due to their moderate to high heritage value.

Overall the archaeological potential in the PDA is higher than most other areas within the Athabasca Oil Sands Region. The results of the four studies undertaken to date suggest that a number of areas within the PDA have not been sufficiently assessed with HRIA field studies, and it is anticipated that additional historical resources will be recorded and subsequently affected by the Project. However, completion of the required HRIA studies and implementation of all mitigation measures as required by ACCS will mitigate the effects on historical resources prior to construction.

3.5.4 Mitigation

Of the 153 sites investigated, 103 are currently within the PDA and are expected to be affected by the Frontier Project. Nine of these are interpreted as having low heritage value and no further study is recommended at those sites; any artifacts at these sites have been documented and collected. The remaining 94 sites within the PDA have moderate to high heritage value and further study is recommended, including:

- additional shovel testing to identify site boundaries, areas of highest artifact density, activity areas and areas with unique or specialized artifacts
- excavation of units in selected areas of sites with high interpretive potential, with recommendations for additional stages of excavation being formulated at those sites which produce significant archaeological deposits
- mapping and documentation of sites

Note that these are recommendations formulated by the archaeological team; ACCS will review and issue a schedule of requirements for the identified sites.

Additional historical resources assessment is also necessary, given that a number of areas with archaeological potential have not yet been assessed. Once all HRIA studies are completed and the Project is approved, the final PDA will be compared to the known site locations and any sites with moderate to high heritage value that will be disturbed will be subject to mitigation studies as required by ACCS.

3.5.5 Responses to Aboriginal Community Concerns

Aboriginal communities have expressed concerns about trails, burials and spiritual sites. These site types might be considered historical resources and will be recorded when encountered during the HRIA field studies to ensure adequate mitigation and consideration of Aboriginal community concerns. Identified sites would be recorded with ACCS as required under the *Historical Resources Act* to ensure their protection. In addition, as traditional knowledge studies become available, any information regarding sites that can be considered historical resources will be considered in the historical resources studies.

Historical resource baseline studies included participation of Aboriginal community members as part of field studies when logistics allowed. Members of local Aboriginal communities will be invited to participate in future historical resources assessments and mitigations where logistically feasible.

3.5.6 Management and Monitoring

Site-specific recommendations are formulated in the HRIA reports submitted to ACCS; however, only ACCS is responsible for issuing requirements relative to HRIA studies and mitigation studies. Requirements issued by ACCS could include site-specific mitigation studies as well as additional Project related studies such as monitoring of vegetation clearing or post-impact assessment studies.

A historical resources management plan will be implemented to track the status of studies and correspondence with ACCS, including *Historical Resources Act* clearance for Project components and for historical resources sites. Included in the management plan will be a statement on discovery protocol to ensure that any sites identified during future phases of the Project (i.e., construction) are properly managed. The management plan would also be the basis for ongoing review of changes to the PDA (including expansion of vegetation clearing areas) relative to the potential changes in effects on historical resources.

3.6 Conclusions

The Frontier Project PDA is located in an area rich in historical resources. Of the 153 heritage resource sites investigated during the studies, 140 have high heritage value and are recommended for further investigation if they will be affected. Of the 153 sites investigated during the studies, 103 sites are situated in the PDA and will be affected by the Project; 94 of these have high heritage value and are recommended for further studies relative to the Project.

ACCS regulates any effects to historical resources sites through the *Historical Resources Act*. ACCS independently assesses the significance of individual sites and determines the need for, and the scope of, mitigation measures. ACCS issues requirements for mitigation at identified historical resources sites, and issues *Historical Resources Act* clearance for the Project to proceed relative to historical resources. Consequently, project-specific effects on archaeological resources are continually mitigated to the standards set by the government. In this context, after implementation of mitigation measures as issued by ACCS, there will be no residual effect from the Project on historical resources.

3.7 References

3.7.1 Literature Cited

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Roskowski, L., M. Netzel and J.C. Tischer. 2011. Historical Resources Impact Assessment Final Report Teck/SilverBirch Frontier Project Permit 2010-123. Consultants report on file, Alberta Culture and Community Spirit. Edmonton, Alberta.

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4 Resource Use

4.1 Introduction

This section of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project) assesses the Project in the context of:

- the *Draft Lower Athabasca Regional Plan* (LARP)
- the *Fort McMurray–Athabasca Oil Sands Subregional Integrated Resource Plan* (IRP)

This assessment describes potential effects and mitigation for interactions between the Frontier Project and:

- aggregate and mineral resources
- forestry resources
- hunting and trapping resources
- sport fishing
- designated parks and protected areas
- environmentally significant areas (ESAs)
- recreation and tourism

A description of the Frontier Project is provided in Volume 1.

4.2 Scoping the Assessment

The scope of the assessment for resource use was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by specific regulatory and public stakeholder inputs and concerns from potentially affected Aboriginal communities. These inputs helped identify the key issues of concern and define the key questions that are the focus of this assessment.

4.2.1 Terms of Reference

The requirements of the TOR relevant to resource use include:

- *Identify the current land uses, including oil and gas development, agriculture, forestry, tourism, cultural use, food collection, trapping, fishing, hunting and other outdoor recreational activities.*
- *Identify and map all Crown land, including bed and shore as well as all Crown Reservations (Holding Reservations (DRS), Protective Notation (PNT), Consultative Notation (CNT).*

- *Identify and map unique sites or special features such as Parks and Protected Areas, Heritage Rivers, Historic Sites, Environmentally Significant Areas, culturally significant sites and other designations (World Heritage Sites, Ramsar Sites, Internationally Important Bird Areas, etc.).*
- *Identify any land use policies and resource management initiatives that pertain to the Project, and discuss how the Project will be consistent with the intent of these initiatives.*
- *Identify the potential impact of the Project on land uses, including:*
    - *impacts to unique sites or special features;*
    - *changes in public access, including secondary effects related to increased hunter, angler and other recreational access, decreased access to traditional use sites and facilitated predator movement, that may result from linear development;*
    - *the implications of relevant land use policies and resource management initiatives for the Project, including any constraints to development;*
    - *potential impacts to aggregate reserves that may be located on land under UTS/Teck's (now SilverBirch/Teck's) control and reserves in the region;*
    - *the impact of development and reclamation on commercial forest harvesting in the Project Area. Include opportunities for timber salvage, revegetation, reforestation and harvest for the reduction of fuel hazard;*
    - *the amount of commercial and non-commercial forest land base that will be disturbed by the Project. Compare the pre-disturbance and reclaimed percentages and distribution of all forested communities in the Project Area;*
    - *how the Project disturbance impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;*
    - *the potential impact on existing land uses of anticipated changes (type and extent) to the pre-disturbance topography, elevation and drainage pattern within the Project Area; and*
    - *implications of the Project on regional recreational activities, public access, Aboriginal land use and other land uses during and after development activities.*
- *Discuss possible mitigation strategies to address:*
    - *the need for, and plans to address, access management during and after Project operations;*
    - *the process for addressing the needs of other land users in the Local Study Area;*
    - *measures to mitigate impacts on land use created by the Project; and*
    - *how potentially affected aggregate reserves will be salvaged and stockpiled with input provided by Alberta Transportation and Alberta Sustainable Resource Development.*
- *Describe the residual effects of the Project on land use and UTS/Teck's (now SilverBirch/Teck's) plans to manage those effects.*
- *Describe any monitoring programs proposed to measure land use impacts resulting from the Project and the effectiveness of mitigation plans.*

For a concordance table of the TOR and resource use, see Volume 3, Section 1, Appendix 1A.

4.2.2 Regulatory Setting

Regulatory direction for the resource use assessment is provided primarily from the TOR. While they are not regulatory documents, a variety of regional management plans contain guidelines and objectives that were considered in this assessment. These plans are described in Section 4.2.3.4 and in Volume 2, Section 12.4.

4.2.3 Regulatory, Public and Aboriginal Community Input

Input from a variety of potentially affected Aboriginal communities, public stakeholders and regulatory sources influenced the resource use assessment. Potential sources included meetings with regulators, Aboriginal community and public stakeholder consultations and regional committees.

4.2.3.1 Regulatory and Public Stakeholder Input

Since 2006, the Owners (Teck Resources Limited [Teck] and SilverBirch Energy Corporation [SilverBirch]) have consulted with industry members, adjacent leaseholders, and public stakeholders. Teck is the Operator of the Project and Applicant on behalf of the Owners.

Key issues related to resource use were brought forward by regulators and public stakeholders at meetings and public hearings for similar oil sands developments, and during EIA reviews for these developments. Issues identified by public stakeholders and regulators include:

- changes in land use capability and resource use
- disturbance to existing land and resource use activities

Regulatory meetings provided input that influenced the development of the TOR issued for the Project.

Consultation with land users, such as outfitting companies, trappers and other industrial companies with facilities near the Project, influenced the resource use assessment. For example, correspondence and discussions with potentially affected outfitters near the LSA led to the development of some specific mitigation measures for the resource use assessment.

Aboriginal Community Concerns

Issues and concerns related to resource use expressed during consultations with potentially affected Aboriginal communities included the following:

- proximity of the Project to Namur and Moose Lakes, which are traditionally important, and the potential of the Project to impede access to these lakes

- proximity of the Project to the Birch Mountains and non-Aboriginal persons fishing and hunting in the area. Specific concern was expressed by the Athabasca Chipewyan First Nation (ACFN) about non-Aboriginal hunting of wood bison, which is a culturally significant species.
- access to traditional areas once development occurs
- cultural importance of large game species, particularly wood bison and woodland caribou, as well as moose and deer. Specifically, wood bison have been identified as a culturally significant species for the ACFN; the ACFN have expressed concern about the Project's potential impacts to the ability of community members to access and harvest this herd, non-Aboriginal hunting of the herd and overall impact to the health, viability and sustainability of the herd.

Responses to concerns expressed by potentially affected Aboriginal communities are provided following the assessment of each key issue. For a summary of the responses to concerns expressed during Aboriginal community consultations for the Project, see Volume 1, Section 17.

4.2.3.2 Regional Committees

The mandates and goals of the following regional committees and management plans were considered and where relevant, incorporated into the scope of this assessment:

- The *Fort McMurray-Athabasca Oil Sands Subregional IRP*, which contains goals and guidelines for resource development.
- The Lower Athabasca Regional Advisory Council (RAC) coordinated the development of the draft LARP, which contains objectives and strategies for regional land use planning. The finalization of LARP is anticipated during the last quarter of 2011 (Chris Vandenborn 2011, pers. comm.). If the final version is adopted, the land use goals, objectives and policies to be included in LARP will supersede or supplement those contained in the IRP.
- The Sustainable Ecosystems Working Group (SEWG) of the Cumulative Environmental Management Association (CEMA), whose purpose is to recommend a management system to address cumulative effects on ecosystems and landscapes in the RMWB through the pursuit of sustainable development and integrating environmental protection with economic growth and resource use.
- The Reclamation Working Group (RWG) of CEMA has identified reclamation strategies for the region, which have been incorporated into Project planning to mitigate potential effects of the Project in the long-term on resource use.
- The *Municipal Development Plan* for the Regional Municipality of Wood Buffalo (RMWB 2000), which is used by the RMWB to manage land uses within its municipal boundaries and to set directions for specific resource activities, including oil sands operations. Although the RMWB has no direct decision-making authority for energy project dispositions, it does have within its authority the right to grant development permits under its Land Use Bylaw (RMWB 1999). A development permit will not be issued until the applicant holds a current license, permit, approval, or other authorization from the Energy Resources Conservation Board (ERCB), and any other government licenses, permits, approvals, or authorizations required. As part of granting a development permit, the Development Officer may impose conditions

consistent with provincial approvals (RMWB 1999). Energy operators must comply with the Municipality's land use orders and bylaws.

- The Oil Sands Developers Group (OSDG), an industry-funded association which represents oil sands operators and developers, and works in cooperation with related industries, government, Aboriginal peoples, and other organizations active in the Athabasca oil sands region to define and address regional issues related to oil sands development.

4.2.4 Key Issues

Based on input gathered from consultations with potentially affected Aboriginal communities and public stakeholders, a series of key issues were defined for the resource use assessment. A summary of the key issues for each phase of the Frontier Project and their relevance to the Project are summarized in Table 4-1.

Table 4-1 Key Issues – Resource Use

Project Phase	Key Issue	Relevance to the Project
Construction and operation	Changes in land use capability and resource use	• Project development will result in vegetation clearing, terrain alteration and disturbance, and noise during construction and operation. This will result in reductions of certain land uses, changes in land use capabilities, and changes to the availability of resources in the Project assessment area (PAA).
Construction	Disturbance to existing land and resource use activities	• Construction of the Project can result in restricted access and increased noise in the PAA, which can interfere with existing land and resource use activities.
Closure	Change in land use capability and resource use	• At closure, the landscape will have topographic, vegetation and drainage characteristics that differ from pre-disturbance conditions. This may result in changes in land use capabilities and changes in the availability of resources in the PAA.
Closure	Disturbance to existing land and resource use activities	• Closure of the Project can result in restricted access in the PAA, which can interfere with existing land and resource use activities.
All phases	Consistency with land and resource use goals, objectives and policies	• The Project is located on Alberta Crown lands in the planning area boundaries of certain provincial land use planning policy documents (IRP and draft LARP). The goals, objectives and policies of these documents apply to construction, operation and closure of the Project.

Other disciplines and sections in this application also identified resource use-related issues; however, all resource use issues are assessed in this section. For the details of related assessments, see:

- traditional land use – Section 6
- fish and fish habitat – Volume 5, Section 5
- surface water quality – Volume 5, Section 4

- wildlife – Volume 6, Section 4
- closure, conservation and reclamation (CC&R) plan – Volume 1, Section 13

4.2.5 Key Questions

Nine key questions were developed to address the key issues and focus the assessment on these issues of concern. The key questions for the resource use assessment are:

- R1: Is the Frontier Project consistent with regional management goals of the draft *Lower Athabasca Regional Plan* (LARP)?
- R2: Is the Frontier Project consistent with regional management goals of the *Fort McMurray Athabasca Oil Sands Subregional IRP*?
- R3: Could the Frontier Project affect aggregate and mineral resources?
- R4: Could the Frontier Project affect forestry?
- R5: Could the Frontier Project affect hunting and trapping?
- R6: Could the Frontier Project affect sport fishing?
- R7: Could the Frontier Project affect designated parks and protected areas?
- R8: Could the Frontier Project affect environmentally significant areas?
- R9: Could the Frontier Project affect recreation and tourism?

4.3 Approach

4.3.1 Study Areas

4.3.1.1 Study Area

The Project is located approximately 110 km north of Fort McMurray on the west side of the Athabasca River near the Birch Mountains, in Townships (Twps) 98 to 102, Ranges (Rges) 10 and 11, West of the Fourth Meridian (W4M).

Study areas for the resource use assessment were selected on both local and regional scales to examine the potential cumulative changes resulting from the Frontier Project and other operating, approved or planned developments.

4.3.1.2 Local Study Area

The local study area (LSA) is where environmental effects on resource use can be predicted with a reasonable degree of accuracy and confidence, and where environmental effects are likely to be most concentrated. The resource use LSA is identical to the terrestrial LSA (see Figure 4-1), and is an area defined by an average 500 m buffer surrounding the Project assessment area (PAA). The resource use section also makes reference to the Project disturbance area (PDA) and the PAA. The PDA reflects the areas where soil stripping and vegetation clearing will occur, while the PAA incorporates all of the PDA plus additional areas where vegetation may be cleared by the Project. Therefore, the PDA and PAA are useful study areas to reference for assessing the resource uses such as forestry and hunting and trapping that are most dependant on the presence of vegetation.

The LSA includes all or part of Twps 98 to 102, Rges 9, 10 and 11 W4M.

The LSA is 48,958 ha.

4.3.1.3 Regional Study Area

The regional study area (RSA) is where environmental effects from the Project could interact with environmental effects from other projects or developments. A single resource use RSA was chosen to consider effects at the regional level (see Figure 4-2). The resource use RSA follows the planning boundaries of the RMWB and is approximately 6,716,400 ha in size. The RMWB was chosen as the RSA because it is the most relevant, largest and most logical resource use planning area that encompasses the LSA.

4.3.2 Assessment Cases

Resource use key issues and associated key indicators were evaluated in the context of the following conditions:

- Base Case, which includes developments that are currently operating or under construction, activities approved but not yet constructed or those likely to be approved in the near future
- Application Case, which includes developments and activities in the Base Case with the Frontier Project added
- Planned Development Case (PDC), which includes developments and activities included in the Application Case with other planned developments that are reasonably foreseeable added

For more details on the assessment cases and the related developments and activities included in each case and of relevance to the resource use assessment, see Volume 3, Section 1, Appendix 1C.

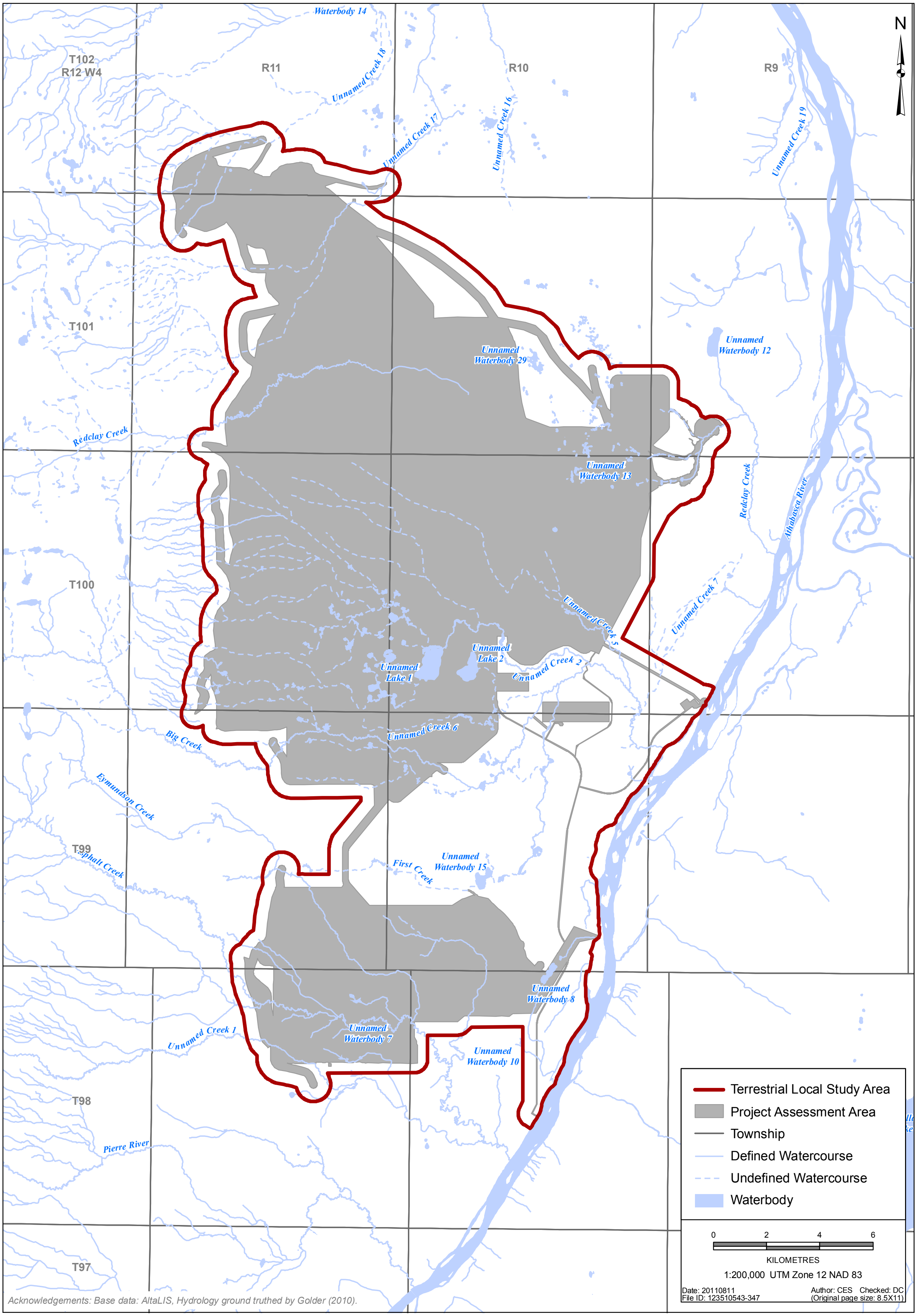

Figure 4-1: Resource Use LSA

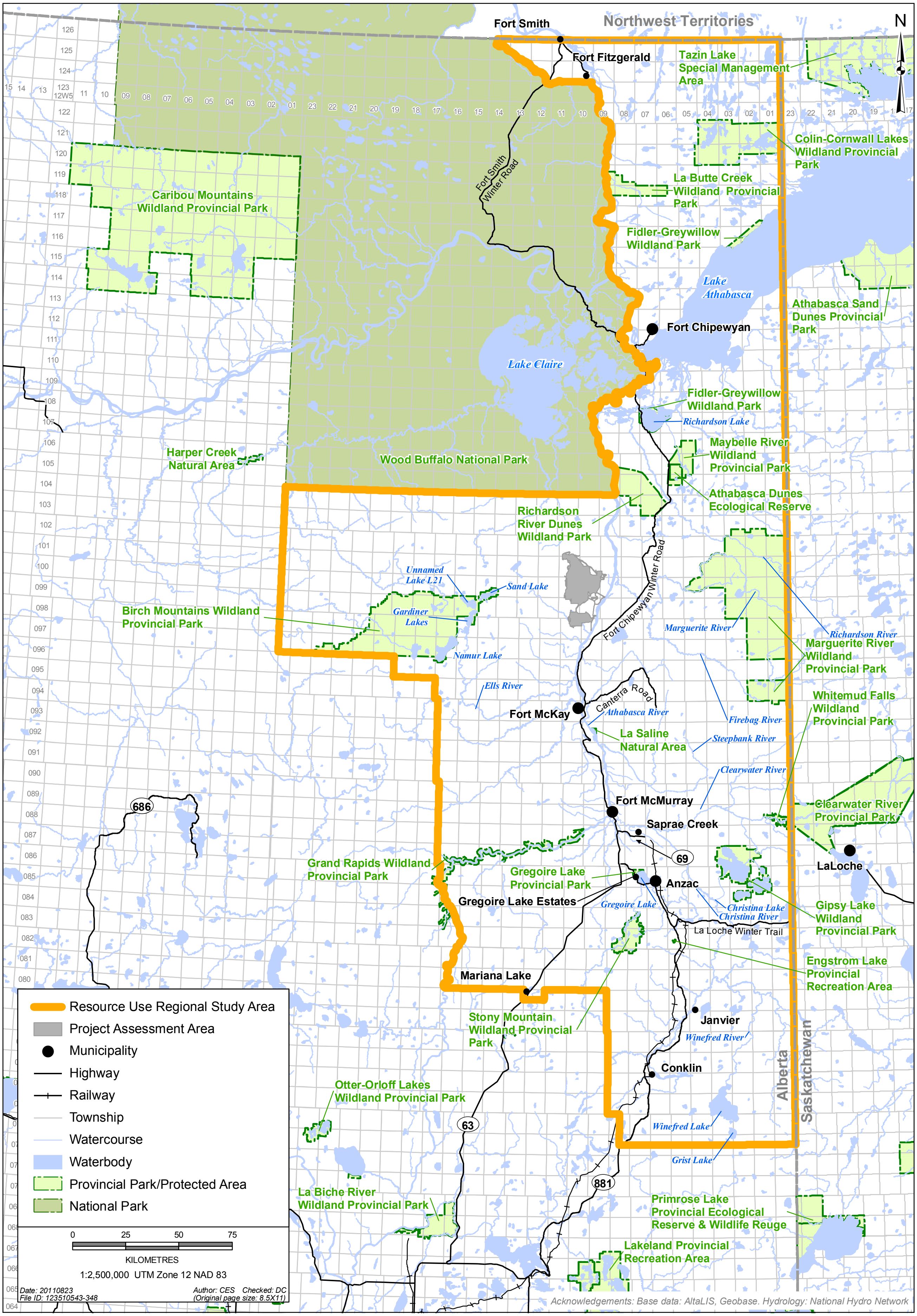

Figure 4-2: Resource Use RSA

4.3.3 Temporal Considerations

4.3.3.1 Reference Conditions

To provide a reference for the assessment of current resource use key issues and associated key indicators, reference condition or reference snapshot was evaluated at the following specific point in time:

- existing (2010)

4.3.3.2 Snapshots

In addition to the reference condition snapshot, the following temporal snapshots were used to evaluate changes for the Frontier Project, in combination with other developments, on resource use as applicable:

- maximum build-out (Year 37) (2057)
- closure (2068)

For maximum build-out or peak production, the date represents the point when maximum land disturbance occurs.

For the EIA, disturbances associated with developments other than the Project are always included as unreclaimed, with the exception of the Shell Pierre River Mine (PRM) fish habitat compensation lake, which is defined as water. As a result, any predicted cumulative effects are conservative (i.e., the assessments overpredict cumulative effects associated with vegetation disturbance).

4.3.4 Key Indicators

To focus the assessment, key indicators and measureable parameters were chosen for each key question. These were examined at the appropriate scale (i.e., local and/or regional) for each key question. At least one measurable parameter was selected for each key question to provide a means of measuring and assessing effects of the Project. See Table 4-2 for a list of key indicators and measurable parameters for each key question.

Table 4-2 Key Indicators – Resource Use

Key Question	Effects Pathway	Key Indicator	Measureable Parameters	Spatial Consideration
R1: Is the Project consistent with regional management goals of the draft LARP?	Consistency with land and resource use goals, objectives and policies	• *Draft* LARP	• Management plan goals	RSA
R2: Is the Project consistent with regional management goals of the *Fort McMurray Athabasca Oil Sands IRP*?	Consistency with land and resource use goals, objectives and policies	• *Fort McMurray Athabasca Oil Sands Subregional IRP*	• Management plan goals	RSA
R3: Could the Project affect aggregate and mineral resources?	Reduction in volume of aggregate or mineral resources from project construction or operation	• Aggregate and mineral resources	• Aggregate volume	RSA
R4: Could the Project affect forestry?	Reduction in timber volume from project construction or operation	• Timber resources	• Volume of merchantable timber • Timber productivity • Land capability	LSA
R5: Could the Project affect guiding, hunting and trapping opportunities?	Reduction in guiding, hunting or trapping opportunities from Project construction or operation	• Hunting and trapping resources	• Quality of wildlife habitat for moose, black bear, bison, waterfowl, beaver, fisher, marten and lynx in the LSA and the quantity that will be removed by the Project	RSA
R6: Could the Project affect sport fishing?	Reduction in fishing opportunities from Project construction or operation	• Fishing resources	• Number of highly-rated or popular recreational sport fishing sites in the LSA and known access routes in the LSA which connect to such sport fishing sites	LSA
R7: Could the Project affect designated parks and protected areas?	Reduction in areal extent of parks or protected areas from Project construction	• Parks and protected areas	• Area of Parks and Protected Areas	RSA
R8: Could the Project affect environmentally significant areas?	Reduction in areal extent of ESAs from Project construction	• Environmentally significant areas	• Areal extent of ESAs	LSA
R9: Could the Project affect recreation and tourism?	Reduction in recreation or tourism opportunities from Project construction or operation	• Recreation and tourism resources	• Number of recreational sites/facilities (i.e., campgrounds, provincial recreational areas, designated walking trails) • Known access routes in the LSA which lead to important recreational areas or facilities	LSA

The criteria used to select key indicators and the methods used to evaluate effects of the Project are described in the following sections:

- alignment of regional management goals in the draft LARP, see Section 4.6
- alignment of regional management goals in the *Fort McMurray Athabasca Oil Sands IRP*, see Section 4.7
- effects on aggregate and mineral resources, see Section 4.8
- effects on timber resources, see Section 4.9
- effects on hunting and trapping, see Section 4.10
- effects on sport fishing, see Section 4.11
- effects on designated parks and protected areas, see Section 4.12
- effects on environmentally significant areas, see Section 4.13
- effects on recreation and tourism, see Section 4.14

4.3.5 Prediction Confidence

4.3.5.1 Rationale

Assessment of project effects has some inherent uncertainty associated with data, methods and the predictive nature of the assessment. In addition, changes in future environmental conditions could also result in added uncertainty. Assessment confidence was determined by considering:

- quality and quantity of baseline data used in the assessment
- confidence in the success of Project-specific mitigation measures
- potential changes in future environmental conditions, such as possible climate change influences on resource use

The effects of climate change are included under prediction confidence discussions because of the uncertainty that climate change might have on predictions, as well as the uncertainty associated with what particular climate changes might occur.

In addition, Project design and mitigation measures were developed with the recognition of climate change.

4.3.5.2 Climate Change

Climate is one of the primary controls of vegetation distribution and occurrence on the landscape. Alterations to vegetation patterns due to climate change in turn can alter the distributions of wildlife species, both herbivores who feed on certain vegetation and the carnivores that feed on the herbivores. This alteration of wildlife distributions can affect hunting and trapping opportunities. For example, popular big-game hunting areas could expand north as climate change occurs. Additionally, through its effect on vegetation, climate change could affect the outcome of reclamation plans, so that end land use potential might be different from what was planned following closure.

4.4 Overview of Baseline Conditions

The two main land use policy documents applicable to the Project are the:

- *Draft Lower Athabasca Regional Plan* (LARP) (Government of Alberta 2011)
- *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan* (ASRD 2002). The most southerly portion of the LSA is located in the Mildred–Kearl Lakes Resource Management Area (RMA) of the IRP, with areas of the LSA near the bank of the Athabasca River falling in part of the Athabasca-Clearwater RMA

For details about these two documents, see Sections 4.5 and 4.6.

Land use objectives, strategies, goals, and statements from these two policy documents specific to the land use types that are assessed in this report are listed within the Application Case for these land use types.

Resource use baseline conditions in the LSA and RSA for the land use types that are assessed in this report are summarized in the Reference Conditions sections for these land use types (see Sections 4.7.3, 4.8.3, 4.9.3, 4.10.3, 4.11.3, 4.12.3 and 4.13.3).

See Volume 2, Section 12 for a full description of resource use baseline conditions.

4.5 Lower Athabasca Regional Plan

This section addresses key question R1: Is the Frontier Project consistent with regional management goals of the draft LARP?

The objectives and strategies from the implementation plan component of the draft LARP related to resource use that are most applicable to the Project include the following:

Objectives

- Opportunities for the responsible exploration, development and extraction of energy, mineral and coal resources are maintained.
- Future shortfalls in timber supply are prevented.
- The regional network of conservation areas to support biodiversity and ecosystem function is enhanced.
- To avoid or mitigate land disturbance effects to biodiversity.
- A wide range of recreation and tourism opportunities are provided that meet the preferences of regional residents and visitors.

Strategies

- Minimize loss of productive forest land. Industrial and commercial operators on public land will use an integrated land management approach including practices such as planning common major access corridors (shared roads) and infrastructure (lodges, remote air strips), progressive reclamation of disturbed lands that are no longer needed to support oil sands development and timely removal and reclamation of linear disturbances.
- Implement the progressive reclamation strategy enhancing the suite of policies, strategies and reporting mechanisms used to drive progressive ongoing reclamation of mining operation. The strategy includes an enhanced reclamation certification process, a transparent public reporting system for reclamation progress and a new progressive reclamation financial security program.
- Increase the amount of provincial Crown land under a conservation designation (see Schedules A and B of the draft LARP).
- 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 (e.g., serviced and un-serviced campgrounds, day-use areas, boat launches, motorized staging areas, designated motorized and non-motorized trails, private sector lodges and developments) (see Schedules A and B).
- Designate public land areas for recreation and tourism in the region that contain unique features or settings to address the growing demand for recreational opportunities in the region and provide an attractive land base for tourism investment (see Schedules A and B of the draft LARP).
- Collect regional data including the completion of a recreation and tourism resource inventory, a scenic resource assessment inventory and a regional recreational demand and satisfaction survey. Data collected will inform recreational planning and priority infrastructure development on provincial Crown land.

The Project is consistent with the vision, outcomes, objectives, strategies and statements of the draft LARP. For information on resource-specific objectives, strategies, and statements, see discussions in the Application Case of each of the specific land use types that are assessed in this report.

4.6 Fort McMurray Athabasca Oil Sands IRP

This section addresses key question R2: Is the Frontier Project consistent with regional management goals of the *Fort McMurray Athabasca Oil Sands IRP*?

The LSA is located partially within the boundaries of the *Fort McMurray–Athabasca Oil Sands Subregional Integrated Resource Plan* (*IRP*). This IRP is subdivided into five RMAs. The most southerly portion of the LSA is located in the Mildred–Kearl Lakes RMA, with areas of the LSA near the bank of the Athabasca River falling in part of the Athabasca-Clearwater RMA.

The goal of the Mildred-Kearl Lakes RMA is to promote orderly planning, exploration and development of resources with emphasis on the area's oil sands reserves (ASRD 2002). The following three goals of the RMA are relevant to the Project:

- To provide opportunities for industry to further identify the extent of oil sands reserves that can be surface mined
- to encourage the orderly, efficient development and production of oil sands reserves that can be surface mined, and to optimize regional and provincial economic and employment benefits
- to encourage the recovery of other valuable mineral, aggregate and surface material resources during the mining and processing of oil sands

The management objective of the Athabasca-Clearwater RMA is to explore and develop mineral and surface material resources in a manner that ensures protection of and minimizes the impacts to unstable slopes, watershed, ecological, historical, traditional and recreational values of the RMA (ASRD 2002).

The Project is consistent with the above goals of the Mildred–Kearl Lakes RMA. With implementation of vegetation, wildlife, traditional use and resource use mitigation measures, the Project will be adhere to the objectives of the Athabasca–Clearwater RMA. For information on resource specific IRP guidelines, see the discussion in the sections following.

4.7 Aggregate and Mineral Resources

4.7.1 Introduction

This section addresses key question R3: Could the Frontier Project affect aggregate and mineral resources?

Within the RSA, aggregate resources and industrial minerals are important resources that are used for the construction and maintenance of roads, infrastructure, concrete production, and industrial processes.

4.7.2 Methods

Data on quantities and sources of aggregate and mineral in the RSA, and estimated aggregate requirements for the Project were used to qualitatively assess the effects of current and future aggregate demands on the availability of the resource. The Project was also evaluated for consistency with the objectives and strategies of the draft LARP and the guidelines in the IRP.

4.7.2.1 Quality Assurance and Quality Control

All data for this assessment was collected during literature reviews.

Data used in this assessment was primarily provided by:

- regional committees
- industrial operators in the area
- consultant reports for the area

4.7.2.2 Data Sources

Data was obtained from reports and websites for companies in the RSA with existing or planned aggregate or mineral operation, including the following:

- Hammerstone Corporation, which operates the Muskeg Valley Quarry, and is proposing an expansion of the quarry called the Hammerstone project
- Parsons Creek Resources, which is proposing a limestone quarry project
- Athabasca Minerals Inc., which operates the existing Susan Lake and Poplar Creek Gravel pits, and has obtained approval for the proposed Kearl Pit

4.7.2.3 Models and Assumptions

No modelling was completed in the assessment of the effects of the Project on aggregate resources.

4.7.3 Reference Conditions

There are no operating aggregate pits or mineral mines intersecting the LSA.

A few aggregate resource studies have been completed in the Athabasca River area of the Athabasca Oil Sands region in the past (Shetsen 1980; Fox 1980; Fisher et al. 1995; Rhine and Smith 1988). These studies have generally found the area to have limited aggregate resource potential, with the deposits consisting mostly of sand with only a few minor gravel beds.

Traditional aggregate resources such as sand and gravel are currently in limited supply in the RSA. In 2006, the total supply of traditional aggregate resources in the Athabasca Oil Sands Region was estimated to be about 80 to 100 million tonnes (Birch Mountain Resources 2006). Currently, the largest operating pits in the RSA are the 3,750 ha Susan Lake Gravel Pit and the 1,490 ha Poplar Creek Gravel Pit, both operated by Athabasca Minerals Inc., and the Muskeg Valley Quarry, operated by Hammerstone Corporation. As of the end of 2010, approximately 845 ha (23%) of the Susan Lake Gravel Pit had been developed, and 57.8 million tonnes of sand and gravel had been removed since 1998 (Athabasca Minerals Inc. 2010). Meanwhile, most of the gravel at Poplar Creek has been extracted, but the pit still contains a significant amount of sand that is still in demand (Athabasca Minerals Inc. 2011a, Internet site).

4.7.4 Base Case

Fort Hills Energy Corp. holds an active Surface Materials Exploration (SME) disposition in the LSA. A SME disposition gives a company the right to conduct an exploration program for surface materials (sand and gravel) to determine if there are sufficient quantities of aggregate to support a commercial operation. In addition, two companies Hammerstone Corporation and Athabasca Minerals Inc., hold several active Metallic and Industrial Minerals Permits or Leases in the LSA. A minerals permit gives a company the exclusive right to explore for minerals while a minerals lease gives a company the exclusive right to develop and mine mineral resources (i.e., gold, silver, iron and other precious metals, diamonds, gypsum, salt, limestone, sandstone, and granite) for the specified location. Hammerstone holds three mineral permits and seven mineral leases, while Athabasca Minerals holds four minerals permits in the LSA (based on the Alberta Energy LSAS search conducted on February 1, 2011).

Three proposed developments will increase aggregate supply in the RSA. These developments include the Hammerstone development, the Parsons Creek limestone quarry development, and the Kearl Pit development. The developments are in various stages of the application and approval process and are all likely to be constructed within the next five years.

Hammerstone Corporation’s proposed Hammerstone development is a southerly expansion of the Muskeg Valley Quarry. The development is located about 60 km north of Fort McMurray, just south of the Albian Sands’ Muskeg River Mine, and involves a major expansion of the Quarry. It is estimated that the Quarry has 1 billion tonnes of limestone reserves over 3,600 acres, enough for over 50 years of production of lime and limestone (Hammerstone Corporation 2011, Internet site). The Hammerstone development will meet the limestone-related requirements of the oil sands industry (Hammerstone Corporation 2011, Internet site). Hammerstone will include processing facilities needed to make quicklime and hydrated lime, which are used by the power and oil sands industries to purify water for steam generation. The Hammerstone development is currently in the application stage and construction has not started.

The Parsons Creek Resources limestone quarry development contains estimated total limestone reserves of 100 million tonnes (Parsons Creek Resources 2006). This site is located just north of the City of Fort McMurray urban service area boundary in Sections 7, 8, 18, 19, 30, and 31 of 90-9-W4M, and a small portion of NE 36 of 90-10-W4M. Quarry life is estimated to be 40 years based on current expectations of market demand. An assessment application for the development was submitted to Alberta Environment and the Natural Resources Conservation Board in June 2010 (Parsons Creek Aggregates 2011, Internet site).

The Kearl Pit development will be located about 60 km east of the Susan Lake Pit near Fort McMurray. Construction is slated to begin immediately (Athabasca Minerals Inc. 2011b, Internet site). On March 8, 2011, Athabasca Minerals Inc. announced that it had received regulatory approval for the Kearl Pit.

4.7.5 Application Case

4.7.5.1 Mitigation

Land use policy objectives prompt the following mitigation measures related to aggregate and mineral resources:

- Consult with Fort Hills Energy Corp., Hammerstone Corporation and Athabasca Minerals Inc. prior to construction to discuss potential opportunities to create synergies between oil sands mining and aggregate development, and to resolve any potential conflicts between the Project and these companies' aggregate or mineral dispositions in the LSA.
- Consult with other industrial and commercial users in the LSA during construction to identify any opportunities for cooperation or sharing infrastructure that could help the create efficiencies in the use of aggregate materials.
- Conserve and stockpile any aggregate materials extracted during project construction and operation activities to conserve surface materials.
- Report to ASRD the location of any aggregate deposits discovered during exploration or construction, as per the IRP.

4.7.5.2 Linkage Analysis

Construction of some of the project components such as roads and infrastructure will use gravel and crushed stone, and operation of the Project will use limestone. Therefore, there is a link between the activities of the Project and the supply and demand of aggregate resources in the RSA.

4.7.5.3 Effects Analysis

Preliminary estimates indicate that construction and operation of the Project will require about 23.17 million tonnes of a limestone equivalent weight 75 mm crushed rock aggregate.

Between Athabasca Minerals Inc. proposed Kearl Aggregate Pit, Parsons Creek Resources proposed limestone quarry project, and Hammerstone Corporation's proposed Hammerstone limestone quarry project, about 1.1 billion tonnes of limestone supply will be made available over the next 50 years. The amount of estimated aggregate resources required by the Project represents a small percentage (2.1%) of the estimated 1.1 billion tonnes of aggregate that is available from aggregate producers in the RSA.

The three proposed developments are expected to meet much of the limestone and aggregate demands of the oil sands industry in the RSA. Hammerstone Corporation alone has estimated that they have enough limestone reserves in their quarries alone to meet the region's lime and limestone demands for over 50 years (Hammerstone Corporation 2011, Internet site). It is important to understand that limestone can serve as a substitute for gravel; thereby minimizing the need to develop more traditional sources of aggregate such as gravel pits in the RSA.

Based on the statements of Hammerstone Corporation, it is anticipated that there will be a sufficient quantity of aggregates produced to meet the needs of the Frontier Project and other approved developments in the RSA for the next 50 years.

Applicable LARP or IRP Goals, Objectives, or Guidelines

The Implementation Plan component of the draft LARP contains the following objectives/statements relevant to the Project:

- *Opportunities for the responsible exploration, development and extraction of energy, mineral and coal resources are maintained.*
- *While oil sands is the dominant energy industry in the region, continued natural gas development and mineral resource exploration, development and extraction, will contribute to the regional and provincial economy, supporting regional, provincial and international sources of supply.*

The *Fort McMurray–Athabasca Oil Sands Subregional IRP* contains a number of specific objectives and guidelines for mineral and aggregate development. Those most applicable to the Project include:

- *To conserve surface material resources and provide opportunities for their orderly exploration and development.*
- *To manage the limited supplies of sand, gravel and topsoil, so as to ensure availability, at reasonable cost, for infrastructure and landscaping activities in the area.*
- *The location of aggregate deposits (i.e., sand and gravel), discovered during exploration or development activity, must be reported to Alberta Land and Forest Service. Aggregate resources not used during mineral development (e.g., industrial road construction) will be stockpiled.*
- In the Mildred-Kearl Lakes RMA, *to encourage the recovery of other valuable mineral, aggregate and surface material resources during the mining and processing of oil sands.*

Aggregate materials that are extracted during Project construction and operation activities will be conserved and stockpiled, and other energy development and aggregate companies that hold dispositions or mineral leases in the LSA will be consulted to discuss potential opportunities to create synergies between oil sands mining and aggregate preservation and development. The location of any aggregate deposits discovered during exploration or construction will be reported to ASRD. Through these mitigations, the Project will be consistent with the IRP and draft LARP objectives and guidelines.

The guidelines for the Athabasca–Clearwater RMA also state that instream gravel production requires a 50-m buffer from the high-water mark of any river. However, a similar buffer is not applied to oil sands mining operations. Mining is allowed throughout the PAA, provided proposed mitigation measures and reclamation procedures reflect the characteristics and sensitivities of the area.

Some aggregate resources might be associated with fluvial deposits along watercourses in the PAA to be disturbed during mining operation. Salvage of these materials would be done as part of orderly mine advance and, hence, would be consistent with IRP guidelines.

Overall, with implementation of the proposed mitigation measures, the Project will be consistent with the aggregate and mineral development related goals, objectives and policies in the draft LARP and IRP.

4.7.6 Planned Development Case

4.7.6.1 Linkage Analysis

Based on available data, the Project is not anticipated to affect aggregate and mineral resources in the RSA for the PDC.

4.7.7 Responses to Aboriginal Community Concerns

No concerns related to aggregate resources were identified during consultations with potentially affected Aboriginal communities.

4.7.8 Prediction Confidence

Overall prediction confidence related to aggregate and mineral resources is moderate. While the total quantity of available aggregate resources in the RSA has not been fully explored, information on available supplies of aggregate and their ability to meet aggregate demand in the RSA was provided by licensed aggregate and mineral extraction operation.

4.7.9 Management and Monitoring

The Owners are members of the Oil Sands Developers Group (OSDG). As members, they would work with the OSDG to identify solutions to mitigate the demand for aggregate resources in the RSA.

4.7.10 Summary

The amount of estimated aggregate resources required by the Project represents a small percentage (2.1%) of the estimated 1.1 billion tonnes of aggregate that will be available from aggregate producers in the RSA. In addition, Hammerstone Corporation has estimated that they have enough limestone reserves in their quarries alone to meet the region’s lime and limestone demands for over 50 years.

4.8 Forestry

4.8.1 Introduction

This section addresses key question R4: Could the Frontier Project affect forestry?

Project construction and operation will require clearing of large forested areas and may affect Al-Pac and Northland Forest Products timber harvesting schedules and plans.

4.8.2 Methods

Details on the calculation of land capability classes are presented in the soils and terrain baseline (see Volume 2, Section 7).

The methods for calculating timber productivity and merchantable timber volume in the LSA are described in Section 4.9.2.2.

4.8.2.1 Data Sources

The main data source for identifying forestry companies and activities in the LSA was a surface activity land search of the Alberta Energy Land Status Automated System (LSAS) that was conducted on February 2, 2011. Other data sources on forestry use in the LSA include the Al-Pac FMP (updated in September 2007, Internet site) for the Al-Pac Forest Management Agreement (FMA) area, the 2011 Annual Operating Plan (AOP) produced by Al-Pac, and correspondence with managers at Al-Pac and Northland Forest Products. Vegetation data collected for the Project from desktop and field work was used to calculate the merchantable timber volumes and Land Capability Classes for the LSA (see Volume 6, Section 3).

4.8.2.2 Models and Assumptions

Timber productivity ratings of good, moderate, fair or unproductive were assigned to individual stand types based on Alberta Vegetation Inventory (AVI) data. The AVI data was approved by Alberta Sustainable Resource Development (ASRD) in 2002 and modified with disturbance information based on current aerial imagery.

Merchantable timber volume was estimated using ASRD’s Volume Look-up Table. This table was developed using historical AVI data for the Central Mixedwood Subregion, and provides average coniferous, deciduous and total volume factors, (e.g., height and crown closure). The process determines the forest class using all species/percentages listed (Coniferous is greater than 79% coniferous species, Deciduous is greater than 79% deciduous species, coniferous–deciduous (CD) is 50% to 79% coniferous species, deciduous–coniferous (DC) is 50% to 79% deciduous species), along with the density and height of the stand to determine to determine the volume factor in the lookup table. The table returns volume factors for coniferous, deciduous and total volumes for each stand. This process is performed for both the overstorey and understory (if applicable). Additionally, a total volume for each is calculated by adding the values for both the over story and under story. The TPR for each stand is determined by calculating a Site Index

(SI) 50 value based on dominant species, stand age, and height. The resulting SI50 value is assigned a TPR rating (U, F, M, or G) based on the dominant species.

4.8.3 Reference Conditions

The LSA falls within two Forest Management Units (FMU): FMU 15 (71% of the LSA) and FMU 10. Al-Pac holds the deciduous timber rights (through its Forest Management Agreement [FMA]) in FMU A15 and Northland Forest Products holds the coniferous timber rights in FMU A15 (through its coniferous timber license [CTL] dispositions).

In FMU A10 Northland Forest Products Limited holds the coniferous timber rights through two coniferous timber license dispositions (CTLs A100005 and A100004), however the deciduous timber rights have not been allocated.

Northland Forest Products also holds two License of Occupation (LOC) dispositions for logging roads in the LSA.

The Al-Pac FMP (Al-Pac 2007, Internet site) sets out an Annual Allowable Cut (AAC), which is the maximum amount of timber that can be harvested in a year. Calculating and following an AAC ensures that the volume of trees harvested in a year does not exceed what the forest can grow. The AAC for FMU A15 is 540,650 m^3 of coniferous timber and 710,348 m^3 of deciduous timber (Source: Table 2 Al-Pac: Approved Allocations and Annual Allowable Cuts, Effective Date May 1, 2007, attached to letter sent to ASRD on November 5, 2008).

The AAC Northland Forest Products has for FMU A10 is 12,800 m^3 of coniferous timber (Rob Hall 2011, pers. comm.).

For FMU A15, the total harvestable land area in the LSA is 34,625 ha, the total volume of coniferous timber in FMU A15 is 2,278,797 m^3, and the total volume of deciduous timber in FMU A15 is 1,990,835 m^3.

For FMU A10, the total harvestable land area in the LSA is 14,333 ha, the total volume of coniferous timber in FMU A15 is 617,335 m^2, and the total volume of deciduous timber in FMU A15 is 564,735 m^3. Overall, the LSA contains 2,896,132 m^3 of merchantable coniferous timber, and 2,555,570 m^3 of deciduous timber.

A breakdown of total merchantable timber in the LSA, separated into FMUs A15 and A10, is provided in Table 4-3.

Timber Productivity in the LSA is presented in Figure 4-3.

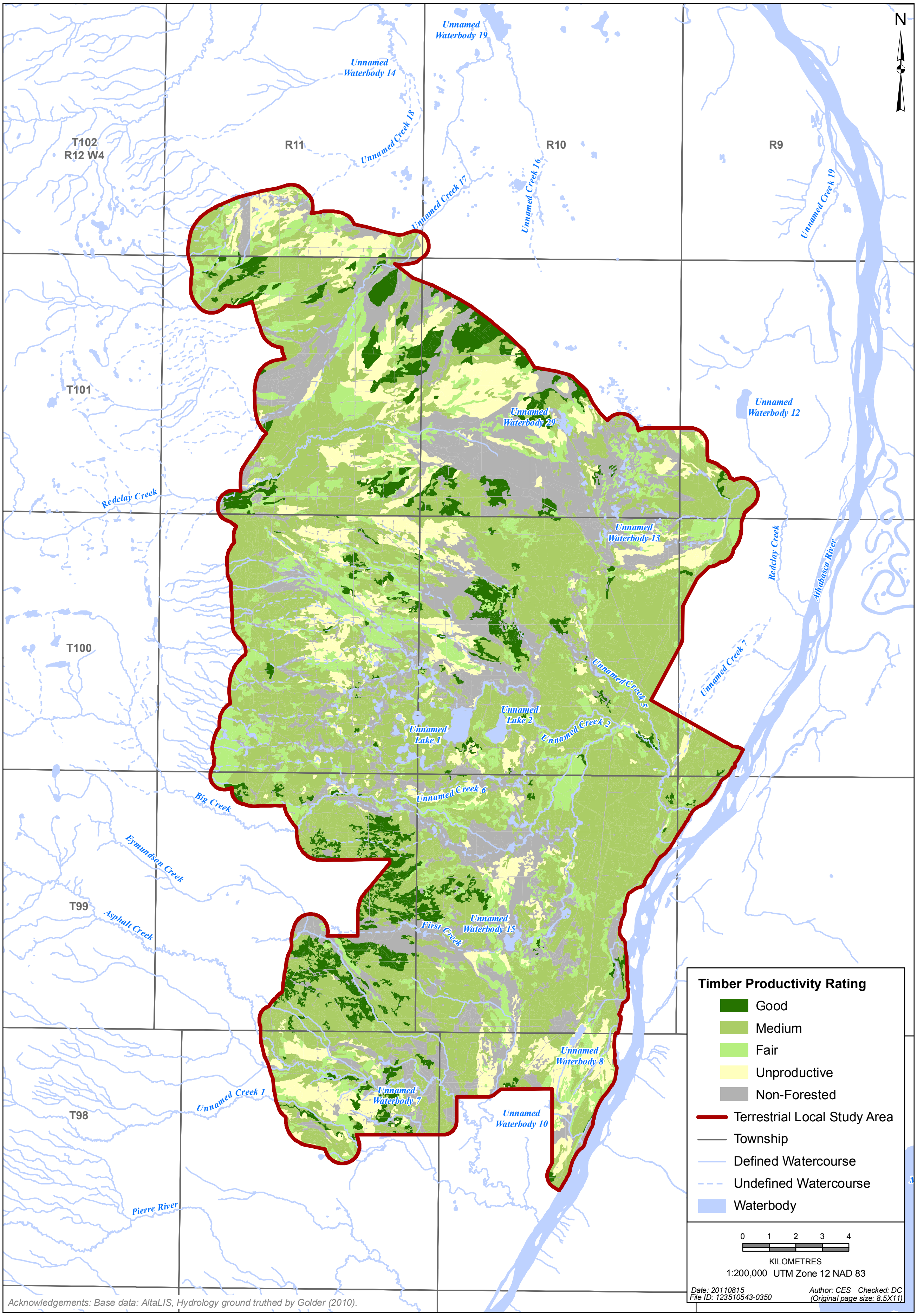

Figure 4-3: Timber Productivity in the LSA – Base Case

Table 4-3 Merchantable Timber Volumes in the LSA

Tree Species Stand Types	Total Volume Coniferous (m^3)	Total Volume Deciduous (m^3)	Total Volume (m^3)	Land Area (ha)
FMU A10				
Coniferous (C)	417,550	44,436	461,987	5,060
Coniferous-Deciduous (CD)	5,977	2,489	8,466	116
Deciduous (D)	175,593	506,367	681,961	5,159
Deciduous-Coniferous	18,214	11,442	29,656	387
Unforested	0	0	0	3,611
Subtotal for FMU A10	617,335	564,735	1,182,070	14,333
FMU A15				
Coniferous (C)	1,403,538	137,807	1,541,345	13,342
Coniferous-Deciduous (CD)	112,895	43,260	156,156	852
Deciduous (D)	636,064	1,717,025	2,353,089	12,674
Deciduous-Coniferous	126,301	92,742	219,043	1,362
Unforested	0	0	0	6,394
Subtotal for FMU A15	2,278,797	1,990,835	4,269,632	34,625
Grand Total for LSA (A10 and A15 combined)	**2,896,132**	**2,555,570**	**5,451,702**	**48,958**
NOTE: Totals might not equal sums due to rounding				

4.8.4 Base Case

A number of terrain alterations and industrial development in the LSA have already removed timber from the LSA's harvestable land base. These terrain alternations, which include roads, cutlines, and other industrial disturbances, total 935 ha (1.9% of the LSA).

4.8.5 Application Case

4.8.5.1 Mitigation

An integrated land management (ILM) strategy will be developed for the Project in consultation with Al-Pac and Northland Forest Products. This strategy will address topics such as coordination of timber harvesting by Al-Pac and Northlands and clearing schedules for the Project, use of common access corridors for locating roads and other infrastructure, use of common facilities (i.e., work lodges) where possible, and progressive reclamation of disturbed land no longer needed for oil sands development.

As much as possible, access to and along existing logging roads used by Northland Forest Products and Al-Pac will be maintained as long as that access does not conflict with mine development plans.

Merchantable timber will be salvaged to specifications provided by Al-Pac or Northland Forest Products so that it can then be transported to local mills. ASRD will be consulted to ensure that deciduous timber in FMU A10 is accounted for and salvaged in an acceptable way. Where merchantable timber cannot be salvaged, a timber damage assessment will be conducted according to ASRD requirements to identify whether compensation may be required.

An environmental management plan will be developed to minimize effects to the environment from harvesting activities.

A closure, conservation and reclamation (CC&R) plan for the Project has been prepared. One of the main goals of the CC&R plan is to reclaim the PDA to equivalent land capability for forestry and meet reforestation standards. The CC&R plan (see Volume 1, Section 13) outlines the methods for re-establishing forest lands in the LSA. Implementing progressive reclamation over the life of the mine will allow re-establishment of forested lands at the earliest opportunity.

4.8.5.2 Linkage Analysis

The LSA contains merchantable timber that forestry companies in the region have timber rights to, and construction of the Project to maximum build-out (Year 37) (2057) will result in the clearing of large amounts of this merchantable timber. The LSA also overlaps with existing infrastructure that belongs to these forestry companies, such as logging roads. Therefore, there is a link between the Project's activities and forestry resources and infrastructure.

4.8.5.3 Effects Analysis

Merchantable Timber Harvesting

Timber in the LSA will be cleared over approximately 37 years. For preliminary estimates of merchantable timber to be harvested from the LSA in FMUs A10 and A15 at maximum build-out (Year 37) (2057), see Table 4-4 and Figure 4-4.

Most clearing will take place in 2014. During 2014, 390,956 m^3 of coniferous timber and 340,669 m^3 of deciduous timber will be cleared from FMU A15, which represents 72% and 48% of FMU A15's AAC for coniferous and deciduous timber respectively. In FMU A10, 101,615 m^3 of coniferous timber will be cleared, which represents 794% of FMU A10's AAC for coniferous timber.

Al-Pac must plan and prioritize their harvesting schedules with consideration to disclosed oil sands mining developments in the Mineable Oil Sands Area (MOSA). Since the LSA is within MOSA, Al-Pac will take into account within its harvesting schedules the timber clearing associated with the Project. The effects of timber clearing for the Project will be mitigated through development of the ILM strategy in cooperation with Al-Pac and Northland Forest Products. As part of the ILM strategy, it is anticipated that merchantable timber within the LSA will be harvested by Al-Pac and Northland Forest Products. ASRD will be consulted to ensure that the unallocated deciduous timber in FMU A10 is accounted for and salvaged in an acceptable way.

Table 4-4 Annual and Cumulative Timber Clearing Schedule

Year Calendar/ Mine Development	A10 Volume Coniferous (m^3)	A15 Volume Coniferous (m^3)	Total Volume Coniferous (m^3)	A10 Volume Deciduous (m^3)	A15 Volume Deciduous (m^3)	Total Volume Deciduous (m^3)	A10 Total Volume (m^3)	A15 Total Volume (m^3)	Total Volume (m^3)	Annual Cumulative Timber Clearing Area A10 (ha)	Annual Cumulative Timber Clearing Area A15 (ha)	Annual Cumulative Timber Clearing Area A10 and A15 (ha)
2014/-08	101,615	390,956	492,571	48,308	340,670	388,978	149,923	731,625	881,548	1,493	6,185	7,678
2015/-07		25,242	25,242		3,502	3,502		28,744	28,744		193	193
2016/-06		15,787	15,787		1,241	1,241		17,029	17,029		130	130
2017/-05		1,020	1,020		1,877	1,877		2,898	2,898		44	44
2018/-04		3,909	3,909		5,540	5,540		9,449	9,449		89	89
2019/-03		49,715	49,715		55,152	55,152		104,867	104,867		839	839
2020/-02		63,981	63,981		35,710	35,710		99,692	99,692		716	716
2021/01	16,710	23,246	39,956	10,442	41,845	52,287	27,152	65,092	92,244	1,020	726	1,747
2022/02		16,769	16,769		15,555	15,555		32,324	32,324		388	388
2023/03	1,109	167,641	168,749	1,191	192,655	193,846	2,300	360,296	362,596	36	2,698	2,734
2024/04		15,374	15,374		34,586	34,586		49,960	49,960		339	339
2025/05		70,669	70,669		99,467	99,467		170,136	170,136		1,521	1,521
2026/06		14,247	14,247		37,362	37,362		51,610	51,610		318	318
2027/07		50,212	50,212		79,447	79,447		129,658	129,658		857	857
2028/08		37,101	37,101		43,486	43,486		80,587	80,587		546	546
2029/09		48,677	48,677		88,154	88,154		136,831	136,831		916	916
2030/10		60,019	60,019		29,694	29,694		89,713	89,713		689	689
2031-2035/11-15	21,654	96,052	117,706	19,279	89,120	108,399	40,934	185,172	226,105	559	2,055	2,614
2036-2040/16-20	35,017	20,652	55,670	79,005	23,529	102,534	114,022	44,182	158,204	1,038	608	1,646
2041-2045/21-25	117,564	13,642	131,206	131,026	15,125	146,152	248,590	28,767	277,357	2,851	255	3,106
2046-2050/26-30	69,855	7,885	77,740	68,105	12,013	80,118	137,960	19,898	157,858	2,017	207	2,224
2051-2057/31-37		0	0		0	0		0	0		0	0
Total	363,524	1,192,797	1,556,321	357,357	1,245,732	1,603,089	720,881	2,438,529	3,159,409	9,015	20,320	29,335

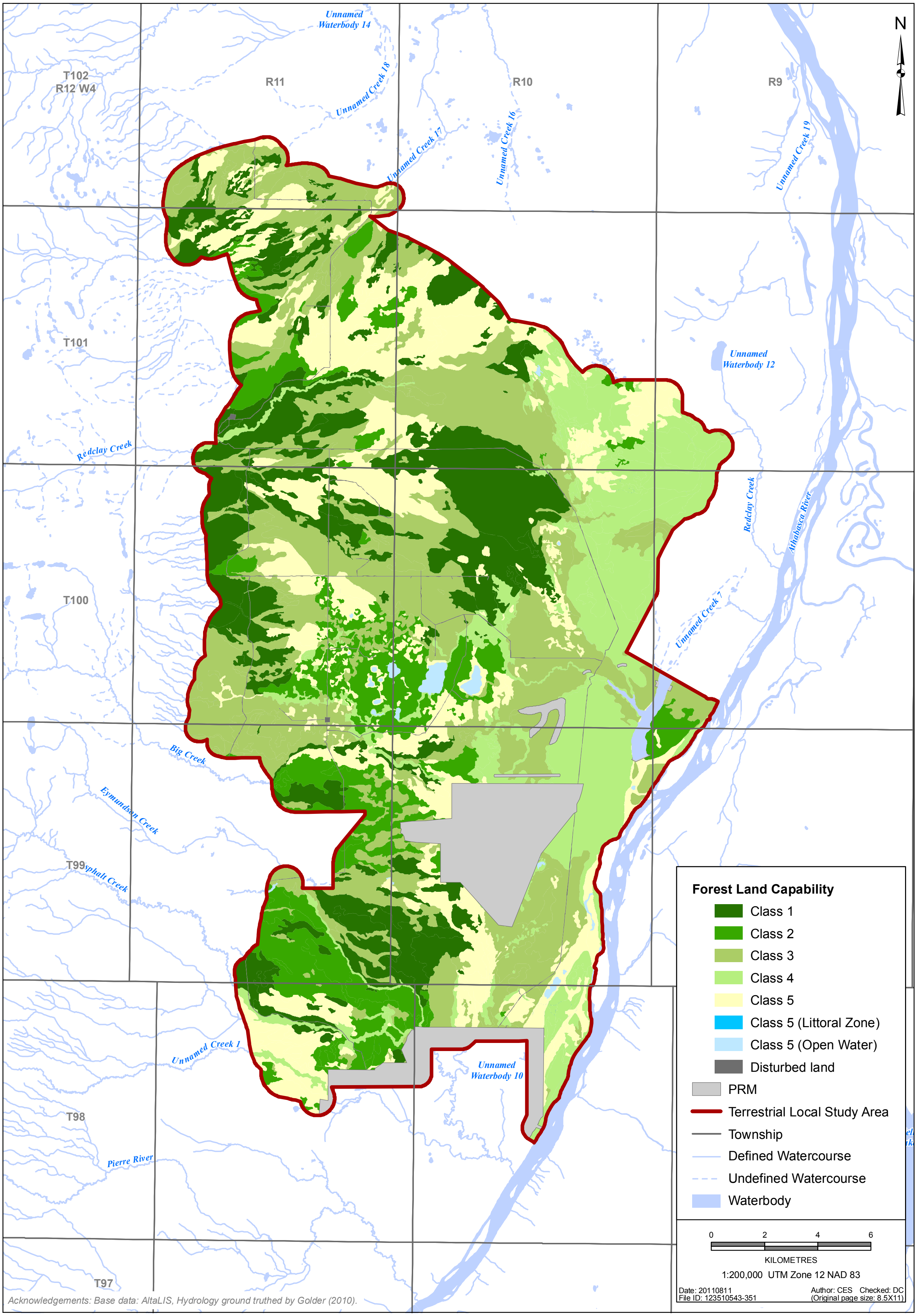

Figure 4-4: Forest Land Capability Classes – Base Case

Land Capability

One of the goals of reclamation is to re-establish productive forest ecosystems. The *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (LCCS) was used to compare the existing and closure conditions with respect to forest capability. The LCCS recognizes five classes of land, rated according to the potential and limitations for productive forest use: Classes 1, 2 and 3 are capable of supporting commercial/ productive forests, whereas Class 4 and Class 5 are non-commercial/lower productivity forest lands (see Table 4-5).

Table 4-5 Land Capability Classification System for Forest Ecosystems

Capability Class	Index Points	Forest Capability: Productivity and Limitations
1	81 to 100	High capability: Land with no significant limitations to supporting productive forestry, or only minor limitations that can be overcome with normal management practices.
2	61 to 80	Moderate capability: Land with limitations that, combined, are moderately limiting for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will still be attractive, but appreciably inferior to that expected on Class 1 land.
3	41 to 60	Low capability: Land with limitations that, combined, are moderately severe for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will be low.
4	21 to 40	Conditionally productive: Land with severe limitations, some of which might be surmountable through management, but which cannot be feasibly corrected with existing practices.
5	0 to 20	Non-productive: Land with limitations that appear so severe as to preclude any possibility of successful forest production.
SOURCE: AENV 2006		

Land capability ratings are a function of several characteristics, including:

- landform type
- topographic position
- surface drainage
- soil moisture regime
- cover soil characteristics

Based on the proposed closure plan, the area of high and moderate capability productive land for forestry in the PDA (classes 1 to 2) will increase overall by 4,897 ha (17%) from the Base Case to closure of the Project. Class 1 (high capability forest) lands will be increased by 284 ha in the PDA, while Class 2 lands will be increased by 4,613 ha. Table 4-6 summarizes the changes in the PDA for each of the five forest capability classes from the Base Case to closure of the Project.

Once reclaimed, trees will be available for commercial harvest again in 80 years for deciduous species and 120 years for coniferous species, based on typical growth rates for the area.

Table 4-6 Changes in LCCs in the PDA following Reclamation

Capability Class	Base Case LCC (ha)	Project Closure LCC (ha)	Change from Base Case to Closure (ha)
1	5,869	6,153	+284
2	3,952	8,565	+4,613
3	9,163	3,269	-5,894
4	3,189	2,591	-598
5 – total	7,162	8,756	+1,594
5 – terrestrial areas	7,086	5,344	-1,742
5 – littoral areas	0	628	+628
5 – waterbodies	76	2,784	+2,708
Total	29,335	29,335	0
NOTE: PDA = Project disturbance area			

For land capability classes at Base Case and Application Case at closure, see Figure 4-5.

Applicable LARP and IRP Goals, Objectives, or Guidelines

The draft LARP and the *Fort McMurray–Athabasca Oil Sands Subregional IRP* address forestry development.

The Implementation Plan component of the draft LARP includes the following objectives and strategies relevant to the Project:

- Objective: *Prevent future shortfalls in timber supply.*
- Strategy: *To minimize loss of productive forest land, industrial and commercial operators on public land will use an integrated land management approach including practices such as planning common major access corridors (shared roads) and infrastructure (camps, remote air strips), progressive reclamation of disturbed land no longer needed for oil sands development and timely removal of linear disturbances.*

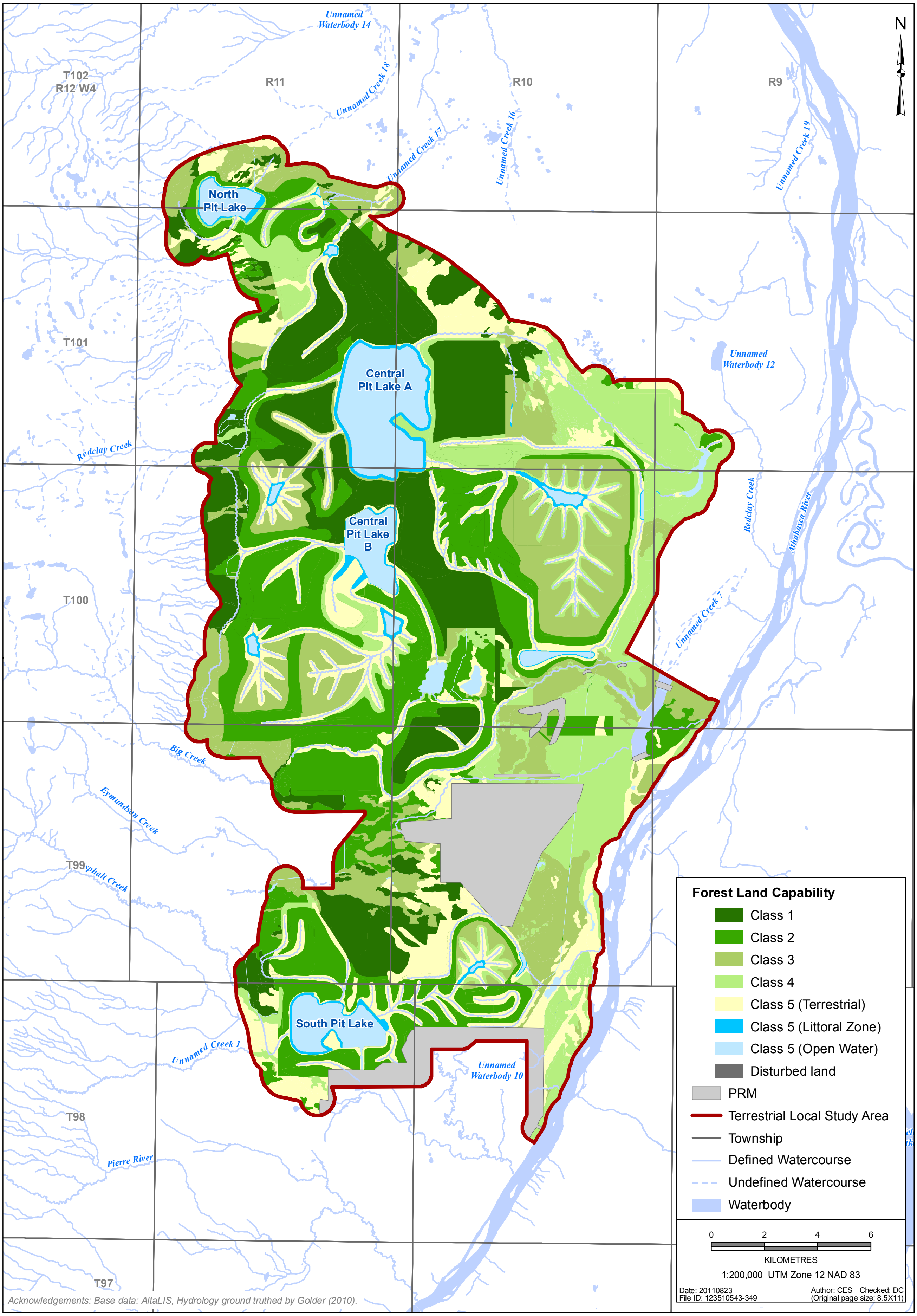

Figure 4-5: Forest Land Capability Classes – Closure

The Strategic Plan component of the draft LARP includes the following statements related to forestry land use:

- The expansion of oil sands development in the region creates challenges for forest companies. A growing portion of timber for the region's mills now comes from salvage connected to oil sands and other non-renewable resource developments. Reductions in the forestry land base accumulate because of the long time horizon for reclamation of oil sands areas. Timber shortfalls are projected over the term of the regional plan.
- Of particular significance in this region, the Government of Alberta encourages the forest and energy sectors to engage in integrated land management (ILM) practices in an effort to coordinate their operations and minimize the industrial footprint. Progressive reclamation helps to ensure environmental and land management objectives are met.
- Industrial operators, along with the diversity of commercial and industrial operators who directly or indirectly support oil sands development, must work together to better integrate their activities on public land. To date, the oil sands and forest industries have engaged in integrated land management practices on a voluntary basis in an effort to minimize environmental footprint. For example, sharing roads and collaboratively planning operations. The draft LARP proposes to make integrated landscape management between all industrial operators on public land a necessary element of doing business. This will co-ordinate industrial activities such as shared road networks and infrastructure on public lands, reduce land disturbance to productive forest land base, reduce timber shortfalls and reduce environmental impacts.

An ILM strategy will be developed and implemented in consultation with the local forestry companies, and through this mitigation, the Project will be consistent with the draft LARP objectives/statements above.

The *Fort McMurray–Athabasca Oil Sands Subregional IRP* contains a number of specific objectives and guidelines for forestry and timber resources, including the following, which are most applicable to the Project:

- *To promote the coordination of timber harvest planning in conjunction with other surface disturbances.*
- In the Mildred–Kearl Lakes RMA, *disturbed forested lands shall be reclaimed to a level of capability equivalent to that which existed before disturbance. Where commercial forest is the reclamation objective, the capability will be measured in terms of meeting reforestation standards.*
- In the Mildred–Kearl Lakes RMA, *where loss of the forest land base occurs through surface mining, reforestation may be undertaken at locations identified during the development and reclamation stages*.

In addition to the development of an ILM strategy with the local forestry companies, a CC&R plan has been developed for the Project. One of the main goals of the CC&R plan is to restore the PDA to equivalent land capability for forestry and meet reforestation standards. Progressive reclamation over the life of the mine will also be completed, permitting re-establishment of forested lands at the earliest opportunity. Through this mitigation, the Project will be consistent with the IRP guidelines above.

4.8.6 Planned Development Case

4.8.6.1 Linkage Analysis

There are no foreseeable developments that might affect forestry resources or facilities in the LSA; therefore, the PDC linkage is not valid.

4.8.7 Responses to Aboriginal Community Concerns

No concerns related to forest resources were identified during consultations with potentially affected Aboriginal communities.

4.8.8 Prediction Confidence

Overall prediction confidence for the effects of the Project on forestry resources is high. Confidence in the quality of AVI and disturbance data used in this assessment is high. Confidence in the industry standard analytical techniques used to calculate timber volumes and forest productivity is high. Confidence in the ability of ILM planning to reduce the effects on forest resource planning is high. Confidence in the use of progressive reclamation to re-establish forest land capability is also high.

4.8.9 Management and Monitoring

Al-Pac and Northland Forest Products will be consulted to develop an ILM strategy.

Reclamation in the LSA will be monitored to ensure that the lands are returned to a land capability that supports forestry and meets reforestation standards. These reclamation-monitoring programs will be developed to assess various aspects of reclamation success, including timber productivity, and will be developed in consultation with the appropriate regulatory authorities. Monitoring programs will be designed to integrate with regional monitoring programs as much as possible. Information gathered during monitoring can also be used to verify environmental effect predictions and fed into the adaptive management program.

Reclamation Working Group initiatives will be supported through participation in CEMA.

4.8.10 Summary

The effects of timber clearing for the Project will be mitigated through development of the ILM strategy in cooperation with Al-Pac, Northland Forest Products and ASRD. As part of the ILM strategy, it is anticipated that merchantable timber within the LSA will be harvested by Al-Pac and Northland Forest Products.

ASRD will be consulted to ensure that the unallocated deciduous timber in FMU A10 is accounted for and salvaged in an acceptable way.

Reclamation of the Project is expected to return the LSA to equivalent land capability for forestry and meet reforestation standards.

With implementation of the proposed mitigation measures, which includes reclamation, the Project will be consistent with the forestry related goals, objectives and policies in the draft LARP and IRP.

4.9 Hunting and Trapping

4.9.1 Introduction

This section addresses key question R5: Could the Frontier Project affect hunting and trapping?

Hunting is a popular activity in the RSA and is pursued by area residents, including Aboriginal community members, local outfitters and recreational hunters. Trapping is also carried out by area residents, including Aboriginal community members, which have obtained licenses to trap. Hunting and trapping activities occur in the LSA that could be affected by construction and operation of the Project.

4.9.2 Methods

Development footprints and associated habitat loss for each assessment case were used to quantify the loss of hunting and trapping opportunities in the LSA and RSA.

4.9.2.1 Data Sources

Data sources used in relation to hunting and trapping included:

- a surface activity land search of the Alberta Energy Land Status Automated System (LSAS) conducted on February 2, 2011
- a search of the Alberta Outfitter directory for moose and black bear guiding and outfitting companies operating in the RSA
- correspondence with potentially affected outfitters near the LSA
- wildlife habitat quality ratings for popular game and fur-bearer species modelled as part of the wildlife assessment for the Project (see Volume 6, Section 4).

4.9.2.2 Models and Assumptions

See Volume 6, Section 4 for information about wildlife modelling used to generate habitat quality ratings in the LSA for particular wildlife species.

4.9.3 Reference Conditions

General Hunting and Trapping Resources

The LSA is located in the Birch Mountains Wildlife Management Unit (WMU 531). WMU 531 is bordered by the Athabasca River on the east, the Wabasca River and 114 0’ 00’’ to the west, Wood Buffalo National Park on the north, and 57 2’ 00’’ to the south. Key summer and winter ungulate habitat in WMU 531 occurs along the east slope of the Birch Mountains (ASRD 2009).

Four Registered Fur Management Areas (RFMAs) and Trapping Areas (TPAs) intersect portions of the LSA: RFMA/TPA 1275, 2892, 2939 and 2016. Most of the LSA (85%) is in RFMA 1275; small portions of the northern quarter of the LSA (13% of the LSA) intersect 2892; very small portions around the eastern boundary of the LSA (2% of the LSA) intersect RFMA 2939; and even smaller portions along the southern boundary of the LSA (0.2% of the LSA) intersect 2016.

Big-game species with specified hunting seasons in WMU 531 include white-tailed deer, mule deer, moose, and black bear. Other species with identified hunting seasons include timber wolves, coyote, game birds (including ruffed grouse, spruce grouse, sharp-tailed grouse, ptarmigan, and ducks), porcupine, rabbit, hare, skunk, raccoon and woodchuck (Government of Alberta 2010). A hunting season for wood bison is not included in the *Alberta Guide to Hunting Regulations*, because they are not defined as wildlife in this area of Alberta. Although a defined hunting season does not exist, wood bison are regularly hunted in and around the LSA (mostly in winter).

Fur-bearer species with identified trapping seasons in the LSA include beaver, coyote, fisher, red/arctic fox, lynx, marten, mink, muskrat, otter, red squirrel, weasel, wolf and wolverine.

Elders of the Athabasca Chipewyan First Nation have identified hunting areas/facilities and game-species habitat in and around the LSA. These include what Elders identified as a moose migration route through the LSA, cabins and moose hunting areas along the Athabasca River south and east of the LSA, bison and moose being hunted near Unnamed Lake 13 in the LSA, and deer habitat in the LSA (see Volume 2, Section 13). Although moose are known to move in and through the LSA, the exact location of the moose movement route identified by the Elders is not known.

Elders of the Athabasca Chipewyan First Nation and the Fort Chipewyan Métis community have also identified trapping areas or facilities and fur-bearer species habitat in and around the LSA. These include cabins at Big Lake, Sandy Lake, Unnamed Waterbody 6, and along the Athabasca River, and fur-bearer areas near Big Lake, Unnamed Waterbody 6, Cranberry Lake, and in an area overlapped by the southern portion of the LSA (see Volume 2, Section 13).

Specific Hunting Species and Resources

The most desirable big-game species to hunt in WMU 531 (and therefore the LSA) are moose in the fall and black bear in the spring. Moderate and high suitability moose and black bear habitat occurs throughout the LSA (see Volume 6, Section 4 for habitat suitability maps). Moose can be hunted in WMU 531 (and thus the LSA) from September 1 to November 30 of each year, although a special license is required. Black bear can be hunted in WMU 531 from September 1 to November 30 and April 17 to June 15 of each year.

Based on information gathered while monitoring the use of access roads by hunters during the winter exploration programs, wood bison is regularly hunted in and around the LSA (mostly in winter). Moderate and high suitability bison habitat occurs throughout the LSA (see Volume 6, Section 4 for habitat suitability maps), and the Ronald Lake Wood Bison herd occurs in and around the LSA. Based on previous historical observations, population estimates for this herd have varied, from 20 bison to over 100 bison. In March 2010, ASRD conducted a mark-resight aerial survey to estimate the population of wood bison in the Ronald Lake area, and the size of the Ronald Lake Wood Bison herd was estimated at 101 (ASRD 2010). Wood bison are a culturally significant species for the ACFN; the ACFN have expressed concern about the Project's potential effects on the ability of community members to access and harvest this herd, non-Aboriginal hunting of the herd and overall effect on the health, viability and sustainability of the herd.

The LSA is located outside the Richardson Caribou range. The nearest woodland caribou herd to the LSA is the Audet herd, located about 19 km east of the LSA.

Moderate and high suitability waterfowl habitat occurs throughout the LSA (see Volume 6, Section 4 for habitat suitability maps). Waterfowl can be hunted in WMU 531 (and thus the LSA) from September 1 to December 16 of each year.

Specific Trapping Species and Resources

There is one trapping cabin located in the LSA and another seven cabins located just outside the LSA (see Figure 12-6). These cabins are not inhabited by trappers or other individuals on a permanent basis, but rather are temporary cabins that are used infrequently. The cabin in the LSA (located in NW24-99-10-W4M) in RFMA 1275 is held under a Miscellaneous Lease Permit (MLP) disposition.

Beaver and fisher are the two most targeted species trapped in WMU 531 (Traci Morgan 2011, pers. comm.). A small amount of moderate and high suitability beaver habitat occurs in the LSA (see Volume 6, Section 4 for habitat suitability maps). Beaver can be trapped in the LSA from October 1 to May 15 of each year. A small amount of moderate and high suitability fisher habitat is available in the LSA (see Volume 6, Section 4 for habitat suitability maps). Fisher can be trapped in the LSA from November 1 to January 31 of each year.

Outfitters

Due to its remoteness, WMU 531 is not heavily used by outfitters for hunts. In spite of this, three companies do carry out hunts in WMU 531 (Alberta Professional Outfitters Society 2011, Internet site):

- Garrett Brothers Outfitting – offers a fly-in black bear hunting camp in WMU 531, they take 16 hunters per year into this camp

- Double Diamond Wilderness Hunts – offer black bear hunts in WMU 531 including bear bait stations placed in the LSA
- Wizard Lake Outfitting – offer black bear hunts in WMU 531. Their camp is located north of Fort McMurray in WMU 531 bordering Wood Buffalo National Park.

Of the three outfitters found in WMU 531, only Double Diamond Wilderness Hunts currently uses the LSA as a primary part of their guiding operation, including placing black bear bait stations in the LSA (Jeremy Hatala 2011, pers. comm.).

As part of the resource use assessment section for the PRM project, a Resource User Survey (RUS) was developed and conducted between June 21 and August 9, 2007 to obtain information from members of the public living near the PRM project who also indicated they participated in outdoor activities outside the urban centres (Shell Canada Ltd. 2007). The number of respondents who completed the survey was 412. Since the PRM project is located adjacent to the Frontier Project and its habitat types and access are similar to the Frontier Project resource use LSA, some of the results of the PRM RUS are also useful for describing hunting and trapping use in the Frontier Project resource use LSA. In the RUS, seven respondents indicated they hunted in the general area around the PRM LSA, and that four game species are hunted (moose, deer, black bear and grouse), with moose being the most sought after. Given their proximity and overlapping nature, it is assumed hunting in the Frontier Project resource use LSA will be similar to the PRM LSA; therefore, it is likely that the same species will be hunted and hunting pressure is likely to be low.

4.9.4 Base Case

Industrial developments in the RSA have removed large areas of land used for hunting and trapping in WMU 531 and RFMA's 1275 and 2892. Additional disturbance to hunting and trapping lands have resulted from the construction of roads and cutlines, although such linear disturbance elements also improve access to preferred trapping and hunting areas. A summary of the estimated disturbances to hunting and trapping management areas within the RSA for the Base Case, Application Case and PDC is presented in Table 4-7.

Table 4-7 Areas of Disturbance of Various Hunting and Trapping Management Areas

Management Area		Base Case Disturbance		Application Case Disturbance		PDC Disturbance	
Name	**Area** (ha)	**Area** (ha)	%	**Area** (ha)	%	**Area** (ha)	%
Terrestrial LSA	48,958	3,062	6.25	36,187	73.91	36,187	73.91
RFMA 2892	52,840	0	0.00	3,963	7.50	3,963	7.50
RFMA 1275	55403	4,314	7.79	33,112	59.77	33,112	59.77
RSA	6,853,944	201,285	2.94	234,409	3.42	264,997	3.87
WMU 531 – Inside RSA	1,471,613	45,563	3.10	78,688	5.35	81,272	5.52
WMU 531 – Outside RSA	223,899	831	0.37	831	0.37	831	0.37
Total WMU 531 disturbance	1,695,512	46,394	2.7%	79,519	4.69	82,103	4.84

For the Base Case, approximately 2.7% of the lands in WMU 531 are disturbed, 7.8% of the lands in RFMA 1275 are disturbed and 0% of the lands in RFMA 2892 are disturbed.

4.9.5 Application Case

4.9.5.1 Mitigation

Potential effects to hunting and trapping resulting from the Project will be mitigated primarily through reclamation and access management. One of the goals of the CC&R plan is to restore habitat for key game and fur-bearer species of concern to hunters and trappers.

A wildlife mitigation and monitoring plan will be developed and implemented before construction to mitigate direct and indirect mortality effects resulting from increased access in the LSA. Specific mitigation measures relating to wildlife mortality are described in the wildlife assessment (see Volume 6, Section 4).

In addition, ASRD will be consulted to address access management concerns and develop an access management plan (AMP). The purpose of this AMP will be to set out objectives for managing access in and through the LSA as much as possible while maintaining public safety.

Local registered trappers with trapping licenses or permits will be consulted and, if merited, compensation will be negotiated for registered trappers with proven damage to traplines or losses of fur revenue or other extra costs because of the Project.

The trapper's cabin with the MLP disposition located in NW24-99-10-W4M may be relocated as part of the mitigations for the Project in consultation with the leaseholder.

The Government of Alberta, ACFN and other potentially affected Aboriginal communities and public stakeholders will be consulted to develop appropriate mitigation or management measures related to the Ronald Lake bison herd.

In this spirit of cooperation, consultation has been pursued with Double Diamond Wilderness Hunts, which conducts hunts in portions of the LSA, and with Wizard Lake Outfitting, which conducts hunts just south of the Resource Use LSA but uses the Birch Mountain Forestry Road for access purposes (Gunther Tondeleir 2011, pers. comm.), and Garrett Brothers Outfitting. These outfitters will continue to be consulted.

As part of the CC&R plan, tailing areas will be reclaimed to provide waterfowl and riparian habitat.

Mitigation measures relating to increased wildlife mortality in the LSA from vehicle collisions and hunting are described in the wildlife assessment (see Volume 6, Section 4). Mitigation measures that will be implemented include erecting wildlife caution signs on access roads, trimming roadsides of vegetation, management of food wastes, not permitting the use of recreational vehicles by Project personnel, and restricting hunting or firearm use by Project personnel.

4.9.5.2 Linkage Analysis

The LSA overlaps with licensed trapping areas and trappers' cabins, and site clearing for the Project will alter the available habitat for species of hunting and trapping importance in the LSA.

The Project can also result in direct and indirect mortality of wildlife species. Increased access to the LSA during construction and operation to maximum build-out (Year 37) (2057) could increase direct mortality from hunting. Accidental or indirect mortality from vehicle collisions could also increase because of increased human access in the LSA.

For these reasons, there is a link between Project activities and hunting and trapping resources.

4.9.5.3 Effects Analysis

Clearing associated with the construction of the Project to maximum build-out (Year 37) (2057) will result in a temporary loss of wildlife habitat in the RSA. In WMU 531 there will be an incremental loss of 33,124 ha (see Table 4-7). This amounts to 2% of WMU 531 (1,695,512 ha) and will not adversely affect hunting opportunities.

Clearing associated with the construction of the Project will result in a temporary loss of trapping habitat in the RSA. In RFMA 1275 there will be an incremental loss of 28,798 ha (52%) of the total area of 55,402 ha (see Table 4-7). In RFMA 2892 there will be an incremental loss of 3,962 ha (7.5%) of the total area of 52,840 ha (see Table 4-7).

The Project will temporarily remove habitat for game and fur-bearer species. The wildlife assessment (see Volume 6, Section 4) calculated changes in habitat availability from the Base Case to Project closure for certain wildlife species of hunting and trapping importance. The change in habitat availability is based on the net change in habitat units, which are a representation of habitat quality and quantity. See Table 4-8 for a summary of the results for moderate and high capability habitat in the LSA.

Table 4-8 Changes in Habitat Availability – Base Case to Project Closure

Species of Hunting and Trapping Importance	Percent Change in Habitat Availability in the LSA (%) – High Capability Habitat	Percent Change in Habitat Availability in the LSA (%) – Moderate Capability Habitat	Percent Change in Habitat Availability in the LSA (%) – Combined High and Moderate
Moose	-60	79	52
Black bear	290	-10	-5
Wood bison	29	44	38
Waterfowl	-16	-43	-29
Beaver	73	-19	17
Fisher	-67	-63	-64

Following closure and reclamation, there will be an increase in the combined high and moderate capability habitat for moose, wood bison and beaver (see Table 4-8). There will be a decrease in the combined high and moderate capability habitat for waterfowl and fisher. For black bear, there will be a small decrease in combined high and moderate capability habitat (-5%).

Increases in wildlife mortality resulting from increased access during construction and operation will be mitigated through the development and implementation of the AMP and the wildlife mitigation and monitoring plan.

Hunting and Trapping Related IRP Land Use Guidelines

The *Fort McMurray–Athabasca Oil Sands Subregional IRP* contains a number of specific objectives and guidelines for trapping and hunting, including the following, which are most applicable to the Project:

- *Conflicts between trappers and other users will be reduced through consultation with trapping area holders during detailed planning of a development's operation.*

Local trappers with trapping licenses or permits will be consulted and compensation will be negotiated for trappers with proven losses or extra costs because of the Project. Through this mitigation, the Project will be consistent with the IRP guideline above.

- *To maintain and if possible, enhance the diversity, abundance and distribution of wildlife resources for Native subsidence, recreational and commercial benefits. Such resources include the following:*
    - black bear
    - ungulates
    - bird game
    - upland and aquatic habitats required to retain the current fur-bearer populations
- *To promote and develop opportunities for both consumptive (e.g., hunting, trapping) and non-consumptive (e.g., viewing, photography) uses associated with wildlife.*
- In the Mildred–Kearl Lakes RMA, *where development activities have a negative impact on important moose habitat, off-site habitat enhancement or special on-site protection measures (particularly those concerning harassment) may be required.*

One of the goals of the CC&R plan is to reclaim habitat for key game and fur-bearer species of concern, including wood bison, moose and waterfowl. A wildlife mitigation and monitoring plan will be implemented in consultation with potentially affected Aboriginal communities and public stakeholders, prior to construction. Through these mitigation measures, the Project will be consistent with the IRP guidelines above.

- In the Athabasca–Clearwater RMA, *to maintain the limited waterfowl habitat found in this RMA.*
- For lakes in the Mildred–Kearl Lakes RMA, *a backshore buffer will be maintained to protect waterfowl nesting, staging areas and fish-spawning sites. If, however, a lake must be mined, a plan is required that will result in full replacement of the fish-spawning habitat and strive to replace waterfowl habitat. A flexible approach will be used for the timing and location of habitat-mitigation programs so that off-site and post-disturbance habitat replacement options can be considered.*

As part of the CC&R plan, pit and tailing areas will be converted into man-made lakes that will contain waterfowl and riparian habitat.

4.9.6 Planned Development Case

4.9.6.1 Linkage Analysis

Based on the small percentage of the RSA that is affected by the Project with respect to hunting and trapping resources combined with the fact that the Project will be reclaimed by 2068 to include habitat for species of hunting and trapping concern, the linkage is not considered valid.

4.9.7 Responses to Aboriginal Community Concerns

Elders of the Athabasca Chipewyan First Nation identified hunting areas/facilities and game-species habitat in and around the LSA. These include what Elders identified as a moose migration route through the LSA, cabins and moose hunting areas along the Athabasca River south and east of the LSA, wood bison and moose being hunted near Unnamed Lake 13 in the LSA, and deer habitat in the LSA (see Volume 2, Section 13).Additionally, wood bison have been identified as a culturally significant species for the ACFN; the ACFN have expressed concern about the Project's potential impacts to the ability of community members to access and harvest this herd, non-Aboriginal hunting of the herd and over-all impact to the health, viability and sustainability of the herd.

Although moose move in and through the LSA, the exact location of the moose movement route identified by the Elders is not known. Elders of the Athabasca Chipewyan First Nation and the Fort Chipewyan Métis community also identified trapping areas/facilities and fur-bearer species habitat in and around the LSA. These include cabins at Big Lake, Sandy Lake, Unnamed Waterbody 6, and along the Athabasca River, and fur-bearer areas near Big Lake, Unnamed Waterbody 6, Cranberry Lake, and in an area overlapped by the southern portion of the LSA (see Volume 2, Section 13).

The PAA is outside of the Richardson Caribou range. The nearest woodland caribou herd is the Audet herd, located about 19 km east of the LSA on the east side of the Athabasca River. As a result there will be no direct effects of the Project on caribou.

The Government of Alberta, ACFN and other potentially affected Aboriginal communities and public stakeholders are being consulted to develop appropriate mitigation or management measures related to the Ronald Lake bison herd.

A closure landscape that will reclaim a variety of wildlife habitats that can be used for hunting and trapping will be developed. Consultations will continue with potentially affected Aboriginal communities regarding reclamation of landscapes that will support game and fur-bearer species of importance to traditional users such as moose, deer and wood bison. This landscape will be robust and self-sustaining in the long term.

The Aboriginal community concerns related to hunting and trapping have been addressed through the development of the closure plan and other specific mitigation measures (see Section 4.9.5.1).

4.9.8 Prediction Confidence

Prediction confidence for the effects of the Project on hunting and trapping resources in the LSA is moderate to high. Wildlife field surveys were done throughout the LSA to characterize habitat conditions and habitat suitability modelling was done using standard and accepted procedures.

4.9.9 Management and Monitoring

Local Aboriginal communities and public stakeholders will be consulted to monitor reclamation success of the PDA so that the lands are returned to a land capability that will provide good quality habitat for waterfowl, game and fur-bearer species.

Participation in the Reclamation Working Group and Sustainable Ecosystem Working Group of CEMA is planned, as is collaboration with the Alberta Biodiversity Monitoring Institute.

4.9.10 Summary

Clearing associated with the Project will result in an additional disturbance of 2.0% of WMU531 and will not result in a substantial reduction in hunting opportunities.

Consultation with local trappers will continue and compensation will be negotiated for trappers with proven damage to traplines or losses of fur revenue or other extra costs because of the Project.

Effects resulting from clearing are expected to be temporary and will return gradually as reclamation of the PDA occurs.

Following reclamation and closure, there will be a decrease in habitat availability for black bear, waterfowl, and fisher and an increase in habitat availability for moose, wood bison, and beaver.

4.10 Sport fishing

4.10.1 Introduction

This section addresses key question R6: Could the Frontier Project affect sport fishing?

Project activities may affect watercourses and waterbodies in the LSA, a few of which contain sport fish species or sport fish habitat. Changes to sport fish habitat in turn could affect sport fishing opportunities; therefore, the linkage is valid.

Potential effects of the Project on sport fishing were assessed by examining habitat alteration near sport fishing locations.

Data sources for sport fishing resources included consultant reports on recreational activity in the Regional Municipality of Wood Buffalo, the PRM EIA, and the fish and fish habitat assessment (see Volume 5, Section 5).

No models or modelling was used in assessment of the effects of the Project on sport fishing.

4.10.2 Reference Conditions

The most popular fishing locations in the RSA include Gregoire Lake, the Clearwater River, tributaries of the Athabasca River north of Fort McMurray, Christina River, Winefred River and Engstrom Lake. These fishing locations are easily accessible and near population centres (Highwood Environmental Management et al. 2003). The nearest waterbody to the LSA that is used for recreational sport fishing is the Athabasca River. which borders the eastern edge of the LSA. The Athabasca River is open all year for fishing. There are guided fishing companies that operate on the Athabasca River (i.e., Reel Angling Adventures, The Great Canadian Adventure Company), with the main guiding season being from June to the end of October. According to the PRM RUS, walleye and northern pike are the most sought after sport fish species in the Athabasca River corridor. Arctic grayling is the species caught most often, however, followed by walleye and northern pike (Shell Canada Ltd. 2007).

There are no known highly frequented (or “popular”) sport fishing sites within the LSA. Fish communities found within the LSA are predominately forage fish rather than sport fish species. Within the LSA, there are a few watercourses that contain habitat in certain parts of their reaches that can support sport fish species. In general, potential sport fish habitat in the LSA is limited because of high suspended sediment concentrations, shallow waterbody depths, and poor connection to the downstream reaches of these watercourses where the better-quality fish habitat is located.

4.10.3 Base Case

The PRM project is the only development that may affect watercourses, and therefore sport fishing habit and opportunities, in the LSA. Construction and operation of the PRM will result in fish habitat loss in the lower reaches of Pierre River and its unnamed tributaries. The small changes to the flow or water levels of watercourses downstream of the PRM project are not expected to affect fish habitat (Shell 2007). Compensation for the loss of habitat in Pierre River will be achieved, if the PRM project is approved, by constructing the PRM fish habitat compensation lake. With the application of the PRM fish habitat compensation plan and appropriate mitigation measures, Shell (2007) concluded that there will be no adverse effects on fish habitat.

4.10.4 Application Case

4.10.4.1 Linkage Analysis

There are no popular sport fishing locations within the LSA and sport fish habitat in the LSA is limited. Therefore, there is no linkage between the Frontier Project’s activities and sport fishing resources.

4.10.5 Prediction Confidence

Prediction confidence for the effects of the Project on sport fishing resources is moderate to high. Confidence in information gathered from the fish habitat surveys and the findings of the fish and fish habitat assessment is high. Confidence in data on preferred sport fishing locations in the LSA and RSA is moderate because reports on recreational activities in the MD of Wood Buffalo are slightly out-dated, dating from 2003.

4.10.6 Summary

There are no popular sport fishing locations within the LSA. Although there is some habitat in the LSA that could potentially support sport fish species, habitat in the LSA is limited and the fish communities found within the LSA are predominately forage fish rather than sport fish species.

4.11 Designated Parks and Protected Areas

4.11.1 Introduction

This section addresses key question R7: Could the Frontier Project affect designated parks and protected areas?

4.11.2 Methods

The potential effects of the Project on designated parks and protected areas were assessed by determining the size and ecological quality of the lands within a park and protected area that would be disturbed by the Project.

4.11.3 Reference Conditions

There are no existing provincial or federal parks and protected areas in the LSA.

The draft LARP identifies several new proposed conservation areas and provincial recreation areas for the Lower Athabasca Region in Schedules A and B of the Implementation Plan component of the draft LARP. However, none of these proposed new parks and protected areas is located in the LSA.

4.11.4 Application Case

4.11.4.1 Linkage Analysis

There is no direct linkage between the Frontier Project and existing and proposed parks and protected areas.

4.11.5 Prediction Confidence

Confidence in the quality of the mapping of park locations is high.

4.11.6 Summary

There are no existing or proposed provincial or federal parks and protected areas in the LSA. Therefore, the Project is not anticipated to have any potential effects on parks and protected areas.

4.12 Environmentally Significant Areas

4.12.1 Introduction

This section addresses key question R8: Could the Frontier Project affect environmentally significant areas?

The LSA overlaps with a small portion of ESA 692.

4.12.2 Methods

The potential effects of the Project on ESAs were assessed by determining the size and ecological quality of the lands within an ESA that would be disturbed by the Project footprint.

4.12.2.1 Data Sources

The main data sources were the *Environmentally Significant Areas: Provincial Update 2009* report (Fiera Biological Consulting 2009), and the draft LARP.

4.12.3 Reference Conditions

ESA 692 is a large (667,295 ha) ESA that is located along more than 500 km of the Athabasca River valley, and extends east and west of the river to include several large sand dune complexes and fens north of McClelland Lake. Because it encompasses a number of different important terrain, habitat, and riverine elements and contains a large number of elements of conservation concern, ESA 692 has a National significance rating (Fiera Biological Consulting 2009).

The LSA overlaps with primarily upland and river valley habitats in ESA 692.

The draft LARP does not discuss ESA 692.

4.12.4 Base Case

A few existing terrain alterations in the LSA intersect with ESA 692, which include roads and cutlines.

4.12.5 Application Case

4.12.5.1 Linkage Analysis

The LSA overlaps with a small portion of ESA 692. Therefore, there is a link between the Frontier Project's activities and ESAs.

4.12.5.2 Mitigation

Habitat within the portion of ESA 692 that is affected by the Project will be reclaimed.

4.12.5.3 Effects Analysis

The portions of ESA 692 located in the LSA (3,641 ha) that will be directly or indirectly disturbed by the Project represents 0.55% of the entire ESA 692 area. Therefore, the Project will not have a material effect on ESA 692.

ESAs identify important, unique and often sensitive natural features and landscapes. Unlike parks and protected areas, however, ESAs do not have legislative protection, but instead are intended to be an information tool to help inform land use planning at local, regional and provincial scales (ATPR 2010, Internet site). Additionally, the EIA conducted for the Project involves carrying out greater levels of study than what was used to identify ESAs in Alberta in the Fiera report. The Project EIA identifies important natural features in the LSA and sets out mitigation measures for these features; therefore fulfilling the purpose of identifying ESAs.

Environmentally Significant Areas Related IRP Guidelines

The *Fort McMurray–Athabasca Oil Sands Subregional IRP* contains some specific objectives and guidelines applicable to ecological resources and ESAs in the LSA, including the following, which are most applicable to the Project:

- *To protect representative, significant and unique examples of the natural features, landscapes and ecosystems of the Boreal Mixedwood Ecoregion.*
- In the Athabasca-Clearwater RMA, *development proposals will mitigate adverse impacts on the nationally or provincially significant natural features identified in the following areas:*
    - *Athabasca River Tar Sands Reach* (Note that the Athabasca River Tar Sands Reach ESA referenced in the IRP has been superseded by ESA 692 in the updated 2009 ESA report.)

With the completion of the Project EIA and the implementation of mitigation measures, the Project will be consistent with the goals of the IRP.

4.12.6 Planned Development Case

4.12.6.1 Linkage Analysis

There are no other reasonably foreseeable ESAs anticipated for the LSA; therefore, the PDC linkage is not valid.

4.12.7 Prediction Confidence

Confidence in the published data on the location and ecological functions and features of ESAs is high.

4.12.8 Management and Monitoring

Participation in the Reclamation Working Group and Sustainable Ecosystem Working Group of CEMA is planned.

Consultations will continue with potentially affected Aboriginal communities and local stakeholders to develop reclamation monitoring programs to assess various aspects of reclamation success, including the reestablishment of natural ecological conditions on the lands.

4.12.9 Summary

The portions of ESA 692 located in the LSA (3,641 ha) that will be directly or indirectly disturbed by the Project represents 0.55% of the entire ESA 692 area. The mine footprint, while altering local biophysical conditions, is not expected to measurably change the conservation values of ESA 692. The Project EIA identifies important natural features in the LSA and sets out mitigations for these features; therefore fulfilling the purpose of identifying ESAs.

4.13 Recreation and Tourism

4.13.1 Introduction

This section addresses key question R9: Could the Frontier Project affect recreation and tourism?

Recreation and tourism is pursued by area residents and visitors to the region. Formal recreation and tourism activities do not occur in the LSA, but informal recreation activities like ATV and snowmobile use may occur in the LSA. Additionally, recreational activities like boating likely occur adjacent to the LSA along the Athabasca River and access to recreational activities could be affected by construction and operation of the Project.

4.13.2 Methods

Information from recreation surveys in the area was used to qualitatively assess the effects of development on recreation and tourism.

4.13.2.1 Data Sources

The main data sources for information on recreation and tourism in the LSA and RSA were consultant reports on recreational activity in the Regional Municipality of Wood Buffalo, and the PRM EIA (Shell 2007).

4.13.2.2 Models and Assumptions

No models or modelling was used in assessment of the effects of the Project on recreation and tourism.

4.13.3 Reference Conditions

In the LSA, outdoor recreational activities are limited because of the distance from major centres, limited road access, and existing or planned future resource development. The LSA supports no formal recreation; there are no formal campgrounds in the LSA, and there are no public land use dispositions for specific recreational facilities in the LSA. The RMWB, however, holds a private road disposition in the LSA for an access road (the Birch Mountain Forestry Road) that provides access through the LSA to important backcountry recreation areas in the western parts of the RSA such as the Birch Mountains Wildland Provincial Park and Namur Lake. No formal ATV or snowmobile trails exist in the LSA; however, ATV users and snowmobilers may use forestry cutlines, trails, and other related linear corridors to access portions of the LSA for informal recreational purposes and for hunting and trapping. Some limited recreation may also take place near the LSA along the Athabasca River.

Overall, non-consumptive outdoor recreational activities in the LSA (or along the edge of the LSA in the Athabasca River) may include the following:

- boating, canoeing, and kayaking
- ATV or quad use and snowmobiling
- bird watching, wildlife viewing, plant studies, and photography

Since the PRM project is located just south of the Frontier Project and its environment and access are similar to the Frontier Project resource use LSA, some of the results of the PRM RUS are also used to describe recreational use in the Frontier Project resource use LSA. Within the PRM LSA, including the Athabasca River corridor, respondents participated in ATV use (10 respondents), snowmobiling (4 respondents), boating (4 respondents), and camping (3 respondents) (Shell 2007). Assuming recreational use in the Frontier Project resource use LSA will be similar to recreational use in the PRM LSA, then it is likely that ATV driving, snowmobiling, boating and camping are the most common recreational activities in the Frontier resource use LSA. Additionally, the low number of respondents (ranging from 3 to 10) participating in these recreational activities in the PRM RUS suggests that recreational use of the Frontier Project resource use LSA by the general public is also low.

The draft LARP identifies several proposed new “public land areas for recreation and tourism” (PLAs) for the Lower Athabasca Region in Schedules A and B of the Implementation Plan component of the draft LARP. However, none of these proposed new PLAs is located in or adjacent to the resource use LSA.

4.13.4 Base Case

The PRM project could diminish recreation opportunities in the LSA. Additionally, the LSA contains access routes and cutlines that may be used by local residents as informal ATV and snowmobile trails, and these trails will no longer be available for informal recreation use once the PRM project begins.

4.13.5 Application Case

4.13.5.1 Linkage Analysis

The Project will result in vegetation and terrain disturbance which could potentially diminish recreation opportunities in the LSA. The LSA contains access routes and cutlines that may be used by local residents as informal ATV and snowmobile trails, and these trails will no longer be available for informal recreation use once the Frontier Project begins. Additionally, the Birch Mountain Forestry Road travels through the southern portion of the LSA, and the Project could potentially block or remove access along this road. Therefore, there is a link between the Project’s activities and recreation resources and infrastructure.

4.13.5.2 Mitigation

One of the goals of the CC&R plan is to return the LSA to provide a diversity of “end land uses” that will enable activities currently taking place in the PDA to continue in the future, including recreation.

An AMP will be developed and implemented in the LSA in consultation with potentially affected Aboriginal communities and public stakeholders. The purpose of this AMP will be to control access in and through the LSA while maintaining public safety. One of the primary objectives of the AMP will be to maintain access to and along existing roads in the LSA, such as the Birch Mountain Forestry Road in the southern portion of the LSA, that provide access to important recreational areas outside the LSA. This may include implementing a road use agreement on the Birch Mountain Road with the RMWB.

4.13.5.3 Effects Analysis

Project construction activities will require the clearing of vegetation, which will temporarily reduce recreation potential within the LSA. Access management will be provided to maintain public safety during operation, and this access management could block existing access roads in the LSA (i.e., the Birch Mountain Forestry Road) that are used to access important recreational spots outside of the LSA.

The LSA also contains access routes and cutlines that may be used by local residents as informal ATV and snowmobile trails. These ATV and snowmobile trails will no longer be available for informal recreation use once construction of the Project begins.

Recreation and Tourism Related IRP Guidelines

The *Fort McMurray–Athabasca Oil Sands Subregional IRP* contains a number of specific objectives and guidelines for recreation and tourism in the LSA, including the following, which are most applicable to the Project:

- *Public access to recreation opportunities, most notably to the major rivers and lakes, will remain a priority.*
- In the Athabasca–Clearwater RMA, *maintain or enhance access to recreational opportunities in the river valleys.*
- In the Athabasca–Clearwater RMA, *minimize impacts of developments upon river users and recreationists using the river as a travel corridor*.
- *Resource development facilities and structures that must be located in the Athabasca–Clearwater RMA should be screened from the river using natural features, and architecturally designed and landscaped to complement the natural surroundings.*

With implementation of the proposed mitigation measures, the Project will be consistent with the recreation related goals, objectives and policies in the IRP.

4.13.6 Planned Development Case

4.13.6.1 Linkage Analysis

There are no other reasonably foreseeable recreational developments in the LSA and therefore the linkage is not valid.

4.13.7 Prediction Confidence

Prediction confidence for the effects of the Project on recreation and tourism is moderate because consultant reports on recreational activities in the MD of Wood Buffalo are slightly out-dated, dating from 2003.

4.13.8 Management and Monitoring

Reclamation monitoring programs will be developed to assess various aspects of reclamation success, including the ability of the lands to support recreational uses, and will be developed in consultation with the appropriate regulatory authorities. Monitoring programs will be designed to integrate with regional monitoring programs as much as possible. Information gathered during monitoring can also be used to verify environmental effect predictions and fed into the adaptive management program.

Participation in the Reclamation Working Group of CEMA is planned.

4.13.9 Summary

The LSA supports no formal recreation activities or facilities. However, low levels of informal recreation (ATV or snowmobile use) may take place in the LSA. The Project will temporarily disrupt informal recreation opportunities in the LSA. One of the goals of the CC&R plan is to return the LSA to provide a diversity of end land uses that will enable activities currently taking place in the PDA to continue in the future, including recreation, so that the Project will have no long-term effects on recreation opportunities in the LSA.

4.14 Conclusion

This assessment describes potential effects and mitigation for interactions between the Frontier Project and resource uses including:

- aggregate and mineral resources
- forestry resources
- hunting and trapping resources
- sport fishing
- designated parks and protected areas
- environmentally significant areas (ESAs)
- recreation and tourism

Overall, potential effects of the Project on resource uses other than forestry resources and hunting and trapping resources is very limited. Mitigations, such as an Integrated Land Management strategy, a wildlife mitigation and monitoring plan, an AMP, and the closure, conservation and reclamation plan, will be implemented to address the effects of the Project on forestry and hunting and trapping resources.

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5 Visual Aesthetics

5.1 Introduction

This section of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project):

- describes the mitigation measures that will be implemented to reduce the effects of the Project on visual aesthetics
- identifies processes used to determine the scope of the visual aesthetics assessment
- describes the visual aesthetics study area, temporal considerations, visual key indicators and prediction confidence
- presents the existing visual aesthetics baseline conditions in the study area
- assesses the potential effects of the Project on visual aesthetics during construction, operation and closure

A detailed description of the Frontier Project is provided in Volume 1.

5.2 Scoping the Assessment

The scope of the assessment was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by specific regulatory and public stakeholder inputs and concerns from potentially affected Aboriginal communities. These inputs helped identify the key issues of concern and define the key questions that are the focus of this assessment.

The term visual aesthetic is intended to cover a broad range of visual, scenic, cultural, and spiritual aspects of the landscape. Visibility of the Project is a quantitative criterion presenting the geographic area from which the Project will be visible (i.e., the visual aesthetics study area). Visibility is also discussed as part of the air assessment (see Volume 4, Section 3). In this section haze is assessed.

5.2.1 Terms of Reference

The TOR (AENV 2009) does not require an assessment of the Project on visual aesthetics.

5.2.2 Regulatory Setting

There are no provincial or federal acts, regulations or codes of practice that address visual aesthetics. Therefore, the regulatory setting for the assessment is guided by plans and draft plans set out by the regional committees active in the area (see Section 5.2.3.3).

5.2.3 Regulatory, Public and Aboriginal Community Input

Input from a variety of potentially affected Aboriginal communities, public stakeholders and regulatory sources informed the visual aesthetics assessment. These sources included meetings with regulators, Aboriginal community and public stakeholder consultations and regional committees.

5.2.3.1 Regulatory and Public Stakeholder Input

Since 2006, the Owners (Teck Resources Limited [Teck] and SilverBirch Energy Corporation [SilverBirch]) have consulted with industry members, adjacent leaseholders and public stakeholders. Teck is the Operator of the Project and Applicant on behalf of the Owners.

The Owners have also participated in regulatory meetings with provincial and federal authorities. No relevant visual concerns were identified during these consultations.

Input from regulatory and public sources has been incorporated into the assessment.

5.2.3.2 Aboriginal Community Concerns

Issues and concerns related to visual aesthetics expressed during consultations with potentially affected Aboriginal communities included the following:

- visibility of the Project, especially the river water intake (RWI) by people travelling along the Athabasca River
- visibility of the Project from Fort McKay
- visibility of the Project from nearby sacred sites
- visibility of the Project from nearby trapper and historic cabins

Concerns about Project contributions to haze were raised at a workshop (held in Calgary on January 26 and 27, 2010) attended by the Athabasca Chipewyan First Nation (ACFN), the Mikisew Cree First Nation (MCFN) (as well as their technical specialists, Management and Solutions in Environmental Sciences [MSES]); however, participants did not express concerns about visual aesthetics (for a discussion on haze see Volume 4, Section 3.6.9).

Responses to concerns expressed by Aboriginal communities are provided following the assessment of the key issues. For a summary of the responses to Aboriginal community concerns raised during consultation activities for the Frontier Project, see Volume 1, Section 17.

5.2.3.3 Regional Committees

The following policy documents guide land use practices in the region of the Project and directly or indirectly address visual aesthetics:

- The *Draft Lower Athabasca Regional Plan* (LARP) (Government of Alberta 2011) – Prepared by the Government of Alberta with stakeholder input, this plan outlines a strategic direction for growth in the Athabasca Oil Sands Region with priority given to balancing economic, environmental, and social priorities. One of the objectives is to provide a wide range of recreation and tourism opportunities to meet the preferences of regional residents and visitors. For the area covered by the Draft LARP, see Volume 2, Section 12.4.2, Figure 12-3.
- *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan* (ASRD 2002) and accompanying guidelines under the Mildred-Kearl Lakes Resource Management Area (RMA) and Athabasca-Clearwater RMA, that indicate Alberta Economic Development and Tourism will be included in the referral system for any proposals that might adversely affect potential roadside recreation and tourism opportunities, including viewing areas of special interest, as well as the need to limit effects of developments on river users and recreationists using the river as a travel corridor. For the area covered by this plan, see Volume 2, Section 12.4.3, Figure 12-4.
- *Cumulative Environmental Management Association* (CEMA 2011, Internet site) and their goals to ensure the availability of wilderness experiences and sustain aesthetic values

A review of these documents helped to direct the assessment methodology to ensure that appropriate concern groups and areas were captured and effective mitigations could be developed to meet the objectives and goals of the land use policies. The following issues and concerns were identified:

- the effect of development on sport and recreational fishing areas on the Athabasca River and nearby waterbodies
- the effect of development on major access routes and the potential reduction of recreational activities and hunting and trapping

5.2.4 Key Issues

Based on input gathered from regulatory sources and consultations with potentially affected Aboriginal communities and public stakeholders, a series of key issues were defined for the visual aesthetics assessment. A summary of key issues for each phase of the Frontier Project and their relevance to the Project are summarized in Table 5-1.

Table 5-1 Key Issues – Visual Aesthetics

Project Phase	Key Issue	Relevance to Project
Construction and operation	Changes in visual aesthetics	• Elevated Project components could be visible at certain receptor locations and could affect visual characteristics
Closure	Changes in visual aesthetics	• Changes in topography associated with the closure landscape will be visible from a number of receptor locations and will affect visual characteristics

Other disciplines and sections in this application also identified visual aesthetic issues; however, all key visual aesthetics issues are assessed in this section. For details of these assessments, see:

- air quality – Volume 4, Section 3
- resource use – Section 4

5.2.5 Key Questions

Key questions were developed to address the key issues and focus the assessment on these issues of concern. The key question for the visual aesthetics assessment is:

- V1: Could the Frontier Project affect visual aesthetics?

5.3 Approach

5.3.1 Study Area

The Project is located approximately 110 km north of Fort McMurray on the west side of the Athabasca River and east of the Birch Mountains, in Townships (Twps) 98 to 102, Ranges (Rges) 10 and 11, West of the Fourth Meridian (W4M).

The study area was delineated to assess changes in visual aesthetics (see Figure 5-1). The visual aesthetics study area boundary is based on limits of visual acuity and light refraction studies (ESRI 2011, Internet site), consultation reports and literature reviews of visual acuity thresholds (Ogburn 2006).

5.3.2 Assessment Cases

Visual aesthetics key issues and associated key indicators were evaluated in the context of the following development scenarios:

- Base Case, which includes developments that are currently operating or under construction, activities approved but not yet constructed or those likely to be approved in the near future
- Application Case, which includes developments and activities in the Base Case with the Frontier Project added
- Planned Development Case (PDC), which includes developments and activities included in the Application Case with other planned developments that are reasonably foreseeable added

Oil sands developments other than the Project could obstruct or contribute to visibility of the Project. Thus, visual aesthetic key issues and associated key indicators were evaluated in the context of the Application Case, which includes the Project. The Shell Pierre River Mine (PRM) project was also included in the Application Case because of its proximity. A separate Base Case was not explicitly included in this assessment; rather relevant Base Case developments (i.e., PRM project) were included in the Application Case assessment. A PDC was not examined

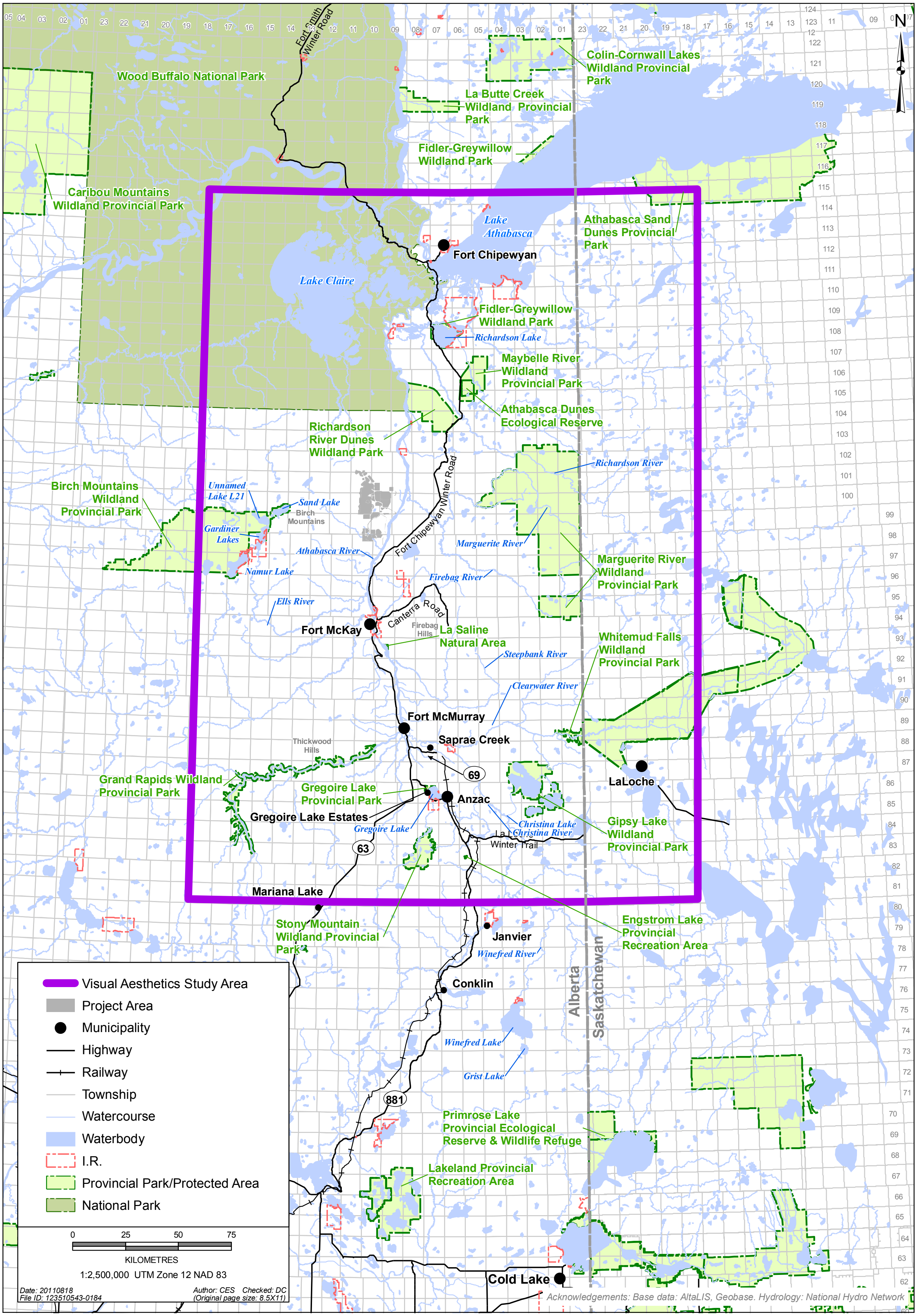


Figure 5-1: Visual Aesthetics Study Area

For more details on the assessment cases and the related developments and activities included in each case and of relevance to the visual aesthetic section, see Volume 3, Section 1, Appendix 1B.

5.3.3 Temporal Considerations

5.3.3.1 Reference Conditions

To provide a reference for the assessment of visual aesthetics key issues and associated key indicators, an existing reference condition (2008) is evaluated.

5.3.3.2 Snapshots

In addition to the reference condition snapshot, the following temporal snapshots were used to evaluate changes from the Frontier Project, in combination with other oil sands developments, on visual aesthetics as applicable:

- maximum build-out (Year 37) (2057) – for visibility of Project components
- closure (Year 48) (2068) – for visibility of closure landscape

5.3.4 Key Indicators

To focus the assessment, key indicators were chosen for each key question. For each key indicator, at least one measurable parameter was selected to provide a means of measuring and assessing effects of the Project. The key indicators and measurable parameters for the visual aesthetics key question and key issue are listed in Table 5-2.

The criteria used to select key indicators and the methods used to evaluate effects of the Project are described in Section 5.5.

Table 5-2 Key Indicators – Visual Aesthetics

Key Question	Effects Pathway	Key Indicator	Measureable Parameter	Spatial Considerations
V1: Could the Frontier Project affect visual aesthetics?	Changes in visual aesthetics	• Two-dimensional (2D) line of sight viewshed • Three-dimensional (3D) simulations	• Presence or absence of visibility at receptors • Extent of visibility of the Project from receptors • Linear extent of visibility of the Project along roads and watercourses	Visual aesthetics study area

5.3.5 Prediction Confidence

The purpose of the assessment is to predict future environmental conditions that result from the Project, together with approved and planned developments and activities, as well as developments that are already operational. Assessment of Project effects has some inherent uncertainty associated with data, methods and the predictive nature of the assessment.

Prediction confidence was addressed in different ways depending on the EIA discipline. Sensitivity and uncertainty analysis were used as tools for determining prediction confidence where feasible. For classification of effects that used semi-quantitative methods prediction, assessment confidence was determined by considering:

- quality and quantity of baseline data used in the assessment
- confidence in measurements and analytical techniques
- confidence in the success of Project-specific mitigation measures

Overall prediction confidence is defined as low, moderate or high.

5.4 Overview of Baseline Conditions

This section provides an overview of baseline conditions and variables that are relevant to current visual aesthetics in the study area.

The topography of the study area is generally flat to undulating. Topographic expression is greatest along the Athabasca and Clearwater River valleys, along other watercourses that discharge to these major rivers, and along the sides of uplands including the Birch Mountains, Muskeg Mountain and Thickwood Hills. These features create natural barriers to visibility west of the Birch Mountains and within the river valleys.

Vegetation in the study area is dominated by mature wooded cover classes. Long distance visibility is largely limited by vegetation, except in areas with low density or large clearings to allow for an undisturbed line of sight. For a complete description of vegetation baseline conditions, see Volume 2, Section 8.

The potential for long distance visibility occurs at high points in and around the study area, including the Birch Mountains, along the east bank of the Athabasca River and along Highway 63 where there are breaks in vegetation cover.

Most residential areas are located south of the study area and along the Athabasca River. For a complete description of communities see Volume 2, Section 12.6.2.

5.5 Visual Aesthetics

5.5.1 Introduction

This section addresses the key question:

- V1: Could the Frontier Project affect visual aesthetics?

Increased development is a growing concern for tourism, recreation and traditional land users in the region. These activities are based on natural attractions, including waterbodies, watercourses, forests, and natural areas. Residents, Aboriginal communities, and visitors explore the region and engage in a range of activities from fishing, hunting and trapping, camping, hiking, bird watching, wildlife viewing, water sports, and all-terrain vehicle use and snowmobiling.

Vegetation clearing during construction will affect visual aesthetics in the study area. Project components and elevated areas might also be visible from various vantage points on the landscape during construction and operation. In addition, as topography will be different at closure than it is currently, a closure snapshot was also examined.

There is potential for the Project to degrade the visual aesthetics and reduce cultural and outdoor recreational use in what people might expect to be wilderness areas.

5.5.2 Methods

A desktop computer analysis was used to quantify visibility of the Project in the study area. The analysis was completed using geographic information systems (GIS) computer software to model line of sight viewsheds that determine presence, absence and spatial extents of visibility. A viewshed model is a binary raster that predicts visibility of a viewpoint from an area of interest. It is considered an accepted method for calculating visual effects (Ogburn 2006; IEMA 2002).

5.5.2.1 Data Sources

The following sources of visual aesthetic information were used in the assessment:

- resource use, air quality, traditional land use, and vegetation baseline reports
- resource use, air quality, and traditional land use receptor locations
- Project elevation models
- LiDAR elevation data for local topography
- NASA digital elevation data (DEM) for regional topography
- Alberta Vegetation Inventory (AVI) for vegetation heights

5.5.2.2 Models and Assumptions

Spatial modelling was used to determine the extent of visibility of the Project in the study area. Potential Project visibility was assessed using 2D line of sight viewsheds to measure:

- effects of the Project components during maximum build-out and at closure
- effects on selected receptors

Elevation Models of the Project at Maximum Build-out

Elevations of Project components at maximum build-out were added to existing datasets for topography, including LiDAR for the Project area and NASA DEM for the study area (see Table 5-3). Vegetation cover and heights were also incorporated into the model from the AVI dataset. For the general site layout that includes Project components, see Figure 5-2.

Table 5-3 Project Components used in the Visual Aesthetic Models

Project Component	Height above Grade (m)
Main Development Area	
Flare stack	71
North Plant Site Buildings	
Froth treatment Phase 1	50
Froth treatment Phase 2	50
Froth treatment Phase 3	50
Tank farm Phase 1	30
Tank farm Phase 2	30
Tank farm Phase 3	30
Extraction and tailing area Phase 1	37
Extraction and tailing area Phase 2	37
Extraction and tailings area Phase 3	37
External disposal area 1	58
External disposal area 2	37
External disposal area 5	40
External tailings area 1 – coarse sand tailings area (CSTA)	60
External tailings area 1 – thickened tailings area (TTA)	60
Ex-pit dyke	77
Main pit slope	60
River water intake (RWI)	7
South Development Area	
External disposal area 3	50
External disposal area 4	53
Other	
Transmission towers	24

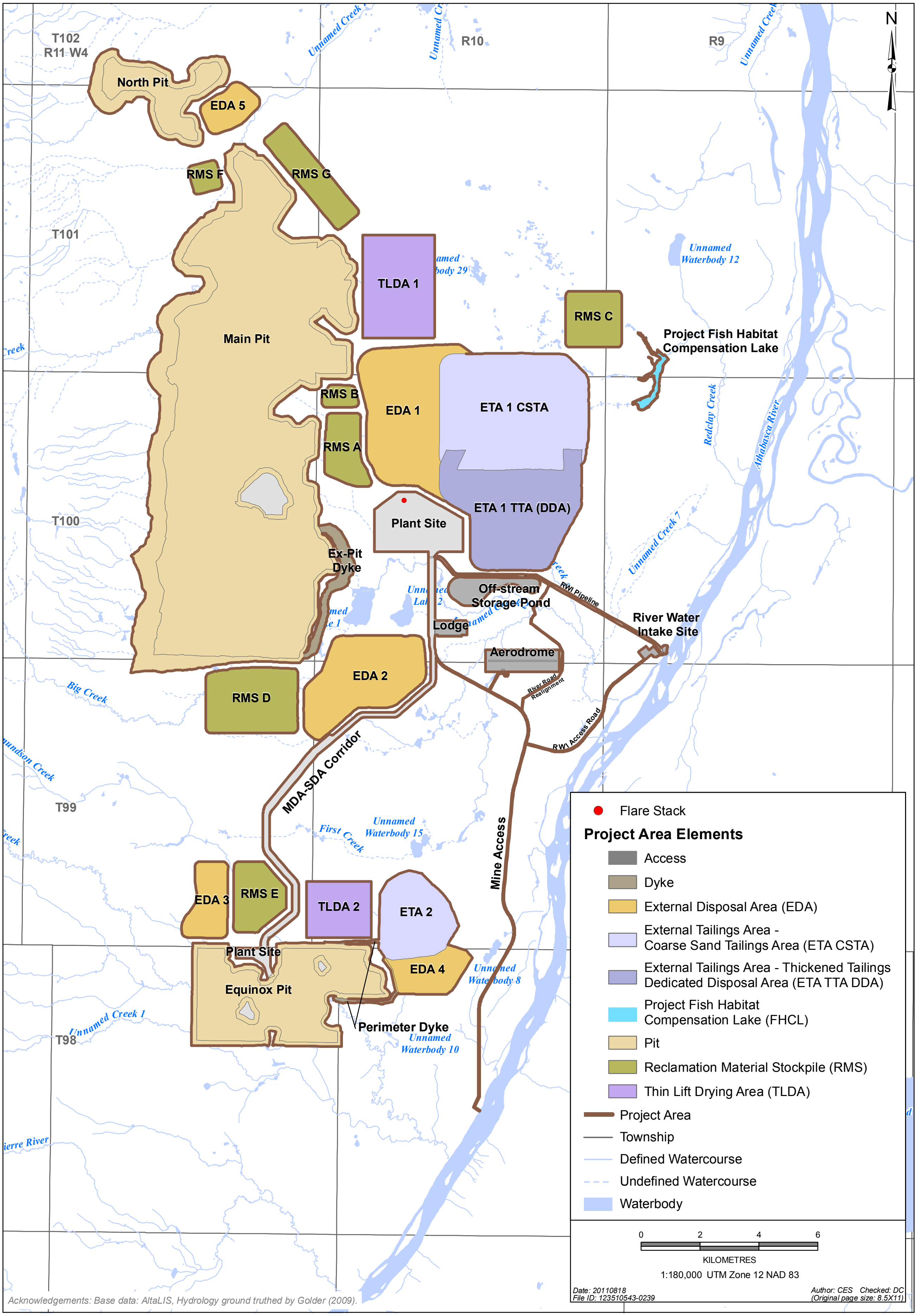


Figure 5-2: Project Area and General Site Layout

Visual Receptor Model

Visual receptors were selected based on the receptors identified by the air quality, acoustic, and human health assessments, as well as the results of consultations and the results of the Project viewshed models (see Table 5-4). The selected receptors were considered to have the highest sensitivity to visibility from the Project, based on consultation results. The visual receptors were modelled using viewsheds to determine the presence, absence, and spatial extents of visibility. For the locations of the receptors, see Figure 5-3.

Table 5-4 Visual Receptors

Receptor	Description	Easting	Northing	Distance from Project (km)
VP1	Fort McKay	460811	6337080	37.3
VP2	Dushcarme's historic cabin	467600	6373550	7.1
VP3	Ian Faichney historic cabin	461934	6365350	98.6
VP4	Poplar Point historic cabins	475441	6417970	16.6
VP5	Sacred Story Place	479503	6399440	5.6
VP6	Ronald Lake historic cabin	460750	6424860	14.8
VP7	Trapper cabin	452393	6377650	4.9
VP8	Fort McMurray	476829	6288340	88.6
VP9	Fort Chipewyan	495546	6515520	115.6

Model Assumptions

The viewshed models include the following assumptions:

- A height of 2 m was used as the average height of an observer standing on the ground or driving in a vehicle.
- The earth's curvature and light refraction were factored in based on the model mechanics available in the GIS software (ESRI 2011, Internet site).
- Line of sight viewshed results were reported as either presence or absence of visibility and do not include rankings or levels of visibility.

5.5.2.3 Quality Assurance and Quality Control

Quality assurance processes were followed to ensure the quality of data and the results of the models were as accurate as possible.

The most current input data were used for all the models, either acquired from data suppliers or downloaded from public sources. Project and discipline data were received from engineers and discipline leads. Spatial information was stored in Project databases. When updates were received, older versions were archived with date stamps.

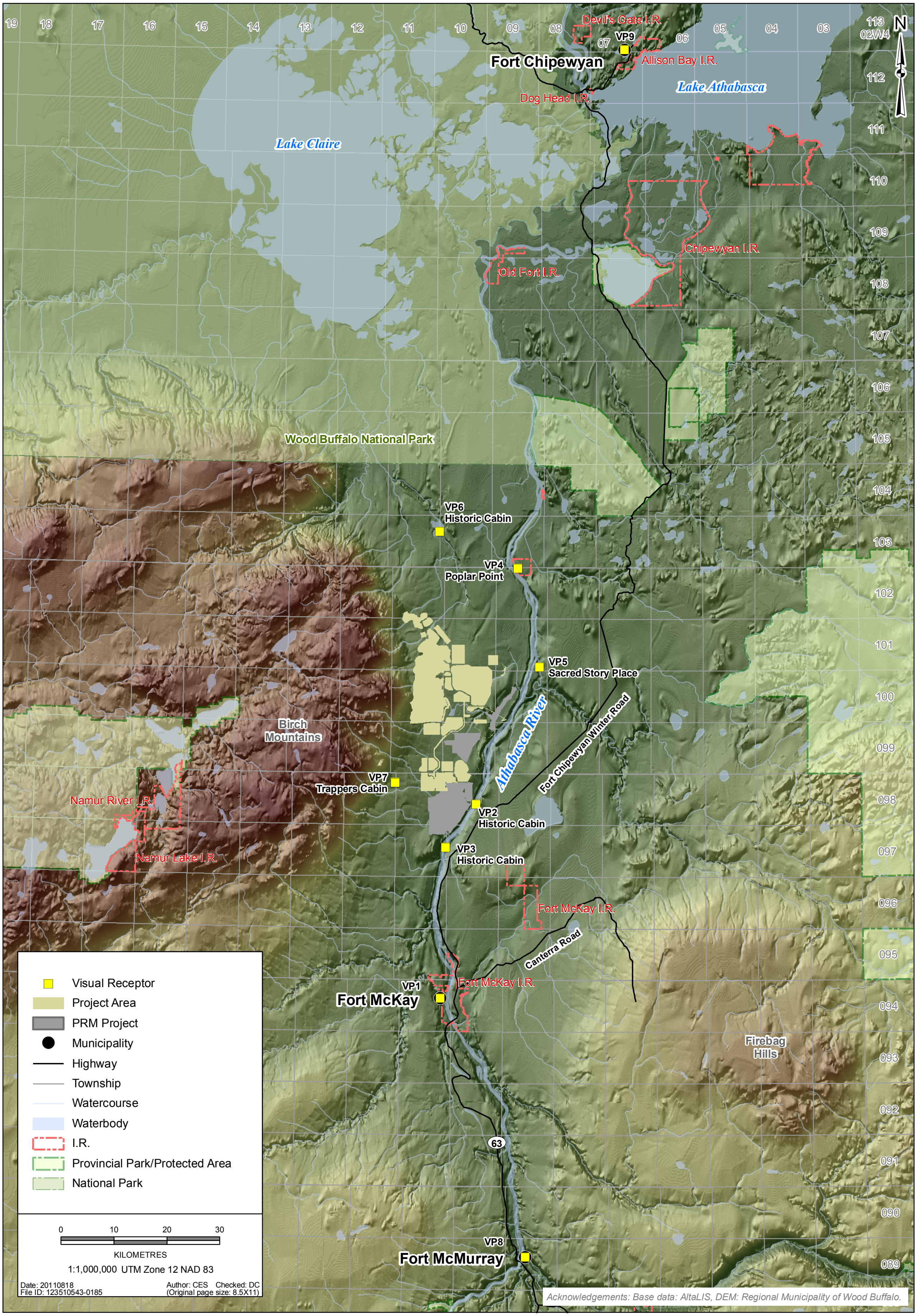


Figure 5-3: Visual Receptors

Model results were checked against all input data sources to ensure they were yielding expected results. Quality control of figures followed existing processes set in place to ensure the content, cartographic style, and message were appropriate and correct. The assessment report was reviewed by senior technical advisors for completeness.

5.5.3 Reference Conditions

For a description of existing conditions in the study area, see Section 5.4.

5.5.4 Application Case

5.5.4.1 Mitigation

Effects of the Project on visual aesthetics will be mitigated by maintaining vegetated buffers between the Project and the Athabasca River and along Project transportation corridors to the extent feasible. In some cases vegetated buffers may not be feasible as a line of sight may be required along a transportation corridor for safety reasons. In addition to buffers, reclamation techniques will be used that integrate closure plans with the surrounding landscape and adjacent operator development closure plans, including:

- contouring slopes to mimic natural topography
- establishing a variety of vegetation communities

5.5.4.2 Linkage Analysis

Vegetation clearing, construction of Project components, and changes in closure topography may alter the 2D line of sight from various locations. As a result, the linkage analysis is valid and a visual aesthetics assessment is completed.

5.5.4.3 Visibility of the Project

The Project at maximum build-out will be visible to an observer from the following areas on the landscape:

- between the Birch Mountains Escarpment and the Athabasca River where the topography is flatter
- at higher elevations on the east side of the Athabasca River

The Project is not visible from Fort McKay, Fort McMurray or Fort Chipewyan. For the modelled extent of the Project's visibility in the study area, see Figure 5-4.

The results show that there is very little visibility of the Project along the Athabasca River with the RWI being the only visible component. The length of visibility of the RWI on the Athabasca River is 1.7 km. Three-dimensional simulations of the RWI from the Athabasca River are shown in Figure 5-5. The steeper slopes along the banks of the river in combination with vegetation cover block the visibility of the rest of the Project.

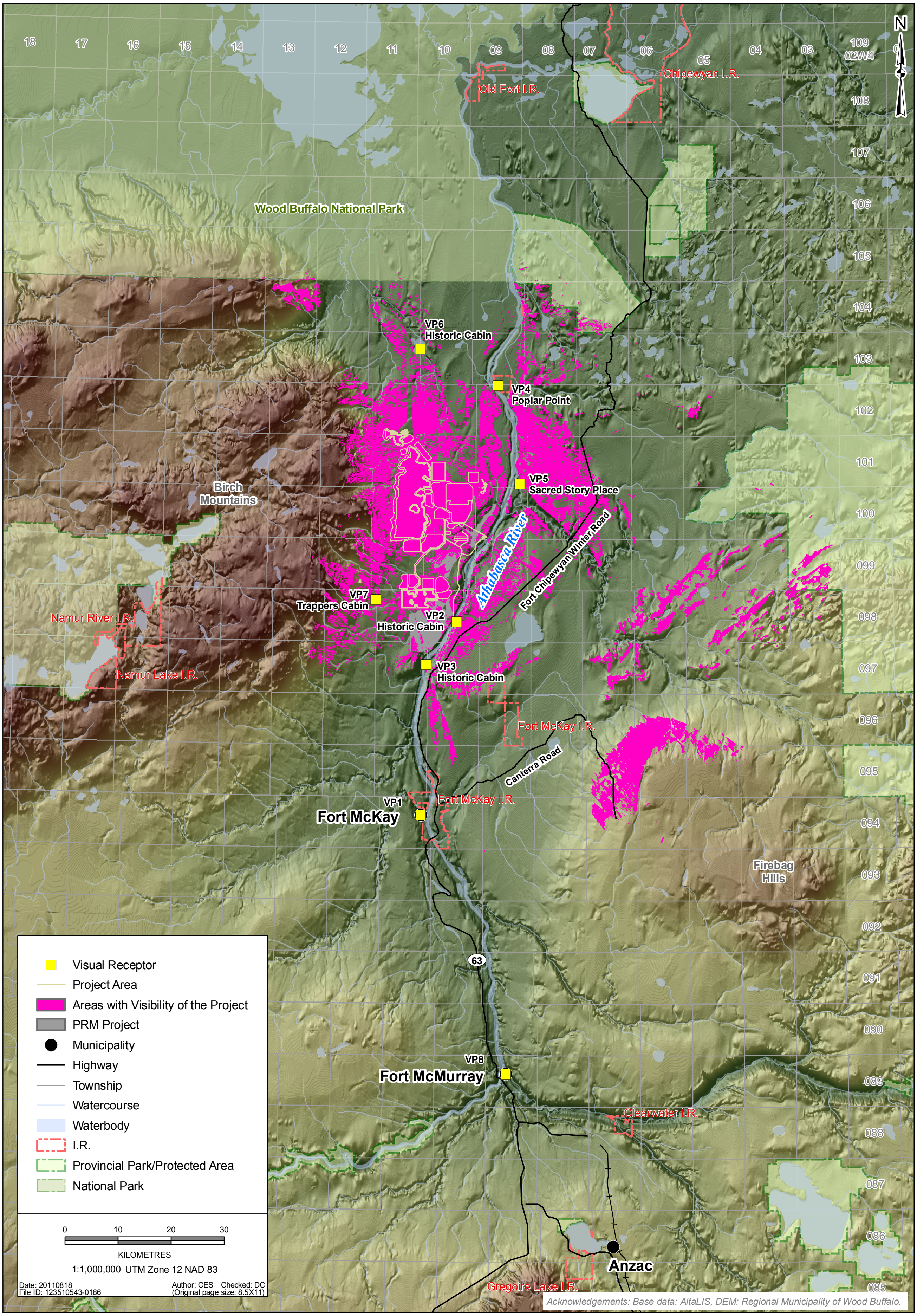
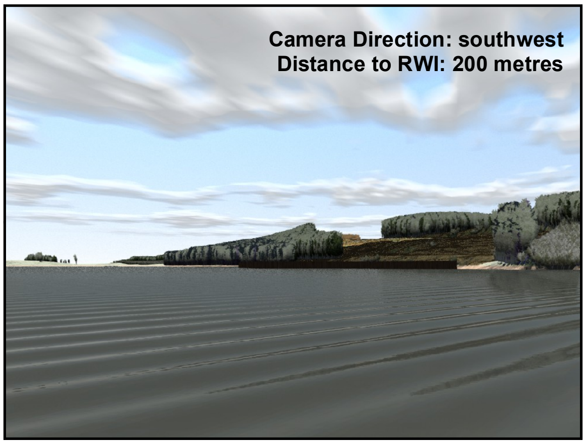


Figure 5-4: Visibility of the Frontier Project

1



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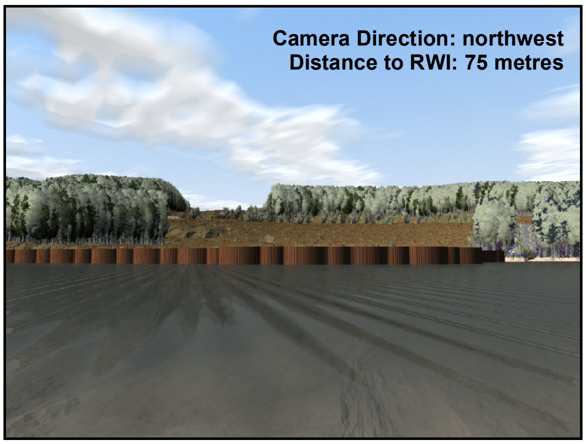

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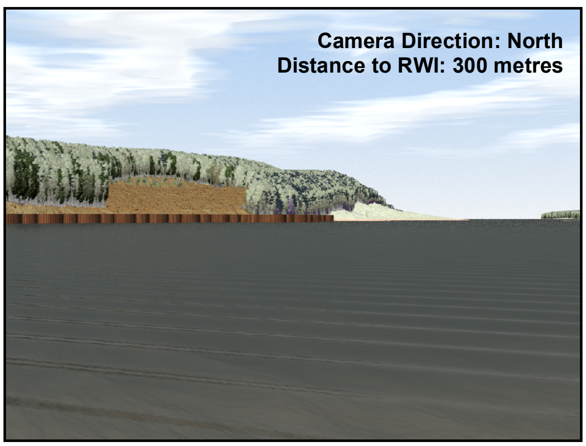

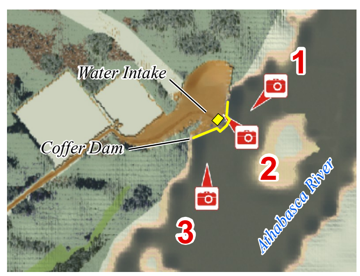

Figure 5-5: 3D Simulations of the RWI from the Athabasca River

There is intermittent visibility of the Project for a stretch of 26.7 km along the Fort Chipewyan Winter Road north of Fort McKay. There is also visibility of the Project on Canterra Road at higher elevations for a stretch of 10.7 km; other potential recreational access roads in the region show minimal visibility of the Project.

5.5.4.4 Visibility of the Project from Visual Receptors

The viewshed results for each receptor are shown in Figures 5-6 to 5-14, with the magenta areas showing what is visible to the receptor. The model results indicate that during construction and operation, only the trapper cabin at VP7 has visibility of the Project. At this receptor there is visibility of the proposed transmission towers which are located 150 m from the cabin.

At closure, the Project will be reclaimed using vegetation types similar, though not identical, to existing conditions creating a contiguous, vegetated landscape. Visibility of reclaimed areas would only occur at VP7 where the transmission towers were visible at maximum build-out.

5.5.5 Prediction Confidence

Overall prediction confidence for the visual aesthetics assessment is moderate.

5.5.5.1 Baseline Information

Inputs into the assessment of visual aesthetics included detailed digital elevation models as well as Project design information. Both types of inputs had reasonable accuracy; as a result, prediction confidence associated with baseline information is considered high.

5.5.5.2 Modelling

Prediction confidence in the models used for the assessment is moderate. Although viewshed modelling is considered the appropriate method for calculating visibility, this approach has a number of limitations. The following variables are not accounted for in the models:

- variability in observer visibility
- changes in light and weather conditions that affect contrast levels on the landscape that might limit or increase visibility (i.e., current visibility was examined at optimal conditions that included transparent conditions with minimal wind)
- seasonal changes in foliage that might increase potential visibility along with growth in vegetation
- variability of vegetation density (species and fire induced) that might increase potential visibility

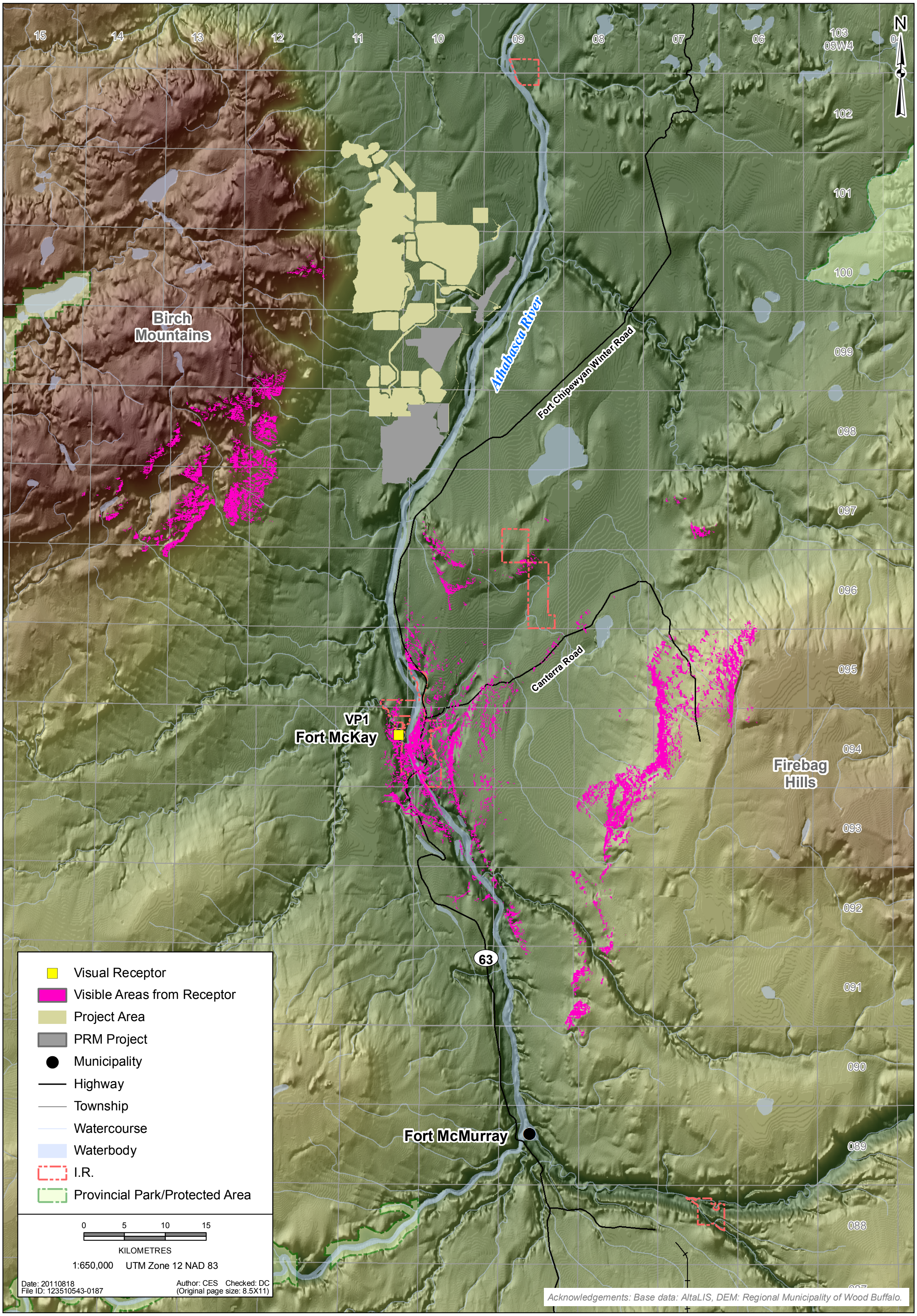

Figure 5-6: Visibility from VP1 – Application Case (Maximum Build-out)

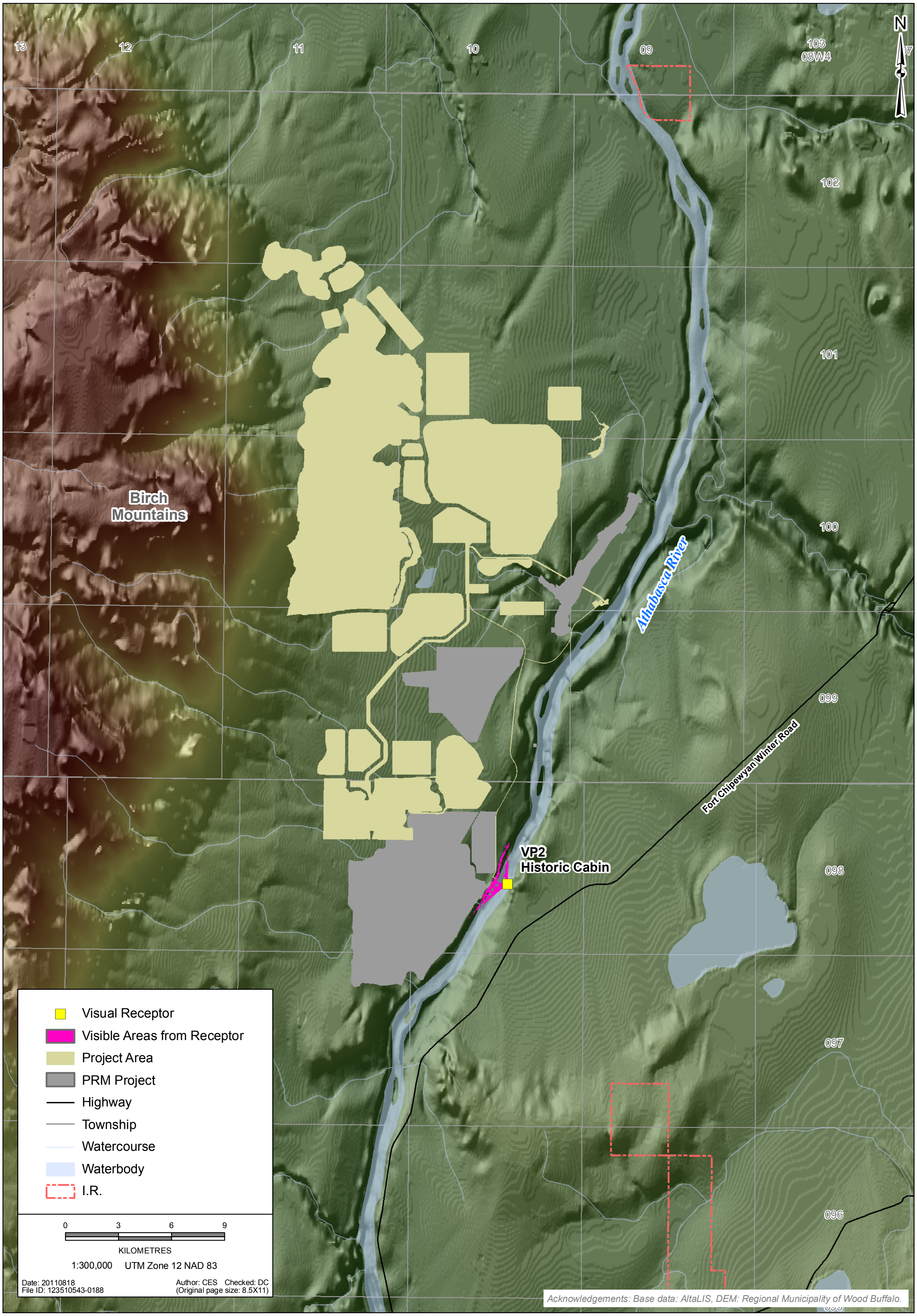

Figure 5-7: Visibility from VP2 – Application Case (Maximum Build-out)

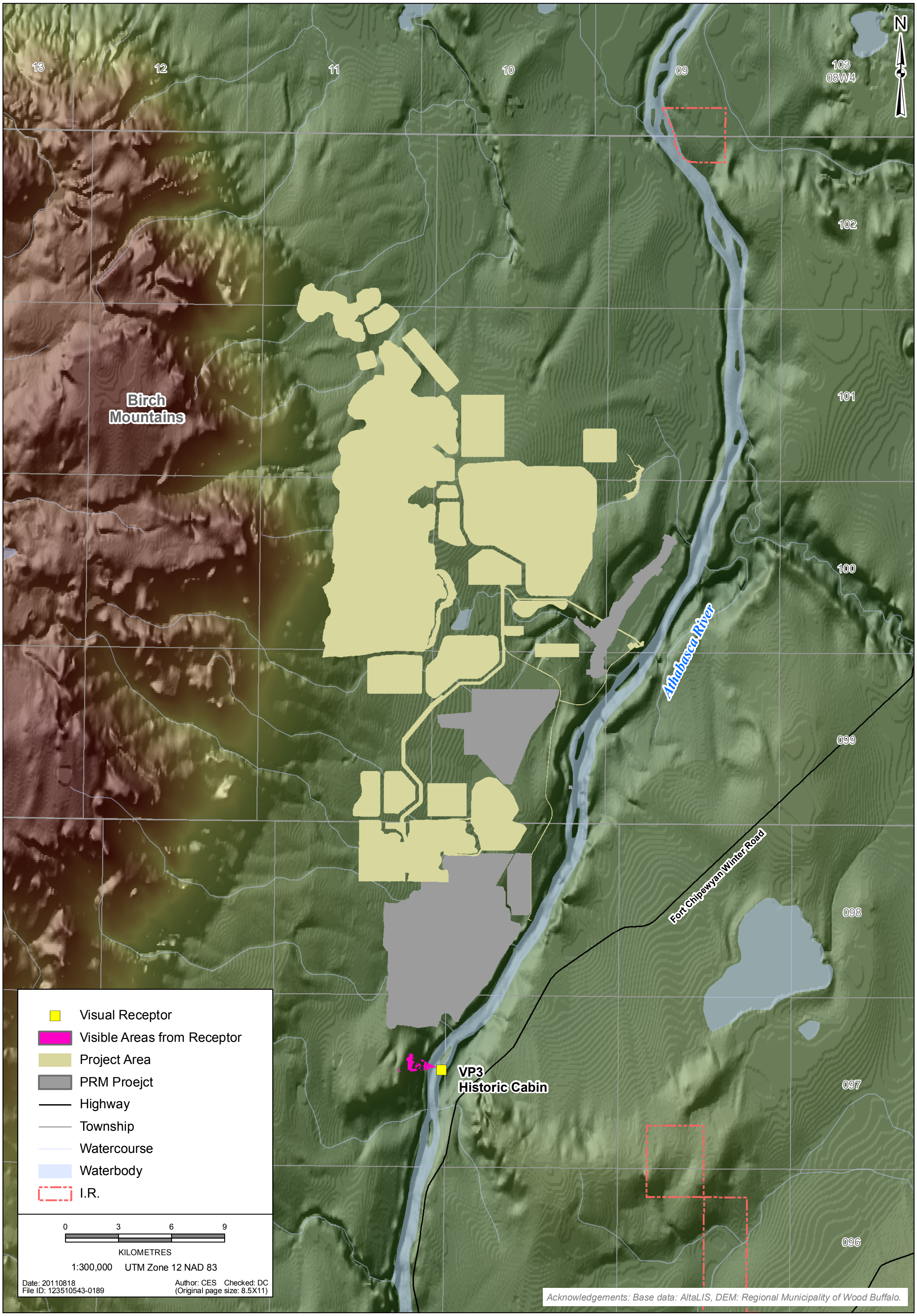

Figure 5-8: Visibility from VP3 – Application Case (Maximum Build-out)

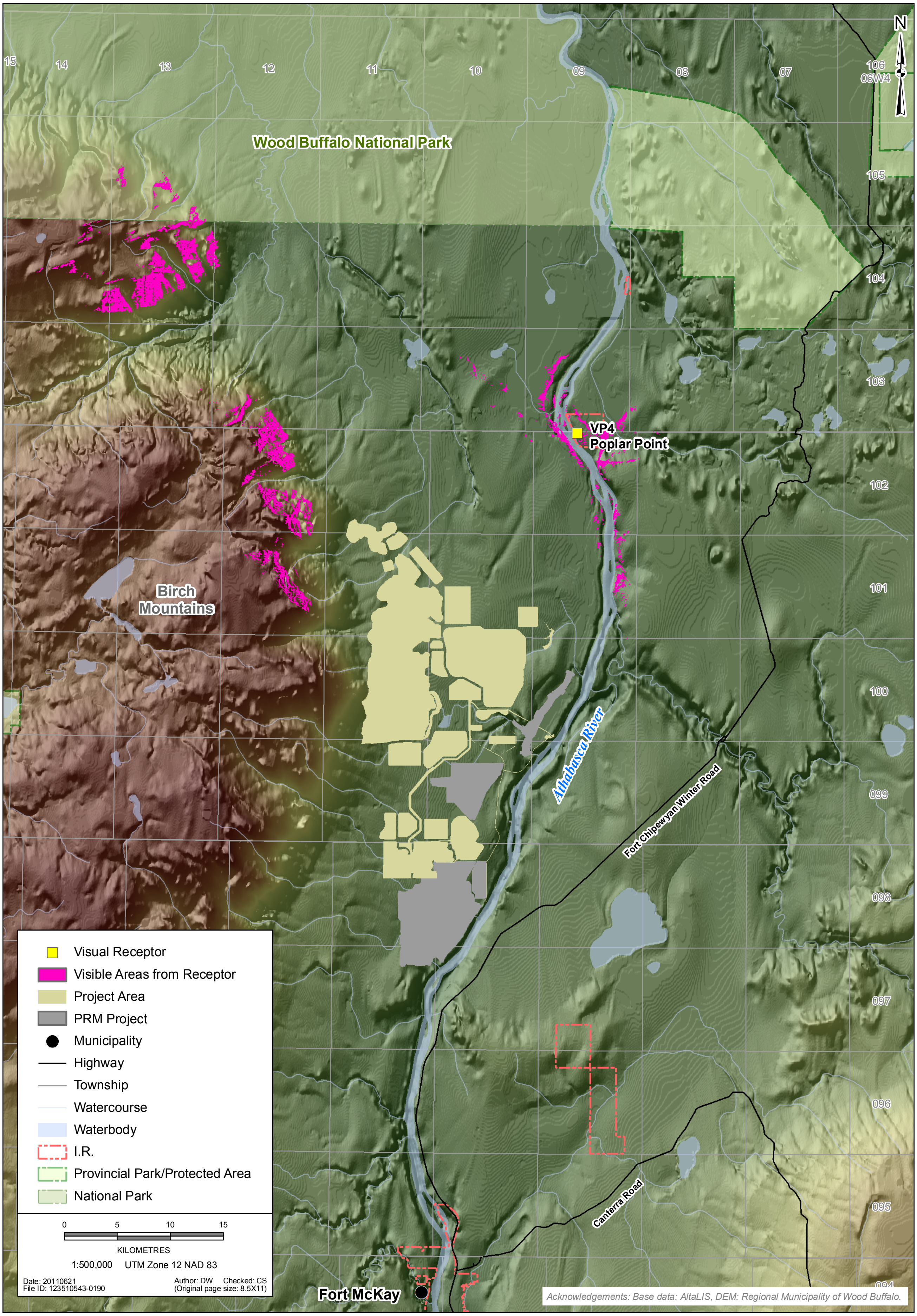

Figure 5-9: Visibility from VP4 – Application Case (Maximum Build-out)

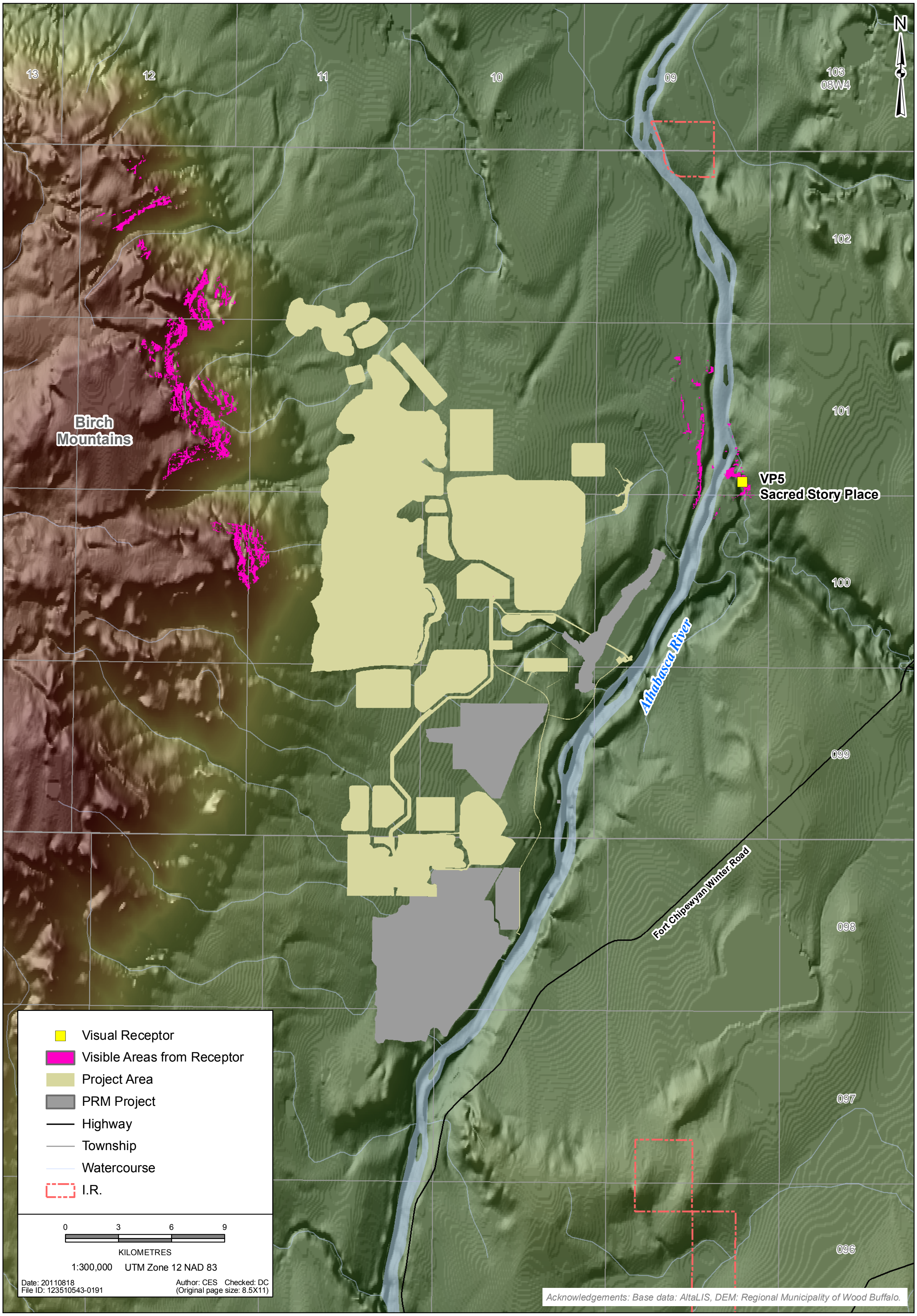

Figure 5-10: Visibility from VP5 – Application Case (Maximum Build-out)

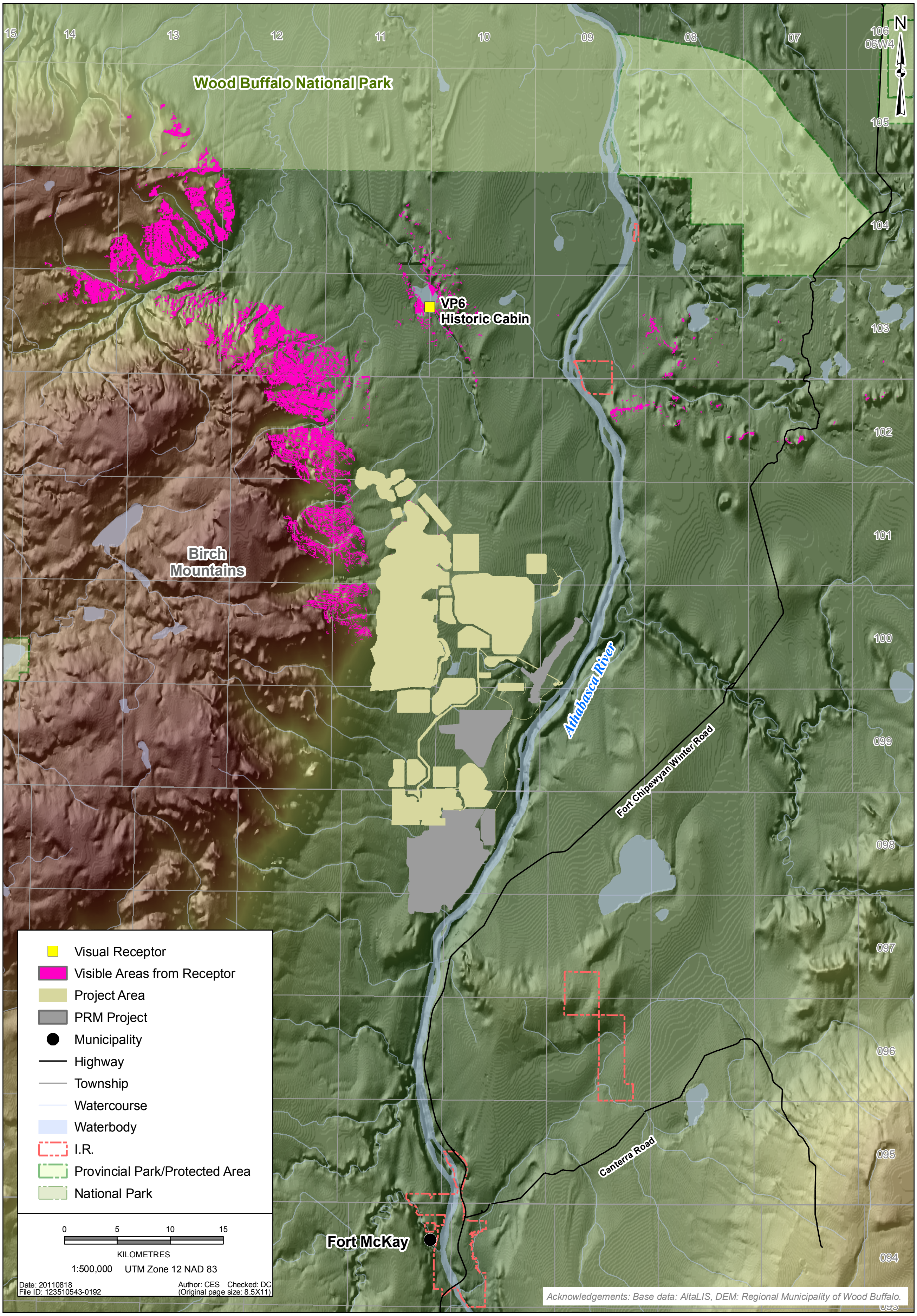

Figure 5-11: Visibility from VP6 – Application Case (Maximum Build-out)

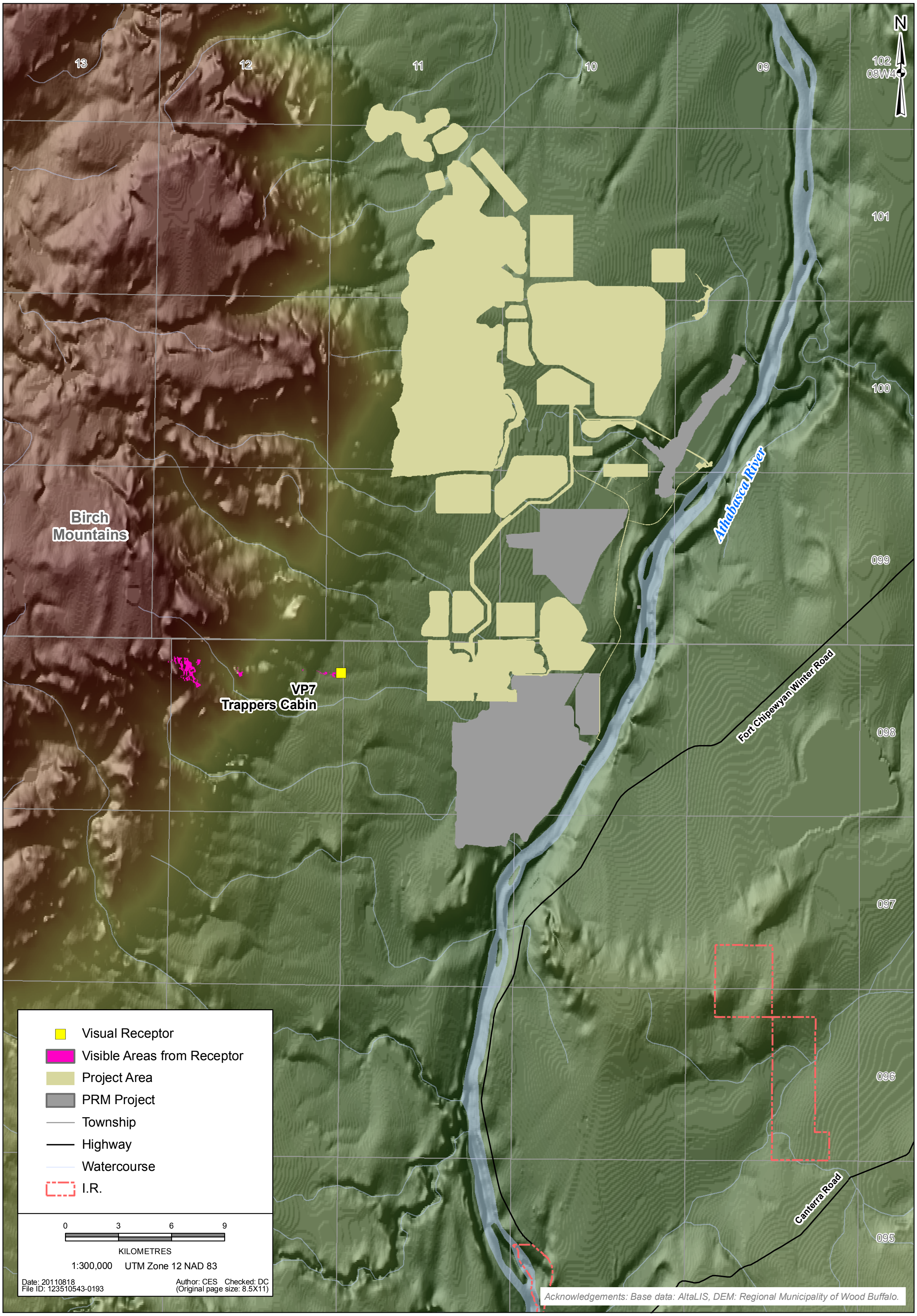

Figure 5-12: Visibility from VP7 – Application Case (Maximum Build-out)

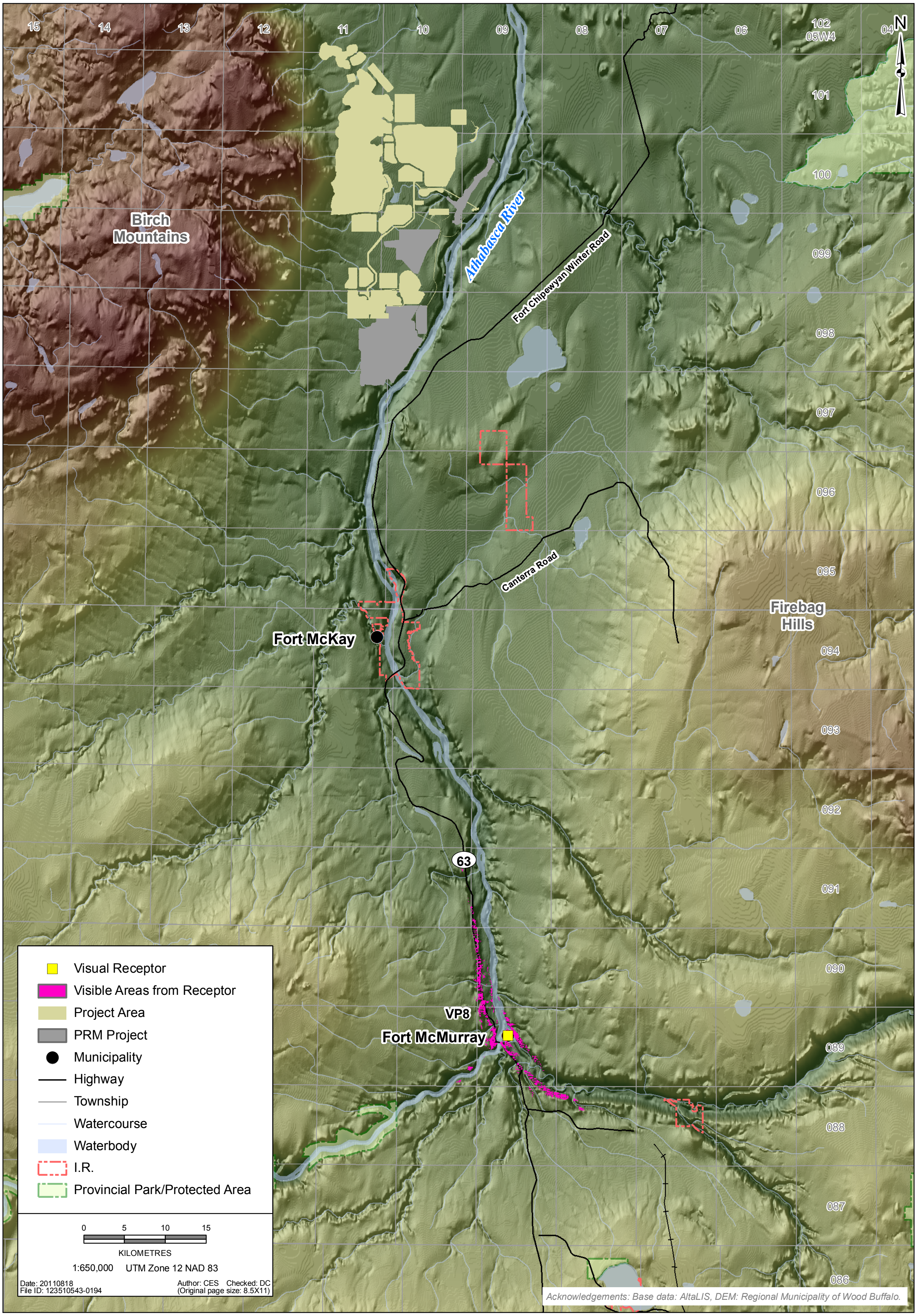

Figure 5-13: Visibility from VP8 – Application Case (Maximum Build-out)

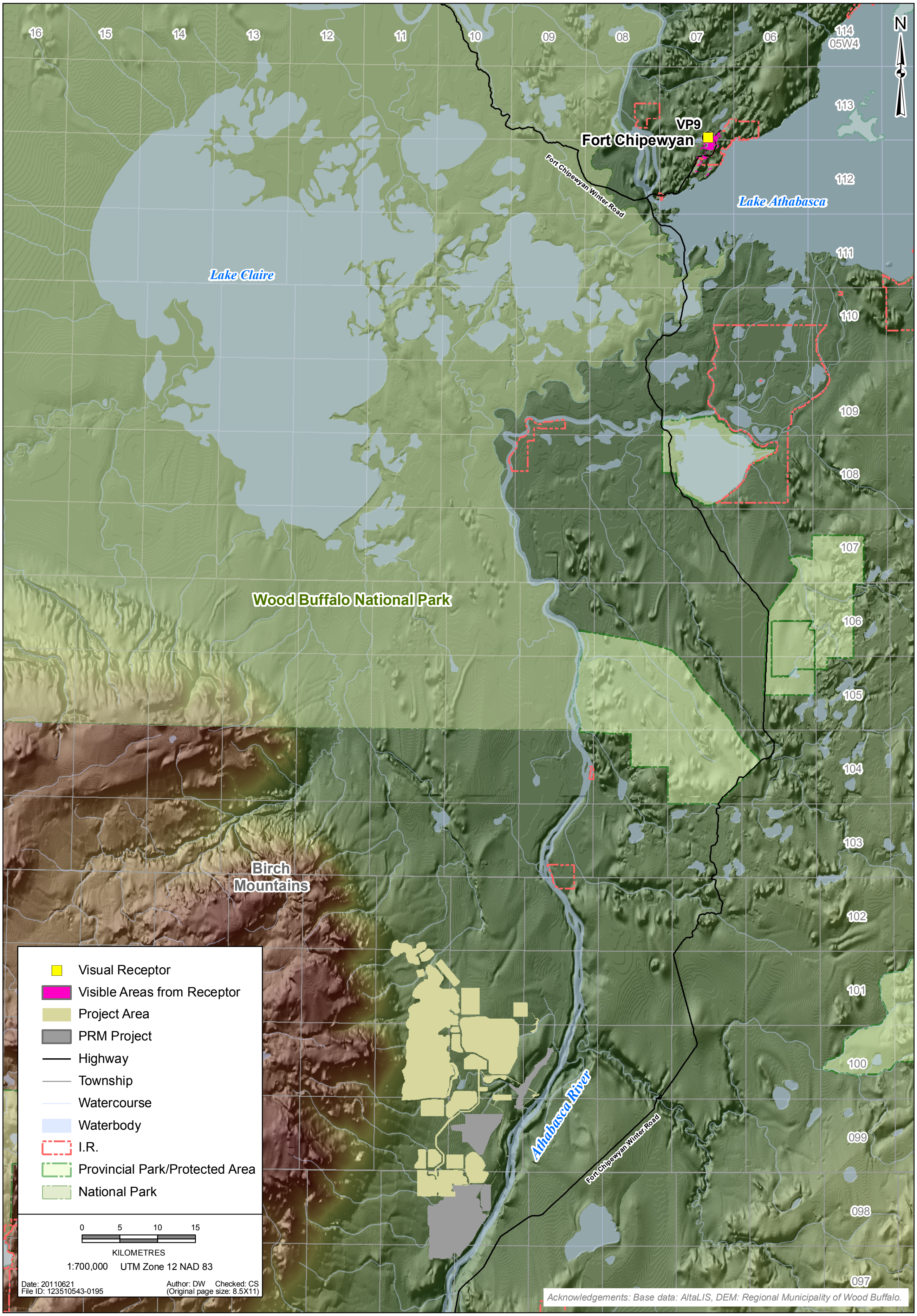

Figure 5-14: Visibility from VP9 – Application Case (Maximum Build-out)

5.5.5.3 Mitigation

The Project's closure plans will be discussed with adjacent operators to:

- integrate and contour slopes to mimic natural topography
- establish a variety of vegetation communities and avoid unnatural-appearing breaks at joining development boundaries

Mitigation measures can be implemented only where they do not conflict with safety requirements for a line of sight use, as a mitigation measure will not be consistently effective. Confidence in mitigation measures is moderate.

5.5.6 Responses to Aboriginal Community Concerns

Visibility of the Project (whether it is visible from specific vantage points) was identified as a concern, particularly from along the Athabasca River at the river water intake, Fort McKay, nearby sacred sites and trapper and historic cabins.

Mitigation measures to reduce potential effects will be implemented where practical, as identified in Section 5.5.5.3. For the identified locations of concern, several techniques can be used, including:

- use of construction materials that reduce contrast, limiting visual attraction to Project features and blending built structures into the natural surrounding environment
- use of construction materials that minimize reflecting light, potentially reducing viewing distances of Project features

To further mitigate visual aesthetics, the Project's closure plans will be discussed with adjacent operators to:

- integrate and contour slopes to mimic natural topography
- establish a variety of vegetation communities and avoid unnatural-appearing breaks at joining development boundaries

5.5.7 Management and Monitoring

To further manage potential visual effects, all complaints associated with the Project will be recorded in a complaint log book or register, investigated and followed up with the complainant.

5.6 Conclusions

Project components will be seen at:

- the Athabasca River (1.7 km)
- potential recreational access routes, including 26.7 km along the Fort Chipewyan Winter Road and 10.7 km along the Canterra Road at higher elevations
- one visual receptor (VP7)

The visual aesthetics assessment is considered to have a moderate overall prediction confidence. The model inputs were considered accurate and reliable, yet they have several limitations that do not account for variability in local site conditions and vegetation cover.

5.7 References

5.7.1 Literature Cited

AENV (Alberta Environment). 2009. *Final Terms of Reference Environmental Impact Assessment Report for the Proposed UTS Energy Corporation/Teck Cominco Limited Frontier Oil Sands Mine Project*. Edmonton, Alberta.

ASRD (Alberta Sustainable Resource Development). 2002. *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan*. Approved by Cabinet on May 7, 1996. Amended June 2002.

Government of Alberta. 2011. *Draft Lower Athabasca Integrated Regional Plan 2011–2021*. Strategic Plan, Implementation Plan and Regulations. Edmonton, Alberta. April 2011.

IEMA (The Landscape Institute, Institute of Environmental Management and Assessment). 2002. *Guidelines for Landscape and Visual Impact Assessment, Second Edition,* Spon Press: New York, p.166.

Ogburn, D.E 2006. Assessing the level of visibility of cultural objects in past landscapes. *Journal of Archaeological Science*. 33 pp. 405–413

5.7.2 Internet Sites

CEMA (Cumulative Environmental Management Association). 2011. *Studying Cumulative Effects in Wood Buffalo.* Available at: http://library.cemaonline.ca/front-page (Contract Number 2005-0037 SEWG) and (Contract Number 2002-0008 SEWG). Accessed: March 2011.

ESRI (Environmental System Research Institute), ArcGIS 9.3 Desktop Help. 2011. *How Viewshed Works*. Available at http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName= How%20Viewshed%20works. Accessed: March 2011.

6 Traditional Land Use

6.1 Introduction

This section of the environmental impact assessment (EIA) for the Frontier Oil Sands Mine Project (Frontier Project):

- describes mitigation to reduce Project effects on traditional land use (TLU) activities. Traditional land uses include hunting and trapping, plant harvesting, fishing, cultural activities, or any travel related to these activities. Traditional land use areas include land that is used to harvest traditional resources including game and berries or medicinal plants. It may also include areas of spiritual or historical significance based on oral tradition. In this assessment, traditional knowledge refers to Aboriginal knowledge and understanding of the activities and areas identified above.
- assesses potential effects of the Project on areas used for traditional land use by First Nations and Métis groups around the Project
- considers the potential for cumulative effects from the Project together with other operating, approved and planned developments in the Athabasca Oil Sands Region

A description of the Frontier Project is provided in Volume 1.

The Frontier Project is located within the traditional lands of the Fort McKay First Nation (FMFN), Athabasca Chipewyan First Nation (ACFN) and the Mikisew Cree First Nation (MCFN); and is also located on lands that have been traditionally used by the Métis communities of Fort Chipewyan and Fort McKay.

Teck Resources Limited and SilverBirch Energy Corporation (the Owners) have actively consulted with the FMFN, ACFN, MCFN and the Métis Communities of Fort Chipewyan (Métis Local 125) and Fort McKay (Métis Local 63) with the intent of understanding the nature and extent of traditional activities in the vicinity of the Project. These consultation activities will continue throughout the life of the Project.

Information collected from a review of available literature, historical studies for other developments in the region, and interviews with Aboriginal communities were used to inform the EIA for the Project. Potential disturbance data for Base Case, Application Case and Planned Development Case (PDC), as well as information gathered from the Owners' consultations with the MCFN, ACFN, FMFN and Métis communities of Fort McKay and Fort Chipewyan have also been incorporated into this assessment.

6.2 Scoping the Assessment

The scope of the traditional land use assessment was directed by the terms of reference (TOR) issued for the Frontier Project by Alberta Environment (AENV 2009), as well as by specific regulatory inputs and concerns from potentially affected Aboriginal communities. These inputs helped identify the key issues of concern and define the key questions that are the focus of this assessment.

6.2.1 Terms of Reference

The requirements of the TOR relevant to traditional land use include:

Provide:

- *a description of the extent of traditional use of land in the local study area*
- *a summary of information provided to the communities during consultation (e.g., map containing lease boundaries, traplines, mine plan, pipelines etc.) and any specific TLU or TEK studies*
- *references for information gathered during consultations and interviews in a format similar to literature citations (e.g., Last Name or Participant Code and date). This will help to clearly identify information sources*
- *a discussion of:*
    - *access to traditional lands on the lease site (including pre-development, baseline, operational and closure scenarios)*
    - *Aboriginal views on traditionally meaningful land reclamation and how those views were incorporated into the reclamation plan*
    - *trapper compensation*
    - *ongoing impacts to traditional lands and culture*
- *a discussion of the vegetation and wildlife used for traditional, food, ceremonial, medicinal and other purposes, and any potential effects the Project may have;*
- *a discussion of traditional uses including fishing, hunting, trapping, nutritional or medicinal plant harvesting, and cultural use by affected aboriginal peoples;*
- *a map of cabin sites, spiritual sites, graves and other traditional use sites considered as historic resources under the Historical Resources Act (if the aboriginal community or group is willing to have these locations disclosed), as well as traditional trails and resource activity patterns; and*
- *a description of how traditional ecological knowledge was gathered and incorporated into the assessment, Project design and mitigation*

Determine the impact of development of traditional uses of land and identify possible mitigation strategies in consultation with aboriginal communities and groups.

For a concordance table of the TOR and traditional land use, see Volume 3, Section 1, Appendix 1A.

6.2.2 Regulatory Setting

In the context of regulations, guidelines and policies indirectly pertaining to traditional land use, this assessment was primarily directed by the specific set of requirements outlined by the TOR (see Section 6.2.1). Key questions were developed to address the TOR (see Section 6.2.5), and guide the assessment of the potential effects of the Project on traditional land use.

6.2.3 Regulatory and Aboriginal Community Input

Input from a variety of potentially affected Aboriginal communities and regulatory sources influenced the traditional land use assessment. These sources included meetings with regulators, Aboriginal community and public stakeholder consultations and regional committees. Correspondence and consultation activities with Aboriginal communities and public stakeholders regarding the Project were documented and updated regularly, tracking the consultation process and emerging issues.

Out of respect for the personal information of community members, references for information and concerns gathered during consultation (similar to literature citations) are not generated and therefore not presented here. Formal interviews with potentially affected Aboriginal community members were undertaken during community-led, Project-specific traditional land use (TLU) and traditional use studies (TUS). Upon request by the communities undertaking these studies, specific results or quotations from these interviews are not cited in this application, and therefore not referenced.

6.2.3.1 Aboriginal Community Concerns

Based on input received during consultations with potentially affected Aboriginal communities, concerns were expressed about loss of traditional lands. Issues and concerns related to traditional land use expressed during these consultations include:

- proximity to Moose Lake, including Moose Lake trail, the Birch Mountain area (burial grounds)
- proximity to Poplar Point Indian reserve
- access to lease land and land beyond the Frontier Project for traditional use
- addition of new developments within the ACFN traditional lands results in difficulties carrying out Aboriginal and Treaty Rights
- proximity to areas that are traditionally used by ACFN for hunting, trapping and fishing
- Project will further destruct hunting and trapping areas, further adversely affect quality and quantity of fish and adversely affect the water and ecosystem

- ACFN members find it increasingly difficult to exercise Treaty Rights in the face of ongoing development; ACFN members have been told to "go elsewhere", this results in increased time and cost due to longer travel
- ACFN Elders are finding it difficult to transmit their knowledge to youth because of ongoing development within their traditional lands

The TLU baseline identified TLU-specific Aboriginal community concerns related to resource development in the Athabasca Oil Sands Region (see Volume 2, Section 13.3). The concerns generally have the following themes:

- Concern about cumulative effects related to resource development in the Athabasca Oil Sands Region, and the effects of development already having a large effect on traditional activities
- That Aboriginal peoples in the oil sands region maintain a strong connection to the land and highly value environmental integrity
- Concern that changes to access in the region may result in an increase in non-traditional resource users and reduced access for traditional resource users

Traditional land use concerns identified by Aboriginal communities—some of which were identified in the TLU baseline (see Volume 2, Section 13.3)—have been considered in this assessment. All other EIA sections in this Application also identify Aboriginal concerns and inputs and respond to those concerns and inputs as part of each discipline's assessments.

Responses to concerns expressed by Aboriginal communities are provided following the assessment of each key issue. For a summary of the issues and concerns expressed during Aboriginal community consultations for the Project, and the responses to these issues and concerns, see Volume 1, Section 17. In addition to the summary, each section of the EIA contains details on potentially affected Aboriginal community concerns and how these have been specifically addressed.

6.2.3.2 Regional Committees

The Cumulative Environmental Management Association (CEMA) includes a traditional environmental knowledge committee that guides CEMA's working groups in the collection and use of traditional knowledge. Strategies and reports generated by CEMA were considered during this assessment.

6.2.4 Key Issues

Based on input gathered from regulatory sources and consultations with potentially affected Aboriginal communities, a series of key issues were defined for the traditional land use assessment. These key issues are consistent with those identified in previous TLU studies, project-specific EIAs and other regional reports regarding the potential effects of resource development on traditional land uses.

A summary of the key issues for each phase of the Frontier Project and their relevance to the Frontier Project are summarized in Table 6-1.

Table 6-1 Key Issues – Traditional Land Use

Project Phase	Key Issue	Relevance to Project
Construction, operation, closure	• Potential effects on wildlife habitat that may affect traditional hunting and trapping	• Project activities such as disturbance may affect wildlife habitat
	• Potential effects on traditional trails, cabins and sacred sites	• Project activities such as disturbance may affect traditional trails, cabins and sacred sites
	• Potential effects on fish or fish habitat that may affect traditional fishing	• Project activities, such as disturbance, runoff water and Project-related dust, may affect fish habitat
	• Potential effects on traditional use plants used for consumption, medicinal or spiritual purposes	• Areas with traditional use plant potential may be disturbed due to the Project
	• Potential effects on culturally important sites or areas	• Project activities may cause disturbance to culturally important areas, or affect the use of the areas

Other disciplines and sections in this EIA also identified traditional land use-related issues; however, all key traditional land use issues are assessed in this section. For the details of related assessments and the incorporation of traditional land use information into other assessments, see:

- closure, conservation and reclamation plan – Volume 1 Section 13
- fish and fish habitat – Volume 5, Section 5
- vegetation – Volume 6, Section 3
- wildlife – Volume 6, Section 4
- palaeontology – Section 2
- historical resources – Section 3
- resource use – Section 4

6.2.5 Key Questions

Two key questions were developed to address the key issues and focus the assessment on these issues of concern. Key questions for the traditional land use assessment are:

- TLU1: Could the Frontier Project affect traditional land uses?
- TLU2: Could the Frontier Project in combination with other developments cumulatively affect the potential for traditional land uses?

6.3 Approach

6.3.1 Study Areas

The Project is located approximately 110 km north of Fort McMurray on the west side of the Athabasca River near the Birch Mountains, in Townships (Twps) 98 to 102, Ranges (Rges) 10 and 11, West of the Fourth Meridian (W4M).

A local study area (LSA) and regional study area (RSA) were defined for the purpose of this TLU assessment (see Figures 6-1 and 6-2). The LSA represents the spatial extent of known traditional land use and traditional knowledge activities that may be directly or indirectly affected by the Project. The RSA represents the farthest expected cumulative effect of the Project in combination with operating, approved and planned developments on terrestrial resources. The boundaries and rationale for the study areas are described below.

6.3.1.1 Local Study Area

The LSA for the traditional land use assessment is based on the LSA used for the vegetation and wildlife assessments (see Volume 6, Sections 3.3.1 and 4.3.1). The LSA includes the Project assessment area (PAA) (i.e., the maximum extent where vegetation clearing may occur but is not currently planned) as well as a buffer area within which environmental effects of the Project can be predicted with a reasonable degree of accuracy and confidence, and where effects are likely to be most concentrated (see Figure 4-1). The buffer is about 500 m wide but varies along the eastern margin from 0 m to 1,700 m where it intersects the Athabasca River).

6.3.1.2 Regional Study Area

The RSA for the traditional land use assessment is based on the RSA used for the vegetation and wildlife assessments (see Volume 6, Sections 3.3.1 and 4.3.1). The RSA has been defined to encompass the farthest cumulative effect of the Project in combination with operating, approved and planned developments.

The RSA considers the potential effects on wildlife and vegetation, which are important components of traditional land use activities. Traditional aquatic resources, such as fish, are also considered within the RSA and LSA.

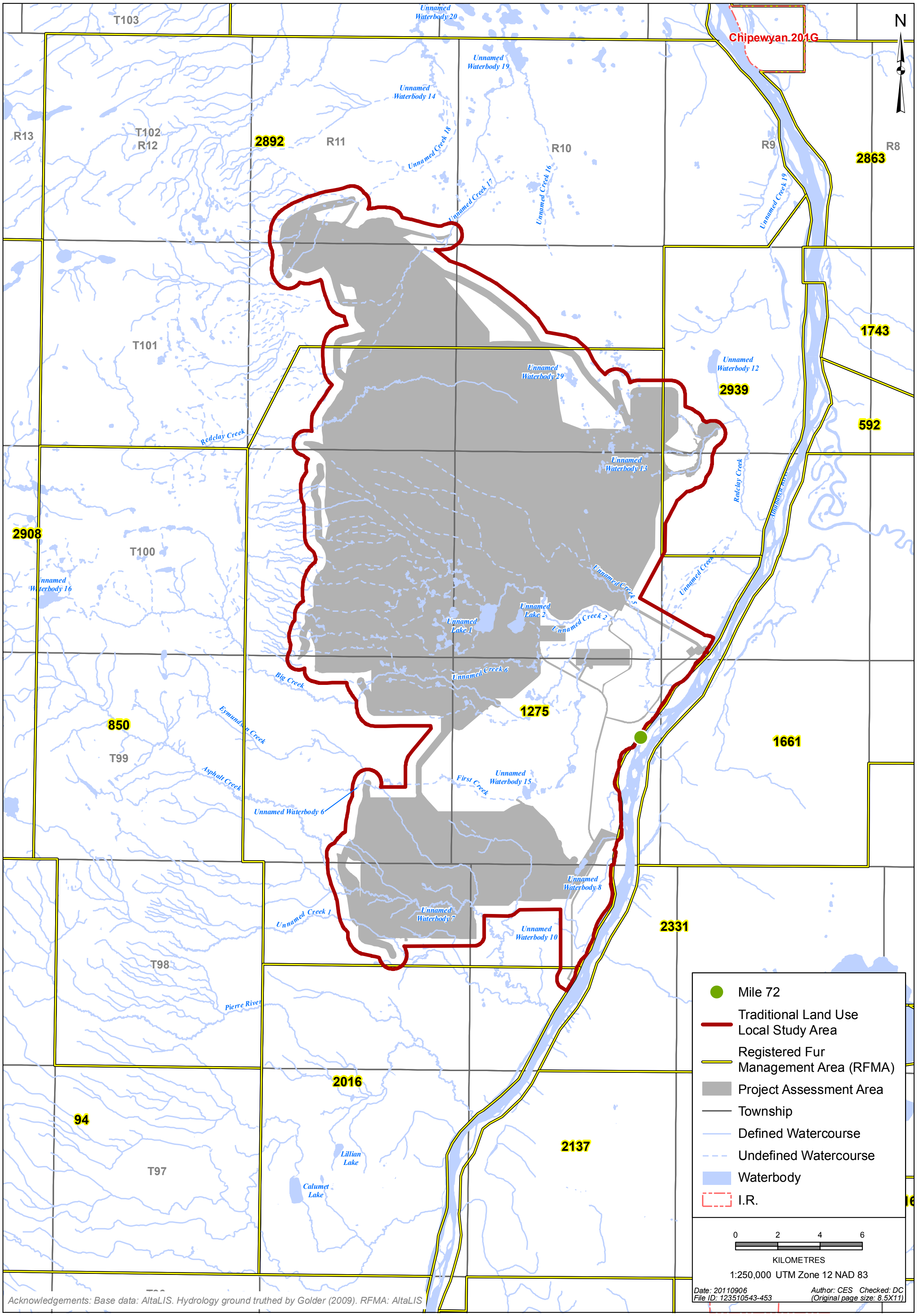

Figure 6-1: Traditional Land Use LSA and RFMAs

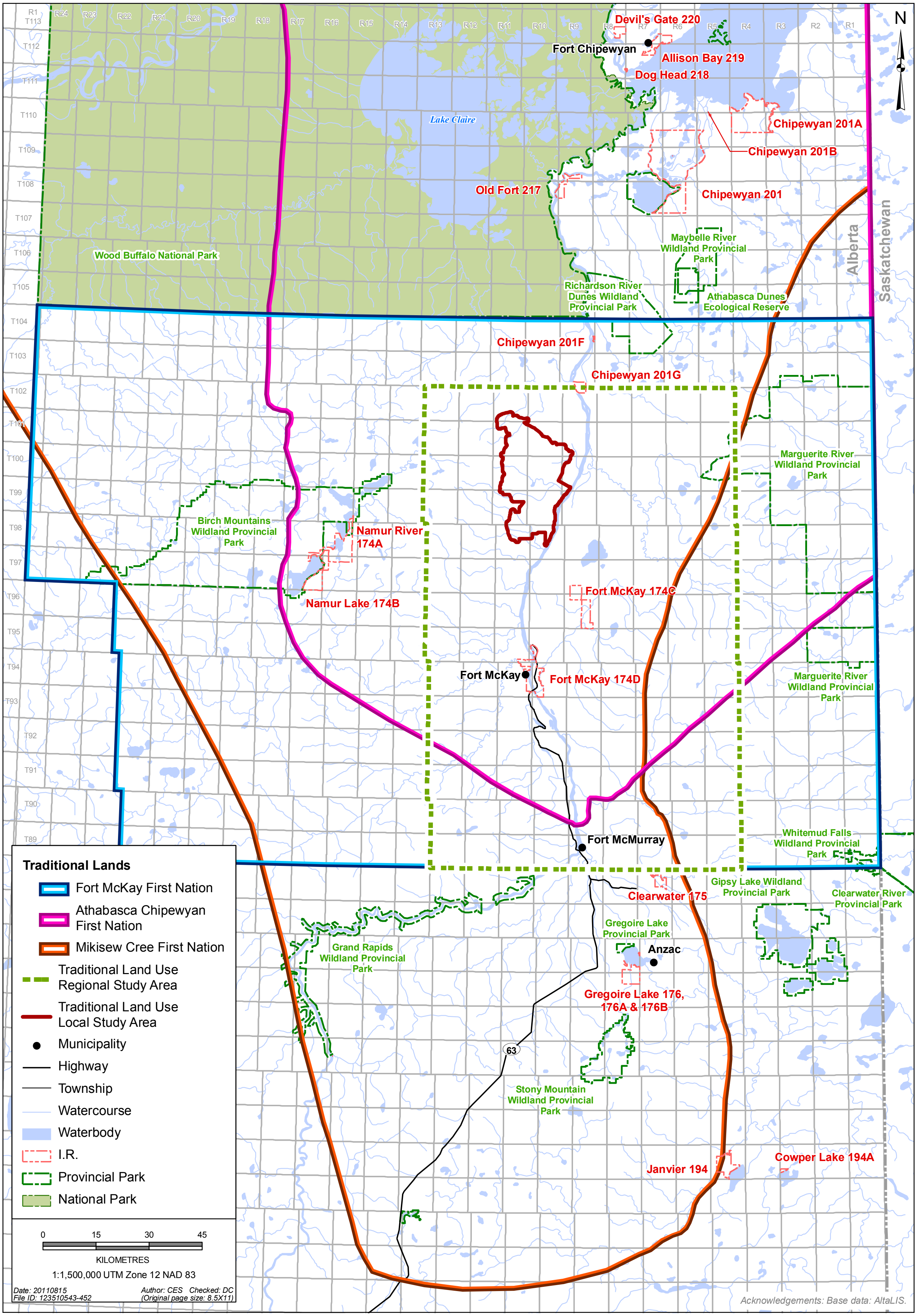

Figure 6-2: RSA and First Nations Traditional Lands

Information derived from previous and available reports commissioned by industry and Aboriginal communities indicates that traditional land use activities overlap the RSA. As a result, this area provides a base from which to assess effects on traditional land use. The RSA overlaps the traditional territories of the ACFN, MCFN and FMFN (see Figure 6-2). The RSA also partially overlaps the traditional territories of the Fort McMurray #468 First Nation (FM468) and the Chipewyan Prairie Dene First Nation (CPDFN). A review of the CPDFN TLU study, *Kai'Kos' Dehseh Dené* (CPDFN 2007) indicates that although the Project LSA is situated in the northern portion of the CPDFN territory, the majority of CPDFN traditional activities have occurred south of the Town of Fort McMurray. No activities were identified in the LSA. The FM468 TLU study, *Nistawaya, Where Three Rivers Meet* (FM468 2006), indicates that the Project LSA is located inside and close to the northern border of the FMFN territory. Although some traditional wildlife harvesting has occurred in the general vicinity of the LSA, historically most FM468 traditional activities have occurred south of Fort McKay and on the east side of the Athabasca River (FM468 2006).

6.3.2 Assessment Cases

Traditional land use key issues and associated key indicators were evaluated in the context of the following development scenarios:

- Base Case, which includes developments and activities that are currently operating or under construction, activities approved but not yet constructed or those likely to be approved in the near future
- Application Case, which includes developments and activities in the Base Case with the Frontier Project added
- Planned Development Case (PDC), which includes developments and activities included in the Application Case with other planned developments that are reasonably foreseeable added

For more details on the assessment cases and the related developments and activities included in each case and considered relevant to the traditional land use assessment, see Volume 3, Section 1, Appendix 1C.

6.3.3 Temporal Considerations

6.3.3.1 Reference Conditions

To provide a reference for the assessment of traditional land use key issues and associated key indicators, reference conditions or reference snapshots were evaluated in a general context. Specific time periods cannot be established because traditional land use is often described in a way that is not attributable to a specific or definitive time period. Where a specific period of time can be identified, that distinction has been made. Reference conditions generally considered the following:

- historic, which includes predevelopment (i.e., no disturbance)
- recent, which includes existing (2008)

The predevelopment landscape was generated by assigning vegetation types to all existing visible surface disturbances on the landscape. Where available, predevelopment landscape information from previous EIAs was used to identify vegetation types and associated wildlife habitat. If information was not available, disturbance areas were assigned vegetation types based either on adjacent vegetation types or vegetation occurrence and distribution in areas with similar surficial geology.

6.3.3.2 Snapshots

In addition to the reference condition snapshots, the following temporal snapshots were used to evaluate changes from the Project, in combination with other developments, on traditional land use as applicable:

- maximum build-out (2057), represents the point of maximum land disturbance
- closure (2068)

Disturbances associated with developments other than the Project are always included as unreclaimed, with the exception of the Shell Pierre River Mine (PRM) project fish habitat compensation lake, which is defined as water. As a result, any predicted cumulative effects are conservative (i.e., the assessments overpredict cumulative effects associated with vegetation disturbance).

6.3.4 Key Indicators

To focus the assessment, key indicators were chosen to represent effects on traditional land use. These key indicators are examined at the appropriate scale (i.e., LSA and/or RSA) for each key question. For each key indicator, at least one measurable parameter was selected to provide a means of measuring and assessing effects of the Project. A list of key indicators and measurable parameters for each key question and key issue is found in Table 6-2.

6.3.5 Prediction Confidence

Assessment of Project effects has some inherent uncertainty associated with data, methods and the predictive nature of the assessment. In addition, changes in future environmental conditions could also result in added uncertainty. Assessment confidence was determined by considering:

- quality and quantity of baseline data used in the assessment
- confidence in measurements and analytical techniques
- confidence in the success of Project-specific mitigation measures
- potential changes in future environmental conditions, such as possible climate change influences on traditional land uses

The effects of climate change are included under prediction confidence discussions because of the uncertainty that climate change may have on predictions as well as the uncertainty associated as to what particular climate changes may occur.

Table 6-2 Key Indicators – Traditional Land Use

Key Question	Effects Pathway	Key Indicator	Measureable Parameter	Spatial Consideration
TLU1: Could the Frontier Project affect traditional land uses?	Potential effects on wildlife habitat that may affect traditional hunting and trapping	• Traditional knowledge of wildlife habitat and hunting and trapping areas and locations	• RFMA locations • Traditional hunting and trapping areas and locations	LSA
	Potential effects on traditional trails, cabins and sacred site	• Traditional knowledge of traditional trails, cabins and sacred site	• Traditional trails, cabins and sacred site	LSA
	Potential effects on fish or fish habitat that may affect traditional fishing	• Traditional knowledge of fishing areas and locations	• Traditional fishing areas and locations	LSA
	Potential effects on traditional use plants used for consumption, medicinal or spiritual purposes	• Traditional knowledge of plant areas and locations	• Traditional plant areas and locations	LSA
TLU2: Could the Frontier Project in combination with other developments cumulatively affect the potential for traditional land uses?	Potential effects on Registered Fur Management Areas (RFMAs)	• RFMAs that intersect the PAA	• RFMAs area	RSA
	Potential effects on traditional lands of First Nations	• Traditional lands of First Nations	• Area of traditional lands of First Nations	RSA
	Potential effects created by linear access	• Linear access	• Length of linear access	RSA
	Potential effects on culturally important sites or areas	• FMFN culturally significant ecosystems (CSEs)	• Area of FMFN CSEs	RSA
	Potential effects on traditional plant potential in the RSA	• Traditional plant potential in the RSA	• Area of traditional plant potential in the RSA	RSA

6.4 Overview of Baseline Conditions

A review of previous TLU studies prepared by Aboriginal communities and industry demonstrate that traditional land use activities, such as hunting, trapping, plant harvesting and fishing occur in the LSA and RSA. The following is an overview of the baseline conditions as described in the TLU baseline (see Volume 2, Section 13.4). Of the four Aboriginal communities discussed in the overview, only the FMFN and MCFN present information relevant to a predevelopment condition. The LSA partially overlaps four RFMAs, primarily RFMA #1275. Although some of the above RFMAs are registered to non-Aboriginal trappers, RFMA #2892 is held by a member of MCFN and #1275 has been trapped in the past by a Métis person.

The baseline results of the FMFN, MCFN, ACFN and Fort Chipewyan Métis studies (as summarized below) will inform Project planning, as appropriate.

The location of historical resources that might also be considered traditional land use sites can be found in the historical resources baseline (see Volume 2, Section 11, Figure 11-1).

6.4.1 Fort McKay First Nation

As stated in the Fort McKay Specific Assessment (Fort McKay IRC 2010), the predevelopment condition indicates that the traditional trail system was essentially unaffected by development disturbance. The only 'disturbance' of traditional trails at that time was about 175 km of trails affected by forest fires.

The FMFN has identified areas of high, moderate and low utilization for traditional harvesting activities. The CSEs include areas for all traditional uses, large game harvesting, fishing, fur-bearer harvesting, bird harvesting and plant (berry) harvesting.

Moose is considered an indicator species by the FMFN. Other important large game wildlife species include deer, woodland bison and black bear. The LSA overlaps high and moderate utilization areas in the large game CSE. Similarly, the RSA overlaps high and moderate utilization areas.

Previous studies identified an extensive list of plants and berries considered important for food, medicine or spiritual purposes. Examples include rat root, blueberries, cranberries (low bush and bog), Saskatoon berries and mint. The eastern portion of the LSA overlaps an area of high utilization in the CSE for plant (berry) harvesting. The remaining portion of the LSA overlaps an area of moderate utilization. The RSA overlaps areas of high, moderate and low utilization for plant (berry) harvesting. The high utilization area is a broad area that overlaps the Athabasca River.

The LSA overlaps moderate and low utilization areas for the fish harvesting CSE. Important fish species include northern pike (jackfish), pickerel (walleye), and whitefish. The moderate- and low-use areas include the Athabasca River and the lower reaches of its tributaries. The RSA mostly overlaps low- and moderate-use areas, and small areas of high utilization near Fort McMurray and the northern RSA boundary.

The LSA overlaps a high utilization area in the fur-bearer CSE, but does not overlap any RFMAs held by members of the FMFN. Previous studies commissioned by the FMFN have identified beaver, lynx, fisher and marten as indicator species.

The LSA overlaps low and moderate utilization areas in the bird harvesting CSE. Examples of important species include spruce grouse and ptarmigan. The RSA overlaps areas of high, moderate and low use. The high utilization areas tend to be focused on the region between Fort McMurray and Fort McKay and the McClelland Lake area. Refer to Volume 2, Section 13.3.2, Table 13-3 for identified traditional resources used by the FMFN and other Aboriginal communities in the Athabasca Oil Sands Region.

The LSA overlaps some FMFN traditional trails that run north-south along the west bank of the Athabasca River. Traditional trails are considered important for accessing harvesting and other traditional land use areas.

6.4.2 Athabasca Chipewyan First Nation

Traditional activities of the ACFN were identified through their TLU study as well as affidavits provided by Marvin L’Hommecourt and Raymond Cardinal. Trapping for beaver, fox, rabbit and squirrel occurs in the area of Namur and Gardiner lakes. Harvested animals include rabbits, partridges, moose, beaver, wood bison and deer. Wood bison are harvested along the northernmost part of the RSA and the Birch Mountains, as well as in hunting grounds west of the Athabasca River in the winter. The ACFN have identified, during consultation, that the wood bison are a culturally important species, expressing concern about the potential impacts of the Project to the Ronald Lake bison herd.

Overlapping the LSA is a moose migration route. Moose hunting was also indicated in the same general area. Cabins, trails, two graveyards, and areas of good moose hunting, berry picking, canoeing and fishing, and general hunting and trapping were identified along the northern portion of the RSA.

Berry picking areas overlap the RSA. Medicines and plants are also gathered at various times of the year in these locations. Some medicines or plants include sweet grass, rat root, diamond and willow fungus, cat tails and mint. It was noted that many medicines grow west of the Athabasca River from the river shore banks to the Birch Mountains.

Cabins and additional hunting areas were identified along the Athabasca River south of the LSA and cabins and a trapline were identified southeast of the LSA along with the further extension of the moose migration area. Extending east of the LSA on the east side of the Athabasca River, a participant from a previous study identified a current moose hunting area.

Fishing areas for whitefish, northern pike and pickerel were identified east of the Athabasca River in the northern portion of the RSA. It was noted that the water in the Athabasca River was low, which was reported to be associated with “development of tar sands”. It was further noted that changing water levels and water quality has affected a traditional way of life along the Athabasca River.

Camping and cabin areas were reported along the Athabasca River and Firebag River. While it was reported that there were camps all the way down the Athabasca River to Fort Chipewyan, specific camp and cabin locations do not overlap the LSA.

6.4.3 Mikisew Cree First Nation

Funding to undertake a TLU study was provided to the MCFN, the results of which will be provided in confidence to the regulator by the MCFN.

A review of previous assessments suggest that traditional activities of the MCFN generally occur in the Fort Chipewyan area and that the Athabasca River is an important travel corridor.

The following provides information about MCFN traditional activities based upon publicly available information. Elias (2010) summarizes data and results from six previous studies and discusses the traditional land uses of the MCFN in relation to the TOTAL Joslyn North Mine Project (about 30 km south of the Frontier Project). The report identifies the geographic extent of MCFN recorded traditional use and presents evidence to support the assertion that the MCFN have used their traditional territory for at least four generations (>80 years) and likely much longer. Although the focus of Elias (2010) was on the Joslyn North Project, the information in the report suggests that the Mikisew Cree have used a larger area, including the LSA, in the past and continue to use the area.

A review of the following studies was also undertaken:

- *Mikisew Cree First Nation Traditional Land Use Study* (Calliou Group 2010)
- *The Phase I Mikisew Cree First Nation TLU-TOTAL Joslyn North Mine Study* (Tanner 2008)
- *Mikisew Cree First Nation Report on the Southern Territory Use and Occupancy Mapping Project* (PACTeam 2007)

A review of the above studies shows a variety of MCFN traditional harvesting activities and habitation sites in the RSA. Table 6-3 shows the type of traditional activities historically practiced by the MCFN in the RSA.

Table 6-3 Recorded Traditional Land Use Sites in the RSA

Traditional Land Use – MCFN	Data Source
Berry harvesting	Tanner (2008)
Bird harvesting	Tanner (2008)
Birth sites	PACTeam (2007)
Burial sites	PACTeam (2007)
Cabins	Tanner (2008)
Camps	PACTeam (2007); Tanner (2008)
Fur-bearer harvesting	Tanner (2008)
Large game harvesting	PACTeam (2007); Tanner (2008)
Traditional trails	Calliou Group (2010)

The PACTeam (2007) study indicates that prior to 1927, the larger region surrounding the Project was used for trapping by the MCFN. The study further indicates that after 1927, a decline in trapping has occurred in the portion of the RSA within and adjacent to the Project. PACTeam (2007) indicates that a large portion of MCFN trapping moved into Wood Buffalo National Park because of an influx of non-Aboriginal resource harvesters into the region during the 1920s.

A review of mapped information in the Calliou Group (2010) and PACTeam (2007) studies shows many traditional trails in the region surrounding and within the LSA. The information suggests that the Athabasca River was an important travel corridor, and further indicates that traditional trails along the west bank of the Athabasca River may cross through the LSA. Due to the resolution of available mapped information, it is not possible to determine other specific types of MCFN traditional activities within the LSA.

An MCFN member holds RFMA #2892 and currently uses that trapline.

6.4.4 Métis Communities

While traditional land use and traditional knowledge information relating to Métis activities in the RSA is less available than information about FMFN, ACFN and MCFN communities, general information is available through publically available literature. For example, the TLU studies done by the Fort McKay Tribal Administration (1983) and FMFN (1994) included traditional activities of the Fort McKay Métis. Similarly, studies were undertaken with regards to the community of Fort Chipewyan (Fort Chipewyan 1996) included information related to the Fort Chipewyan Métis. Fort McKay Métis is included in studies prepared by the FMFN.

The literature review generally indicated that hunting, trapping, berry and plant harvesting occurred in areas that overlap the LSA. Additionally, cabins, camps and special areas occur in this area. Gravesites occur in the RSA and in proximity to the LSA.

Consultation will continue with the FMFN, ACFN, MCFN and Métis Communities of Fort Chipewyan and Fort McKay, with the intent of gaining an understanding of the nature and extent of traditional land uses in the LSA and RSA. Funding was provided to the FMFN and MCFN to undertake their own TUS and TLU studies for the Frontier Project, and funding was contributed to a Métis Local 125 traditional land use and occupancy study (TLUOS) study. Additionally, the preparation of a biography (Labour and Hermansen 2010) was funded for a Fort Chipewyan Métis Elder who extensively used the lands within and next to the LSA. While the Labour and Hermansen (2010) study remains confidential, permission was received to use specific information in this assessment. A scope of work for a Project-specific TUS is being discussed with the ACFN.

6.5 Traditional Land Uses and the Frontier Project

This section addresses key question TLU1: Could the Frontier Project affect traditional land uses?

6.5.1 Methods

6.5.1.1 Data Sources

Data for the traditional land use assessment was collected from a detailed review of available literature prepared by, contributed to, or commissioned by Aboriginal communities or individuals, and by industry operating in the region (see Volume 2, Section 13.2.1, Tables 13-1 and 13-2). Data from these studies relate primarily to the RSA, although LSA-specific information was derived whenever possible.

These sources include:

- potential disturbance data for lands used for traditional activities
- information collected from Owner consultations with the MCFN, ACFN, FMFN and Métis communities of Fort McKay and Fort Chipewyan

6.5.1.2 Analysis

Qualitative information was collected from TLU studies, project-specific assessments, and other regional reports reviewed in the traditional land use baseline study (see Volume 2, Section 13.2). Previously recorded concerns expressed by First Nations and other Aboriginal communities have also been documented and discussed in the baseline study (see Volume 2, Section 13.3).

At the time of this report, a Project-specific TLU study has been undertaken by the MCFN and a Project-specific TUS has been completed by the FMFN, which includes the Fort McKay Métis. A scope of work is currently being developed for an ACFN Project-specific TUS. A Fort Chipewyan Métis TLUOS has been funded by the Owners (as well as other developers in the region) and is near completion. As additional information becomes available from the ACFN and Métis communities from Fort Chipewyan Métis, it will be used to inform Project planning.

The MCFN has undertaken its own TLU study for the Project and will provide the results to the regulator in confidence. The FMFN has requested that their Project-specific TUS be included directly in this application as a stand-alone document and not included in the assessment. The study has been included as Appendix 6A.

6.5.2 Reference Conditions

6.5.2.1 Hunting and Trapping

A member of the ACFN reported that a moose travel route is located in an area that overlaps the traditional land use LSA (Marvin L'Hommecourt 2009). Another member of the ACFN reported that a hunting area along the Athabasca River is also located in an area that is overlapped by the LSA (Raymond Cardinal 2009). In addition to identifying specific traditional land use areas, an ACFN member also reported that land and traditional activities are, in general, important to the people of the ACFN (Raymond Cardinal 2009). High-use areas of several ACFN groups in the early 1900s have also been reported in areas that overlap the LSA (ACFN 2003).

Specific hunting, trapping and wildlife habitat areas were identified in the LSA and described by Labour and Hermansen (2010). These included:

- buffalo and moose hunting near Kelly Lake
- moose common near Crooked Lake cabin
- good deer habitat along the trail between Big Lake and Cranberry Lake
- several lowland fur-bearer areas near Big Lake, Crooked Lake and Cranberry Lake
- a sandhill crane nesting area east of Cranberry Lake
- beaver habitat around Mile 72 in the creeks inland from the west bank of the river
- cabins at Big Lake and Crooked Lake were used when guiding fall moose hunts

As part of the TLU studies for the Shell Jackpine Mine Expansion (JME) and PRM developments, interviews were conducted with trappers directly affected by these projects, including representatives of the FMFN and ACFN. Interview participants identified three cabins in the LSA (Shell 2007).

Camping and cabin areas have been reported by an ACFN member along the Athabasca River. Although it was reported that camps exist all the way along the Athabasca River to Fort Chipewyan, specific camp and cabin locations do not overlap the LSA (Raymond Cardinal 2009).

6.5.2.2 Traditional Trails, Cabins and Sacred Sites

Trails, cabins, gravesites and other cultural areas, as described in Labour and Hermansen (2010) were reported to be located in the LSA as follows:

- trails connecting Big Lake (Unnamed Lake 1), Moose Cabin and Crooked Lake (Unnamed Waterbody 6)
- a trail from the Mile 72 cabin to Big Lake Cabin (Unnamed Lake 1)
- a cutline between Cranberry Lake (Unnamed Waterbody 15) and Crooked Lake (Unnamed Waterbody 6) that is used as a trail
- cabins were identified at Big Lake (Unnamed Lake 1)
- an historic cabin was identified at Crooked Lake (Unnamed Waterbody 6)
- a cemetery north of Mile 72 along the Athabasca River
- a special place located along Big Creek
- a camp area along the southern portion of the LSA

6.5.2.3 Fishing

Areas of no access, and lost or inhibited traditional land use for the MCFN and ACFN were reported in areas of extreme low water levels, including some areas that overlap the traditional land use LSA (Candler et al. 2010).

It was also reported by a number of Aboriginal communities presented in this report, that there has been a large decrease in the water levels in the Athabasca River.

6.5.2.4 Medicinal Plant and Berry Harvesting

Medicinal plant and berry harvesting areas, as described by Labour and Hermansen (2010) were reported in the LSA as follows:

- Cranberry Lake was identified as a berry picking area
- an area located west of Mile 72 in the LSA was identified as a berry picking area
- a trail to Kelly Lake from Mile 64, which extends north past Kelly Lake, was identified as a good place to pick berries
- staple garden vegetables were harvested, including turnip, carrot, onion, cabbage and potatoes
- the area surrounding Big Lake was identified as a medicinal plant gathering area

6.5.3 Base Case

The PRM is the only major development identified in the LSA. Potential effects on traditional land use are described in the assessment for the PRM project (see Shell 2007).

6.5.4 Application Case

6.5.4.1 Mitigation

The following mitigation measures have been adopted:

Water Quality and Fisheries Resources

- Watershed management strategies will continue to be discussed with potentially affected Aboriginal communities.
- Mitigation, compensation and accommodation plans will be considered in discussion with potentially affected Aboriginal communities where key cultural and traditional use areas are affected.

Wildlife

- Means to reduce effects on wildlife habitat through progressive reclamation and speeding the re-establishment of lost wildlife habitat will be discussed with potentially affected Aboriginal communities.
- Wildlife monitoring in reclaimed areas will be conducted.

Vegetation

- Progressive reclamation and revegetation will be undertaken.
- Reclamation will be carried out according to the guidelines established by the CEMA Reclamation Working Group.
- Land will be reclaimed using traditional use plants, where feasible.
- Means will be considered to develop and implement a program to salvage and relocate known occurrences of rare (vascular) species to areas outside the Project footprint, and the potential to reintroduce rare species into reclaimed areas will be evaluated.
- The preservation of traditional land use opportunities and associated resources will be discussed with potentially affected Aboriginal communities.
- Traditional resource harvesters will be invited to harvest traditional plants before disturbance.

Trapping and Harvesting

- Access will be facilitated for trappers and other traditional harvesters through the Project area.
- Affected trappers will be compensated following industry standards.

Biodiversity

- Participation is planned in CEMA Working Groups, including involvement in research programs such as the Canadian Oil Sands Network for Research and Development (CONRAD) and the Alberta Biodiversity Monitoring Institute (ABMI).

Disturbance

- Potentially affected Aboriginal communities will be involved in determining end land uses for reclamation.

Access Management

- An access management plan (AMP) will be developed in consultation with Alberta Sustainable Resource Development (ASRD), potentially affected Aboriginal communities and public stakeholders for the LSA. The purpose of an AMP will be to control access in and through the LSA as much as possible while maintaining public safety. One objective of the AMP will be to optimize hunting opportunities as well as to allow trappers and other key land users (i.e., established outfitters) continued access through the LSA.

Reclamation

- Potentially affected Aboriginal communities will be consulted in the establishment of criteria to determine reclamation success.

Historical Resources

- Trails, burials and spiritual sites might be considered historical resources and will be recorded when encountered during field studies to ensure adequate mitigation and consideration of Aboriginal community concerns. Identified sites will be recorded with Alberta Culture and Community Spirit (ACCS) as required under the *Historical Resources Act* and mitigated following direction from ACCS.

6.5.4.2 Linkage Analysis

The potential linkages between the Project activities and traditional land use were based on the key issues identified in previous TLU studies, project-specific effect assessments, other regional reports, as well as items specified for evaluation in the TOR. Linkages were analyzed between:

- Project activities and changes in hunting, trapping, fishing and plant harvesting
- Project activities and changes in wildlife abundance and habitat, fish presence and availability of plants to harvest
- Project activities and the effects on cabins, access routes, burial sites and spiritual sites
- Project noise on traditional land uses

All linkages are valid for the Application Case. The effects of Project noise are discussed in Volume 4, Section 2. The effects of noise are considered in Volume 6, Section 4.6 as part of the evaluation of representative wildlife habitats in RFMAs.

6.5.4.3 Effects Analysis – Maximum Build-out Snapshot (2057)

Hunting and Trapping

Specific hunting, trapping, and wildlife habitat areas identified in Labour and Hermansen (2010) overlap the PAA:

- Wood bison and moose were hunted near Kelly Lake
- trails extend from Kelly Lake to the southern portion of the PAA
- lowland fur-bearer areas were identified near Big Lake and Crooked Lake
- Crooked Lake cabins were used when guiding fall moose hunts
- beaver habitat exists near Big Lake and along the southwestern portion of the PAA

In addition, buffalo and moose-hunting areas were identified in general areas overlapping the LSA. The area identified as a hunting area along the Athabasca River (Raymond Cardinal 2009) also overlaps the PAA. It has also been reported that in addition to specific traditional land use areas, the land and traditional activities were, in general, important to the people of the ACFN (Raymond Cardinal 2009).

Traditional Trails, Cabins and Sacred Sites

As part of the TLU studies for the JME and PRM developments, interviews were conducted with directly affected trappers, including representatives of the FMFN and ACFN. Interview participants identified three cabins in an area that overlaps the LSA and potentially the PAA (Shell 2007).

Camping and cabin areas have been reported by an ACFN member along the Athabasca River. While it was reported that there were camps all the way along the Athabasca River to Fort Chipewyan, specific camp and cabin locations do not overlap the PAA (Raymond Cardinal 2009).

Trails, cabins, gravesites and other cultural areas, as described by Labour and Hermansen (2010) were described in locations that appear to overlap the PAA and will be affected by the Project as follows:

- trails extending from Kelly Lake to the southern margin of the PAA
- a historic cabin identified at Crooked Lake

According to Elias (2010), trails along the west bank of the Athabasca River traditionally used by the MCFN may cross through the LSA.

Traditional trails overlapped by the PAA will be unavailable to traditional users.

Fishing

Fishing areas were not specifically identified in the Project area (see Volume 5, Section 5). Therefore, traditional fishing is not expected to be affected by the Project.

Medicinal Plant and Berry Harvesting

Medicinal plant and berry harvesting areas overlapping the PAA were described in Labour and Hermansen (2010) as follows:

- a trail to Kelly Lake from Mile 64, which extends north past the lake, was identified as a good place to pick berries
- the area surrounding Big Lake was identified as a medicinal plant gathering area

6.5.5 Planned Development Case

No planned developments are expected to alter the LSA or interact with the Project. As such, an effects analysis on traditional land uses was not completed for the PDC.

6.5.6 Prediction Confidence

Confidence in the assessment of potential effects of the Project is considered moderate. Information used to assess the potential effects on traditional uses and areas was provided by Aboriginal communities, and incorporated into this assessment. While it is possible that not all individual traditional uses and areas were documented, the assessment was conservative in that it assumed that all traditional uses or culturally important areas in the

PAA will be lost during the construction and operation phases of the Project. Because Aboriginal consultation is ongoing, the confidence level of the predictions is expected to increase as further consultations provide additional details related to the potential effects of the Project on Aboriginal communities and traditional lifestyles.

6.5.7 Responses to Aboriginal Community Concerns

Potential effects to traditional land uses resulting from the Project will be mitigated primarily through access management and reclamation. One of the goals of the closure, conservation and reclamation plan (see Volume 1, Section 13) is to reclaim habitat for key species traditionally hunted, trapped and harvested.

An AMP will be developed for the LSA in consultation with ASRD, potentially affected Aboriginal communities and public stakeholders. The purpose of the AMP will be to control access in and through the LSA to maintain public safety and optimize access for all users. One of the specific objectives of the AMP will be to optimize hunting opportunities for Aboriginal users and ensure continued access through the LSA to:

- Moose Lake and Moose Lake trial
- the larger Birch Mountain area and burial ground
- Poplar Point Indian Reserve
- lease land and land beyond the Frontier Project for traditional use

A conceptual reclamation plan has been developed that includes the reclamation of habitat for key species traditionally hunted, trapped and harvested. For example, the plan has specifically included berry species as well as rat root in areas that will be conducive to their establishment and survival (see Volume 1, Section 13.6.3).

Only in the last two decades has reclamation of disturbed lands in the Athabasca Oil Sands Region begun to focus on natural ecosite reclamation. This has been, in part, a response to Aboriginal community concerns that focus on the need for ecological sustainability and integrity. Potentially affected Aboriginal communities will be consulted to monitor reclamation activities and adapt reclamation plans to incorporate new techniques arising from research completed in the region. In addition, potentially affected Aboriginal communities will be consulted in the establishment of criteria to determine reclamation success.

Aboriginal communities have expressed concerns about trails, burials and spiritual sites. These site types might be considered historical resources and will be recorded when encountered during Historical Resources Impact Assessment field studies (see Section 3.5.2) to assist in the adequate mitigation and consideration of Aboriginal community concerns.

6.5.8 Management and Monitoring

6.5.8.1 Regional

Participation is planned in the following regional committees and research organizations:

- CEMA
- CONRAD
- ABMI

These groups are involved with a variety of research programs designed to understand ecosystem dynamics and to enhance reclamation efforts in the Athabasca Oil Sands Region.

6.5.8.2 Project-specific

Potentially affected Aboriginal communities and other stakeholders will be consulted to monitor reclamation success so that the lands are returned to a land capability that will provide good quality habitat for species traditionally hunted, trapped and harvested. Wildlife monitoring in reclaimed areas will be considered.

6.5.9 Summary

The LSA overlaps with the traditional lands of the FMFN, ACFN, and MCFN where harvesting of large game and fur-bearers, traditional plants and berries, and fishing has been practiced. Areas within the LSA have also been used for camps, cabin sites, burial sites, and traditional trails. The MCFN have indicated that many of their traditional activities have moved into Wood Buffalo National Park because of an influx of non-Aboriginal resource harvesters into the larger region in the 1920s.

The assessment indicates that some traditional areas used for hunting, trapping, and plant and berry harvesting by one or all of the Aboriginal communities discussed in this report overlap the PAA, and will not be available to traditional users during the construction and operation phases of the Project. Traditional fishing areas were not specifically identified within the PAA and therefore are not predicted to be affected by the Project.

Potential effects to traditional land uses resulting from the Project will be mitigated primarily through access management and reclamation. One of the goals of the closure, conservation and reclamation plan (see Volume 1, Section 13) is to reclaim habitat for key species traditionally hunted, trapped and harvested.

6.6 Traditional Land Uses and the RSA

This section addresses key question TLU2: Could the Frontier Project in combination with other developments cumulatively affect the potential for traditional land uses?

6.6.1 Methods

Quantitative analyses were undertaken to assess the amount of land disturbance associated with developments in relation to areas that are of potential use for traditional activities. The analyses focused on examining effects to:

- traditional lands of First Nations in the RSA
- linear access in the RSA
- FMFN CSEs in the RSA
- traditional plant potential in the RSA

The quantitative analysis is considered conservative, as the potential disturbance calculations for the Base Case, Application Case and PDC assumed that disturbances would occur simultaneously and did not consider the temporal staggering of disturbances or the potential for progressive reclamation of disturbances.

Traditional plant potential was calculated to determine the potential re-establishment of land for traditional plant harvesting in the RSA. Traditional plant potential was determined for vegetation cover classes. Traditional plant species were identified from reports prepared for previous assessments in the Athabasca Oil Sands Region, including Raymond Cardinal (2009), Fort McKay IRC (2009) and Fort McKay (1995). Vegetation cover classes were assigned a traditional use potential based on plant species observed during vegetation field surveys and known traditional use plant species in the region. For an assessment of wildlife species habitat availability and inferred presence for traditional use, see Volume 6, Section 6.5.

6.6.2 Reference Conditions

6.6.2.1 Registered Fur Management Areas

The LSA partially overlaps four RFMAs (also referred to as traplines) that may be directly affected by the Project (see Figure 6-1). The four RFMAs that overlap with the LSA and their areas include:

- RFMA #2892 – 52,841 ha
- RFMA #2939 – 9,216 ha
- RFMA #1275 – 55,403 ha
- RFMA #2016 – 15,713 ha

The LSA primarily overlaps RFMA #1275. Although some of the above RFMAs are registered to non-Aboriginal trappers, RFMA #2892 is held by a member of MCFN and #1275 has been trapped in the past by a Métis person.

Traditional Lands of First Nations

Traditional lands of First Nations that intersect the RSA are shown in Figure 6-2. Areas of traditional territory are as follows:

- FMFN – 3,525,091 ha
- MCFN – 8,641,564 ha
- ACFN – 4,383,438 ha

Linear Access

Traditional activities require that users be able to access resources. Increased access to an area may result in increased use of resources for both traditional and non-traditional harvesters. While some resource users support improved access, others—including members of the FMFN—have expressed concerns about disturbances to traditional use areas and trails (Fort McKay IRC 2010).

Traditional trails within the traditional lands of the FMFN are shown in Figure 6-3. The LSA partially overlaps some trails, particularly those running north-south along the west bank of the Athabasca River.

Fort McKay First Nation CSEs

The areas of potential traditional land use for FMFN CSEs are shown in Table 6-4 for predevelopment conditions in the RSA. Areas of intense use range from 59,261 ha (fish) to 932,193 ha (fur-bearers CSEs) to 59,261 ha (fish CSEs).

Maps showing traditional land use CSEs are provided in Figures 6-4 through 6-9.

Table 6-4 FMFN CSEs in the RSA – Predevelopment

CSE	Area at Predevelopment (ha)	CSE	Area at Predevelopment (ha)
All Uses		**Bird Harvesting**	
Low use	371,251	Low use	482,393
Moderate use	584,379	Moderate use	469,651
Intense use	239,868	Intense use	183,152
Total	**1,195,560**	**Total**	**1,195,560**
Large Game Harvesting		**Fishing**	
Low use	34,918	Low use	617,718
Moderate use	444,159	Moderate use	394,888
Intense use	716,482	Intense use	59,261
Total	**1,195,560**	**Total**	**1,195,560**
Fur-bearer Harvesting		**Traditional Plant Harvesting (Berries)**	
Low use	29,357	Low use	195,297
Moderate use	234,010	Moderate use	519,846
Intense use	932,193	Intense use	480,026
Total	**1,195,560**	**Total**	**1,195,560**

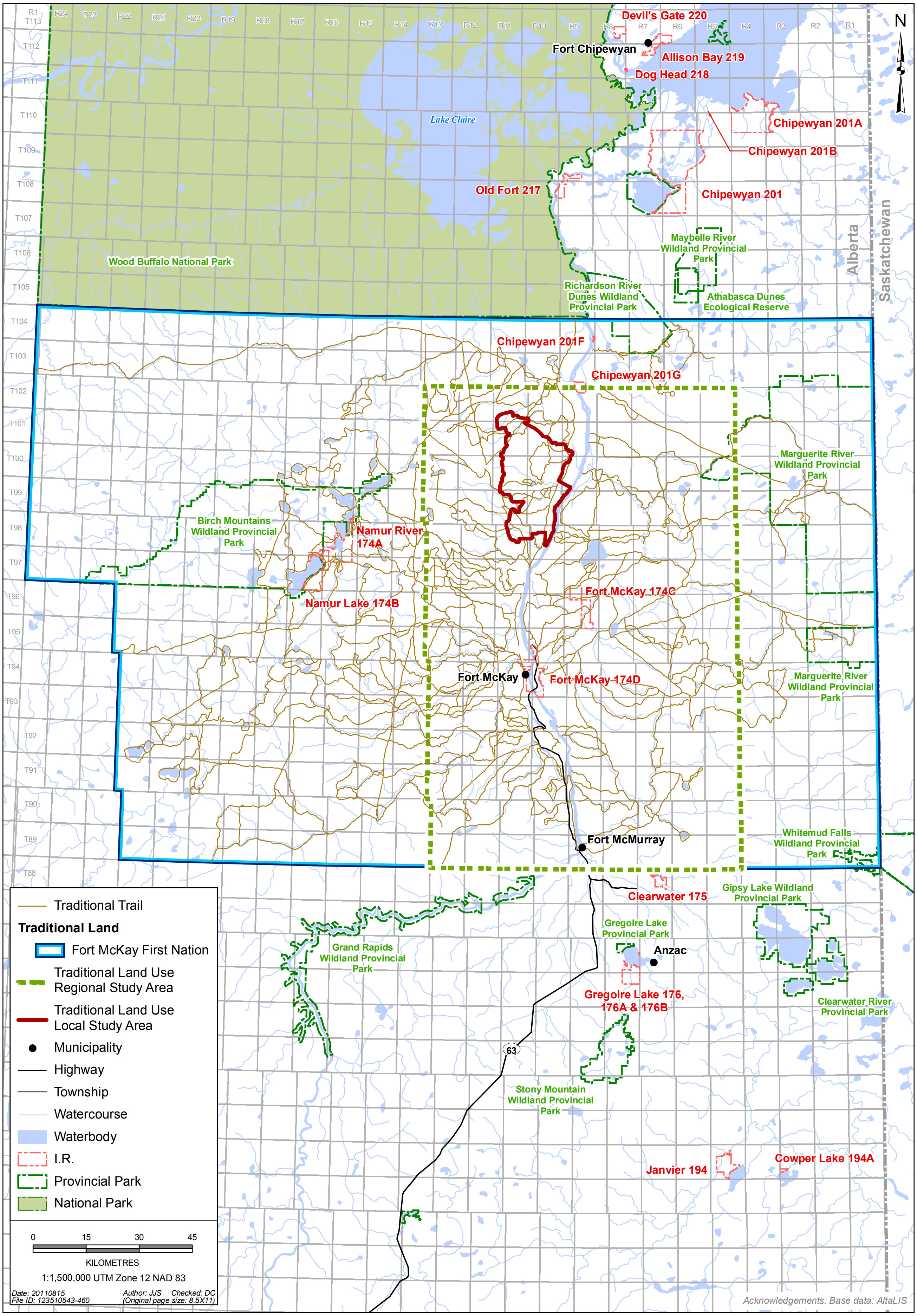

Figure 6-3: FMFN Traditional Trails

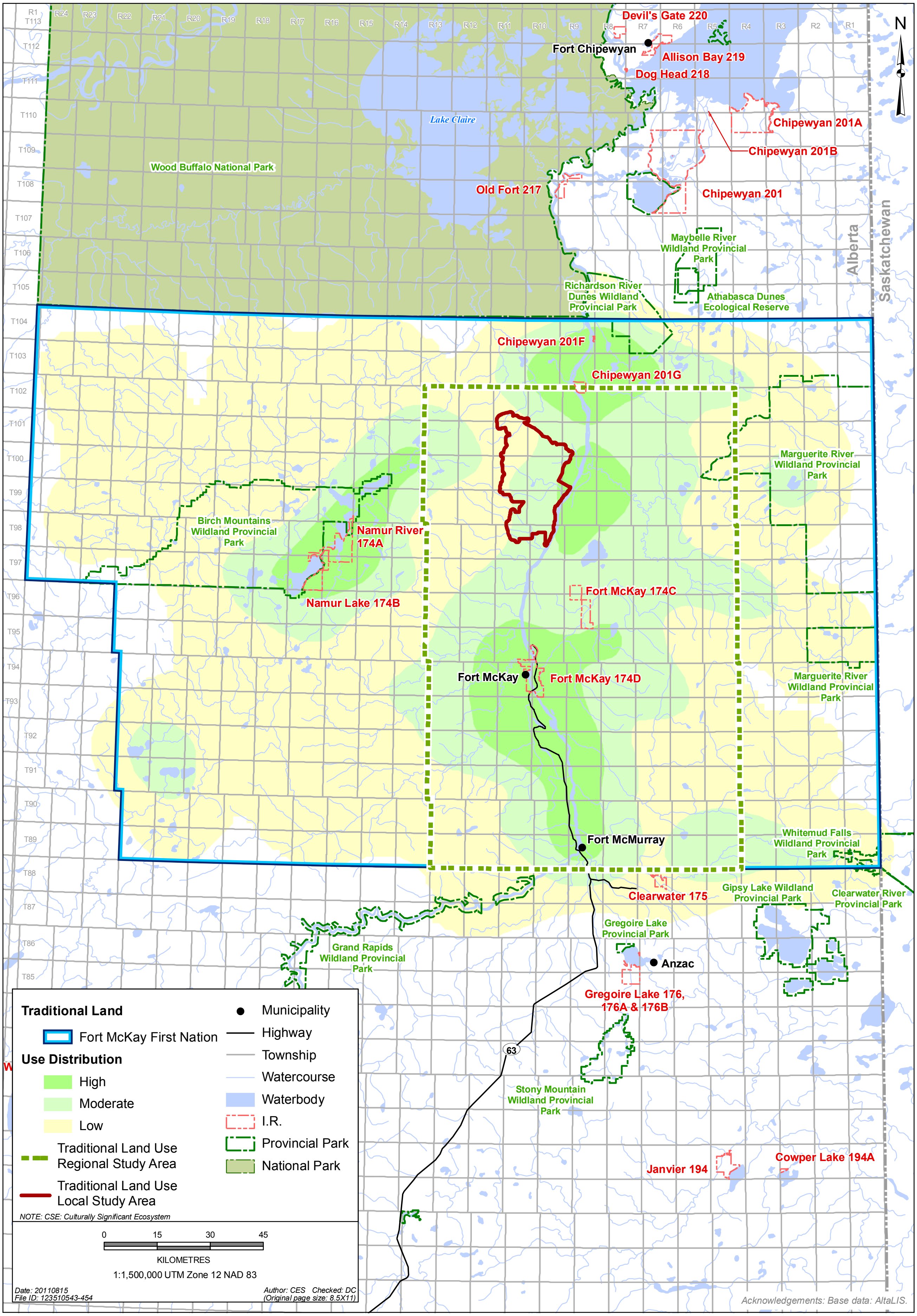

Figure 6-4: FMFN CSE – All Uses

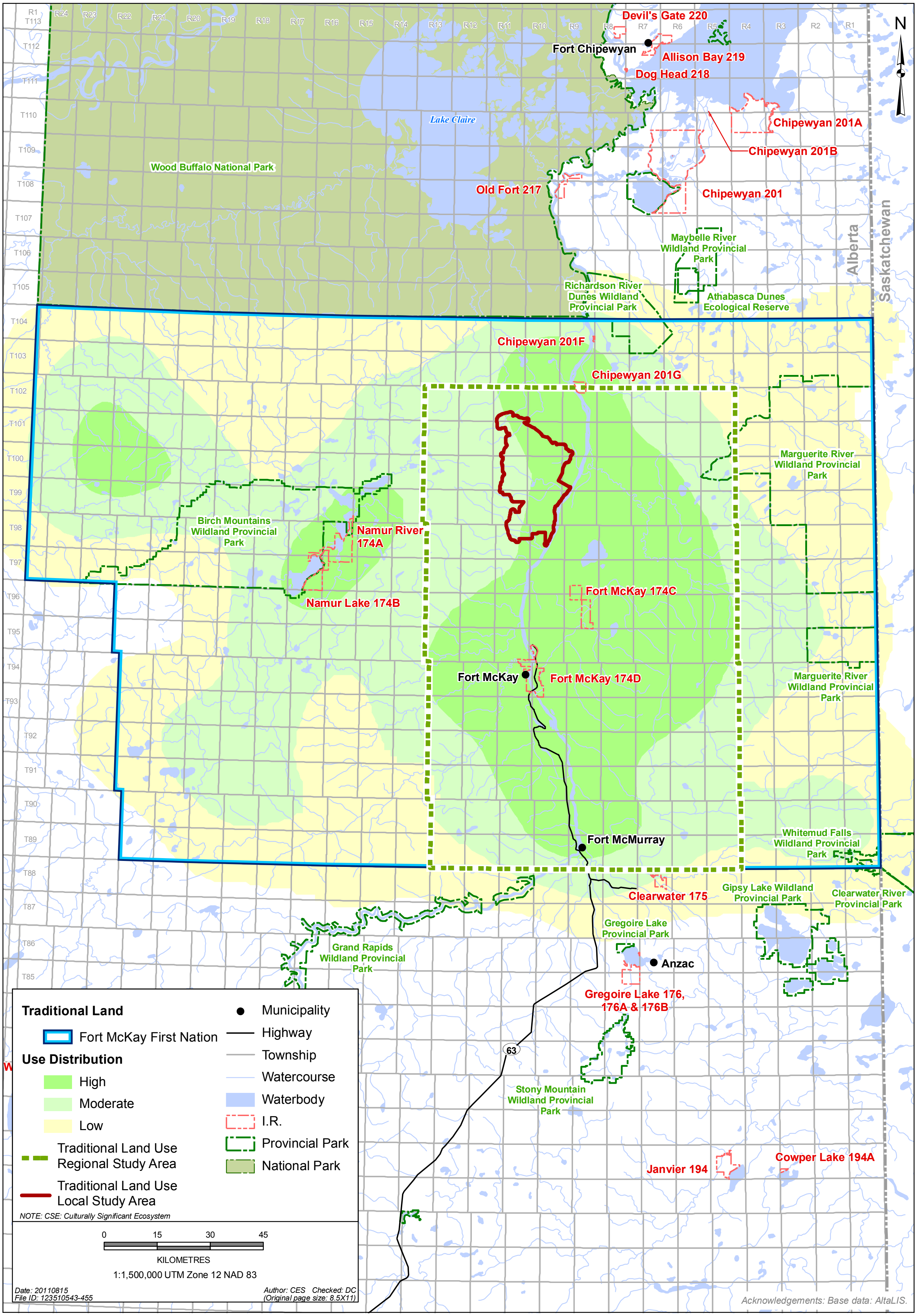

Figure 6-5: FMFN CSE – Large Game Harvesting

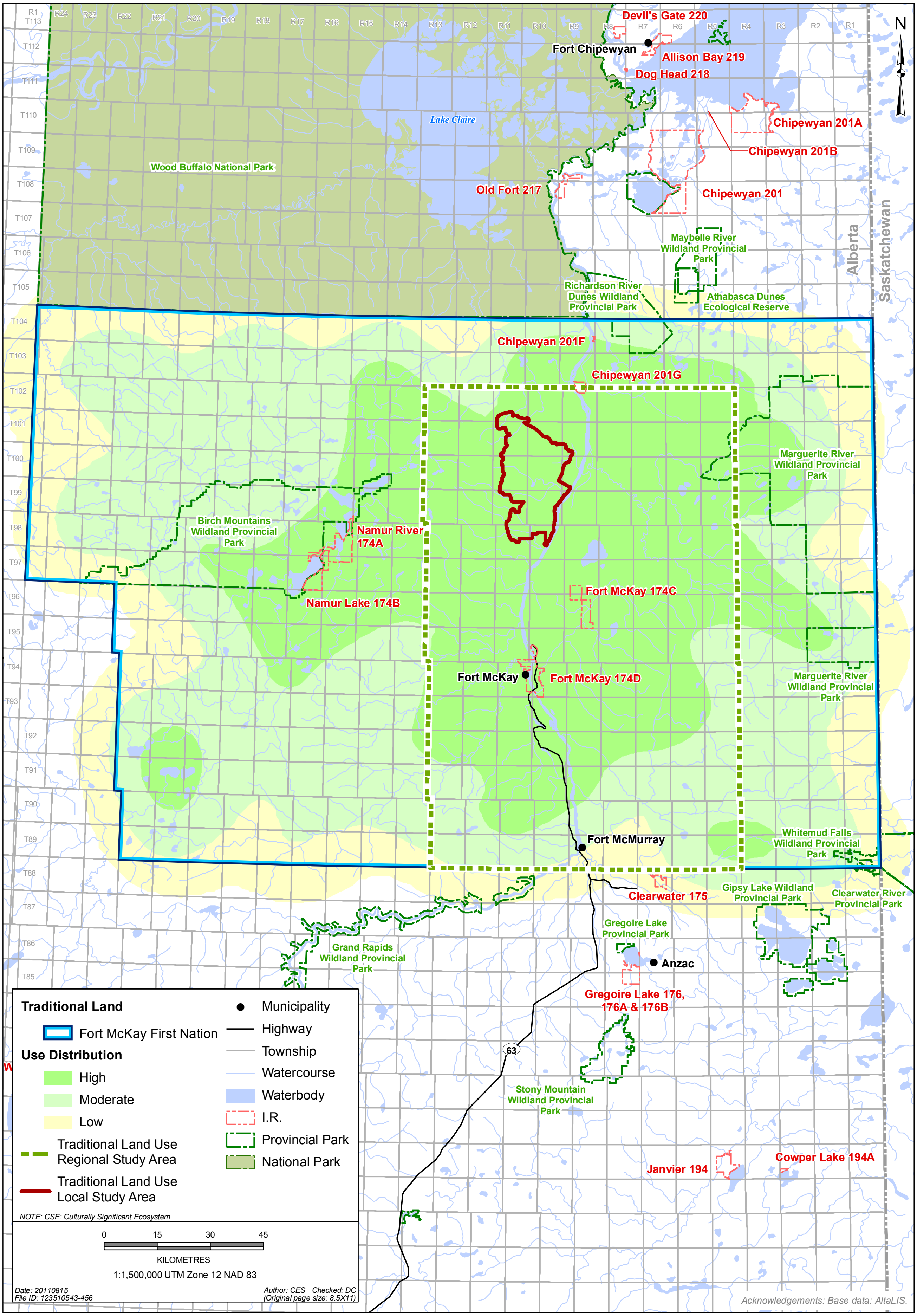

Figure 6-6: FMFN CSE – Fur-Bearer Harvesting

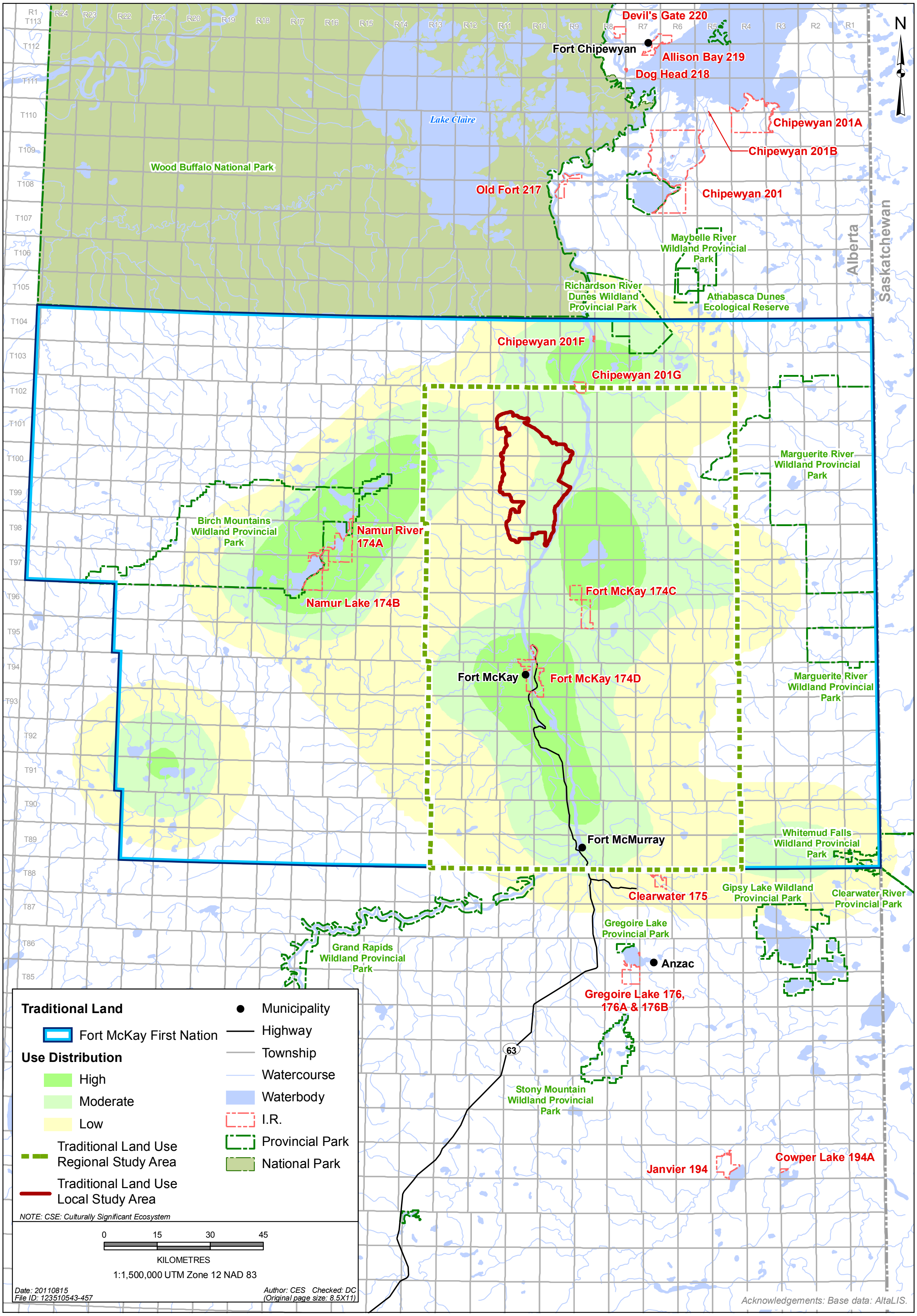

Figure 6-7: FMFN CSE – Bird Harvesting

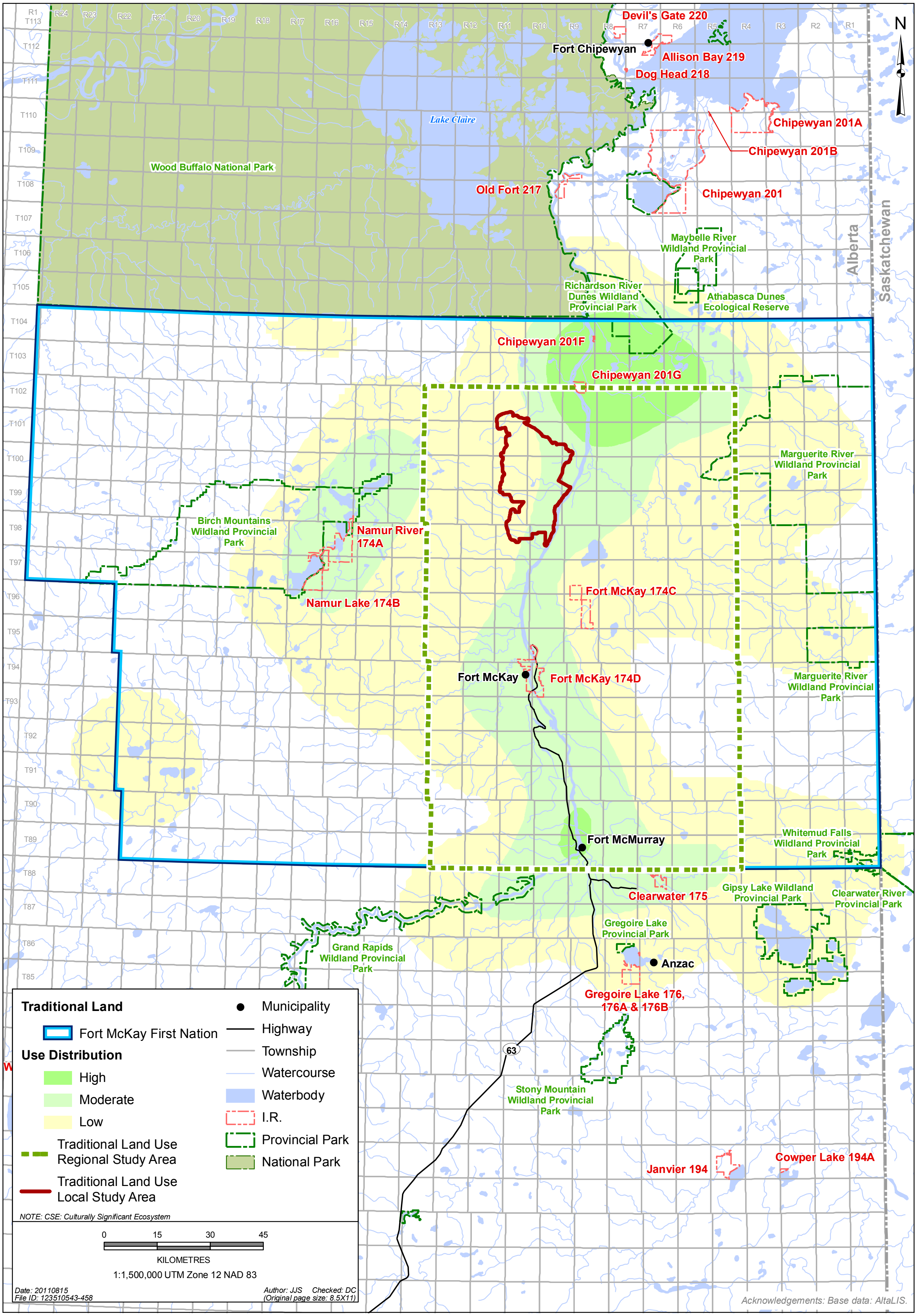

Figure 6-8: FMFN CSE – Fishing

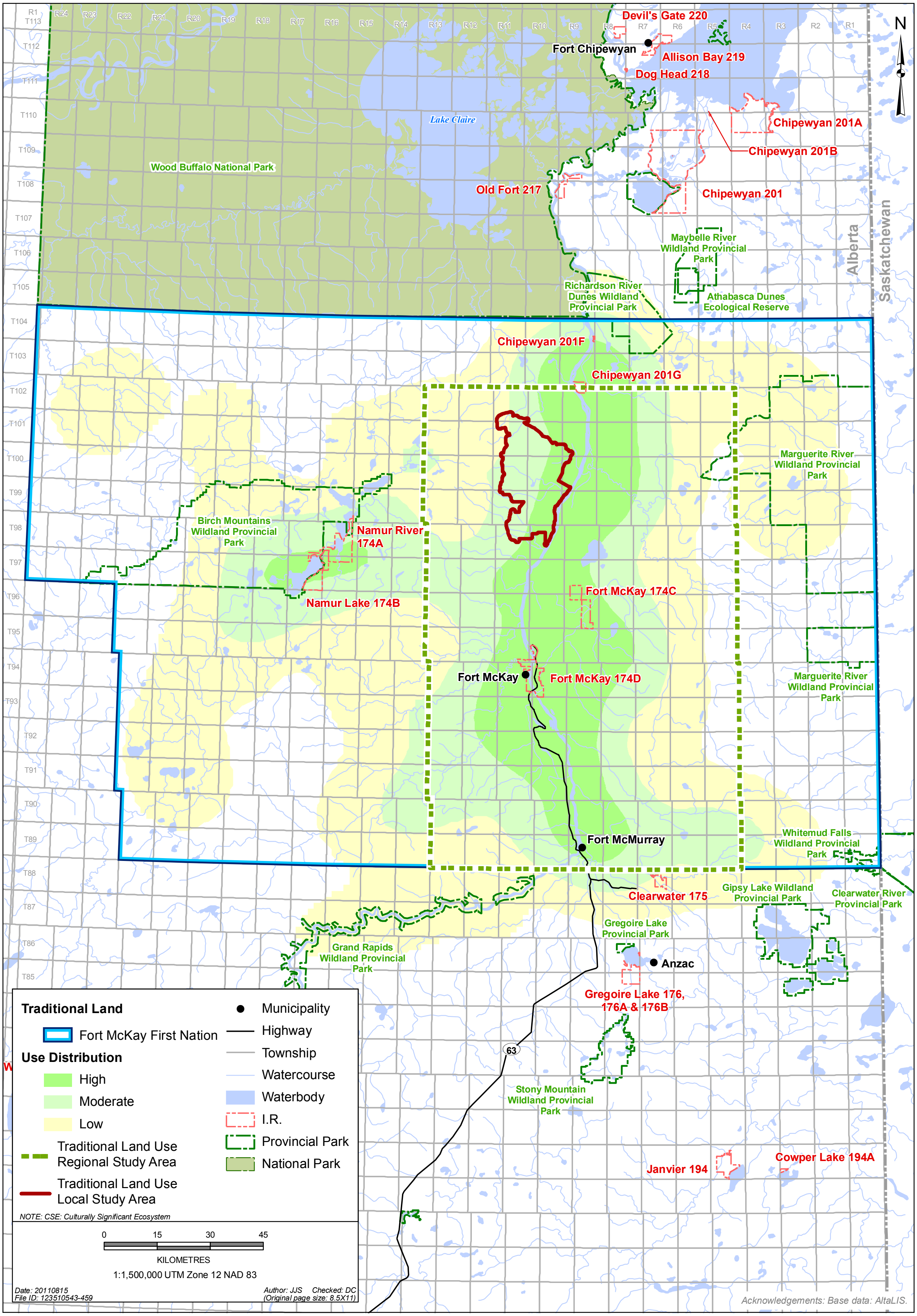

Figure 6-9: FMFN CSE – Traditional Plant Harvesting (Berries)

Traditional Plant Potential in the RSA

About 29% of the RSA includes land with a high potential to support traditional plant use, 39% is ranked as moderate and 30% as low (see Table 6-5). Non-vegetated areas representing about 2% of the RSA at predevelopment were not ranked for traditional plant use potential (see Table 6-5).

Table 6-5 Traditional Plant Potential in RSA – Predevelopment

Predevelopment	Area (ha)	% of RSA
High	343,443	28.7
Moderate	464,564	38.9
Low	364,030	30.4
Not ranked[1]	23,523	2.0
TOTAL	**1,195,560**	**100**

NOTE:
[1] Only vegetated lands were ranked (i.e., water, mineral soil, disturbed lands, other non-vegetated lands were not)

6.6.3 Base Case

6.6.3.1 Effects Analysis – Maximum Build-out Snapshot (2057)

Registered Fur Management Areas

For the RFMAs that overlap the LSA and the total area of disturbed land at Base Case, see Table 6-6. Base Case developments will affect RFMA #2016 by about 39%, #1275 by about 10% and #2892 and #2939 by about 1%.

Table 6-6 Disturbances in RFMAs – Base Case

RFMA	Predevelopment Area of RFMA (ha)	Base Case Total Disturbance Area	
		(ha)	% of RFMA
# 1275	55,403	5,278	10
# 2016	15,713	6,065	39
# 2892	52,832	387	1
# 2939	9,216	62	1

Traditional Lands of First Nations

Base Case disturbances within the traditional lands of the FMFN, ACFN and MCFN are shown in Table 6-7. Disturbance from operating or approved developments represents 3% (MCFN), 5% (ACFN) and 6% (FMFN) of traditional territories.

Table 6-7 Disturbances of First Nations Traditional Territories – Base Case

	Units	FMFN	MCFN	ACFN
Area of traditional territory	ha	3,525,091	8,641,564	4,383,438
Base Case total disturbance area	ha	210,536	234,289	227,209
Percent of traditional territory disturbance	%	6	3	5

Access

There are 7,289 km of linear access in the RSA for Base Case.

Fort McKay First Nation CSEs

FMFN All Traditional Uses

The disturbances in all potential traditional land use areas in the RSA portion of the FMFN CSEs at Base Case are shown in Table 6-8. Since there were also areas of the RSA not overlapped by the CSEs, those areas have been designated as being outside the CSE.

Under the Base Case, 89,064 ha (37%) of the intense-use areas, 121,169 ha (21%) of the moderate-use areas, and 5,187 ha (1%) of the low-use areas in the RSA portion of the FMFN CSE are disturbed for all traditional land uses. The total change at Base Case is equal to 18% of the total CSE for all traditional land uses.

Large Game Harvesting

Base Case disturbances in the RSA portion of the FMFN CSE for large game harvesting are shown in Table 6-8. The disturbance at Base Case for intense-use areas is 207,536 ha (29%), for moderate use areas is 7,584 ha (2%), and for low-use areas is 300 ha (1%). The overall disturbance at Base Case is 18% of the area of the CSE.

Fur-bearer Harvesting

Base Case disturbances in the RSA portion of the FMFN CSE for fur-bearer harvesting are shown in Table 6-8. The Base Case disturbance is 200,138 ha (21%) for intense-use areas, 12,999 ha (6%) for moderate-use areas, and 2,283 ha (8%) for low-use areas. The overall disturbance at Base Case is 18% of the area of the CSE.

Bird Harvesting

Base Case disturbances within the FMFN CSE for bird harvesting are shown in Table 6-8. The Base Case disturbance is 69,823 ha (38%) for intense-use areas, 124,391 (26%) of the moderate-use areas, and 20,833 (4%) of the low-use areas within the RSA portion of the FMFN CSE for bird harvesting. The total disturbance at Base Case is 18% of the total CSE for bird harvesting.

Table 6-8 RSA Developments in the FMFN CSEs – Base Case

CSE	Predevelopment Area of CSE (ha)	Base Case Total Disturbance Area	
		(ha)	% of CSE[1]
All Uses			
Low use	371,251	5,187	1
Moderate use	584,379	121,169	21
Intense use	239,868	89,064	37
Total[2,3]	1,195,560	215,420	18
Large Game			
Low use	34,918	300	1
Moderate use	444,159	7,584	2
Intense use	716,482	207,536	29
Total[3]	1,195,560	215,420	18
Fur-bearers			
Low use	29,357	2,283	8
Moderate use	234,010	12,999	6
Intense use	932,193	200,138	21
Tota[3]	1,195,560	215,420	18
Birds			
Low use	482,393	20,833	4
Moderate use	469,651	124,391	26
Intense use	183,152	69,823	38
Total[3,4]	1,195,560	215,420	18
Fish			
Low use	617,718	89,750	15
Moderate use	394,888	116,735	30
Intense use	59,261	4,879	8
Total[3,5]	1,195,560	211,364	18
Berries			
Low use	195,297	3,286	2
Moderate use	519,846	37,932	7
Intense use	480,026	174,202	36
Total[3,6]	1,195,560	215,420	18

NOTES:

[1] 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

[2] 61 ha of CSE were identified as outside the CSE for large game and not recorded in the table

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

[4] 60,364 ha were reported as outside the CSE and not included in the table

[5] 123,693 ha (about 3%) of the RSA were reported as outside the CSE for fish and not included in the table

[6] 391 ha were reported as outside the CSE and not included in the table

Fishing

Base Case disturbances within the FMFN CSE for fish harvesting are shown in Table 6-8. The Base Case disturbance is 4,879 ha (8%) for intense-use areas, 116,735 ha (30%) for moderate-use areas, and 89,750 ha (15%) for low-use areas within the RSA portion of the FMFN CSE for fish harvesting. The overall disturbance at Base Case is 18% of the area of the CSE.

Traditional Plant Harvesting (Berries)

Base Case disturbances within the FMFN CSE for traditional plant (berry) harvesting is shown in Table 6-8. The Base Case disturbance is 174,202 ha (36%) of the for the intense-use areas, 37,932 ha (7%) of the moderate-use areas, and 3,286 ha (2%) of the low-use areas within the RSA portion of the FMFN CSE for traditional plant (berry) harvesting. The overall disturbance at Base Case is 18% of the area of the CSE.

Traditional Plant Potential in the RSA

There is a decline in traditional plant use potential at Base Case when progressive reclamation of developments is considered. High traditional plant use potential declines by about 1% in the RSA while moderate and low traditional plant use potential declines by 3% and 4% respectively (see Table 6-9).

Table 6-9 Traditional Plant Potential in RSA – Base Case

Traditional Plant Potential	**Predevelopment** (ha)	**Predevelopment** % of RSA	**Base Case**[1] (ha)	**Base Case** % of RSA	**Change** (ha)	**Change %**
High	343,443.3	28.7	331,201	27.7	-12,242.4	-1.0
Moderate	464,564.0	38.9	425,748	35.6	-38,815.7	-3.2
Low	364,029.7	30.4	320,153	26.8	-43,877.0	-3.7
Not ranked[2]	23,522.7	2.0	118,457	9.9	94,934.3	7.9
Total[3]	**1,195,560**	**100**	**1,195,560**	**100**	**0**	**0**

NOTES:
[1] Progressive reclamation of development at 2057 has been included in the analysis. For a description of progressive reclamation methods, see Volume 6, Section 3.6.2.
[2] Only vegetated lands were ranked (i.e., water, mineral soil, disturbed lands, other non-vegetated lands were not)
[3] Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

6.6.4 Application Case

6.6.4.1 Mitigation

For a discussion of mitigation measures for the Project that will be used to reduce effects on potential for traditional land uses, see Section 6.5.4.1.

6.6.4.2 Linkage Analysis

The potential linkages between the Project activities and traditional land use were based on the key issues reviewed in previous TLU studies, project-specific effects assessments, and other regional reports, as well as items specified for evaluation in the TOR. Linkages were analyzed between:

- Project effects on traditional lands of First Nations
- Project effects on linear access
- Project effects on FMFN CSEs
- Project effects on traditional plant potential in the RSA

All linkages are valid for the Application Case.

6.6.4.3 Effects Analysis – Maximum Build-out Snapshot (2057)

Registered Fur Management Areas

For the Application Case at maximum build-out, the Project affects 50% of RFMA #1275 with additional developments contributing another 10% of disturbance. RFMA #1275 is located mainly in the LSA (see Table 6-10). Other RFMAs affected by the Project include #2892 with 8% disturbed, an increase of 7% from Base Case and #2939 with 4% disturbed, an increase of 3% from Base Case. RFMA #2016, while in the LSA, is not directly affected by the Project.

Table 6-10 Disturbances in RFMAs – Application Case

RFMA	Predevelopment Area of RFMA (ha)	Application Case Total Disturbance Area	
		(ha)	% of RFMA
# 1275	55,403	33,198	60
# 2016	15,713	6,067	39
# 2892	52,832	4,278	8
# 2939	9,216	412	4

Traditional Lands of First Nations

Application Case developments in the traditional territories of the FMFN, MCFN and ACFN are shown in Table 6-11. The intersection of the Project and these traditional territories is shown in Figure 6-2.

The amount of disturbance change due to the Project on the FMFN traditional territory will be 2%, and the amount of change due to the Project on the MCFN and ACFN traditional territories will be less than 1%.

Table 6-11 Disturbances of First Nations Traditional Territories – Application Case

Area of Traditional Territory (ha)		Base Case Total Disturbance Area		Application Case Total Disturbance Area		Change Due to Project	
		(ha)	% of Traditional Territory	(ha)	% of Traditional Territory	(ha)	% of Traditional Territory
FMFN	3,525,091	210,536	6	267,119	8	56,583	2
MCFN	8,641,564	234,289	3	260,038	3	25,749	<1
ACFN	4,383,438	227,209	5	243,365	6	16,156	<1

Access

During the construction and operation phases of the Project, linear disturbances in the RSA (e.g., pipelines, roads and cutlines) will decrease from 7,289 km under the Base Case to 6,908 km under the Application Case, or a 5% decrease in linear disturbance. The decrease is primarily because of limited access within the PAA during the construction and operation phases of the Project.

Fort McKay First Nation CSEs

FMFN All Traditional Uses

Table 6-12 presents the change in all potential traditional land use areas in the RSA portion of the FMFN CSEs from Base Case to Application Case for the Project. Disturbance change due to the Project is 127 ha (<1%) for the intense-use area within the FMFN CSE for all traditional uses. For moderate use, 21,266 ha (3%) are disturbed, and for low use 11,437 ha (3%) are disturbed. The total change due to the Project is equal to 3% of the total CSE for all traditional uses.

Large Game Harvesting

Table 6-12 shows Base Case and Application Case disturbances in the FMFN CSE for large game harvesting. The disturbance change due to the Project for intense-use areas is 19,176 ha (3%), and for moderate-use areas is 13,654 ha (3%), and there is 0% change for low-use areas. The overall disturbance change due to the Project is 3%.

Fur-bearer Harvesting

Table 6-12 shows the Base Case and Application Case disturbances for the FMFN CSE for fur-bearer harvesting. The disturbance change due to the Project is 32,829 ha (4%) for intense-use areas and 0% for moderate- and low-use areas. The overall disturbance change due to the Project is 3%.

Table 6-12 RSA Developments in the FMFN CSEs – Application Case

CSE	Area of CSE	Base Case Total Disturbance Area		Application Case Total Disturbance Area		Change Due to the Project	
	(ha)	(ha)	% of CSE[1]	(ha)	% of CSE[1]	(ha)	% of CSE[1]
All Uses							
Low use	371,251	5,187	1	16,624	4	11,437	3
Moderate use	584,379	121,169	21	142,435	24	21,266	3
Intense use	239,868	89,064	37	89,191	37	127	<1
Total[2,3]	1,195,560	215,420	18	248,250	21	32,830	3
Large Game							
Low use	34,918	300	1	300	1	0	0
Moderate use	444,159	7,584	2	21,238	5	13,654	3
Intense use	716,482	207,536	29	226,712	32	19,176	3
Total[3]	1,195,560	215,420	18	248,250	21	32,830	3
Fur-bearers							
Low use	29,357	2,283	8	2,283	8	0	0
Moderate use	234,010	12,999	6	12,999	6	0	0
Intense use	932,193	200,138	21	232,967	25	32,829	4
Total[3]	1,195,560	215,420	18	248,250	21	32,830	3
Birds							
Low use	482,393	20,833	4	40,401	8	19,568	4
Moderate use	469,651	124,391	26	137,700	29	13,309	3
Intense use	183,152	69,823	38	69,825	38	2	<1
Total[3,4]	1,195,560	215,420	18	247,558	21	32,830	3
Fish							
Low use	617,718	89,750	15	113,225	18	23,475	4
Moderate use	394,888	116,735	30	125,917	32	9,182	2
Intense use	59,261	4,879	8	4,879	8	0	0
Total[3,5]	1,195,560	211,364	18	244,021	20	32,657	2
Berries							
Low use	195,297	3,286	2	10,200	5	6,914	3
Moderate use	519,846	37,932	7	54,755	11	16,823	4
Intense use	480,026	174,202	36	183,295	38	9,093	2
Total[3,6]	1,195,560	215,420	18	247,558	21	32,830	3

NOTES:

[1] 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

[2] 61 ha were reported as outside the CSE and not included in the table

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

[4] 60,364 ha were reported as outside the CSE and not included in the table

[5] 123,693 ha were reported as outside the CSE and not included in the table

[6] 391 ha were reported as outside the CSE and not included in the table

Bird Harvesting

Table 6-12 shows the Base Case and Application Case disturbances within the FMFN CSE for bird harvesting. The disturbance change due to the Project is 2 ha (<1%) for intense-use areas, 13,309 (3%) for the moderate-use areas, and 19,568 (4%) for the low-use areas within the FMFN CSE for large game harvesting. The total change due to the Project is 3% of the total CSE for large game harvesting.

Fishing

Table 6-12 shows the Base Case and Application Case disturbances for the FMFN CSE for fish harvesting. The disturbance change due to the Project is 0% for intense use, 9,182 ha (2%) for moderate-use areas, and 23,475 ha (3%) for low-use areas within the FMFN CSE for fish harvesting. The total change due to the Project is equal to 2% of the total CSE for fish harvesting. The predicted loss of fish harvesting reflects generalized CSE maps and not site-specific details. No fishing areas where identified in the Project area.

Traditional Plant Harvesting (Berries)

Table 6-12 shows the Base Case and Application Case disturbances within the FMFN CSE for traditional plant (berry) harvesting. The disturbance change due to the Project is 9,093 ha (2%) for intense-use areas, 16,823 ha (4%) for the moderate-use areas, and 6,914 ha (3%) for low-use areas within the FMFN CSE for traditional plant (berry) harvesting. The total change due to the Project is 3% of the total CSE.

Traditional Plant Potential in the RSA

There is a decline in traditional plant use potential at Application Case when progressive reclamation of developments excluding the Project are considered. High traditional plant use potential declines by about 2% in the RSA, while moderate and low traditional plant use potential declines by 1% and less than 1% respectively (see Table 6-13).

Table 6-13 Traditional Plant Potential in RSA – Application Case

Traditional Plant Potential	Base Case[1] (ha)	Base Case % of RSA	Application Case[1] (ha)	Application Case % of RSA	Change (ha)	Change %
High	331,200.9	27.7	312,838.3	26.2	-18,362.7	-1.5
Moderate	425,748.3	35.6	415,976.8	34.8	-9,771.5	-0.8
Low	320,152.7	26.8	315,848.7	26.4	-4,304.0	-0.4
Not ranked[2]	118,457.0	9.9	150,896.0	12.6	32,439.0	2.7
Total[3]	1,195,560	100	1,195,560	100	0	0

NOTES:
[1] Progressive reclamation of development at 2057 has been included in the analysis for all developments excluding the Frontier Project. For a description of progressive reclamation methods see Volume 6, Section 3.6.2.
[2] Only vegetated lands were ranked (i.e., water, mineral soil, disturbed lands, other non-vegetated lands were not)
[3] Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

6.6.5 Planned Development Case

6.6.5.1 Linkage Analysis

The Project, in conjunction with planned developments, could contribute to additional effects to the potential for traditional land uses and is examined for:

- Project effects on traditional lands of First Nations
- Project effects on linear access
- Project effects on FMFN CSEs
- Project effects on traditional plant potential in the RSA
- All linkages are valid for the PDC.

6.6.5.2 Effects Analysis – Maximum Build-out Snapshot (2057)

Traditional Lands of First Nations

The area of PDC disturbances within the traditional lands of the FMFN, ACFN and MCFN are shown in Table 6-14. The amount of disturbance on the FMFN traditional territory is predicted to be 8%. Disturbance on the MCFN and ACFN territories is predicted to be 3% and 6% respectively, with no consideration of reclamation.

Table 6-14 Disturbances of First Nations Traditional Territories – PDC

Area of Traditional Territory (ha)		Base Case Total Disturbance Area		Application Case Total Disturbance Area		PDC Total Disturbance Area	
		(ha)	% of Traditional Territory	(ha)	% of Traditional Territory	(ha)	% of Traditional Territory
FMFN	3,525,091	210,536	6	267,119	8	296,376	8
MCFN	8,641,564	234,289	3	260,038	3	284,699	3
ACFN	4,383,438	227,209	5	243,365	6	271,637	6

Linear Access

Access to traditional activities is predicted to decrease from the Base Case to the PDC. Linear disturbances are predicted to decrease from a Base Case value of 7,289 km to a PDC value of 6,562 km. The decrease is primarily due to the limit of access within development footprints.

Fort McKay First Nation CSEs

FMFN All Traditional Uses

Table 6-15 presents the disturbance in all potential traditional use areas within the RSA portion of the FMFN CSEs for the PDC. The PDC is expected to disturb 38% of intense-use areas, a 1% increase from the Base Case. The total disturbance represents an increase of 5% over the Base Case disturbances.

Table 6-15 RSA Developments in the FMFN CSEs – PDC

CSE	Area of CSE	Base Case Total Disturbance Area		Application Case Total Disturbance Area		PDC Total Disturbance Area	
	(ha)	(ha)	% of CSE[1]	(ha)	% of CSE[1]	(ha)	% of CSE[1]
All Uses							
Low use	371,251	5,187	1	16,624	4	27,951	8
Moderate use	584,379	121,169	21	142,435	24	157,925	27
Intense use	239,868	89,064	37	89,191	37	91,631	38
Total [2,3]	1,195,560	215,420	18	248,250	21	277,507	23
Large Game							
Low use	34,918	300	1	300	1	300	1
Moderate use	444,159	7,584	2	21,238	5	28,083	6
Intense use	716,482	207,536	29	226,712	32	249,124	35
Total[3]	1,195,560	215,420	18	248,250	21	277,507	23
Fur-bearers							
Low use	29,357	2,283	8	2,283	8	2,283	8
Moderate use	234,010	12,999	6	12,999	6	14,001	6
Intense use	932,193	200,138	21	232,967	25	261,222	28
Total[3]	1,195,560	215,420	18	248,250	21	277,506	23
Birds							
Low use	482,393	20,833	4	40,401	8	55,871	12
Moderate use	469,651	124,391	26	137,700	29	146,521	31
Intense use	183,152	69,823	38	69,825	38	73,744	40
Total[3,4]	1,195,560	215,420	18	247,558	21	276,815	23
Fish							
Low use	617,718	89,750	15	113,225	15	139,935	23
Moderate use	394,888	116,735	30	125,917	32	128,635	33
Intense use	59,261	4,879	8	4,879	8	4,879	8
Total[3,5]	1,195,560	211,364	18	244,021	20	273,449	23
Berries							
Low use	195,297	3,286	2	10,200	5	16,859	9
Moderate use	519,846	37,932	7	54,755	11	74,887	14
Intense use	480,026	174,202	36	183,295	38	185,761	39
Total[3,6]	1,195,560	215,420	18	247,558	21	27,507	23

NOTES:
[1] 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
[2] 61 ha were reported as outside the CSE and not included in the table
[3] Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
[4] 60,364 ha were reported as outside the CSE and not included in the table
[5] 123,693 ha were reported as outside the CSE and not included in the table
[6] 391 ha were reported as outside the CSE and not included in the table

Large Game Harvesting

Table 6-15 presents the disturbance in all large game harvesting areas within the RSA portion of the FMFN CSEs for Base Case, Application Case and PDC for the Project.

The total loss of harvesting area caused by the Project and other planned developments within the RSA is predicted to be 23% of the FMFN CSE for large game harvesting. The PDC is expected to disturb 35% of intense-use areas, 6% of moderate-use areas and 1% of low-use areas in the CSE. The total amount of disturbance under the PDC is about 277,507 ha, an increase of 5% over the Base Case without consideration of reclamation.

Fur-bearer Harvesting

Table 6-15 presents the disturbance in all fur-bearer harvesting areas within the FMFN CSE for Base Case, Application Case and PDC for the Project.

The total loss of harvesting area caused by the Project and other planned developments within the RSA portion of the FMFN fur-bearer CSE is predicted to be 23% of the FMFN CSE for fur-bearer harvesting. The PDC is expected to disturb 28% of intense-use areas, 6% of moderate-use areas and 8% of low-use areas in the CSE. Total PDC disturbance in the CSE is 5% higher than the Base Case disturbance.

Bird Harvesting

Table 6-15 presents the disturbance in all bird harvesting areas within the RSA portion of the FMFN CSE for Base Case, Application Case and PDC for the Project.

The total loss of traditional area caused by the Project and other planned developments in the RSA portion of the FMFN bird harvesting CSE is predicted to be 23%. The PDC is expected to disturb 40% of intense-use areas, 31% of moderate-use areas, and 12% of low-use areas in the CSE. The total PDC disturbance represents a 5% increase over the Base Case disturbance.

Fish Harvesting

Table 6-15 presents the disturbance in all fish harvesting areas within the FMFN CSE for Base Case, Application Case and PDC for the Project.

The total loss of traditional area caused by the Project and other planned developments in the region is predicted to be 23% of the FMFN CSE for fish harvesting. The PDC is expected to disturb 8% of intense-use areas, 33% of moderate-use areas and 23% of low-use areas, and 3% of the no use areas in the CSE. The total amount of PDC disturbance in the CSE represents an increase of about 5% over the Base Case disturbances.

Traditional Plants (Berries)

Table 6-15 presents the disturbance in all large game harvesting areas within the FMFN CSE for Base Case, Application Case and PDC for the Project.

The total loss of traditional area caused by the Project and other planned developments within the RSA portion of the FMFN traditional plants CSE is predicted to be 23% of the FMFN CSE for traditional plant and berry harvesting. The PDC is expected to disturb

39% of intense-use areas, 14% of moderate-use areas and 9% of low-use areas in the CSE. The total PDC disturbance represents an increase of about 5% over the Base Case disturbances.

Traditional Plant Potential in the RSA

There is a decline in traditional plant use potential at PDC when progressive reclamation of developments excluding the Project are considered. High traditional plant use potential declines by about 1.8% in the RSA while moderate and low traditional plant use potential declines by 2% and 1% respectively (see Table 6-16).

Table 6-16 Traditional Plant Potential in RSA – PDC

Traditional Plant Potential	Base Case[1] (ha)	Base Case % of RSA	PDC[1] (ha)	PDC % of RSA	Change (ha)	Change %
High	331,201	27.7	309,284.2	25.9	-21,916.8	-1.8
Moderate	425,748	35.6	397,979.2	33.3	-27,769.2	-2.3
Low	320,153	26.8	308,868.6	25.8	-11,284.1	-0.9
Not Ranked[2]	118,457	9.9	179,427.8	15.0	60,970.9	5.1
Total[3]	**1,195,560**	**100**	**1,195,560**	**100**	**0.0**	**0**

NOTES:
[1] Progressive reclamation of development at 2057 has been included in the analysis for all developments excluding the Frontier Project. For a description of progressive reclamation methods see Volume 6, Section 3.6.2.
[2] Only vegetated lands were ranked (i.e., water, mineral soil, disturbed lands, other non-vegetated lands were not)
[3] Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

6.6.6 Prediction Confidence

Confidence in the assessment of potential effects of the Project on traditional land use potential is considered moderate. Information used to assess the potential effects of traditional areas or activities was provided by Aboriginal communities and potential traditional land use was determined using baseline data and models generated as part of the vegetation assessment (see Volume 6, Section 3).

6.6.6.1 Measurements and Analytical Techniques

For calculations of vegetation-related traditional land use potential, analyses were based on a satellite imagery that is reasonably accurate and is at a more generalized level. As such, confidence in measurements and analytical techniques is considered moderate.

Furthermore, the Project footprint was defined by the mine plan at a level of detail adequate for the EIA. For indirect effects, confidence in analytical techniques is moderate because effects of disturbances on wildlife are less documented in the literature. However, TEMF standards were used wherever possible to define zones of influence from disturbance. Professional judgement was also required to address sensory effects on wildlife and therefore a cautionary approach was taken in defining zones of influence.

6.6.6.2 Mitigation

Confidence in mitigation is moderate. While long-term reclamation monitoring plots appear to be moving largely towards natural ecosystems, some areas (i.e., tailings sand) are developing into novel ecosystems (see Rowland et al. 2009). Therefore, prediction confidence of success of reclamation activities on habitat availability is moderate. To incorporate the added level of uncertainty associated with potential future climate change, adaptive management is included as one of the core principles of the Owner's reclamation plan.

6.6.7 Responses to Aboriginal Community Concerns

Potential effects to traditional land uses resulting from the Project will be mitigated primarily through access management and reclamation (see Section 6.5.7).

6.6.8 Management and Monitoring

For a discussion of management and monitoring related to traditional use potential, see Section 6.5.8.

6.6.9 Summary

The Project will disturb 50% of RFMA #1275 with an additional 10% disturbed by other developments. Other RFMAs affected by the Project include #2892 with 8% disturbed, an increase of 7% from Base Case and #2939 with 4% disturbed, an increase of 3% from Base Case. RFMA #2016, while in the LSA, is not directly affected by the Project.

The amount of disturbance change due to the Project on the FMFN traditional territory will be 2%, and the amount of change due to the Project on the MCFN and ACFN traditional territories will be less than 1%.

With no consideration of reclamation, the Project will affect 3% of CSEs including:

- 4% of the area ranked as high intensity for fur-bearers
- 3% of area ranked as high intensity for large game
- 2% of area ranked as high intensity for berry harvesting
- less than 1% of area ranked as high intensity for bird harvesting

With reclamation these effects will be mitigated with the restoration of wildlife habitat and traditional plant species an important focus of the revegetation plan (see Volume 1, Section 13.7).

There is a decline in traditional plant use potential in the Application Case when progressive reclamation of developments excluding the Project are considered. High traditional plant use potential declines by about 2% in the RSA while moderate and low traditional plant use potential decline by 1% and less than 1% respectively.

6.7 Conclusions

The TLU assessment for the Project included a review of reports commissioned by Aboriginal communities as well as by industry. Consultation will continue with the FMFN, ACFN, MCFN and the Métis Communities of Fort Chipewyan (Métis Local 125) and Fort McKay (Métis Local 63) with the intent of understanding the nature and extent of traditional activities in the PAA.

Information collected from a review of available literature, previous studies for other developments in the region, and interviews with Aboriginal communities were used to inform the EIA for the Project. A qualitative assessment was conducted to determine which traditional activities will be affected by the Project, as defined by those activities within the area of the PAA. Potential effects to access were also assessed. The qualitative assessment indicates that some traditional areas used for hunting and trapping, and plant and berry harvesting for one or all of the Aboriginal communities discussed in this report overlap the PAA, and will not be available to traditional users during the construction and operational phases of the Project. Traditional fishing areas were not specifically identified within the PAA and therefore are not predicted to be affected by the Project.

The amount of disturbance change due to the Project on the FMFN traditional territory will be 2%. For the MCFN and ACFN traditional territories, change because of the Project will be less than 1%.

The Project will disturb 50% of RFMA #1275 with an additional 10% disturbed by other developments. Other RFMAs affected by the Project include #2892 with 8% disturbed, an increase of 7% from Base Case and #2939 with 4% disturbed, an increase of 3% from Base Case. RFMA #2016, while in the LSA, is not directly affected by the Project.

There is a decline in traditional plant use potential in the Application Case when progressive reclamation of developments excluding the Project are considered. High traditional plant use potential declines by about 2% in the RSA while moderate and low traditional plant use potential decline by 1% and less than 1%. It is anticipated that with reclamation of the Project, the decline in traditional use potential will be reversible.

With no consideration for reclamation, the Project will affect 3% of CSEs including 4% of the area ranked as high intensity for fur-bearers, 3% of area ranked as high intensity for large game, 2% of area ranked as high intensity for berry harvesting and less than 1% of area ranked as high intensity for bird harvesting.

Potential effects to traditional land uses resulting from the Project will be mitigated primarily through access management and reclamation. One of the goals of the closure, conservation and reclamation plan is to reclaim habitat for key species traditionally hunted, trapped and harvested. Although restoration will likely extend beyond the lifetimes of current users, traditional land use potential will be returned to the PAA.

6.8 References

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7 Peace-Athabasca Delta

7.1 Introduction

This section provides context for understanding the cumulative effects assessment for the Frontier Oil Sands Mine Project (Frontier Project) as it relates to the Peace-Athabasca Delta (PAD). It has been developed to address federal input, issues identified by Parks Canada and concerns expressed by potentially affected Aboriginal communities and public stakeholders. The information contained in this section is not required by the Alberta Environment terms of reference (TOR) for the Frontier Project.

7.1.1 Location

The PAD is one of the world's largest freshwater deltas and is located in northeastern Alberta at the western end of Lake Athabasca where the Peace, Athabasca and Birch rivers converge (see Figure 7-1). The PAD has a drainage basin of about 600,000 km^2, which includes most of northern Alberta and parts of northern British Columbia and Saskatchewan (Parks Canada 2010a, Internet site); it comprises:

- three main deltas, including:
  - Birch River Delta (168 km^2)
  - Peace River Delta (1,680 km^2)
  - Athabasca River Delta (1,960 km^2)
- numerous interconnected channels (both active and inactive) and shallow, open-water areas; the largest of these include:
  - Lake Claire
  - Baril Lake
  - Mamawi Lake
  - Richardson Lake

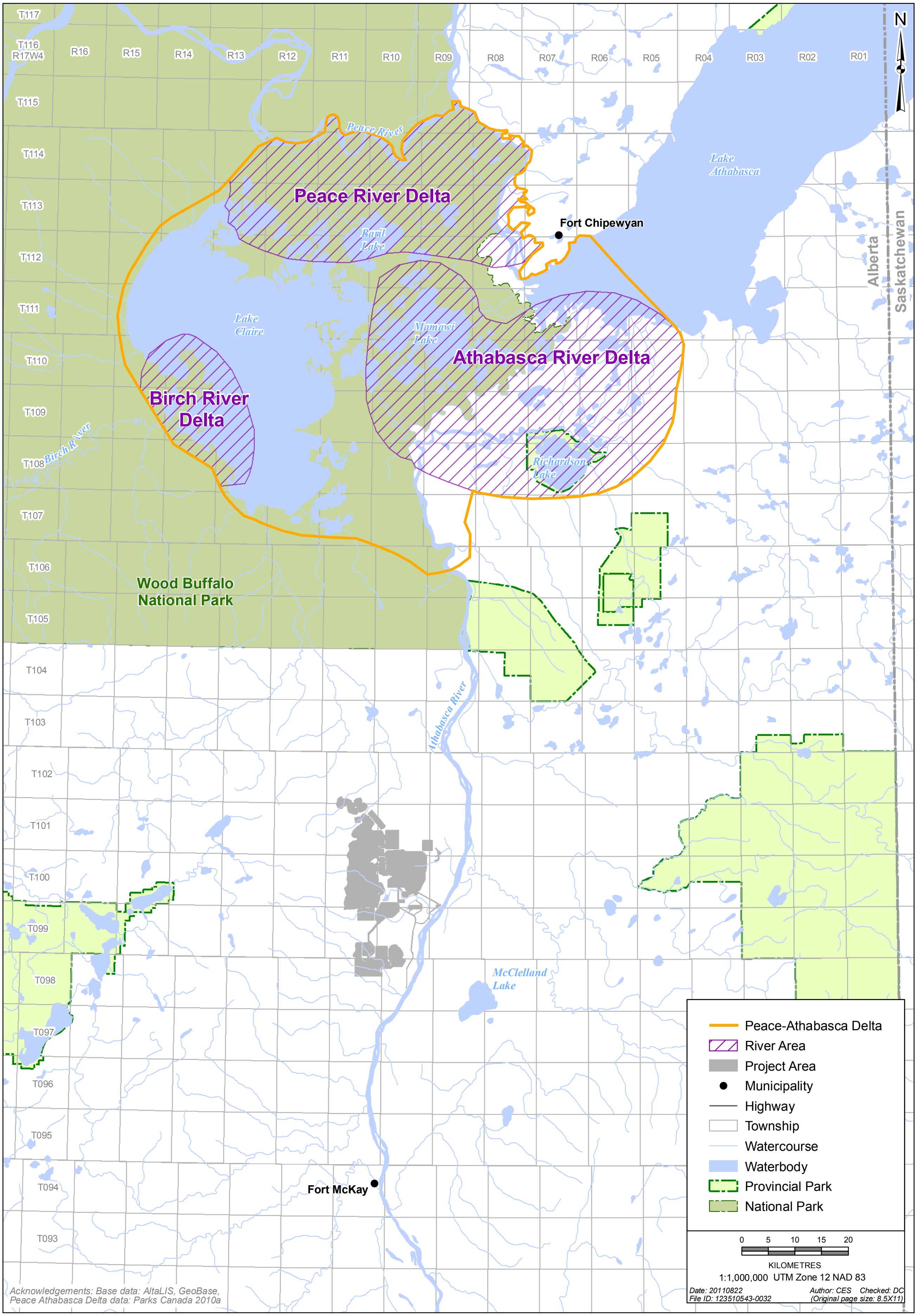

Figure 7-1: Location of the Peace-Athabasca Delta

7.1.2 Status

About 80% of PAD is in Wood Buffalo National Park (WBNP), a designated United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site. As such, it is managed and protected under the regulations of the *Canada National Parks Act* and Parks Canada's *Guiding Principles and Operational Policies* (Parks Canada 2009, Internet site). The PAD is used by Aboriginal communities to undertake traditional pursuits and is considered a wetland of international significance. In 1982, it was listed as a Ramsar site (see Ramsar 2011, Internet site). Within the national park, management of PAD is guided by the WBNP Management Plan (Parks Canada 2010b, Internet site), which identifies a number of objectives and targets focused on ecological integrity, cultural value, stewardship and connection with Parks visitors.

7.1.3 Relevance to the Environmental Impact Assessment

In this EIA, specific regional study areas (RSA) were determined according to the requirements established for each discipline. The RSAs were defined to include all areas where cumulative changes might be caused by the Project when combined with other developments in the Athabasca Oil Sands Region. Based on these criteria, only some disciplines have included the PAD in their RSAs (see Table 7-1). The RSAs in relation to the PAD are shown in Figure 7-2.

7.1.4 Objectives

The cumulative environmental effects assessment completed for the Project in compliance with the TOR predicted that there will be no adverse cumulative effects on PAD from the Project in combination with other developments in the Athabasca Oil Sands Region. However, because of concerns of the federal government, potentially affected Aboriginal communities and public stakeholders, an overview of existing conditions and historical trends in the PAD have been provided, together with an identification of key issues and indicators relevant to the PAD.

7.1.4.1 Federal Requests

This section has been developed specifically to address the federal input (see Canadian Environmental Assessment Agency 2009a and 2009b) and issues identified by Parks Canada for other oil sands applications (Parks Canada 2010b, Internet site).

Table 7-1 PAD Inclusion in RSA by Discipline

Discipline	RSA Includes PAD?	Notes
Air	Yes	Included PAD within the RSA.
Groundwater	No	RSA is defined to include the main general distribution of the basal McMurray Formation aquifer, where it is relevant to regional mining activities. The northern extent of the basal water sands (west of the Athabasca River) is approximately Township (Twp) 101, and the RSA domain extends to Twp 103. This limit is about 5 km south of the PAD and, therefore, the PAD was not included in the RSA.
Aquatics (surface water quality, fish and fish habitat)	Partially	RSA is defined to include the reach of the Athabasca River adjacent to oil sands mines, extending downstream to the Embarras River as well as to the outflow of Ronald Lake. As negligible surface water quantity and water and sediment quality, fish and fish habitat effects are predicted in Ronald Lake and the Athabasca River, including its divergence with the Embarras River[1], the aquatics RSA was not extended further into the PAD. The farthest potential aquatics-related cumulative effect associated with air emissions from the Project was potential acid input (PAI) to waterbodies and watercourses. However, adverse cumulative effects from PAI on waterbodies and watercourses were not predicted for the aquatics RSA, further confirming the PAD's exclusion from the aquatics RSA.
Terrestrial	No	RSA is defined to capture the farthest measurable direct effects associated with the Project in conjunction with operating, approved and planned developments in the Athabasca Oil Sands Region. The farthest measurable direct effect associated with the Project was from air emissions, specifically PAI (on soils) and NO_2 concentrations (on vegetation); however, direct adverse cumulative effects from PAI and NO_2 did not intersect with the PAD confirming that it was appropriate to not include the PAD in the terrestrial RSA.
Human Health	Partially	Included PAD within the RSA for airborne constituents. Because negligible changes to surface water and sediment quality were predicted in the Athabasca River and at the junction of the Embarras and Athabasca rivers and at Ronald Lake, the aquatics RSA was not extended into the PAD for waterborne constituents[1]. Therefore the human health assessment focused only on potential airborne emission effects in the PAD.

NOTE:
[1] The Athabasca River and Embarras River divergence exists in the southern portion of the PAD. The boundary of WBNP extends to the midpoint of the Athabasca River channel in this reach.

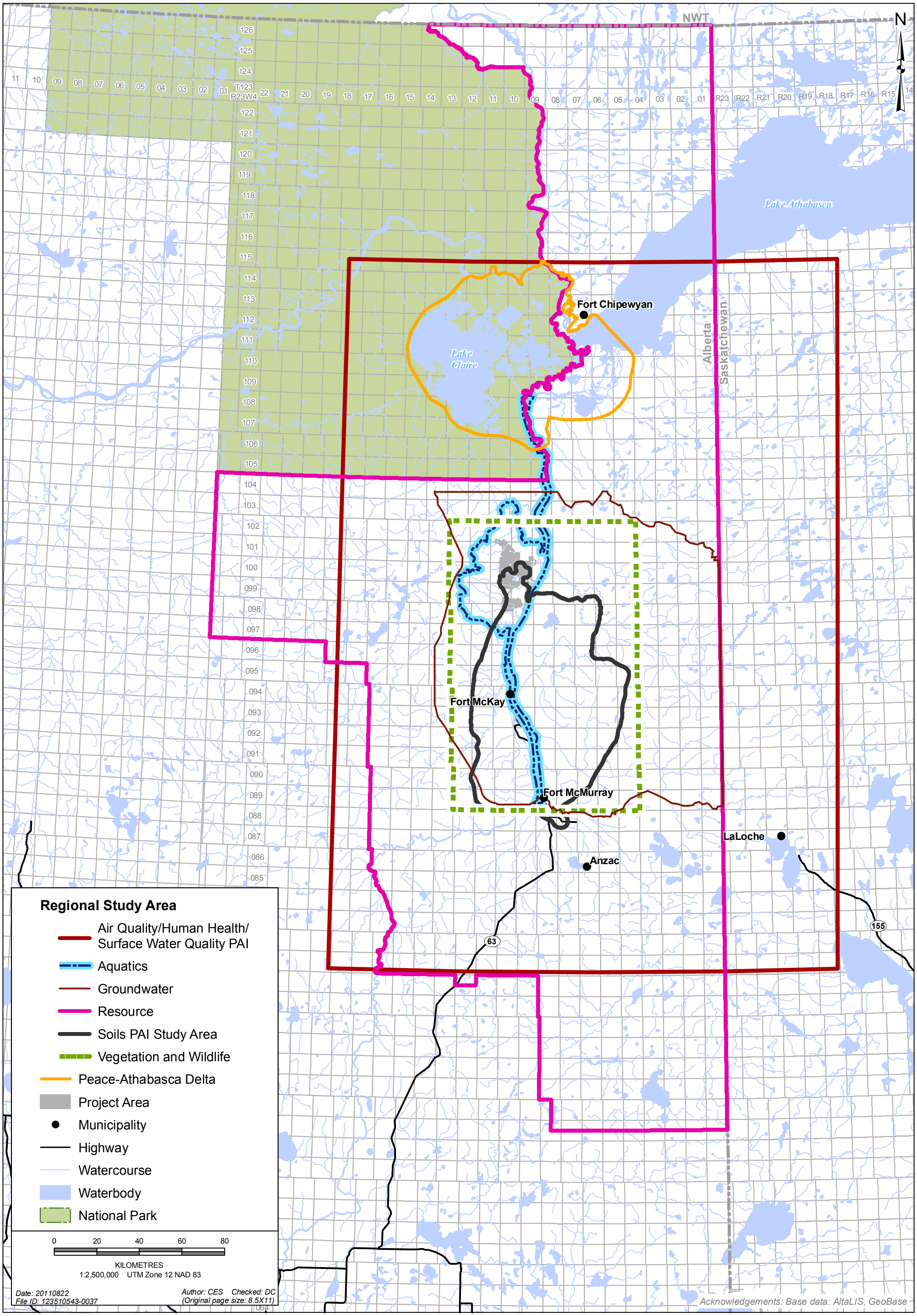

Figure 7-2: RSAs and PAI Study Areas and the Peace-Athabasca Delta

7.1.4.2 Aboriginal Community Concerns

Aboriginal community concerns regarding the PAD were often expressed in the context of larger ecological processes. For example, community members have stated that flowrates in the Athabasca River and through the PAD have changed and continue to change, linking these changes to oil sands development, climate change and construction of the W.A.C. Bennett Dam. Concerns have also been expressed about the potential for contamination of groundwater and surface waters from oil sands activities and contaminated water travelling north to the PAD as well as effects of air emissions on ecosystems and people in the PAD. Effects on ecological processes and ecosystem changes because of changing water levels and potential changes from water and air contamination were also raised as concerns.

7.1.4.3 Scope

To address federal requests and Aboriginal community concerns, existing conditions, historical trends, as well as an environmental evaluation of Project effects, were assessed in conjunction with oil sands developments for each of the following disciplines:

- air
- groundwater
- hydrology
- surface water quality
- fish and fish habitat
- soils and terrain
- vegetation
- wildlife
- human health

Changes to key issues and indicators are evaluated in the context of the PAD using information on existing conditions and historical trends for identified key indicators, as well as from the results of the cumulative environmental effects assessment completed for the Project.

For a review of the assessment methods and approach for the EIA, see Volume 3, Section 1.

7.1.5 References

7.1.5.1 Literature Cited

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7.1.5.2 Internet Sites

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7.2 Air

7.2.1 Key Issues and Key Indicators

To provide focus for the PAD evaluation, key indicators for air quality were chosen. Key indicators included cumulative changes in:

- ambient NO_2, SO_2 and $PM_{2.5}$ concentrations
- acid-forming and nitrogen substance deposition
- PAC and metal deposition
- ground-level ozone

Air quality in the PAD area can be determined from ambient monitoring and from air quality simulation model predictions. Specifically, ambient air quality data are available from a monitoring station located near the community of Fort Chipewyan. The data collected from this station are summarized in Volume 4, Appendix 3B. The air quality assessment for the Project (see Volume 4, Section 3) provides air quality predictions in the PAD area for the existing condition and for the three assessment cases as the PAD is located completely within the air quality RSA.

7.2.2 Historic Data, Existing Conditions and Trends

7.2.2.1 Ambient Air Quality

The Wood Buffalo Environmental Association (WBEA) air quality measurements can provide an indicator of ambient air quality levels in the PAD for the existing condition. Summaries of NO_2, SO_2, and $PM_{2.5}$ concentrations measured at the WBEA station from 1999 to 2010 are shown in Tables 7-2 to 7-4.

- NO_2 concentrations (see Table 7-2): Maximum 1-hour concentrations are in the range of 44.2 to 63.8 $\mu g/m^3$. The Alberta Ambient Air Quality Objective (AAAQO) of 300 $\mu g/m^3$ was not exceeded, and there are no exceedances of the annual AAAQO of 45 $\mu g/m^3$.

  The information in Table 7-2 does not show any obvious temporal trends and this is consistent with other studies. Kindzierski et al. (2010) examined ambient NO_2 data collected at the Fort Chipewyan station for the 9-year period from 1999 to 2007 and found no statistical change in SO_2 concentrations over this period. This is because the Fort Chipewyan station is located far away from major NO_X emitting developments.

- SO_2 concentrations (see Table 7-3): Maximum 1-hour, maximum 24-hour and annual average observations are in the ranges of 34.0 to 64.1, 6.60 to 26.5, and 0.59 to 1.14 $\mu g/m^3$, respectively; there are no exceedances of the respective AAAQO.

  The information in Table 7-3 does not show any obvious temporal trends and this is consistent with other studies. Kindzierski et al. (2010) examined ambient SO_2 data collected at the Fort Chipewyan station for the nine-year period 1999 to 2007 and found no statistical temporal trend in SO_2 concentrations over this period. This is because the Fort Chipewyan station is located far away from major SO_2 emitting developments.

- $PM_{2.5}$ concentrations**:** The maximum 1-hour concentrations exceeded the Alberta Ambient Air Quality Guidelines (AAAQG) of 80 $\mu g/m^3$ in five of the 10 years. The maximum 24-hour concentrations also exceeded the AAAQO of 30 $\mu g/m^3$ in five of the 10 years.

  It is not clear from the information in Table 7-4 whether there is any systematic increasing or decreasing trends. Kindzierski et al. (2010) examined ambient $PM_{2.5}$ data collected at the Fort Chipewyan station for the nine-year period from 1999 to 2007 and found no temporal trends for the higher concentrations over this period and found a decreasing trend for the lower concentrations (e.g., the 90^{th} percentile decreased by 0.3 $\mu g/m^3$ per year). The decrease might be attributable to a decrease in the occurrence of wildfires and/or dust from high winds.

Box plots of concentrations versus wind directions show that NE-E and SE-SW winds contribute to the elevated concentrations of NO_2, which are attributed to the Fort Chipewyan community emissions and more distant industrial emissions. The SE-SW winds contribute to the elevated concentrations of SO_2 and $PM_{2.5}$, which could be due to industrial emissions in the distant south area.

Air quality in the PAD is better than that farther to the south in the Athabasca Oil Sands Region in terms of NO_2 and SO_2 concentrations. $PM_{2.5}$ concentrations in the PAD can be comparable to those measured in the Athabasca Oil Sands Region. This is largely because $PM_{2.5}$ concentrations are strongly influenced by factors that are external to nearby anthropogenic emission sources (e.g., long range transport and wildfires).

7.2.2.2 Ambient PAI and Nitrogen Deposition

Based on air quality model simulations, the PAI deposition values in the PAD are estimated to be in the following ranges:

- predevelopment condition: -0.003 to 0.015 k_{eq} H^+/ha/a
- existing condition: 0.023 to 0.033 k_{eq} H^+/ha/a

These values are less than the most stringent monitoring load criteria for sensitive receptors (i.e., they are less than 0.17 k_{eq} H^+/ha/a). Similarly, the nitrogen deposition values in the PAD are estimated to be in the following ranges:

- predevelopment condition: 1.0 to 1.1 kg N/ha/a
- existing condition: 1.1 to 1.5 kg N/ha/a

The nitrogen deposition values in the PAD are less than the lower (5 kg N/ha/a) and upper (10 kg N/ha/a) critical load limits for Boreal forests.

Table 7-2 NO_2 Concentrations (µg/m^3) – Fort Chipewyan Station (2000 to 2010)

Ambient Criteria			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Max
1-hour														
AAAQO	*Maximum*	*300*	52.8	44.2	63.8	48.1	48.9	56.4	58.3	58.3	52.7	48.9	45.1	63.8
Annual														
AAAQO	*Average*	*45*	1.91	1.67	1.64	2.04	1.86	1.41	1.62	2.92	2.30	2.07	1.98	2.92

Table 7-3 SO_2 Concentrations (µg/m^3) – Fort Chipewyan Station (1999 to 2010)

Ambient Criteria			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Max
1-hour															
AAAQO	*Maximum*	*450*	46.3	34.0	64.1	46.6	51.5	47.1	49.7	47.1	52.3	49.7	47.1	52.3	64.1
24-hour															
AAAQO	*Maximum*	*125*	8.99	6.60	25.1	17.8	24.2	13.8	26.5	15.8	20.0	11.5	11.4	22.2	26.5
Annual															
AAAQO	*Average*	*20*	1.08	0.59	0.95	0.97	1.14	0.89	0.87	0.80	0.87	0.69	0.73	0.90	1.14

Table 7-4 $PM_{2.5}$ Concentrations (µg/m³) – Fort Chipewyan Station (2001 to 2010)

Ambient Criteria			**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Max**
1-hour													
AAAQG	*Maximum*	*80*	57.8	**119**	48.6	76.0	97.3	**214**	**144**	**89.4**	22.6	**269**	**269**
24-hour													
AAAQO	*Maximum*	*30*	14.3	25.0	18.6	27.2	**36.2**	**46.4**	**96.4**	**45.8**	14.5	**68.2**	**96.4**
CWS *Exceedance Trigger* *Planning Trigger* *Surveillance Trigger*	*98th Percentile (1-year)*	*30* *30* *20* *15*	7.9	11.0	7.6	13.6	12.2	10.5	10.2	-	-	-	-
CWS *Exceedance Trigger* *Planning Trigger* *Surveillance Trigger*	*(3 year rolling average)*	*30* *30* *20* *15*	-	-	7.7	10.7	11.2	12.1	10.9	-	-	-	-
Annual													
None	*Average*	-	4.40	2.40	2.41	2.36	2.39	2.57	2.32	2.55	2.29	3.72	4.40

NOTES:
Concentrations that exceed the AAAQG or AAAQO are shown in bold-face font
The 98th percentile values are from Alberta Environment (2009) and have accounted for natural and long-range transport contributions

7.2.2.3 PAC and Metal Deposition

Snowpack measurements and air quality model simulations indicate a strong decrease in polycyclic aromatic compound (PAC) and metal deposition rates with increasing distance from oil sands developments. As the PAD is located more than 50 km from existing PAC and metal emission sources, deposition levels in the PAD are similar to regional background levels.

7.2.2.4 Ground-level Ozone

Ozone is a naturally occurring substance and is not directly emitted by the Project or by other oil sands developments. Ozone maxima occur in springtime (March to May) and are a result of natural background causes. During periods of hot weather in the summer, O_3 can be formed from precursor NO_x and volatile organic compound (VOC) emissions. High NO concentrations from NO_X emitting sources will decrease the natural O_3 levels immediately downwind of the emission source.

A summary of O_3 concentrations at the Fort Chipewyan station from 1999 to 2010 is shown in Table 7-5. The observed O_3 concentrations do not vary substantially from year to year. The observed maximum 1-hour O_3 concentrations did not exceed the AAAQO of 160 $\mu g/m^3$. The 98th percentile 8-hour values are less than the Canada Wide Standard (CWS) of 30 $\mu g/m^3$.

The information in Table 7-5 does not show any obvious temporal trends and this is consistent with other studies. Kindzierski et al. (2010) examined ambient O_3 data collected at the Fort Chipewyan station for the nine-year period 1999 to 2007 and found no statistical temporal trend in O_3 concentrations over this period. Box plots of concentration versus wind direction do not show any obvious variations of O_3 with wind direction.

Table 7-5 O_3 Concentrations (µg/m³) – Fort Chipewyan Station (1999 to 2010)

Ambient Criteria			**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Max**
1-hour															
AAAQO	*Maximum*	*160*	118	100	108	128	124	124	104	130	112	116	108	122	130
8-hour															
CWS *Exceedance Trigger* *Planning Trigger*	4th highest or *99th percentile (1 year)*	*127* *127* *113*	97	92	97	107	108	111	97	104	101	106	99	99	110
CWS *Exceedance Trigger* *Planning Trigger*	*(3-year rolling average)*	*127* *127* *113*	-	-	95	99	108	109	105	104	101	104	102	101	109
Annual															
None	*Average*	-	53	54	57	55	58	59	52	56	53	53	50	54	59

NOTE:
Values are provided to the nearest µg/m³

7.2.3 Environmental Evaluation

7.2.3.1 Air Quality Changes

The Fort Chipewyan air quality simulation model predictions for the three assessment cases provide an additional indicator of future air quality levels in the PAD. These values are discussed in Volume 4, Section 3.6.4 of the air quality assessment and are summarized as:

- NO_2 concentrations for the Base Case are nominally 60% greater than those associated with the existing condition. Depending on the metric, the Project increases NO_2 concentrations up to 3.9%. For the existing condition and the three assessment cases, the maximum NO_2 concentrations are less than the respective AAAQO.
- SO_2 concentrations for the Base Case are nominally 70% greater than those associated with the existing condition. Depending on the metric, the Project increases SO_2 concentrations up to 0.2%. For the existing condition and the three assessment cases, the maximum SO_2 concentrations less than the respective AAAQO.
- $PM_{2.5}$ concentrations for the three assessment cases are all nominally the same, and are nominally twice that associated with the existing condition. Depending on the metric, the Project increases $PM_{2.5}$ concentrations up to 7.5%. The predicted $PM_{2.5}$ concentrations are less than all the applicable ambient criteria. The model predictions, however, do not include wildfire or windblown dust contributions.
- CO concentrations for the three assessment cases are all nominally the same, and are nominally twice those associated with the existing condition. Depending on the metric, the Project increases the CO concentrations up to 0.3%. The predicted CO concentrations are much less than the applicable respective AAAQO.

Air quality in Fort Chipewyan is influenced by local community emissions and by the more distant industrial and non-industrial emissions. For the assessment, the population and the community emissions were assumed to increase by 73% from the existing condition to the Base Case (see Volume 4, Appendix 3A). Much of the predicted ambient concentration increases between the existing condition and the three assessment cases can be attributed to the assumed increased community emissions. Much of the SO_2 concentration contribution is from SO_2 emissions associated with the use of oil for community heating and electrical generation.

Although concentration increases can be attributed to the Base Case relative to the existing condition; the following are noted for the Application Case based on the model predictions:

- Maximum predicted NO_2 concentrations are 3.5 to 7.7 times less than the AAAQO.
- Maximum predicted SO_2 concentrations are 2.9 to 3.1 times less than the AAAQO.
- Maximum predicted $PM_{2.5}$ concentrations are 2.9 to 3.6 times less than the AAAQG/AAAQO.
- Maximum predicted CO concentrations are 42 to 62 times less than the AAAQO.
- Maximum predicted hydrocarbon concentrations are 99 to 15,800 times less than the respective AAAQO.

- Maximum predicted reduced sulphur concentrations are 102 and 86 times less than the respective AAAQO. The predicted odour peaks are 40 to 1,300 times less than the respective odour thresholds.
- Maximum predicted trace metal concentrations are 265 to 5,115 times less than the respective AAAQO.

For many of the substances, the Project contribution is not substantive (i.e., it is less than 1% relative to the Base Case). For the portion of the PAD that is further away from the community, the air quality levels would be less than those indicated by the predictions for the community. The air quality in the PAD is expected to be similar to the existing condition measurements and the PAD is expected to continue to be representative of a remote background location.

7.2.3.2 PAI and Nitrogen Deposition Changes

PAI deposition maxima tend to occur near existing and proposed oil sands developments, and decrease with increasing distance from these developments. Air quality simulation model predictions indicate the following PAI levels in the PAD for the three assessment cases:

- Base Case: 0.033 to 0.036 k_{eq} H^+/ha/a
- Application Case: 0.034 to 0.037 k_{eq} H^+/ha/a
- PDC: 0.035 to 0.037 k_{eq} H^+/ha/a

The indicated values are based on averages for the 1° latitude × 1° longitude grid cells that the PAD is located within. These values are less than the most stringent monitoring load criteria for sensitive receptors (i.e., they are less than 0.17 k_{eq} H^+/ha/a).

Nitrogen deposition maxima tend to occur near existing and planned oil sands developments, and decrease with increasing distance from these developments. Air quality simulation model predictions indicate the following nitrogen deposition values in the PAD for the three assessment cases:

- Base Case: 1.2 to 2.0 kg N/ha/a
- Application Case: 1.3 to 2.1 kg N/ha/a
- PDC: 1.4 to 2.2 kg N/ha/a

The nitrogen deposition values in the PAD are less than the lower (5 kg/ha/a) and upper (10 kg/ha/a) critical load limits for Boreal forests.

7.2.3.3 PAC and Metal Deposition Changes

Kelly et al. (2009, 2010) collected snowpack samples at 31 sites in March 2008. The sample collection sites were in a general north-south corridor that extended from Fort Chipewyan in the north to Fort McMurray in the south. PAC and metal deposition maxima were found at sites located near existing developments and these levels decreased with increasing distance from the developments. Two downwind variations were found: one set found a rapid decrease with distance and was attributed to upgrader stack emissions, and another set found a less rapid decrease and was attributed to local road or mine site contributions.

For locations more than 50 km from the emission sources, the deposition levels were assumed to be background levels. Dispersion model predictions support the snowpack measurements, indicating a strong decrease of deposition rates with increasing distance from the oil sands developments. The PAD is located sufficiently distant from the oil sands development emission sources that PAC and metal deposition levels would remain at background levels.

7.2.3.4 Ozone Concentration Changes

The Project along with other existing and proposed developments in the Athabasca Oil Sands Region collectively result in increased O_3 precursor NO_X and VOC emissions. With the appropriate weather conditions, these emissions can lead to the photochemical production of ozone. Environment Canada, Alberta Environment and CEMA have applied photochemical models to examine the potential for ozone concentration changes from these emissions (see discussion in Volume 4, Section 3.6.8.1 of the air quality assessment).

In the Fort Chipewyan area (i.e., the PAD area) and based on year 2006 emissions, the peak 4^{th} highest daily maximum 8-hour ozone concentrations (99^{th} percentile) were predicted to be in the 48 ppb to 50 ppb range (i.e., in the 96 to 100 $\mu g/m^3$ range). This compares to corresponding measured values that are in the 97 to 111 $\mu g/m^3$ range. The primary contributor to the predicted ozone maxima in the Fort Chipewyan area was Alberta vehicle emissions located outside of the Lower Athabasca Region. In contrast, the primary contributors to ozone maxima in the Fort McMurray and Fort McKay areas were local point and area sources.

The model simulation indicated that the 4^{th} highest daily maximum 8-hour ozone concentrations associated with a future development scenario could increase by 4 to 8 $\mu g/m^3$; resulting in corresponding future ozone concentrations in the 100 to 108 $\mu g/m^3$ range. This increase is relative to the existing condition.

7.2.4 Summary

The southern boundary of the PAD is located about 40 km to the north of the Project area boundary—100 km north of Fort McKay where there are several operating and proposed mining and extraction developments—and 120 km north of the operating Suncor and Syncrude mining, extraction and upgrading developments. Ambient air quality changes associated with these emission sources tend to be the greatest near the respective developments and decrease with increasing distance from the developments. Ambient monitoring measurements and dispersion modelling predictions both support this decrease with increasing distance.

For the most part, air quality in the PAD can be viewed as being representative of a rural remote location, also referred to as a regional background location. Specifically, the WBEA views the Fort Chipewyan station as both a community exposure and a regional background monitoring station (WBEA, 2010). While slight changes in air quality will be expected in the PAD because of future developments, PAD and associated air quality is expected to be still regarded as background.

As the Fort Chipewyan station is the only station in the PAD and it is also the only continuous WBEA station in a background location, the monitoring data collected at this station provide an important reference point. For this reason, the continuation of monitoring at this location is essential to the understanding of air quality changes across the WBEA region.

7.2.5 References

7.2.5.1 Literature Cited

AENV (Alberta Environment). 2009. *Particulate Matter and Ozone Assessment for Alberta: 2001–2007*. Prepared by Air Policy Section, Alberta Environment. April 2009.

Kelly, Erin N., Schindler, David W., Hodson, Peter V., Jeffrey, Short W., Radmanovich, R., and Nielson, Charlene C. 2010. Oil sands development contributes elements toxic at low concentrations to the Athabasca River and its tributaries. *Proceedings of the National Academy of Sciences* 107(37): 16178-16183.

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Kindierski, W. B., Chelme-Ayala, P., and El-Din, Gamal M. 2009. *Ambient Air Quality Data Summary and Trend Analysis. Part 1*. Wood Buffalo Environmental Association, Fort McMurray, Alberta.

WBEA (Wood Buffalo Environmental Association). 2010. *Ambient Air Quality Monitoring in Conklin, AB. August 31 – September 14, 2009*. Final Report. Fort McMurray, Alberta. 16 pp.

7.3 Groundwater

7.3.1 Key Issues and Key Indicators

To provide focus for the PAD evaluation, key indicators for groundwater key issues were chosen. Groundwater surface elevations and groundwater quality in the PAD are the two key indicators selected to quantify and evaluate the cumulative effects of the Project in conjunction with other oil sands developments. For a detailed discussion of key issues and associated key indicators for groundwater included in the assessment, see Volume 5, Section 2.

Geologic and location contexts for the PAD in relation to the Project are provided in Figure 7-3.

7.3.2 Historic Data, Existing Conditions and Trends

7.3.2.1 Groundwater Levels

Geologic conditions associated with the PAD have been described by the Alberta Research Council as follows:

- geology – Bayrock and Root (1972a)
- surficial geology – Bayrock (1972b and 1972c)
- Precambrian Shield geology – Wilson (1986)

The PAD is underlain by granites and gneisses of the Precambrian Shield, Athabasca Sandstone and Devonian strata largely represented by limestone and gypsum. Athabasca sandstone does not outcrop in the PAD. The elevation of the bedrock surface underlying the PAD varies with the type of formation present. The bedrock surface of areas underlain by Precambrian Shield is knobbly with local relief of 60 m, whereas with other formations, the bedrock surface is nearly flat (Bayrock and Root 1972a). Large preglacial valleys have dissected the bedrock and these valleys were subsequently deepened by glacial action. Toward the end of the recession of the continental icesheet, large proglacial lakes covered the PAD region and thick deposit glaciolacustrine sediments were laid down (see Figure 7-4). The PAD began to form with the drainage of proglacial lakes, and now forms a composite, bird’s-foot type inland delta, with deltaic deposits overlaying glaciolacustrine sediments.

There are 32 drilling records on file with Alberta Environment. For a list of well records by identification number, see Table 7-6.

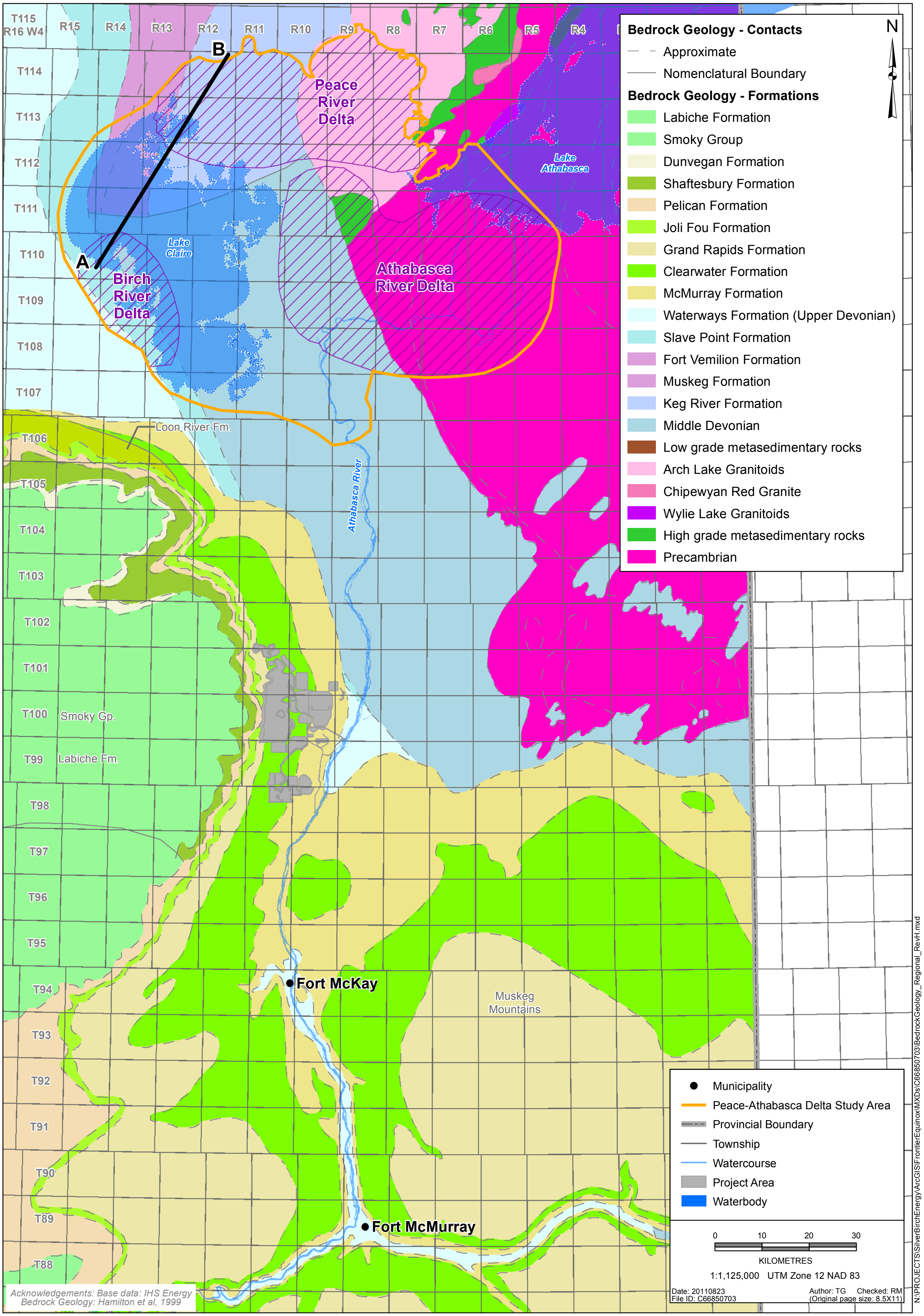

Figure 7-3: Regional Bedrock Geology

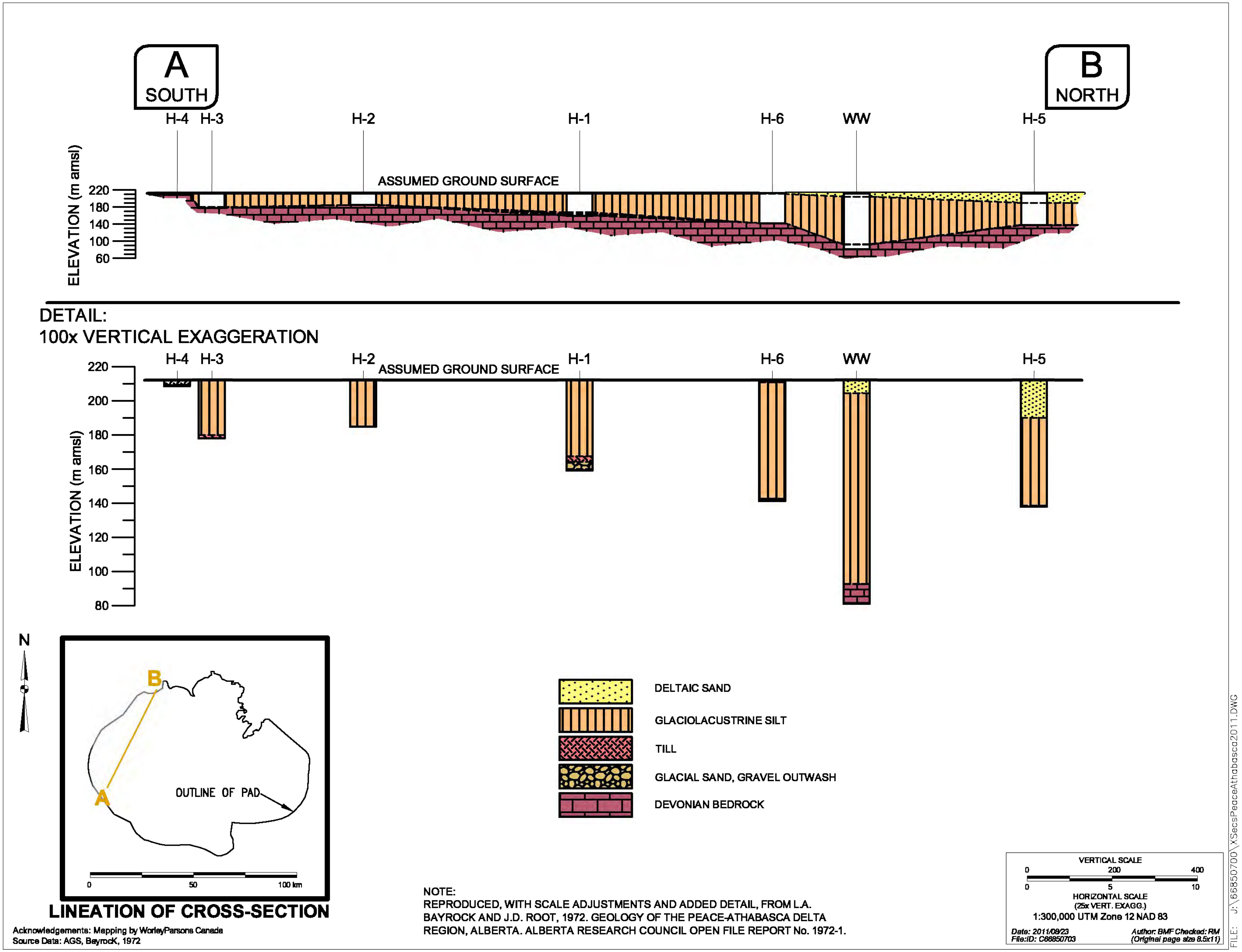

Figure 7-4: Cross-Section A-B'

Table 7-6 Drilling Records in the PAD

Alberta Environment Well Record Identification Number			
231926	231955	232317	232317
231929	231958	232599	232599
231937	231960	232601	232601
231941	231981	232602	232602
231945	232306	232603	232603
231948	232308	232604	232604
231950	232314	232605	232605
231953	232315	232606	232606

Water level readings included in Alberta Environment records are listed in Table 7-7. Datum points are not recorded; however, these were likely at or close to ground level. Where several readings were listed for a single well record, an average was taken. The distribution of groundwater levels is shown in Figure 7-5. The measurements were collected in October to November 1971 and postdate completion of the W.A.C. Bennett Dam. For a discussion of linkages between the PAD and the W.A.C. Bennett Dam, see Section 7.6.

The following can be reasonably inferred:

- the water table will typically be relatively close to ground level in such a deltaic setting, which is consistent with the readings in Table 7-7
- the groundwater is expected to be in direct communication with surface waterbodies within the PAD
- overall water table fluctuations can be expected to have synchronization with water level elevations in major waterbodies

Because of the inferences above and in absence of extensive data, it is expected that groundwater level trends will follow those documented in the hydrology section (see Appendix 7A).

Table 7-7 Groundwater Levels in the PAD

Alberta Environment Well Record Identification Number	Water Level (m)	Alberta Environment Well Record Identification Number	Water Level (m)	Alberta Environment Well Record Identification Number	Water Level (m)
0231929	0.39	0231958	1.82	0232606	1.40
0231937	1.72	0231960	0.81	0232607	1.30
0231941	1.92	0232315	2.15	0232608	1.26
0231950	1.31	0232602	0.95	0232609	1.70
0231953	0.75	0232603	1.60	0232610	1.69
0231955	2.08	0232605	1.17	–	–

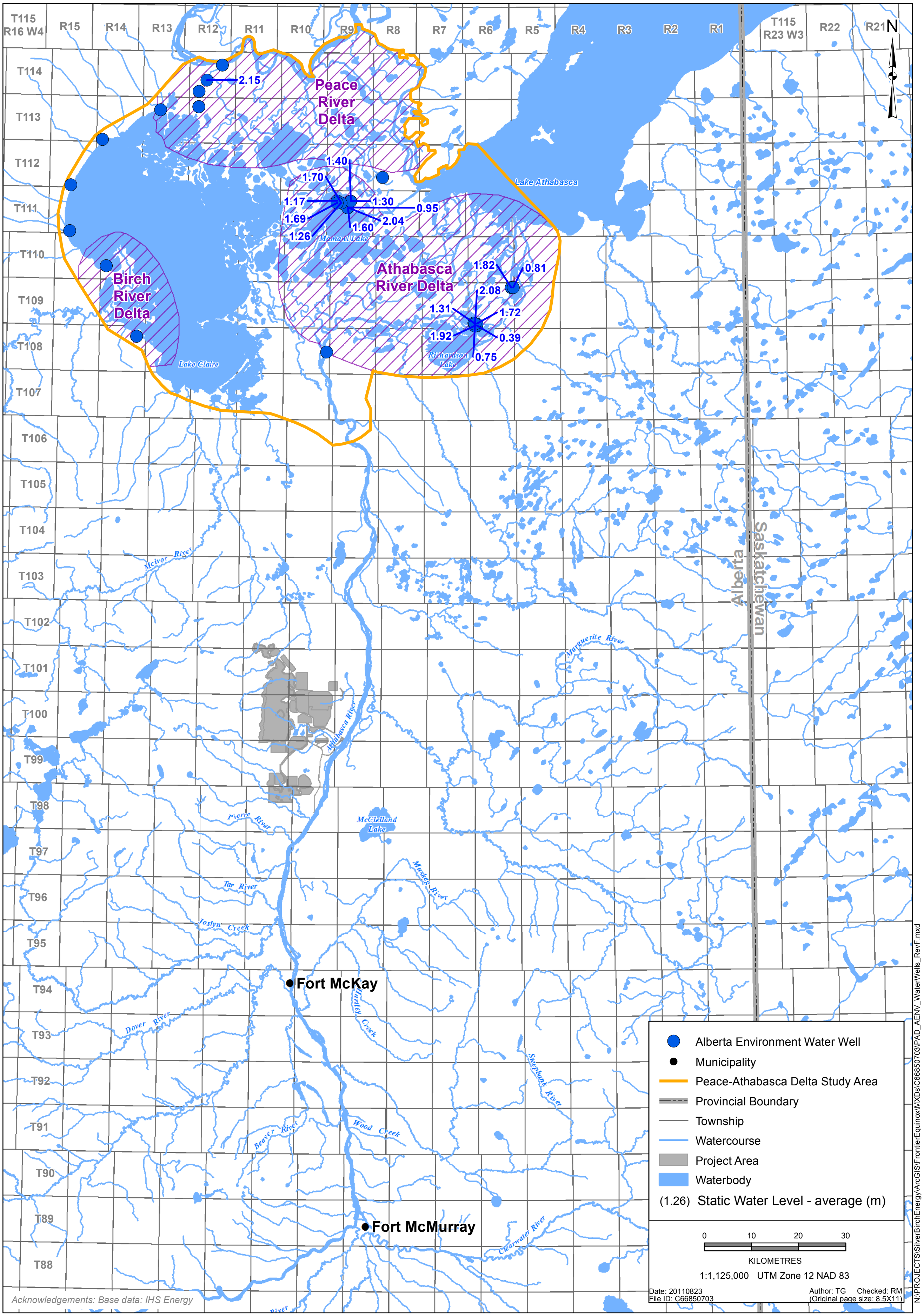

Figure 7-5: Water Well Records in the PAD Study Area

7.3.2.2 Groundwater Quality

In the absence of actual groundwater chemistry readings, definitive information about PAD groundwater quality cannot be provided. Professional judgement indicates that fresh water mineralization of good potable water quality can generally be expected. Localized exceptions might apply. Specifically, Bayrock (1972c) notes the presence of karst features and evaporite deposits in association with the Devonian sequence. Possible discharge of groundwater from Devonian strata into deltaic sediments could result in localized departures in natural groundwater quality. However, the presence of glaciolacustrine silt (see Figure 7-4) would tend to reduce possible influences from the Devonian strata.

7.3.3 Environmental Evaluation

7.3.3.1 Groundwater Levels

To enable safe mining, groundwater pressure and inflow potential must be controlled. Commonly, two water-bearing units must be addressed in the Athabasca Oil Sands Region including:

- Quaternary deposits, which must be dewatered to prevent uncontrolled inflow of shallow groundwater to pits
- basal water sands (BWS), which must be depressured to prevent pit floor instability

In both cases groundwater levels are drawn down and in the Planned Development Case (PDC), when various operations are simultaneously pumping, the potential exists for a cumulative drawdown to exist between operations. However, the Cretaceous strata do not extend north to the PAD (see Figure 7-3), and therefore there is no potential for cumulative BWS depressurization effects to influence the PAD.

7.3.3.2 Groundwater Quality

The quality of PAD groundwater is unlikely to be changed by Project activities because of the absence of a viable groundwater flow path. In addition, mitigation measures are planned for the Project to prevent seepage at a local level, and monitoring will be in place to verify the performance of groundwater seepage control measures.

7.3.4 Summary

Considering mitigation measures and the distance of the PAD from oil sands developments, effects from the Project in conjunction with operating, approved or planned developments in the Athabasca Oil Sands Region are not expected to adversely affect groundwater quantity or quality in the PAD.

7.3.5 References

7.3.5.1 Literature Cited

Bayrock, L.A. and J.D. Root, 1972a. *Geology of the Peace-Athabasca Delta Region*, Alberta. Alberta Research Council Open File Report No. 1972-1.

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Bayrock, L.A., 1972c, *Surficial Geology of the Lake Claire Area, Alberta, NTS 84I.* Scale 1:250,000.1972.

Hamilton, W.N., C.W. Langenberg, M.C. Price and D.K. Chao (compilers). 1999. *Geological Map of Alberta*. Alberta Geological Survey, Alberta Energy and Utilities Board. Map No. 236. Scale 1:1,000,000.

Wilson, J.A. 1986. *Geology of the Basement Beneath the Athabasca Basin in Alberta*. Alberta Geological Survey/Alberta Research Council, Bulletin 55.

7.4 Hydrology

7.4.1 Key Issues and Key Indicators

To provide focus for the PAD evaluation, key indicators for hydrology key issues were chosen. Flows and water levels in the PAD are the two key indicators selected to quantify and evaluate the cumulative effects of the Project in conjunction with other developments in the tributary watersheds. An evaluation of potential cumulative effects for PAD hydrology is discussed in terms of effects pathways including:

- flow regulation
- water withdrawals
- climate change

For a detailed discussion of key issues and associated key indicators for hydrology included in the assessment, see Volume 5, Sections 3.2 and 3.3.

7.4.2 Historic Data, Existing Conditions and Trends

The PAD is formed by the Peace, Athabasca and Birch rivers at the western end of Lake Athabasca (see Figure 7-6). The specific hydrologic variables that are discussed include flows and water levels in the PAD. Sources of hydrologic data include records of long-term monitoring stations operated by Environment Canada's Water Survey Division. Statistics of annual, seasonal, monthly and daily flows were derived from available data. For a summary of hydrologic statistics for the PAD, see Tables 7-8 and 7-9. For the location of long-term monitoring stations, see Figure 7-6. For details of climate and hydrology of the PAD including a discussion of historical trends, see Appendix 7A, including graphs of water levels and flows for key waterbodies (i.e., Lake Athabasca) and watercourses.

Table 7-8 Flow Statistics for Tributary Watersheds of the PAD

Parameter	Athabasca River Fort McMurray Station (07DA001)[1]	Athabasca River Embarras Airport Station (07DD001)[2]	Richardson River Near the Mouth (07DD002)	Birch River below Alice Creek (07KE001)	Peace River at Peace Point (07KC001)[3]	Slave River at Fitzgerald (07NB001)[3]
Drainage area (km²)	133,000	155,000	2,700	9,860	293,000	606,000
Mean annual discharge (m³/s)	620	668	16.6	37.6	2,084	3,414
Maximum daily discharge (m³/s)	4,700	4,190	41.6	394	12,600	11,200
Lowest daily discharge (m³/s)	75	123	8.8	0.142	272	530
100-year daily discharge (m³/s)	5,503	5,454	42.1	475	14,879	11,193
50-year daily discharge (m³/s)	4,951	4953	41.3	442	13,443	10,296
20-year daily discharge (m³/s)	4,238	4,295	39.8	393	11,527	9,152
10-year daily discharge (m³/s)	3,702	3,791	38.3	349	10,046	8,307
5-year daily discharge (m³/s)	3,153	3,268	36.1	297	8,502	7,461
2-year daily discharge (m³/s)	2,347	2,478	31.6	207	6,170	6,247

NOTES:
[1] Based on recorded flows for the period 1957 to 2009
[2] Based on recorded and derived flow series for the period 1957 to 2009
[3] Includes regulated flows from W.A.C. Bennett Dam

Table 7-9 Water Levels Recorded in the PAD

Station Name	Station Name	Mean Water Level	Daily Mean Variation	Maximum Water Level	Minimum Water Level	Maximum Fluctuation
		(m amsl)	(m)	(m amsl)	(m amsl)	(m)
Lake Claire near outlet to Prairie River	07KF002	209.27	0.56	210.77	208.04	2.73
Mamawi Lake Channel at Old Dog Camp	07KF003	208.81	1.38	211.37	206.46	4.91
Lake Athabasca at Fort Chipewyan	07MD001	208.85	1.30	211.33	205.63	5.70
Lake Athabasca near Crackingstone Point	07MC003	208.79	0.88	210.64	207.31	3.33
Rivière Des Rochers above Slave River	07NA001	207.42	1.52	210.96	204.69	6.28
Rivière Des Rochers east of Little Rapids	07NA007	208.51	1.12	210.34	206.16	4.18
Rivière Des Rochers west of Little Rapids	07NA008	207.40	1.84	210.30	204.76	5.54

Figure 7-6: Long-term Hydrology Monitoring Stations in the PAD

7.4.2.1 Flows and Ice Jams

Flow in the PAD complex is typically northward but can reverse when water levels on the Peace River are higher than those of the more southerly lake and river systems. The hydrology of the delta is heavily influenced by inflows from the Athabasca River and the complex river ice regime. The biological productivity and diversity of this extensive riparian landscape depends on periodic flooding and drying cycles. Deltaic landscapes, such as the PAD, are intimately affected by temporal and spatial variability in river discharge and flooding. The Peace River ice jams are considered a critical component sustaining the ecology of the PAD by raising the water levels enough to create flow reversals in some of the delta channels and refreshing many of the lakes and wetlands.

During the past three decades, perceived effects of flow regulation of the Peace River on the PAD following the construction in 1968 of the W.A.C. Bennett Dam for hydroelectric power production led to a number of environmental studies to assess the hydrological and ecological consequences. Several studies conducted for the PAD concluded that ice-jamming is the most effective mechanism for producing extremely high backwaters capable of recharging perched watersheds, in particular, the elevated region of the Peace River Delta where productive wetlands are situated. By contrast, the historic high, open-water flow events generated by the Peace River basin were insufficient to cause greater than bankfull flow conditions within the Peace River Delta. Even without the influence of flow regulation on the Peace River, overflow of the lower Peace River would have been a rare occurrence during ice-free conditions. However, the unregulated Athabasca River occasionally produces localized overland flow in the Athabasca River Delta under both open-water and ice jam conditions.

7.4.2.2 Drainage

The fluvial hydrology of the PAD is highly variable because of its extremely low topography and temporally variable water levels and discharges of the Peace and Athabasca rivers and Lake Athabasca. Both rivers orginate in the Rocky Mountains and exhibit nival flow regimes driven by seasonal snowmelt (Wolfe et al. 2006).

Besides comprising the three deltas (i.e., the Athabasca River, the Peace River and the Birch River deltas), the PAD also encompasses Lake Claire (about 1,200 km^2) and Mamawi Lake (about 170 km^2). These lakes are linked to Lake Athabasca (7,800 km^2) by the Prairie River and Chenal des Quatre Fourches and drain into the Peace and Slave rivers by the Rivière des Rochers, Revillion Coupé and Chenal des Quatre Fourches (Peters et. al. 2006).

Drainage of the system is normally northward to the Slave River. However, when the Peace River stage is higher than the level of the central lakes, typically during spring ice breakup and summer high discharge events, flow in the connecting channels reverses into the delta lakes as shown in Figure 7-6 (PAD-PG 1973).

Construction of the W.A.C. Bennett Dam on the Peace River and the filling of Williston Lake behind the dam led to low flows in the Peace River from 1968 to 1971. These low flows prevented flooding in the delta, raising concerns about the ecological integrity of the delta in the absence of the annual flood (MRBB 2004, Internet site; Prepas and

Mitchell 1990). Permanent weirs were constructed in 1975 and 1976 on the Rivière des Rochers and Revillion Coupé, a distributary of the Rivière des Rochers. According to studies conducted during the 1980s by the Peace-Athabasca Delta Implementation Committee, these weirs nearly restored peak summer water levels in the lakes and delta, and counteracted many of the effects that regulation of the Peace River had on the delta (MRBB 2004; Prepas and Mitchell 1990). The weirs do not affect water levels in the Peace River, however, and perched basins in the Peace River Delta that were dependent on regular flooding have been lost (Prepas and Mitchell 1990).

The Athabasca sector of the delta consists of the Athabasca River and its four major distributary channels that bring water into Lake Athabasca and several other surrounding lakes and channels. The distributary channels are (from west to east) the Embarras River, the Fletcher Channel, the Goose Island Channel and the Big Point Channel. A breakthrough channel formed in 1982 (PADTS 1996) that now connects the Embarras River to Mamawi Lake. Past studies (PADTS 1996) estimate that the Embarras River captures on average about 10% of the Athabasca River flow entering the delta, with the breakthrough channel taking about 58% of the Embarras River's flow during normal conditions.

Sources of water flowing into Lake Athabasca include the Athabasca, Fond du Lac, Birch rivers in addition to smaller tributaries and seasonal flows from the Peace River. The Athabasca River and its tributaries contribute the largest proportion of the annual inflow to Lake Athabasca (53%). The Fond du Lac River, arising in Wollaston Lake, Saskatchewan, flows through several lakes before discharging into the eastern end of Lake Athabasca. The Fond du Lac River contributes about 21% of the total inflow to the lake and the delta. Inflow to the south side of the lake and delta, such as Richardson, Old Fort, William and McFarlane rivers, provide less than 6% of the total inflow. Another river, the Birch River, flowing through Lake Claire and Mamawi Lake into the western side of Lake Athabasca, provides less than 3%. Part of the time, flow from the Birch River System bypasses Lake Athabasca, as water levels in the PAD change. Miscellaneous inflows and direct runoff from the catchment area account for the final 18% of the total inflow. The Peace River flows from Williston Lake (the reservoir created by the W.A.C. Bennett Dam in British Columbia in 1968) to its delta located northwest of Fort Chipewyan. Water flow from the Peace River to Lake Athabasca is seasonal.

Lake Athabasca is drained by the Rivière des Rochers, which carries the bulk of the outflow and the Chenal des Quatre Fourches. The volume of outflow leaving Lake Athabasca via these two channels is largely dependent on water levels in Peace River. During the flood season, high flows in the Peace River have historically provided a natural barrier to the outflow of water from Lake Athabasca, thus allowing the PAD to be flooded. The water level in Lake Athabasca would rise an average of about 1.7 m during spring and summer and then recede during fall and winter (Muzik 1991).

The Peace sector of the PAD is incised by two major channels, the Rivière des Rochers on the east and the central Chenal des Quatre Fourches, plus the Revillon Coupe, a smaller subsidiary channel of the Rivière des Rochers. These channels usually flow north, but they also undergo transient flow reversals at times of high relative water level in the

Peace River as shown in Figure 7-6. This tends to occur when water levels in the Peace River exceed those in Lake Athabasca, which normally occurs because of ice jams during the spring breakup period and during periods of sustained high flows produced by runoff from the Peace River headwaters (Leconte et al. 2001). Spring flooding of the PAD is governed by ice jams in the Peace River that restrict and reverse outflow from Lake Athabasca, resulting in a backup of water in the lake, which, in turn, floods the delta.

7.4.3 Environmental Evaluation

7.4.3.1 Effects of Flow Regulation

An analysis of available hydrometric data in the PAD show that regulation has increased flows during the fall and winter seasons and reduced the spring/summer peak flows at Peace Point and associated water levels within the PAD (see Appendix 7A for details). For example, results of preliminary analyses show that the average June flow has been reduced by about 50% from 7,500 to 3,400 m^3/s following regulation, while average winter (March) flows have increased by about 200% from 500 to 1,500 m^3/s. The changes from the regulation effects of the W.A.C. Bennett Dam are listed in Table 7-10. Historically, monthly mean flows reached their maximum and minimum values in June and December, respectively. Analysis of the data before and after the dam suggests there has been a change in flow regimes during these two periods. There has been a reduction in mean flows for June and an increase in mean flows for December.

Table 7-10 Difference in Flow Statistics on the Peace River

Parameters	Pre-Bennett Dam[1]	Post-Bennett Dam[1]	Percent Change[1]
Mean Annual (m^3/s)	2,300	2,150	-7%
2-year (m^3/s)	10,000	5,400	-46%
5-year (m^3/s)	11,000	7,400	-32%
10-year (m^3/s)	11,500	8,800	-23%
Mean Summer (m^3/s)	3,200	2,300	- 28%
Mean Winter (m^3/s)	400	1,500	+ 200%

NOTE:
[1] As measured at Peace Point (07KC001)

Prowse et al. (2002) and Prowse and Conly (2002) provide a succinct review of the results of the multi-component research program initiated by the Northern River Basins Study (NRBS) to assess how flow regulation in the Peace River could affect the PAD's aquatic ecosystem. At about the same time as the NRBS studies were underway, another major research program, the Peace-Athabasca Delta Technical Studies (PADTS 1996), was initiated by a multi-agency group presenting governments and Aboriginal communities living in the PAD and dependent on its resources for traditional lifestyles (Prowse and Conly 2002). Results of the NRBS studies indicate that the regulation of the Peace River has shifted the pattern of seasonal flows and dampened flow extremes creating a less variable annual flow regime. Increased winter releases from the reservoir created by the dam have delayed ice cover formation downstream of the dam. Higher ice levels that accompany increased winter flows are thought to reduce the frequency and magnitude of ecologically important ice-induced floods that occur during the spring. In general, the higher the freeze-up cover, the greater the flows the river can pass without breaking.

Prowse and Conly (1998) noted that the frequency of ice-induced backwater flooding of perched basins has declined since the 1970s. They state that flow regulation seems to have produced only minor changes in factors such as ice thickness and strength, and not to have reduced the flow at the time of breakup. Prowse and Lalonde (1996) suggest that an important source of spring flow affecting breakup at Peace River originates from tributaries downstream of the regulated headwaters. Prowse and Conly (1998) suggest that, since the mid-1970s, spring runoff has declined in the downstream portions of the Peace River watershed that is unaffected by regulation. This has been linked to a decrease in the magnitude of the winter snowpack. Elevated ice levels and winter flows resulting from regulation have further reduced the potential for tributary runoff to produce severe breakup floods. Thus, the absence of a high order event between 1974 and 1992 seems to be related to the combined effect of flow regulation and the reduced snowpacks in the unregulated portions of the Peace River watershed. Since the construction of the dam in 1968, about 24% of the drainage area is captured by Williston Reservoir at the dam (Leconte et al. 2001).

With large-scale drying of the PAD beginning in the 1970's, engineering structures (weirs) were built to restore water levels within the PAD. The focus was on open-water conditions. Referencing the Peace-Athabasca Delta Technical Studies (PADTS 1996), Leconte et al. (2001) states that two weirs were installed in 1975 and 1976 to restrict the northward outflow of water and mitigate the effects of the Peace River flow regulation on the PAD complex. The fixed crest weirs were constructed on the Rivière des Rochers and Revillon Coupe (Prowse and Lalonde 1996). Although these measures have been largely successful in restoring the natural summer peak water levels within the PAD, average summer and minimum water levels have also been raised (Aitken and Sapach 1994). The Peace-Athabasca Delta Technical Studies (PADTS 1996) state that open-water floods from the Peace River were unlikely to flood the ecologically sensitive perched basins within the PAD (Prowse and Conly 2002). It was concluded that the weirs, designed for control of open-water flood conditions, do not influence the recharge of perched basins flooded from the Peace River (PADTS 1996).

Peters et al. (2006) conducted a systematic examination of the effect of flow regulation using one-dimensional hydraulic modelling, analysis of satellite images and DEM-derived flood maps of historically notable events (both ice jam and open-water flood events). Hydraulic modelling was used to remove the effect of regulation and produce a naturalized (no dam and no weirs) water-level. Comparison of the regulated and naturalized (1976 to 1996) data at Peace River below Chenal des Quatre Fourches near Rocky Point showed that the winter water levels were on average more than 1 m higher after flow regulation and the summer peak level was on average similarly lower. The estimated difference between the regulated and naturalized channel levels was relatively minor (winter about 0.3 m and summer about 0.1; within model error) at the Athabasca River near Jackfish Creek. The results indicate that the influence of flow regulation varies seasonally and decreased with distance from the Peace River.

7.4.3.2 Effects of Water Withdrawals

Peace-Athabasca Delta

Recent expansions in oil sands development along the lower Athabasca River have generated interest in determining the effects of water withdrawals on the hydrology and ecology of the southern part of the PAD (i.e., the Athabasca Delta). The Athabasca sector of the delta is fed by the Athabasca River, which divides into a number of distributaries that flow northeast into Lake Athabasca. Water withdrawals in the Athabasca River could affect the extent and depth of flooding in the PAD, and thus affect the ecology of the perched basins.

A summary of current water licence allocations and projected annual allocations of all operating and planned oil sands developments for surface water withdrawals from the Athabasca River and its tributary streams and the return flows is provided in Volume 5, Section 3.5.3.1. Considering the variability in the cumulative annual water requirement from the Athabasca River prior to closure of all mines, the predicted maximum cumulative annual average water requirement is about 25.4 m^3/s, including 6.0 m^3/s for the non-oil sands users and 2.27 m^3/s for the Frontier Project. The predicted maximum cumulative instantaneous peak withdrawal depends on the total existing and planned pump intake capacities and is estimated to be about 34.6 m^3/s of which 4.2 m^3/s is for the Frontier Project.

Distributary Channels

Andrishak and Hicks (2010) developed a one-dimensional hydrodynamic network model of the Athabasca Delta and assessed the anthropogenic water withdrawal schemes on the flow distributions among the major Athabasca Delta distributary channels. Analyses completed using HEC-RAS model show that flows of about 2,500 to 3,000 m^3/s on the Athabasca River entering the PAD are expected to result in bank-full stage. The lower bound of this range is about the one- in two-year flood and close to the median summer peak flow over the period of record.

Andrishak and Hicks (2010) used a withdrawal rate of 20 m^3/s in their analyses to assess the effect of such withdrawals on the frequency of flow cut-off to the distributary channels. The 20 m^3/s value is arbitrary and represents about a 20% reduction of the average minimum winter flow on the Athabasca River. This withdrawal rate results in a reduction of about 2 cm in the average mean daily simulated Lake Athabasca water level, with a corresponding reduction in simulated lake outflow of about 19 m^3/s. The model also indicated that the most sensitive area to flow reductions is the Fletcher Channel, for which complete flow cut-off frequency has increased from 31% to 48% within the 48 years considered as the historic period.

The analysis completed by Andrishak and Hicks (2010) assumed that a withdrawal rate of 20 m^3/s will occur during the winter period as well as during the open-water flow period. However, during the winter periods (weeks 1 to 14 and weeks 49 to 52) the maximum allowable withdrawal rate is 10 m^3/s and is governed by the *Phase 1 Water Management Framework* developed by Alberta Environment and Fisheries and Oceans Canada (DFO) (2007). Hence, the effect of water withdrawal on Lake Athabasca and distributary channels will be considerably less than the estimates provided by Andrishak and Hicks (2010) during the winter low flow period.

Using the flow distribution profiles developed by Andrishak and Hicks (2010) for distributary channels and maximum allowable withdrawal rates provided by the *Phase I Water Management Framework* (AENV and DFO 2007) as an upper bound, the effects of water withdrawals on distributary channels were re-evaluated and the results are shown in Figures 7-7a, 7-7b and 7-7c. Using the plots for winter flows in the three figures as an example, the solid light green lines in each figure show the split in winter flows as percentages between the Athabasca and Embarras rivers under no water withdrawal conditions and the red dash lines represent the percentage of winter flows including water withdrawals. The spacing between these two lines on two of the figures indicates that the percentage of flow directed to the Embarras River (see Figure 7-7a) decreases by less than 1% and percentage of flow directed to Fletcher Channel (see Figure 7-7b) decreases by less than 1.3%. The percentage reductions during open-water periods, which are the differences between percentage of open-water flows without water withdrawals represented by solid blue lines and the percentage of open-water flows including water withdrawals represented by the green dotted lines, are less than those during the winter periods. The effects of winter water withdrawals on Goose Island distributary channel (reductions vary from 1.6% to 4.1%) and Big Point distributary channel (reductions vary from 1.9% to 11%) are higher than the effects on Embarras River and Fletcher Channel.

Perched Basins

During open-water periods, the perched basins in the Athabasca Delta are affected by flood flows that spill over the banks of the distributary channels (i.e., flows more than about 2,500 m^3/s). This is about the one- in two-year flood in the Athabasca River based on recorded data (see Figure 7-8 for plots of flows in the Athabasca River).

Applying the allowable maximum water withdrawal rate from the Athabasca River prescribed by the *Phase I Water Management Framework* (AENV and DFO 2007) does not change the frequency of flooding as shown in Figure 7-9 and will result in negligible decrease in the depth of flooding.

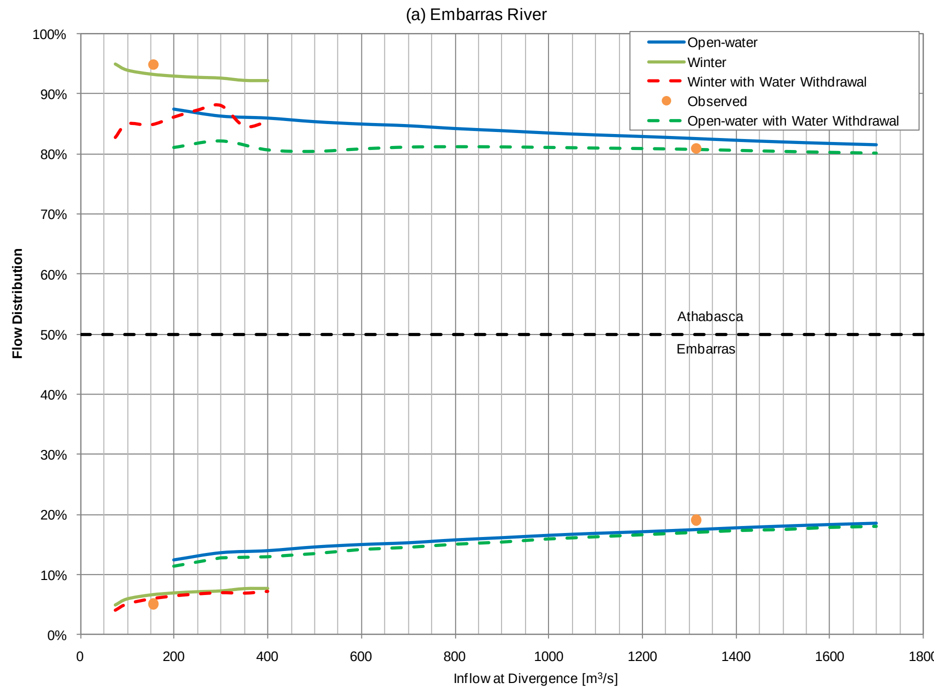

Figure 7-7a Effects of Water Withdrawals on Distributary Channels

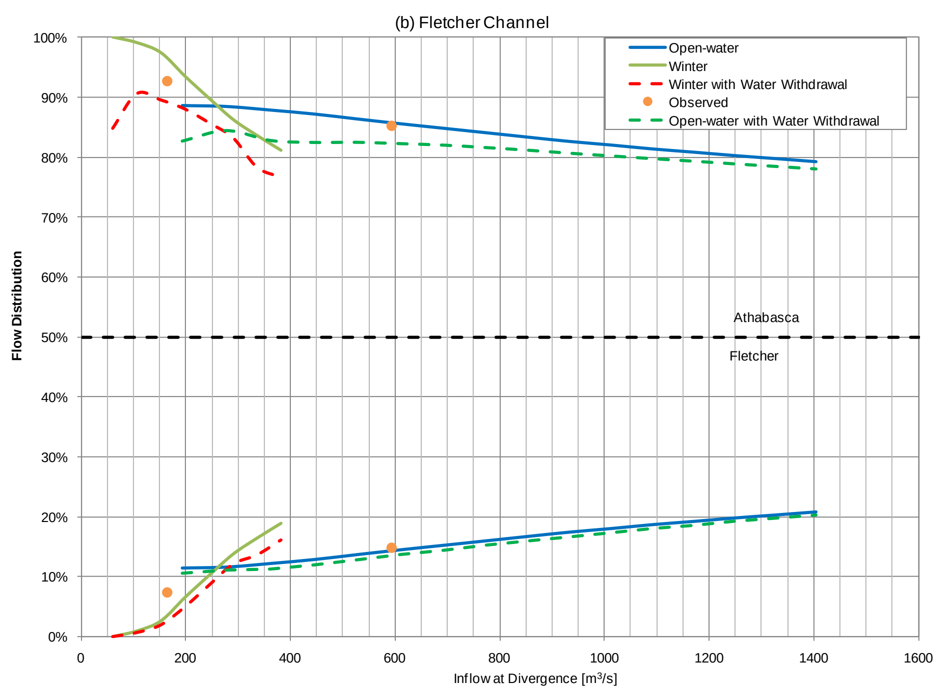

Figure 7-7b Effects of Water Withdrawals on Distributary Channels

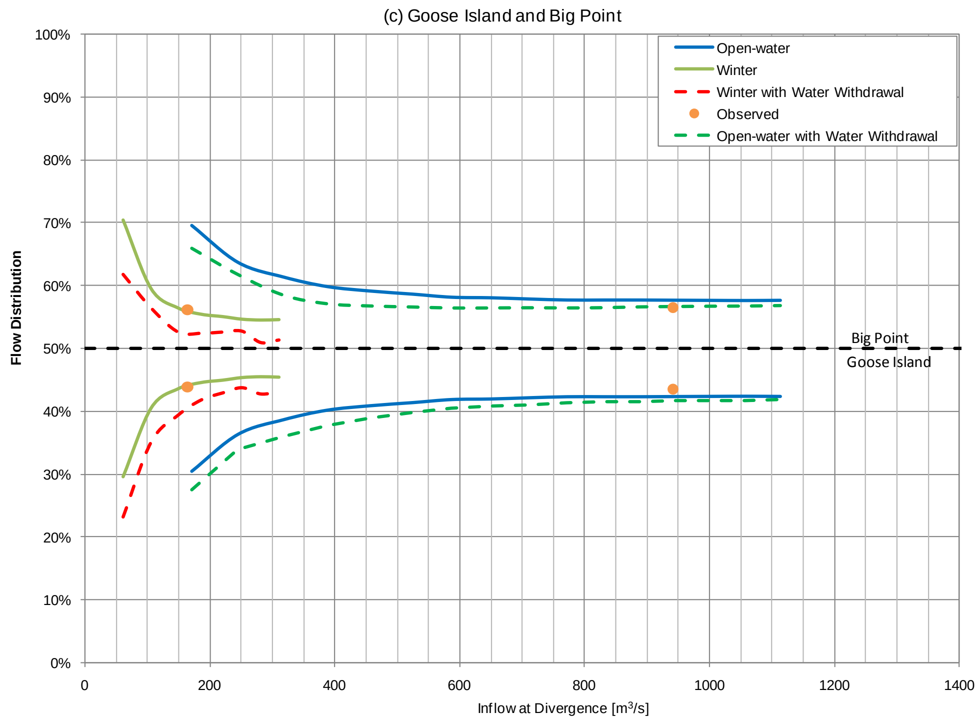

Figure 7-7c Effects of Water Withdrawals on Distributary Channels

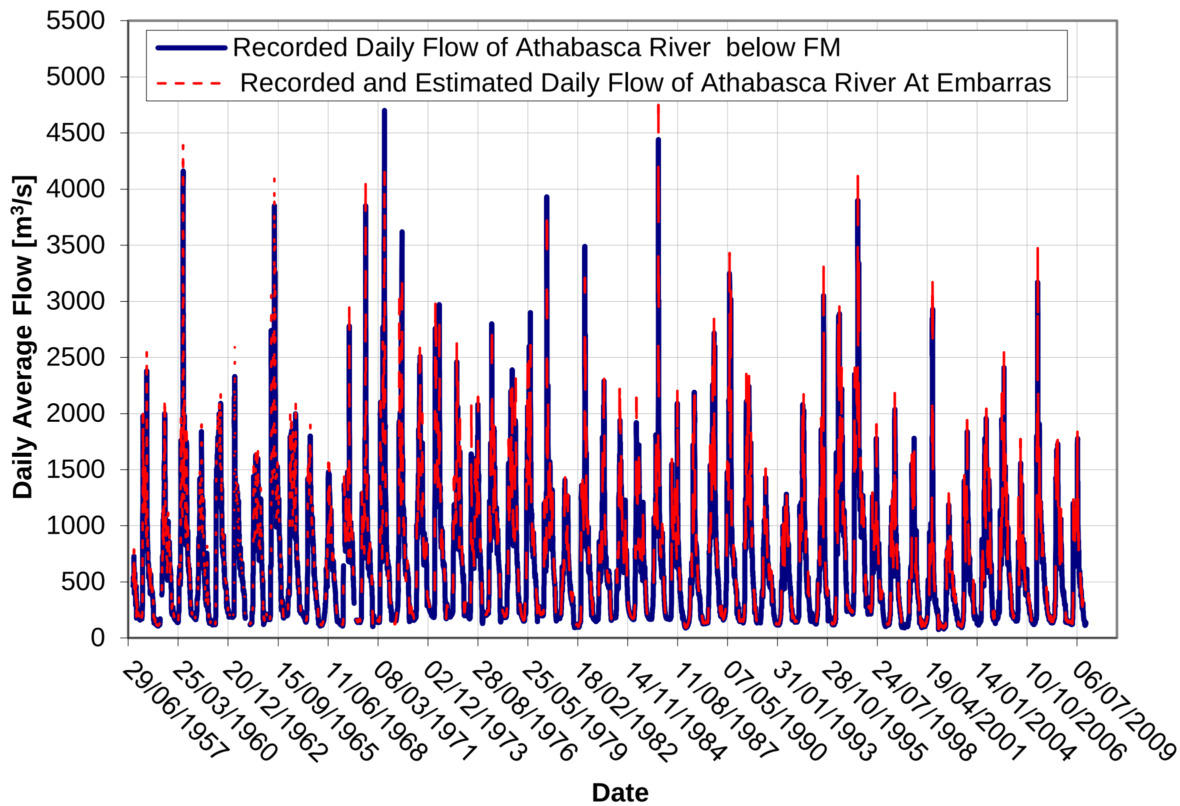

Figure 7-8 Recorded Athabasca River Flows

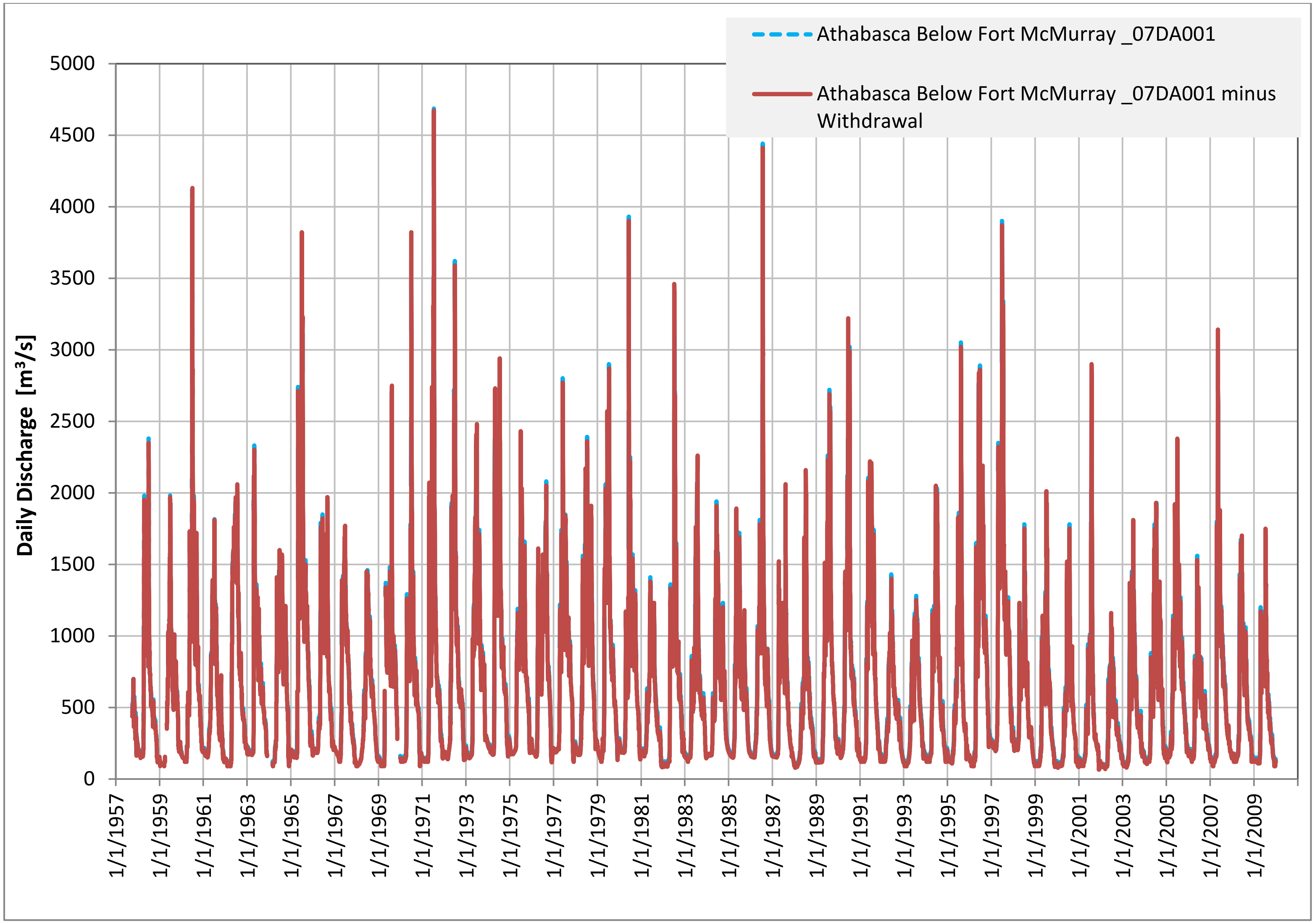

Figure 7-9 Athabasca River Flow – Considering Water Withdrawals

Athabasca River

The possible changes in water levels in the Athabasca Delta including Lake Athabasca were evaluated using the open-water flood level of July 1971 measured on Lake Athabasca River at Fort Chipewyan as an indicator. Based on recorded water levels at Old Fort and near Crackingstone Point during this event, the Lake Athabasca water level change from June 29, 1971 to end of July 1971 is about 0.61 m. The volume of water that flowed to Athabasca Delta over this period is about 6.85 billion m^3. Assuming an area of about 9,760 km^2 for the Athabasca Delta including Lake Athabasca (i.e., 7,800 km^2 for Lake Athabasca and 1,960 km^2 for the Athabasca River Delta), this volume translates to a depth of about 0.7 m. This is comparable to the average change in Lake Athabasca water level during the June to July period (i.e., 0.61 m) assuming the balance of inflow from other tributary watersheds is equivalent to the outflow that occurred from the lake during that period. The maximum allowable withdrawal of 30 m^3/s from the Athabasca River as stipulated in the *Phase I Water Management Framework* will reduce the volume of water that will flow to Athabasca River Delta to 6.78 billion m^3, which in turn means a reduction of less than 1 cm in water level in the Athabasca River Delta, as shown in Table 7-11. Considering only the maximum withdrawal rate of 4.2 m^3/s for the Frontier Project, the reduction of water level in the Athabasca River Delta will be less than 0.1 cm.

7.4.3.3 Effects of Climate Change

A combination of hydro-climatic changes and flow regulation has influenced the formation of ice jams and might have resulted in an overall drying trend in the delta (Prowse et al. 1996). With the expected occurrence of a change in climate over the next 50 years, the effects of the change on the hydrodynamics of the delta might very well be significant, and quantitative estimates of such effects should be made. In the conclusions of the Northern River Basins Study (NRBS 1996) recommendations were made that it is important to understand the climate-hydrology interactions within this region. Pietroniro et al. (2006) have investigated the potential effects of climate change on the flows and water levels. This was done using WATFLOOD, a conceptual distributed hydrological model capable of simulating river flows over a long period of time. To look at climate change in the PAD, Pietroniro et al. (2006) used downscaled climate change scenarios as inputs into the WATFLOOD modelling system.

Table 7-11 Changes from Water Withdrawals on Water Level in the Athabasca River Delta

Date	Athabasca River at Embarras Airport Station (07DD001) (m^3/s)	Volume (Mm^3)	Volume after Maximum Allowable Withdrawal Rate (Mm^3)	Recorded Lake Athabasca Water Level (m amsl)	
				Old Fort Station (07DD011)	Crackingstone Point Station (07MC003)
29-Jun-71	2,020			208.794	208.736
30-Jun-71	2,340	188	186	208.785	208.742
01-Jul-71	2,490	209	206	208.788	208.758
02-Jul-71	2,490	215	213	208.837	208.770
03-Jul-71	2,340	209	206	208.904	208.782
04-Jul-71	2,150	194	191	208.858	208.809
05-Jul-71	2,060	182	179	208.934	208.828
06-Jul-71	2,120	181	178	208.959	208.843
07-Jul-71	2,370	194	191	208.965	208.837
08-Jul-71	2,920	229	226	208.907	208.867
09-Jul-71	3,230	266	263	208.934	208.882
10-Jul-71	3,230	279	276	208.995	208.889
11-Jul-71	3,230	279	276	208.956	208.904
12-Jul-71	3,370	285	283	208.895	208.931
13-Jul-71	3,430	294	291	208.910	208.931
14-Jul-71	3,400	295	292	208.965	208.943
15-Jul-71	3,540	300	297	209.163	208.940
16-Jul-71	3,910	322	319	209.123	208.965
17-Jul-71	4,190	350	347	209.099	209.020
18-Jul-71	4,130	359	357	209.154	209.068
19-Jul-71	3,820	343	341	209.169	209.123
20-Jul-71	3,430	313	311	209.239	209.160
21-Jul-71	3,090	282	279	209.297	209.184
22-Jul-71	2,830	256	253	209.355	209.199
23-Jul-71	2,580	234	231	209.468	209.212
24-Jul-71	2,340	213	210	209.306	209.251
25-Jul-71	2,170	195	192	209.288	209.276
26-Jul-71	2,060	183	180	209.373	209.273
Total Volume (billion m^3)		6.85	6.78		
Equivalent Depth in Athabasca R. Delta (m)		0.70	0.69		
Maximum Change in Lake Water Level (m)				0.683	0.540
Average Change in Lake Water Level (m)				0.612	

Pietroniro et al (2006) found that under the selected climate change scenarios, water levels in Lakes Athabasca, Claire and Mamawi peaked on average, 40 to 50 days earlier than at present. The lake response signal to expected climate change is not as clear. The Commonwealth Scientific and Industrial Research Organization Model (CSI) and Hadley Centre Climate Prediction and Research Model (HAD) predict an increase (0.25 m and 0.1 m) in spring levels for Lake Athabasca while the General Circulation Model based on European Centre for Medium Range Weather Forecasts (ECH), Geophysical Fluid Dynamic Laboratory Model (GFD) and Canadian Circulation Model (CGC) predict a spring level decrease (-0.4 m. -0.25 m, and -0.15 m). However, all global climate model (GCM) scenarios predicted higher winter levels in the PAD system, which would result in elevated pre-melt spring levels in the PAD. In regards to increased precipitation and temperatures in winter, thaw events would increase and result in a higher variability in water levels.

In the rivers within the PAD, it was found that spring peak water levels in the rivers in the future will be lower by up to 1.0 m and occur 20 to 30 days earlier. Average annual peak elevations will vary from +0.1 to 0.6 m, depending on the GCM scenarios. Of particular concern is the occurrence of lower levels in the Peace and Athabasca rivers with decreases averaging 0.5 m and 0.2 m, respectively. This is important as the rivers are often used for navigation and others purposes. These activities can be jeopardized if river levels get too low.

As climate change will be affecting the winter hydrology in regards to lake and river water levels, it is important to assess the potential effect on flooding in the PAD. Prowse et al (2006) looked at the effects of climate change on the potential for ice jam-related floods in the PAD. It was found that major floods required a total winter snowpack of at least 150 mm at Grande Prairie and intense spring heating to generate a large ice jam flood. Using these benchmarks it was determined that the frequency of ice jams would be further reduced in the future, mainly because of the reduced snowpack. The latter effect results from the advent of mid-winter thaws, which have been reported to becoming more frequent even under current climate conditions (Romolo et al. 2006). In fact, Wolfe et al. (2006) found that flooding frequency in the PAD has been highly variable in the past 300 years but in decline for many decades beginning as early as the late nineteenth century, well before the Peace River regulation. Therefore, there is some evidence to show that the ice jam-related flooding frequency will potentially decrease in the future because of climate change.

7.4.4 Summary

There are negligible effects between changes in water levels and flooding in the PAD and the Project in conjunction with operating, approved and planned developments in the Athabasca Oil Sands Region. As negligible surface water quantity effects are predicted in Ronald Lake and the Athabasca River, including its divergence with the Embarras River, the aquatics RSA was not extended farther into the PAD.

7.4.5 References

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7.5 Surface Water Quality

7.5.1 Key Issues and Key Indicators

Key issues for the surface water quality evaluation of potential relevance to the PAD included potential for changes in water quality, thermal regime, dissolved oxygen and sediment quality. Potential acid input (PAI) and its contribution to potential acidification of waterbodies and watercourses was shown to not be a concern and is not discussed further (see Volume 5, Section 4.9). For a detailed discussion of key issues and associated key indicators for surface water quality, see Volume 5, Sections 4.2 and 4.3.

To provide focus for the PAD evaluation, key indicators for surface water quality key issues were chosen to quantify and evaluate the cumulative effects of the Project in conjunction with other oil sands developments in the PAD. Key indicators included:

- water quality substances including conventional, major ions, nutrients, metals and polycyclic aromatic hydrocarbons (PAHs)
- water temperature
- dissolved oxygen and biochemical oxygen demand
- sediment quality constituents including metals and PAHs

7.5.2 Historic Data, Existing Conditions and Trends

Historical water and sediment quality data in the PAD were obtained from the following sources:

- Environment Canada
- Alberta Environment's Water Data System
- Regional Aquatic Monitoring Program (RAMP)
- Northern River Basin Study (NRBS)

Historical water quality data in the PAD were collected between 1967 and 2010. Water quality data collected in the Peace River at Peace Point, about 25 km north of the PAD, were included in this evaluation because data were not available in the Peace River within the PAD. Samples collected at this location represent water quality in the Peace River upstream from the mouth. Limited water quality data were found in Lake Athabasca, the Peace River Delta, Lake Claire and Birch River Delta. The available information provided a general overview of water quality in surface waters within the PAD. Water quality data for these waters were sorted by geographic location and compared to aquatic guidelines.

Temporal trends upstream of the PAD were presented in previous monitoring reports for the Athabasca River at Old Fort (Hebben 2009) and at the Baseline 27 station, and in Peace River at Peace Point (Glozier et al. 2009). The studies were completed at locations relatively close to the PAD and were considered representative of temporal trends in the PAD. A general overview of the temporal trends is summarized herein.

Few literature sources relating to sediment quality in the PAD were available. Data were limited to sediment quality in the Athabasca River at the mouth, Athabasca River Delta, and Lake Athabasca. Sediment quality data were also sorted by geographic location and compared to sediment quality guidelines.

Temporal trends analyses were completed on sediment quality constituents using the same RAMP sediment dataset used by Timoney and Lee (2011). This analysis is discussed in more detail in Section 7.5.2.6.

7.5.2.1 Conventional Parameters

Water in the PAD was generally alkaline and well oxygenated based on the median values of field measurements (see Appendix 7B, Tables 7B-1 to 7B-3). The minimum and maximum levels of pH in the Athabasca River Delta were below and above the guideline pH ranges for the protection of aquatic life (pH range of 6.5 and 8.5; AENV 1999). The minimum pH level (pH of 5.4) in the delta was measured at one of the Alberta Environment's monitoring stations in March 1988. The pH level could be an immediate occurrence at the sampling time or a possible outlier; total alkalinity in the sample was high (142 mg/L). The second lowest pH (pH of 6) was also lower than the acute and chronic ranges of the guidelines.

Minimum concentrations of dissolved oxygen (DO) observed in the Athabasca River Delta, Rivière Des Rochers and Birch Lake were below the acute and chronic guidelines for the protection of aquatic life (5 mg/L and 6.5 mg/L; AENV 1999). Total suspended solids (TSS) concentrations were elevated in these waters compared to concentrations considered harmful to aquatic life (TSS concentration greater than 25 mg/L, from Newcombe and MacDonald 1991).

Major ions concentrations ranged from moderately low to high as indicated by conductivity levels and total dissolved solids (TDS) concentrations (see Appendix 7B, Tables 7B-1 to 7B-3). Concentrations of major ions and TDS are known to increase along the lower reach of the Athabasca River because of inputs from geological weathering and saline groundwater (Glozier et al. 2009). Waters in the PAD were moderately soft and likely not sensitive to acid deposition, with the exception of the western portion of Lake Athabasca. Major ion concentrations were lower in the western portion of Lake Athabasca compared with other waters in the PAD. The lake had soft water and lower levels of alkalinity. Higher sulphate concentrations were observed in Lake Claire and Birch River Delta compared with other waters in the PAD. Fluoride was generally high in the PAD, with maximum concentrations often above the chronic aquatic guideline.

Nutrient levels were moderate to high in waters in the PAD based on median concentrations of total nitrogen (TN) and total phosphorus (TP) (see Appendix 7B, Tables 7B-1 to 7B-3). Maximum concentrations of TN and TP were above the chronic guidelines for the protection of aquatic life (1.0 mg/L and 0.05 mg/L, respectively from AENV 1999) in most of the waterbodies and watercourses of the PAD.

Trophic status in waters in the PAD was variable. As median TP concentrations in waterbodies in the PAD ranged from 0.041 mg/L to 0.071 mg/L (see Appendix 7A, Table 7A-1 to 3), the waterbodies in the PAD were likely in the mesotrophic to eutrophic range according to Vollenweider and Kerekes (2002) and Wetzel (2001), and eutrophic according to Canadian Council of Ministers of the Environment (CCME) (2004). Maximum levels of chlorophyll *a* in the waterbodies of Athabasca River Delta and Birch River Delta were indicative of mesotrophic to eutrophic conditions (Mitchell and Prepas 1990). The west portion of Lake Athabasca was the exception and was likely oligotrophic based on TP concentrations.

Median concentrations of TP in the watercourses in the PAD ranged from 0.033 mg/L to 0.051 mg/L (see Appendix 7B, Tables 7B-1 to 7B-3) and were likely indicative of mesotrophy based on the classification system in Dodds et al. (1998) and CCME (2004).

7.5.2.2 Total Metals

Median concentrations of total metals were below guidelines in waters in the PAD with few exceptions (see Appendix 7B, Tables 7B-1 to 7B-3). Total metals that were above the relevant chronic guideline for the protection of aquatic life include:

- aluminum in the Athabasca River Delta and Peace River
- chromium in the Athabasca River downstream of Old Fort and Athabasca River Delta
- copper in the Peace River
- iron in the Athabasca River downstream from Old Fort, Athabasca River Delta, Peace River and Lake Athabasca
- mercury in the Athabasca River Delta

The total aluminum median concentration was above the acute guidelines for the protection of aquatic life in waters in the PAD (0.75 mg/L from US EPA 2002). The concentrations that were above the acute guidelines were found to be directly related to the naturally high sediment loads in these rivers and were deemed unlikely to have negative effects on aquatic life (Glozier et al. 2009). Guideline exceedances for other total metals were also thought to be related to naturally high suspended sediment in the Athabasca River, although causative factors were not specifically examined (Hebben 2009).

7.5.2.3 Organic Compounds

Organic compounds were generally below both detection limits and applicable guidelines (see Appendix 7B, Tables 7B-1 to 7B-3). Low concentrations of total naphthenic acids and total recoverable hydrocarbons were consistently observed throughout the PAD. At all sites except the Birch River Delta, maximum concentrations of total phenolics exceeded the chronic guidelines for the protection of aquatic life (0.004 mg/L from CCME 1999).

7.5.2.4 Long-term Temporal Trends

Studies by Hebben (2009) and Glozier et al. (2009) were reviewed to provide an overview of temporal trends in waters at the upstream boundaries of the PAD. A summary of parameters that showed trends at a p-value of 0.05 at these locations is presented in Table 7-12 and discussed below.

In both the Peace and Athabasca rivers, levels of pH, DO, TSS and turbidity showed a large increase over the study period. Based on the trends detected at the upstream boundaries, levels of these parameters in the PAD are expected to have also increased over the study periods.

Major ions followed few detectable trends in both rivers. When concentrations were flow-adjusted, temporal trends of major ions shifted from no trend to decreasing and from increasing to no trend. The cause of the decreasing trends in major ion concentrations after flow adjustment is unclear (Glozier et al. 2009).

Nutrients generally increased substantially in both rivers over the studied time frame (see Table 7-12). When concentrations were flow adjusted, temporal trends of TP changed from no trend to increasing in the Athabasca River at Old Fort, which indicates that TP might have also increased in the PAD over this period. The increasing trends in flow-adjusted TP might have been because of decreased flow in the Athabasca River (Glozier et al. 2009).

Total metals generally decreased or did not change in both rivers over time, with some exceptions. Concentrations of total aluminum and arsenic increased in the Athabasca River at Old Fort. This increasing trend was likely associated with the increased TSS. After evaluating temporal trends in the Peace and Athabasca rivers, Glozier et al. (2009) concluded that:

- total metals in the Athabasca River appeared to be largely of natural origin
- concentrations of metals did not increase in the Peace River
- the transport of metals associated with sediment load into depositional environments is likely not an issue in the PAD

Table 7-12 Temporal Trends for Water Quality Parameters

Parameter	Athabasca River at Old Fort[1] (Between 1987 and 2008)		Athabasca River at 27 Baseline[2] (Between 1989 and 2006)		Peace River at Peace Point[2] (Between 1989 and 2006)
	Concentration Trend	Flow-adjusted Trend	Concentration Trend	Flow-adjusted Trend	Concentration Trend
Conventional Parameters					
Temperature	↓	↔	NA	NA	NA
Dissolved oxygen	↔	↔	↑	↔	↑
pH	↑	↑	↑	↑	↑
Conductivity	↔	↓	↔	↓	↔
Turbidity	↑	↑	↔	↑	↔
Total suspended solids	↑	↑	↔	↑	↔
Dissolved organic carbon	↔	↔	↔	↔	↓
Major Ions					
Total alkalinity	↔	↔	↔	↓	↔
Bicarbonate	↔	↔	↔	↓	↔
Calcium	↔	↔	↔	↓	↔
Chloride	↔	↓	↔	↓	↓
Fluoride	↔	↔	↑	↔	↔
Potassium	↔	↔	↑	↑	↔
Sodium	↔	↔	↔	↔	↓
Sulphate	↔	↔	↑	↔	↑
Nutrients					
Total Ammonia	↑	↔	↑	↔	↔
Nitrite + Nitrate	↑	↔	↑	↔	↑
Total phosphorus	↔	↑	↑	↑	↔
Total Metals					
Aluminum	↑	↑	NA	NA	NA
Arsenic	↔	↑	↔ [3]	↔ [3]	NA
Copper	↓	↔	↓	↔	↔
Iron	NA	NA	↓	↔	↔
Lead	↔	↔	↓	↓	↓
Nickel	NA	NA	↓	↔	↔
Molybdenum	↓	↔	NA	NA	NA
Zinc	NA	NA	↓	↔	↔

NOTES:
[1] Results of temporal trend analysis completed by Hebben (2009) were presented
[2] Results of temporal trend analysis completed by Glozier et al. (2009) were presented
[3] Temporal trend for dissolved arsenic was included because total arsenic was not available
NA = Not available
↑ = Increasing trend, significant at a p-value of 0.05
↓ = Decreasing trend, significant at a p-value of 0.05
↔ = Any trends not reporting significance at a p-value of 0.05

7.5.2.5 Sediment Quality

A literature review was conducted for data sources relating to sediment quality in the PAD. Information was limited to the sediment quality in the Athabasca River, Athabasca River Delta and Lake Athabasca (RAMP 2010; Bourbonniere et al. 1996).

Based on the reviewed studies, bottom sediments in the PAD were predominantly silt and sand. In the west portion of Lake Athabasca, the bottom sediment was predominantly clay.

Metals and PAH concentrations in sediments were below guideline values in the PAD with some exceptions (see Appendix 7C, Table 7C-1). Arsenic and chromium concentrations in the Athabasca River Delta were occasionally above the CCME interim sediment quality guideline (ISQG, 5.9 mg/kg and 37.3 mg/kg, respectively). In one sample, the chromium concentration was also above the CCME Probable Effect Level (PEL) of 90 mg/kg. In the west portion of Lake Athabasca, arsenic and cadmium concentrations were above the CCME ISQG (0.6 mg/kg for cadmium).

Concentrations of C1-napthalenes were often above the ISQG (0.0202 mg/kg) in the Athabasca River Delta (see Appendix 7C, Table 7C-1). Phenanthrene was above the ISQG (0.0419 mg/kg) in one sample from the west portion of Lake Athabasca (Bourbonniere et al. 1996).

Concentrations of total recoverable hydrocarbons ranged from 600 to 1,400 mg/kg in the Athabasca River Delta, and from 500 mg/kg to 900 mg/kg in the Athabasca River at the mouth (see Appendix 7C, Table 7C-1). As noted in RAMP (2010), the highest concentrations of hydrocarbons in Athabasca River sediments have historically been measured upstream of oil sands development at a baseline station.

7.5.2.6 Long-term Temporal Trends

A recent analysis of RAMP data by Timoney and Lee (2011) found that PAH concentrations in PAD sediments over all areas had increased by 0.05 mg/kg/a between 1999 and 2009, and found no change at a group of upstream reference sites. The analysis by Timoney and Lee (2011) was restricted to total PAH. For this evaluation, an analysis of trends in individual constituents at individual stations was undertaken.

The same RAMP sediment dataset used by Timoney and Lee (2011) was used in this analysis. From this dataset, results from the site on the Athabasca River downstream from Fort McMurray (ATR-DC-W) were selected as reference data for a site upstream from the oil sands development. This site had the longest record (1998 to 2004) of any of the upstream reference sites, but was still downstream from urban effects from the Town of Fort McMurray, such as municipal wastewater and urban runoff. Two sites downstream from all oil sands development were selected for intensive analysis. These were the sites on the Athabasca River at Embarras divergence (site ATR-ER) and site BPC-1 in the Peace Athabasca Delta. These two sites had the most years of sediment data (nine years from 2000 to 2009) of any of the lower river and delta sites. Site ATR-ER provided a measure of constituents moving into the delta from the Athabasca River, and Site BPC-1 was furthest out in the delta. All individual species of PAH and metals were tested, as these were the constituents identified in two recent papers on contaminant transport from the oil sands developments (Kelly et al. 2009, 2010). Associated variables such as total organic carbon, and some major ions that were also in the dataset were tested, but no trends were found in these other variables.

The long-term temporal trends analysis was completed on 70 constituents: 45 individual PAH species, 23 metals, total PAH and total organic carbon. Data were obtained from the RAMP long-term sediment monitoring stations, which include Athabasca River downstream of Fort McMurray at Donald Creek (ATR-DC-W) as a reference station, the Athabasca River at Embarras divergence (ATR-ER) and three stations in the PAD (BPC-1, GIC-1 and FLC-1).

A nonseasonal Mann-Kendall test was used to test for monotonic trends. Sen slopes were calculated to provide an estimate of the approximate magnitude of significant monotonic trends. Procedures in the water quality statistics package WQHYDRO (Aroner 2011) were used for all trend and slope analysis. As recommended by Ward et al. (1990), a 0.10 level of significance was used in all trend analysis. Samples that were below the detection limit were replaced by half of the detection limit before inputting the data.

Statistically significant trends in individual PAH species and metals are summarized in Table 7-13, and selected significant trends are plotted in Appendix 7D, Figures 7D-1 to 7D-4. There were no significant trends detected for other variables.

Levels of C3- and C1-fluorene (see Appendix 7D, Figure 7D-1), C4-phenanthrenes/ anthracenes (see Appendix 7D, Figure 7D-2), and both dimethyl- and methyl-biphenyl increased at two or more sites downstream of oil sands development, but no trend was detected at the upstream reference site (see Table 7-13). C4-naphthalenes, C2-fluoranthenes/pyrenes and C4-dibenzothiophenes also increased at single sites downstream of oil sands development, again with no trend detected at the upstream reference site. Fluorene and phenanthrene/anthracene are dominant components of bitumen (Kelly et al. 2009). Accordingly, the increasing trends found downstream from oil sands developments might reflect increased rates of bitumen input to the Athabasca River during the sampling period.

Fluorene concentrations at all sites downstream from oil sands developments were below the CCME (1999) ISQG for the protection of aquatic life (0.021 mg/kg), and well below the probable effect concentration of 0.144 mg/kg throughout the period of record. A single value at the upstream site exceeded the ISQG for fluorene. Similarly, the highest naphthalene value at the single site where naphthalene increased significantly (BPC-1) was at the ISQG of 0.0346 mg/kg, and well below the probable effects level of 0.391 mg/kg. Other CCME sediment guidelines are for individual PAH rather than the alkylated PAH species that demonstrated increasing trends. Accordingly, it is not possible to evaluate whether the other PAH that increased have exceeded guidelines.

Acenaphthylene (see Appendix 7D, Figure 7D-3) and C1-benzo[a]anthracenes/chrysenes (see Appendix 7D, Figure 7D-4) levels declined significantly at two of the sites downstream of oil sands development, and C2-benzo[a]anthracenes/chrysenes declined at one downstream site (site GIC-1). Alkylated chrysene is a dominant component of bitumen (Kelly et al. 2009), which, in contrast to the increasing trends of fluorene and phenanthrene/anthracene, might reflect decreased rates of bitumen input to the Athabasca

River during the sampling period. However, the reasons for increasing or declining levels cannot be definitively determined from the available data.

Acenaphthylene declined significantly from an unusually high concentration in 2000 (see Appendix 7D, Figure 7D-3), which could reflect some analytical or sampling concern. Timoney and Lee (2011) found that discharge was not significantly correlated with total PAH at mainstem sites. However, individual PAH species might behave differently, and some have a greater propensity to adsorb to particulate material. Furthermore, Hebben (2009) found reach-specific differences in flow trends in the Athabasca River, with a declining trend in the Lower Athabasca and no trend near Fort McMurray. Constituents affected by flow might behave differently in different reaches.

An increasing trend in C1-benzo[a]anthracenes/chrysenes was detected at the upstream reference site (site ATR-DC-W). The reason for this increasing trend at site ATR-DC-W cannot be determined from the available data. A likely source would be a bitumen outcrop on the Athabasca River, as documented in RAMP (2010). Other possible inputs at this site include urban runoff from Fort McMurray or natural sources such as forest fires. It should be noted that only six years of data are available from this site, and apparent trends might disappear over a longer sampling period. Aside from this one trend at the upstream reference site, no increasing trends were detected for any of the carcinogenic substituted forms of PAH such as benzo[a]pyrene, at any site.

No significant trend in total PAH was found at any site. While this might seem to contradict the findings of Timoney and Lee (2011), their work and the current study used different methods of data preparation and analysis, and the findings are not directly comparable. For example, the current study substituted values half the detection limit for values below detection limits, while Timoney and Lee (2011) substituted the exact detection limit. Both forms of substitution might introduce a bias to total PAH, as the exact value below detection limits is unknown.

No increasing trend in total metal concentration was found at the Peace Athabasca Delta site that was tested (site BPC-1, Table 7-13). However, a variety of metals, including aluminum, arsenic, barium, chromium, cobalt, copper, mercury, nickel, selenium and zinc declined in concentration in sediments from the Athabasca River downstream from oil sands developments (site ATR-ER). Accordingly, these sediment results provide no evidence of increased transport of these metals from oil sands development areas, as described in Kelly et al. (2010). Metal concentrations are often strongly influenced by flow effects on particulate metals, and the declining flow trend documented by Hebben (2009) might complicate any interpretation of sediment metal concentrations. Accordingly, these metal trends should be interpreted with caution.

Table 7-13 Temporal Trends for Constituents with Significant Change

Parameters	Upstream Oil Sands Development	Downstream Oil Sands Development			
	Athabasca River downstream from Ft McMurray	Athabasca River at Embarras Divergence	Athabasca Delta		
	ATR-DC-W	ATR-ER	BPC-1	GIC-1	FLC-1
	1998 to 2004	2000 to 2009	2000 to 2009	2001 to 2009	2001 to 2009
Metals					
Aluminum	-	↓	↔	-	-
Arsenic	-	↓	↔	-	-
Barium	-	↓	↔	-	-
Chromium	-	↓	↔	-	-
Cobalt	-	↓	↔	-	-
Copper	-	↓	↔	-	-
Mercury	-	↓	↓	-	-
Nickel	-	↓	↔	-	-
Strontium	-	↓	↔	-	-
Zinc	-	↓	↔	-	-
Polycyclic Aromatic Hydrocarbons					
Acenaphthylene	↔	↓	↓	↔	↔
C1-benzo[a]anthracenes/ chrysenes	↑	↔	↓	↓	↔
C1-fluoranthenes/pyrenes	↔	↑	↔	↔	↔
C1-fluorenes	↔	↑	↑	↔	↑
C2-benzo[a]anthracenes/ chrysenes	↑	↔	↔	↓	↔
C2-fluoranthenes/pyrenes	↔	↑	↔	↔	↔
C3-fluorenes	↔	↑	↑	↔	↔
C4-dibenzothiophenes	↔	↔	↑	↔	↔
C4-naphthalenes	↔	↔	↑	↔	↔
C4-phenanthrenes/ anthracenes	↔	↑	↑	↔	↑
Dimethyl-biphenyl	↔	↔	↑	↔	↑
Methyl-biphenyl	↔	↔	↑	↔	↑
Total PAH	↔	↔	↔	↔	↔

NOTES:

Dash "-" = Trend analysis was not completed because no significant trends were observed both at Athabasca River at Embarras divergence (ATR-ER) and BPC-1 in the Athabasca Delta.

↑= Increasing trend, significant at an α-value of 0.1

↓= Decreasing trend, significant at an α-value of 0.1

↔ = Any trends not reporting significance at an α-value of 0.1

7.5.2.7 Sediment Toxicity

Several toxicity test samples were collected in Athabasca River and Athabasca Delta by RAMP (RAMP 2010). Toxicity testing included the organisms *Chironomus tentans*, *Hyalella azteca* and *Lumbriculus variegates.* The survival values were often less than 100% compared to the laboratory control (see Appendix 7C, Tables 7C-1 to 7C-2), but reductions in survival were small and survival values were greater than 100% nearly as often. These results suggest that the sediment samples collected in the Athabasca River and Athabasca Delta were nontoxic to slightly toxic to the test organisms compared to control samples.

7.5.3 Environmental Evaluation

7.5.3.1 Effects on Water Quality

Project activities that might affect water quality in the PAD include:

- diversion of flow from the Athabasca River upstream from the PAD
- Project activities that might affect water quality in the Athabasca River

The hydrology evaluation indicated that no significant temporal trend was observed in flows in the PAD, and that surface water withdrawals from the Athabasca River will result in negligible changes in flows in the PAD. Therefore, the effects of water withdrawals from the Athabasca River on water quality in the PAD were not evaluated further.

The effects of Project activities on water quality in the Athabasca River were predicted to be negligible, with all parameter concentrations predicted to be within 10% of baseline concentrations or below applicable aquatic health thresholds, as discussed in Volume 5, Section 4.6, Table 4-10. Although the changes in water quality in the Athabasca River upstream from the PAD were predicted to be negligible, the parameters that might have increased from upstream to the mouth in the Athabasca River were qualitatively evaluated further, as described below.

Results of a cumulative effect assessment completed in the Athabasca River (Squires et al. 2009) found increasing trends as one moves downstream from the headwaters to the mouth in Athabasca River for chloride, total organic carbon, sodium, turbidity and TP. However, the concentrations of these parameters did not show significant temporal increasing trends or decreasing trends over the past 20 years in the PAD, with the exception of TP and turbidity (see Section 7.5.2.4). Total metals concentrations have not shown increasing trends and high total metals were primarily of natural origin in the Athabasca River. Total metals related to the potential sediment loading from the Project are discussed in Section 7.5.2.2.

Levels of TP in the waterbodies and watercourses in the PAD may have increased over the past 20 years (see Sections 7.5.2.1 and 7.5.2.4). The primary source of the TP input in the Athabasca River was unknown because several potential sources might have contributed to the increasing trend, including pulp mills, large growth in municipal population, as well as the oil sands (Glozier et al. 2009). However, the modelling of TP concentrations in the Athabasca River upstream of the PAD indicated that cumulative inputs from all oil sands developments are expected to result in increases in TP concentrations of about 3% (see Volume 5, Section 4.6).

Mitigation measures described in Volume 5, Section 4.6, such as creating polishing ponds, a Project fish habitat compensation lake (FHCL) and pit lakes, will be implemented to reduce or eliminate changes in TSS, and hence turbidity, in receiving watercourses. Polishing ponds will be tested before release to the receiving environment to verify acceptability of release waters for parameters defined under the Project's *EPEA* approval. Because of these measures, sediment yield, TSS and turbidity are not predicted to change in the Athabasca River or the PAD as a result of the Project.

Based on the predicted results in the LSA and in the RSA, the literature review as described above, and the mitigation plan for the Project, potential effects of Project activities and other developments on water quality concentrations in the PAD are expected to be negligible.

7.5.3.2 Effects on Thermal Regime

Project activities that might affect the thermal regime in the PAD are as follows:

- diversion of flow from the Athabasca River upstream of the PAD
- Project activities that might affect water quality in the Athabasca River (see Volume 5, Section 4.6)

The hydrology assessment (see Volume 5, Section 3.6) predicted that surface water withdrawals from the Athabasca River will result in negligible changes in overall flows, including low flow in the PAD. The water quality assessment (see Volume 5, Section 4.7) predicted negligible changes in thermal regime in the Athabasca River at any location. Therefore, the effects of Project activities on the thermal regime in the PAD are expected to be negligible and were not evaluated further.

7.5.3.3 Effects on Dissolved Oxygen Levels

Project activities that might affect DO concentrations in the PAD are as follows:

- diversion of flow from the Athabasca River upstream of the PAD
- Project activities that might affect water quality in the Athabasca River (see Volume 5, Section 4.6)

The hydrology assessment (see Volume 5, Section 3.6) predicted that surface water withdrawals from the Athabasca River will result in negligible changes in flows in the PAD (see Section 7.4.4). Based on the literature review, the DO level in the PAD might have increased slightly over the past 20 years (see Section 7.5.2.4). In addition, a model developed by Alberta Environment indicates that the range of withdrawals from the Athabasca River is unlikely to exert a measurable influence on DO (McEachern 2010). The water quality assessment (see Volume 5, Section 4.8) predicted negligible changes in DO concentrations in the Athabasca River at any location. Therefore, the effects of Project activities on DO concentrations in the PAD are expected to be negligible and were not evaluated further.

7.5.3.4 Effects on Sediment Quality

Changes to sediment quality in the PAD might occur through either of the following two pathways because of Project activities:

- direct inputs of sediment that could be transported down the Athabasca River and deposited in the PAD
- changes in water quality concentrations that will interact with sediments through partitioning and other reactions

Changes in suspended sediment inputs and runoff quality from the Project might change the sediment quality of waterbodies and watercourses within the PAD. The potential effects of each of these pathways were qualitatively assessed, as described below.

- Transport of metals associated with sediment load into a depositional environment like the PAD was examined by Glozier et al. (2009). Total metal concentrations appear to be largely of natural origin, with flow decreasing in the Athabasca River overall, and concentrations not increasing over the past 20 years (Glozier et al. 2009).
- Spatial and temporal comparisons of sediment quality as monitoring by RAMP do not indicate any consistent trends over time in concentrations of metals (see Section 7.5.2.6), nor do they indicate any consistent, regional differences in sediment quality between baseline and test stations. Furthermore, these results do not show any relationships between sediment chemistry and composition of benthic invertebrate communities (RAMP 2010).
- Analysis of sediment cores taken from the west portion of Lake Athabasca indicate that PAH concentrations in lake sediments are generally consistent through time and lower than levels observed in other Canadian lakes (Bourbonniere et al. 1996).
- Monitoring of watercourses with and without oil sands development has shown considerable natural or background concentrations of hydrocarbons and other compounds (Tetreault et al. 2003; Colavecchia et al. 2004; Headley et al. 2001, 2002, 2005).
- There was a weak tendency for naphthalene and fluorene to increase in concentration from the main body of the Athabasca River to the Athabasca River Delta channel, although lower molecular weight compounds of PAH have a tendency to increase in concentration from upstream sources to downstream depositional area. There is no evidence of effects on these substances from the oil sands developments (Evans et. al 2002).
- A significant increasing trend was observed in some PAH sediment concentrations and reducing trends observed in others (see Section 7.5.2.6). The cause of these changes cannot be determined from the limited data and the current RAMP sampling design. There are no sediment concentrations from these stations before development began. Accordingly, it is not possible to discern whether the observed trends in sediment PAH and metals are within the ranges that would occur naturally.

Polishing ponds, wetlands and pit lakes created for the Project will be implemented to trap eroded suspended and bed-transported particulate material. These water systems will have sufficiently long residence times to enhance settling of solid materials and associated metals. Polishing ponds will be tested to verify acceptability of release waters for constituents defined under the Project's *EPEA* approval.

Sampling of sediments at a suitable upstream reference station is required to evaluate spatial and temporal changes at stations downstream from oil sands development. Sampling of sediment stations upstream and downstream from development is recommended to be sampled concurrently. As part of ongoing improvements to RAMP, an enhanced sediment quality monitoring program will be developed in consultation with Alberta Environment and Environment Canada to monitor long-term temporal and spatial trends in sediment concentrations in the Athabasca River Delta and at appropriate locations upstream from oil sands developments.

Considering the reviewed literature, lack of change in modelled water concentrations, and mitigation to be employed, potential cumulative effects of Project activities on sediment quality in the PAD are expected to be negligible.

7.5.4 Summary

The environmental evaluation of surface water quality changes to the PAD demonstrates that effects on water and sediment quality predicted in Ronald Lake and the Athabasca River, including its divergence with the Embarras River from the Project in conjunction with operating, approved and planned developments are negligible. As effects on water and sediment quality were predicted to be negligible upstream of the PAD, the aquatics RSA did not include the PAD in the assessment.

7.5.5 References

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7.6 Fish and Fish Habitat

7.6.1 Key Issues and Key Indicators

Key issues for the fish and fish habitat evaluation of potential relevance to the PAD included potential for changes in fish habitat and changes in fish relative abundance. For a detailed discussion of key issues and associated key indicators for fish and fish habitat, see Volume 5, Sections 5.2 and 5.3. Fish health potential issues are discussed in Section 7.10.

To provide focus, key indicators for the key issues were chosen to quantify and evaluate the cumulative effects of the Project in conjunction with other oil sands developments on the PAD. Key indicators included:

- changes in water flow and levels that would result in changes in fish habitat
- changes in fish habitat area that would result in a change in fish relative abundance

7.6.2 Historic Data, Existing Conditions and Trends

7.6.2.1 Water Flows and Water Levels

The ecology of the PAD is driven by its hydrology (NERI 2010). Water management of instream flows of the Athabasca River is managed through the *Athabasca River Water Management Framework* (AENV and DFO 2007) and ensures relative flow levels are maintained in the PAD during different seasons. For a more detailed discussion on existing conditions and historical trends of water flow and levels in the PAD, see Section 7.4 and Appendix 7A.

7.6.2.2 Fish Habitat and Fish Relative Abundance

The PAD provides a number of different fish habitat types including, migration pathways, rearing, feeding and spawning habitat.

The benthic habitat of the PAD is naturally impaired because of the freezing of bottom sediments and anoxia during winter for the lake areas and often reworked or shifting sediments in the riverine portions of the PAD. The benthic fauna of the PAD is sparse and has a low diversity (AECOM 2010). In the Athabasca River delta sampling has been conducted on a number of river channels and the Embarrass River through RAMP. All RAMP sites within the PAD were depositional. Two of the four sites were dominated by tubificid worms followed by chironomids. Tubicid worms were abundant at the third sample location but ostracods and chironomids dominated numerically. The fourth site was numerically dominated by chironomids followed by bivalves (RAMP 2011).

The PAD supports over 20 species of fish. Common sport fish in the PAD include goldeye, burbot, northern pike and walleye. Non-sport fish species include the longnose and white sucker. Important forage fish include the emerald shiner, flathead chub, lake chub, spottail shiner and trout-perch.

A large proportion of the aquatic area of the PAD comprises Lake Claire and Mamawi Lake. Percentage fish community composition for these two lakes was assessed every three years between 1947 and 1994 (AECOM 2010). The fish community in these two lakes is dominated by goldeye which use these areas during spring, summer and fall for spawning, rearing and feeding. Goldeye migrate back into rivers to overwinter as these lakes are shallow and provide poor overwintering habitat. Northern pike was the next most common species found. Lake whitefish, walleye, longnose and white suckers were relatively rare during the assessment studies. The fish community in Lake Claire and Mamawi Lake have been constant and stable (AECOM 2010).

Only the southwestern portion of Athabasca Lake is within the PAD. Fisheries data for Athabasca Lake have largely been obtained through commercial fish harvest data and is focused on the weight of total harvest of species and not on numbers of fish captured (AECOM 2010). Commercial harvest information is available on lake whitefish, lake trout, walleye, northern pike, burbot, longnose and white sucker.

Existing conditions and historical trends for hydrology which relate to fish habitat are discussed in Section 7.6.2 and for water quality in Section 7.5.2.

7.6.3 Environmental Evaluation

7.6.3.1 Water Flows and Water Levels

Changes in water flows into the PAD have been attributed to the W.A.C. Bennett Dam located on the Peace River. The dam has reduced flows in the spring and summer and increased flows during the fall and winter (see Section 7.4.3.2). With mitigation, changes in flows and water levels because of water withdrawals from the Athabasca River are expected to be negligible for distributional channels and Athabasca Lake within the PAD.

7.6.3.2 Fish Habitat and Fish Relative Abundance

Negligible changes to water flow and levels in the PAD because of the Project are expected to result in negligible or no loss of fish habitat area within the PAD. Adherence to the *Athabasca River Water Management Framework* should reduce or negate any potential for loss of fish habitat area in the future.

Fish relative abundance can be affected by water quality conditions. Poor water quality can lead to reduced fecundity, hatching success and overall survival. Most chemical water quality parameters have not shown increasing or decreasing temporal changes in the past 20 years with the exception of TP and turbidity, which have increased. Although oil sands activity might have contributed to increased levels of TP and turbidity, other factors such as increased municipal populations upstream and the presence of pulp mills also likely added to this increased trend. Levels have not increased to the point that fish relative abundance appears affected, as fish populations appear stable within those areas sampled within the PAD.

As the Project is expected to have negligible effects on other water quality parameters such as thermal regime (see Volume 5, Section 4.7) or dissolved oxygen levels (see Volume 5, Section 4.8), no effects should be carried downstream to the PAD and therefore the Project should have no effect on fish relative abundance.

Mitigation measures such as polishing ponds, pit lakes and a Project FHCL will be important in improving water quality and reducing or eliminating changes in turbidity in receiving waterbodies. Water quality conditions in the PAD because of Project activities are expected to be negligible and therefore should not affect fish relative abundance.

There have been no significant changes in catch per unit effort reported for Mamawi Lake and Lake Claire, nor has there been any downward trend in commercial fish catches of walleye in Lake Athabasca (AECOM 2010). Because of the Project FHCL, it was predicted that there would be negligible to no decline in fish relative abundance in the LSA or RSA (see Volume 5, Section 5) and therefore no potential for Project-related declines in fish relative abundance in the PAD. In addition to the Project FHCL, pit lakes and closure drainage channels will naturally evolve at Closure into fish habitat, further reducing the potential for declines in fish relative abundance in the PAD.

7.6.4 Summary

There are negligible changes expected to water quantity and water and sediment quality at Ronald Lake and the Athabasca River, including its divergence with the Embarras River from the Project in conjunction with operating, approved and planned developments upstream from the PAD. Accordingly, effects on fish and fish habitat are also considered to be negligible.

7.6.5 References

7.6.5.1 Literature Cited

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7.7 Terrain and Soils

7.7.1 Key Issues and Key Indicators

Key issues for the terrain and soils evaluation of potential relevance to the PAD included potential for changes in soil series diversity. Potential acid input (PAI) is not considered a concern because annual monitoring loads defined as 0.17 keq H+/ha/a (kiloequivalent hydrogen ion/ha/a) fall outside, and well south of the PAD (see Volume 6, Section 2.9.4). For a detailed discussion of key issues and associated key indicators for terrain and soils, see Volume 6, Sections 2.2 and 2.3.

To provide focus, key indicators for the key issues were chosen to quantify and evaluate the cumulative effects of the Project in conjunction with other oil sands developments in the PAD. Key indicators that could potentially result in a change in soil series include changes in water levels.

7.7.2 Historic Data, Existing Conditions and Trends

For a brief discussion on the geological conditions of the PAD, see Section 7.3.

There is limited published information on soils for the PAD. The Alberta Oil Sands Environmental Research Program soil survey (Turchenek and Lindsay 1982) covered part of the eastern portion of the PAD; however, the update to this report (Golder 2004) did not include the PAD. The only soil survey for the entire PAD area was a preliminary survey from 1962 (Lindsay et al. 1962). The Soil Landscapes of Canada coverage (Government of Canada, Agriculture and Agri-Food Canada 2011, Internet site) is 1:1,000,000 scale and is limited to soil orders. Accordingly, for the PAD most of the information on soils in the Soil Landscapes of Canada has been taken from Lindsay et al. 1962.

The Soil Landscapes of Canada describes Gleysols, Brunisols and Organic soils, along with Regosols in the PAD region. Lindsay et al. (1962) describes Brunisols and gleyed Regosols in the delta area, along with Organics, Brunisols and occasional Luvisols. The most recent survey of the area, Turchenek and Lindsay (1982) covers a limited area in the eastern portion of the PAD. Map associations listing the primary soil series include:

- Chipewyan: Gleyed Cumulic Regosols, Gleyed Regosols, Rego Gleysols, peaty Gleysols and Organics developed on fluvial delta deposits
- Eaglesham: Deep Organic soils developed on mesic fen peat. Includes Typic Mesisols, assorted weakly to moderately developed Organics and peaty Gleysols
- Heart: Brunisolic soils developed on sandy, eolian deposits. Includes Eluviated Dystric and Eutric Brunisols, peaty Gleysols and Orthic Regosols
- Kenzie: Organics developed on mesic and fibric bog deposits. Includes Fibric Mesisols, Terric Mesisols along with other Organic subgroups
- Mamawi: Poorly drained soils developed on fluvial delta deposits. Includes primarily Rego Gleysols, along with Gleyed Cumulic Regosols and Rego Gleysols of the Chipewyan association

- Mildred: Rapidly drained Brunisols developed on sandy outwash materials. Primarily Eluviated Dystric and Eutric Brunisols along with gleyed subgoups and peaty Gleysols
- Rock: Non-soil consisting of bedrock outcrops

7.7.3 Environmental Evaluation

Reductions in PAD water levels could result in a shift to drier soil processes particularly for poorly drained soils of the Organic and Gleysolic soil order. Associated with changes in water levels are changes in flooding extent and frequency that could also result in a shift in soil processes away from the Regosolic soil order towards more developed soils.

As discussed in the hydrology evaluation (see Section 7.4) water levels in the PAD are affected by flow regulation in the Peace River from the W.A.C. Bennett Dam, and could also be affected by water withdrawals from the Athabasca River and effects of climate change on basin hydrology and ice jam regimes. Overall, large-scale drying of the PAD has been noted since the early 1970s, with constructed weirs mitigating effects to an extent; however, recharge of perched basins flooded from the Peace River was still not occurring because of weir location (PADTS 1996). In addition, there is some evidence to show that the ice jam-related flooding frequency could decrease in the future because of climate change, resulting in further potential for water level decreases. In contrast, with the use of mitigation measures and adherence to the *Athabasca River Water Management Framework*, effects from the Frontier Project in conjunction with operating, approved and planned oil sands developments are not expected to adversely affect hydrology in the PAD.

7.7.4 Summary

For areas of the PAD historically flooded by the Peace River, it is likely that soil processes associated with Organic and Gleysolic orders will shift to drier processes whereas Regosolic soil processes will shift toward more developed soils. Shifts in soil processes have likely already occurred and might continue to occur from climate change and flow regulation. However, as effects on water levels and flooding in the PAD from the Project in conjunction with operating approved and planned developments in the Athabasca Oil Sands Region are predicted to be negligible, effects on soils are also expected to be negligible.

7.7.5 References

7.7.5.1 Literature Cited

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7.7.5.2 Internet Sites

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7.8 Vegetation

7.8.1 Key Issues and Key Indicators

Key issues for the vegetation evaluation of potential relevance to the PAD included potential for changes in community and species diversity. Effects from air emissions on vegetation, including NO_2 and SO_2 fumigation, Nitrogen-deposition, PAI and dust are not considered as critical levels and loads defined as protective of sensitive vegetation fall outside and well south of the PAD (see Volume 6, Section 3.9). For a detailed discussion of key issues and associated key indicators for vegetation, see Volume 6, Sections 3.2 and 3.3.

To provide focus, key indicators for the key issues were chosen to quantify and evaluate the cumulative effects of the Project in conjunction with other oil sands developments in the PAD. Key indicators that could potentially result in a change in community diversity include changes in water levels.

7.8.2 Historic Data, Existing Conditions and Trends

The PAD is a heterogeneous, dynamic system with thousands of basins variable in their size, isolation, hydrology, landform and corresponding vegetation communities. Hydrologically driven changes, such as channel bifurcation, flooding and sediment accumulation have been occurring in the PAD since deglaciation (Peterson 1998), with the distribution and occurrence of vegetation communities reflecting hydrologic conditions (Timoney 2008). Fluctuations in flood frequency in the past 300 years have resulted in correlated vegetation cover changes in the PAD (Timoney 2006).

Vegetation communities in the PAD are summarized in Table 7-14 in relation to relative water levels. Changes in water level as little as 0.2 m at any given location will result in a shift in wetland vegetation communities and, as with other marsh ecosystems, changes at any one location can occur in a season. For a discussion on the dynamic nature of the distribution and occurrence of vegetation communities in the PAD see Timoney (2008).

Table 7-14 Vegetation Communities in the PAD

Vegetation Community	Description	
Wetlands		
Open Water	Aquatic vegetation might be present	↑ Increased water level.
Wet	Clear or muddy open water in channels, open drainage, lakes and ponds with <10% emergent species dominated by *Equisetum fluviatile*	
Emergent Marsh	Over 50% shallow open water with 10 to 50% emergent vegetation dominated by *Typha* spp.; can result from or oscillate between open water cover type	
Marsh	Over 50% emergent vegetation dominated by *Carex* spp. and <10% shrub (*Salix* spp.) or forest; in semi-restricted and perched basins	
Mudflats	Unvegetated	
Meadow and Disturbed Meadow	Marginal marsh wetland dominated by *Calamogrostis canadensis* and <10% shrub (*Salix* spp.) or forest; in semi-restricted and perched basins. When grazed by bison (i.e., disturbed) dominant species include *Poa palustris, Hordeum jubatum* and *Anemone canadensis*	
Uplands		
Willow Savannah	Occasionally flooded, patchy 10-50% willow (*Salix* spp) cover; on levees and in encroached basins; remain stable or might transition to forest if desiccated	↑ Increased water level.
Willow Thicket	Occasionally flooded, over 50% willow (*Salix* spp) cover; on levees and in encroached basins; remain stable or might transition to forest if desiccated	
Forest (deciduous, mixedwood and conifer) and Exposed bedrock	Forest - Over 50% tree cover; located on high levees and alluvial terraces Exposed bedrock - Thin, patchy soil cover over bedrock with over 50% lichen, grass or shrub cover and <50% tree cover; no transition to other cover types	
Data sources include Peterson (1998) and Timoney (2006, 2008)		

7.8.3 Environmental Evaluation

Reductions in PAD water levels could result in a shift to drier conditions, which would be of particular concern for wetland communities and associated species. As discussed in the hydrology evaluation (see Section 7.4) water levels in the PAD are affected by flow regulation in the Peace River from the W.A.C. Bennett Dam and could also be affected by water withdrawals from the Athabasca River and effects of climate change on basin hydrology and ice jam regimes. Overall large-scale drying of the PAD has been noted since at least the early 1970s, with constructed weirs mitigating effects to an extent; however, recharge of perched basins flooded from the Peace River has not occurred because of weir location (PADTS 1996). In addition, there is some evidence to show that the ice jam-related flooding frequency could decrease in the future because of climate change, which could lead to the potential for water level decreases. In contrast, effects from the Project in conjunction with operating, approved and planned oil sands developments in the Athabasca Oil Sands Region are not expected to adversely affect hydrology in the PAD because of the use of mitigation measures.

7.8.4 Summary

It is likely that wetlands will continue to shift towards drier communities with species, particularly in the area of the PAD historically flooded by the Peace River. Shifts toward drier communities might continue to occur from climate change and flow regulation. However, since effects on water levels and flooding in the PAD from the Project in conjunction with operating, approved and planned developments in the Athabasca Oil Sands Region are predicted to be negligible (see Section 7.4), effects on vegetation are also expected to be negligible.

7.8.5 References

7.8.5.1 Literature Cited

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7.9 Wildlife

7.9.1 Key Issues and Key Indicators

Key issues for the wildlife evaluation of potential relevance to the PAD included potential for changes in habitat availability and population levels. Habitat values and composition in the PAD might change because of hydrologic changes. The construction of the WAC Bennett dam in 1968 in British Columbia has been shown to have affected vegetation communities in the PAD during draw down of the Peace River (see Section 7.8).

Secondly, species composition of the PAD could be affected by displacement of animals from the Project area into the PAD. Of the species that will be displaced from the Project area, those most likely to relocate to the PAD include mobile species such as wood bison, moose, black bear and Canada lynx.

For a detailed discussion of key issues and associated key indicators for wildlife, see Volume 6, Section 4.

7.9.2 Historic Data, Existing Conditions and Trends

Parks Canada (2008, Internet site) states there are 214 species of birds and 42 species of mammals in the PAD. The PAD contains some of the largest undisturbed grass and sedge meadows in North America (RAMP 2011) that support many of WBNP's approximately 5,000 wood bison (Parks Canada 2009, Internet site). The PAD is also one of the most important nesting and staging areas for waterfowl in North America (Butterworth et al. 2002). All four major continental flyways converge at the delta (Timoney 2006, Wetlands International 2008, Internet site). During fall migration, an average of 300,000 to 600,000 waterbirds use the PAD each day (Timoney 2006). The PAD is also used by tundra peregrine falcon and the only self-sustaining population of whooping cranes in the world (Timoney 2002, IBA 2010, Internet site).

The PAD, by its nature, is a dynamic environment that has undergone wide fluctuations in wetness (Timoney 2002, Timoney 2009). Since the mid 1920's, there has been an overall drying trend in the PAD (Timoney 2006) that might be caused by geomorphic evolution of the delta, and by climate change. The installation of the W.A.C. Bennet dam on the Peace River in British Columbia is often cited as a cause of low water levels and reduced recharge of wetlands in the PAD (NRBS 1997, Carbyn et al. 1998).

Waterfowl use of the delta is responsive to the hydrodynamics of the system. A flood event in the PAD in 1996-1997 resulted in many perched basins being flooded for the first time in 25 years followed by an 89% increase in total ducks during the following two years (USFWS 2001).

Whooping cranes are a globally endangered species with only 237 individuals left in the wild as of 2007 (Environment Canada 2007). The only self-sustaining population nests in the northern part of WBNP. The PAD is an important stop over during whooping crane spring and fall migration (Environment Canada 2007). However, this species nests at the northern end of the park, over 150 km from the PAD

The PAD is the most important primary winter and summer range for wood bison in WBNP (Carbyn et al. 1998). Wood bison populations in WBNP have undergone broad fluctuations within historical times. Unregulated hunting in the 19^{th} century caused the population to decline to about 300 individuals at the turn of the century (Carbyn et al. 1998). From 1925 to 1928, 6,673 plains bison were introduced into WBNP (Carbyn et al. 1998). These animals, infected with the cattle diseases brucellosis and tuberculosis, hybridized with many of the remaining wood bison in the park. The bison population in WBNP reached 12,500 – 15,000 animals in the park in the late 1940's and early 1950's, but was about 11,000 animals in 1971 (Carbyn et al. 1998). Because of a variety of factors including disease and the end of wolf control, numbers tapered to a low of about 2,300 in 1998 (Carbyn et al. 1998). Population in the park began to rise in late 1990's to about 5,600 animals in 2005 (Parks Canada 2009, Internet site).

7.9.3 Environmental Evaluation

Changes in PAD water levels could result in a shift to drier conditions, which would be of particular concern for wildlife species that rely on wetland communities and associated plant species. However, with the use of mitigation measures, there is no evidence to suggest that changes of water levels and flood events in the PAD are linked to the Frontier Project, in conjunction with existing, approved and planned developments in the Athabasca Oil Sands (see Sec. 7.5). Therefore, for species like waterfowl which use the wetlands found in the PAD for staging and nesting, effects from the Project within the PAD are considered negligible.

The temporary loss of wildlife habitat resulting from construction of the Frontier Project might cause some wildlife to be displaced into the PAD. Species likely to be displaced include large mobile mammals such as moose, wood bison, black bear and Canada lynx. The PAD contains abundant summer and winter habitat for wood bison and moose. It is likely that any individuals displaced into the PAD would find suitable habitat to meet their requirements. It is unlikely that enough individuals would be displaced into the PAD to negatively affect the community composition of the delta. Less habitat is available in the PAD for black bear and lynx, and any individuals displaced from the Frontier Project area would likely relocate to other areas outside of the PAD. As a result, effects of the Project on wildlife populations within the PAD are considered negligible.

7.9.4 Summary

While shifts toward drier communities might continue to occur from climate change and flow regulation, effects on water levels and flooding in the PAD from the Project in conjunction with operating, approved and planned developments in the Athabasca Oil Sands Region are predicted to be negligible (see Section 7.4.4). Effects on wildlife are also considered negligible.

The temporary loss of wildlife habitat resulting from construction of the Frontier Project might cause some wildlife to be displaced into the PAD, particularly for large mobile mammals such as moose, wood bison, black bear and Canada lynx.

7.9.5 References

7.9.5.1 Literature Cited

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7.10 Human Health

7.10.1 Key Issues and Key Indicators

Fort Chipewyan is the only community that is next to the PAD and was included in the human health risk assessment (HHRA) to ensure that potential human health risks were adequately characterized for this area, which relies on the PAD for traditional foods.

As presented in the HHRA (see Volume 7, Section 2.2.3), key health-related issues identified in discussions with residents from Fort Chipewyan included the following:

- The concern that fish from the Athabasca River and nearby waterbodies are unsafe to eat.
- The traditional Aboriginal diet is being replaced by store-bought diets. Some individuals were concerned about the health implications associated with a shift in diet.
- The pollution of the rivers and lakes and the related effects on health.
- The high rates of cancer and respiratory diseases in the community of Fort Chipewyan. Community members indicated that these diseases were very uncommon in the past.
- The overall human health consequences of the Frontier Project in combination with the other industrial activity in the region.

These concerns, as well as requirements set forth by the Government of Alberta, were addressed in the completion of the HHRA. The full HHRA for this Project is in Volume 7, Section 2.

7.10.2 Historic Data, Existing Conditions and Trends

Section 2.9 of the HHRA (see Volume 7, Section 2) provides a detailed overview of the existing health-related conditions in the region, including the PAD. Some general findings regarding human health and existing conditions in the area, as discussed in the HHRA, include:

- Air quality in Fort Chipewyan is only being slightly affected by regional development (Kindzierski et al. 2010).
- There is no evidence that environmental contaminant exposures associated with regional oil sands activities are present at Fort Chipewyan at levels expected to cause elevated human cancer rates (RSCEP 2010).
- A 2009 assessment of mercury concentrations in fish collected from the oil sands area determined that mercury concentrations measured in local fish were comparable to concentrations reported in the scientific literature for the same fish species in other areas of Alberta and Canada.

- In the Northern Lights Health Region (NLHR), within which Fort Chipewyan is located, the Age Standardized Incidence Rates (ASIR) for all invasive cancers was lower than the provincial average for females, and not significantly different than the average for males, in the years 2001 to 2003 (ACB 2006). Age Standardized Mortality Rates (ASMR) were comparable between the NLHR and the provincial average. While the overall observed cancer rate in Fort Chipewyan was higher than expected in a 2009 study conducted by the Alberta Cancer Board (ACB), the ACB (2009) concluded that the increased rates were likely attributable to the small number of cases identified, and that further investigation would be required to determine if the incidence rates were actually increased in the community or not, relative to other areas.
- Increased rates of cardiovascular disease, hypertension, chronic bronchitis, chronic obstructive pulmonary disease, diabetes and arthritis were observed per 100,000 individuals in the NLHR compared with the provincial average. Rates of cerebrovascular disease, asthma and chronic renal failure in the NLHR were at or below provincial averages (AHW 2007).

7.10.2.1 Results of the HHRA

The HHRA included an assessment of potential short-term and long-term health risks to residents in the region (including those living in the Fort Chipewyan area) in association with chemical emissions into either air or surface water.

To ensure that all individuals living in the region were included, the HHRA took into account all life stages (infant, toddler, child, adolescent and adult), with age-specific exposure assumptions being employed where possible and relevant.

While the inhalation assessment was limited to include only inhalation exposures, the potential long-term health risks of both inhalation of air and ingestion of local foods and surface water (including traditional food items and fish) were evaluated for residents. All locations where people are likely to frequent (communities, cabins, etc.) were included in the group of locations classified as residents, and the HHRA focused the results and discussion on the worst-case predictions for the group as a whole. Site-specific information regarding types of foods consumed (e.g., wild game, plants, fish) was taken into consideration where available. As the evaluation of chronic exposures from multiple pathways (food, water etc.) was based on worst-case exposures that people living permanently in the LSA might receive, given the distance to Fort Chipewyan from many of the emission sources, the risk estimates presented in the HHRA are higher than those expected for residents in the PAD.

The overall findings of the HHRA with respect to residents from all locations within the health study area (including Fort Chipewyan) are as follows:

- Emissions from the Project alone, and in combination with emissions from other sources, are not expected to result in adverse health effects in the oil sands region. The changes between the Base Case and Application Case risks are generally small, suggesting that the Project is not expected to contribute appreciably to health risks in the region. Cumulative environmental risks associated with the additional projects and activities planned for the region are also not expected to result in adverse health effects in relation to the chemicals of potential concern (COPCs).

- The predicted short-term air concentrations do not exceed health-based guidelines for any of the COPCs for the community of Fort Chipewyan. As such, the expected health risks associated with short-term exposures to the COPCs are expected to be low in the PAD.
- Accidental releases of the COPCs from upset conditions are not expected to result in adverse human health effects at the Project boundary. The predicted air concentrations in association with upset conditions at Fort Chipewyan are very low, and are much lower than applicable health-based exposure limits.
- The predicted long-term air concentrations of the COPCs evaluated in the HHRA are predicted to be below health-based guidelines in the community of Fort Chipewyan.
- The predicted incremental cancer risks for the Project are all less than the level considered to be "essentially negligible" by Health Canada (2009), for both inhalation and oral exposures, respectively, for all carcinogenic COPCs. All predicted incremental lifetime cancer risks at Fort Chipewyan evaluated in the HHRA are less than 1.0 in 100,000 and are thus considered to be essentially negligible.
- For the chronic multiple pathway assessment, the exposures are predicted to be below the health-based exposure limits for most of the COPCs, with a few exceptions. Exceedances were predicted for cobalt, manganese and methyl mercury. The predicted exposures of residents to these three COPCs are comparable to typical Canadian exposures. Because of conservative assumptions employed in the HHRA, the potential for adverse health effects as a result of exposure to these COPCs over the long-term is considered to be low.
- A pit lake scenario also was evaluated in the HHRA. The number and magnitude of exceedances predicted are comparable to those of the PDC case. In all instances, the conservative assumptions applied in the HHRA, specifically the exposure and toxicity assessments, likely resulted in the predicted risks being over stated. The pit lake scenario includes the assumption that access to the pit lakes will be restricted until such a time that access to the water could be considered to be safe for human exposure. As a result, it was presumed that people would not be consuming fish or be directly exposed to surface water in the pit lakes until such access was provided.

7.10.3 Summary

Overall health risks associated with the COPCs released from the Frontier Project and other developments are predicted to be low for residents of Fort Chipewyan.

7.10.4 References

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7.11 Discussion and Conclusion

The PAD is one of the world's largest freshwater deltas and is located in northeastern Alberta at the western end of Lake Athabasca where the Peace, Athabasca and Birch rivers converge. About 80% of PAD is in Wood Buffalo National Park (WBNP), a designated United Nations Educational, Scientific and Cultural Organization World Heritage Site (UNESCO) World Heritage Site. As such, it is managed and protected under the regulations of the *Canada National Parks Act* and Parks Canada's *Guiding Principles and Operational Policies* (Parks Canada 2009a, Internet site). The PAD is used by Aboriginal communities to undertake traditional pursuits and is considered a wetland of international significance; in 1982, it was listed as a Ramsar site.

The PAD, by its nature, is a dynamic environment that has undergone wide fluctuations in wetness. Since the mid 1920's, there has been an overall drying trend in the PAD that might be caused by geomorphic evolution of the delta or climate change (or both). The installation of the W.A.C. Bennett dam on the Peace River in British Columbia is often cited as a cause of low water levels and reduced recharge of wetlands in the PAD. Regardless of the cause, this historical drying trend has resulted in a drop in water levels and a decrease in ice-jam-related flooding frequency. In addition to lower water levels, particularly in perched basins, changes to soils and vegetation have occurred along with shifts in associated wildlife habitat. These observations corroborate the expressed concerns of Aboriginal community members regarding decreasing water levels and changes in ecosystems.

The cumulative environmental effects assessment completed for the Project in compliance with the TOR—included the PAD as part of the assessment only when the Project—when combined with other developments in the Athabasca Oil Sands Region, could have an effect on the PAD. For this reason:

- the assessment of air emissions and associated health risks included the PAD and, specifically, Fort Chipewyan
- the aquatics disciplines included the southern part of the PAD up to the divergence of the Embarras River from the Athabasca River

Other disciplines, including groundwater, soils, vegetation and wildlife did not include the PAD as part of their assessment as effects were restricted well south, including effects from air emissions.

The environmental evaluation of the PAD completed in this section was undertaken to address federal requests as well as concerns expressed by potentially affected Aboriginal communities and public stakeholders. The environmental evaluation noted:

- Groundwater quality and quantity would not be adversely affected in the PAD.
- Negligible surface water quantity and water and sediment quality, fish and fish habitat effects in Ronald Lake and the Athabasca River, including its divergence with the Embarras River. As a result of these negligible predicted changes, the aquatics RSA was not extended further into the PAD.

- Negligible changes to soils and vegetation as well as wildlife habitat as effects on water levels were considered negligible. In addition, the temporary loss of wildlife habitat resulting from construction of the Frontier Project was expected to result in some wildlife displacement into the PAD particularly for large mobile mammals such as moose, wood bison, black bear and Canada lynx. It is likely that any individuals displaced into the PAD would find suitable habitat to meet their requirements. It is unlikely that enough individuals would be displaced to negatively affect the community composition of the PDA. As a result, effects on wildlife populations within the PAD from the Project are considered negligible.
- Slight changes in air quality are expected in the PAD because of future developments including the Project; however, the general location and associated air quality of Fort Chipewyan and the larger PAD area will likely be still regarded as having the air quality of a rural remote location, also referred to as a background location.
- Overall health risks associated with the COPCs released from the Frontier Project and other developments are predicted to be low for residents of the PAD.

Glossary

μg/L	micrograms per litre
μg/m³	micrograms per cubic metre
μm	micrometre
μS/cm	microsiemens per centimetre
3H:1V	*A method used to describe the steepness of a slope, e.g., 3 units horizontal to 1 unit vertical.*
7Q	Lowest 7-day consecutive average flow – *This can be measured at different intervals. Commonly 7Q10 (10-year) but also 7Q2 (2-year) or 7Q100 (100-year).*
95UCLM	upper 95 percentile confidence limit on the mean
/a	per annum, year
AADT	average annual daily traffic
AAAQG	Alberta Ambient Air Quality Guideline
AAAQO	Alberta Ambient Air Quality Objective
AAC	annual allowable cut
AAFRD	Alberta Agriculture, Food and Rural Development
AANDC	Aboriginal Affairs and Northern Development Canada
ABMI	Alberta Biodiversity Monitoring Institute
ACB	Alberta Cancer Board
ACCS	Alberta Culture and Community Spirit
ACFN	Athabasca Chipewyan First Nation
ACGIH	American Council of Governmental Industrial Hygienists
acidification	*A gradual increase in the acidity of a soil due to deposition processes. Acidification is caused by acid depositions which originate from anthropogenic emissions of three main pollutants: sulphur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3).*
ACIMS	Alberta Conservation Information Management System
ACMF	Air Contaminants Management Framework

ACR	acute-to-chronic ratio
ADAG	Alberta Acid Deposition Assessment Group
adaptive management	*A continuous improvement process of planning, implementing and evaluating results through monitoring and research programs and developing new plans from lessons learned.*
ADMF	Acid Deposition Management Framework
admixing	*Mixing topsoil with subsoil. It is of particular concern when subsoil is of poorer quality than topsoil.*
advanced low NO_x burner system	*A fuel burner system that produces low nitrogen oxides during combustion.*
advection	*The process of transport of an atmospheric property solely by the mass motion of the atmosphere.*
AENV	Alberta Environment
AEP	Alberta Environmental Protection
AESA	Alberta Environmentally Sustainable Agriculture
AESO	Alberta Electric System Operator
AFB	absolute fractional bias
AFE	authority for expenditure
aggregate	*Sand, gravel, crushed stone, or other granular material used for construction or industrial purposes.*
AGRASID	Agricultural Region of Alberta Soil Inventory Database
AGS	Alberta Geological Survey
AHS	Alberta Health Services
AIES	Alberta Interconnected Electric System
alkalinity	*A measure of the buffering capacity of a watercourse or waterbody, it provides an indication of sensitivity to acid deposition. It is expressed in terms of calcium carbonate ($CaCO_3$) and mainly reflects the presence of carbonates, bicarbonates and hydroxides.*
alluvial channel	*A river channel cut in alluvium. Its form reflects the load and discharge of the river rather than bedrock constraints.*

alluvial fan	*A fan-shaped deposit of sand and gravel, usually located at the mouth of a tributary valley. Material is transported and deposited by concentrated running water; the fan is typically formed by a combination of stream flood and debris flow activity.*
alluvium	*Loose, unconsolidated soil or sediments, eroded, deposited and reshaped by water in a non-marine setting. It typically comprises a variety of materials, including fine particles (silt and clay) and larger particles (sand and gravel).*
Al-Pac	Alberta-Pacific Industries Limited Inc.
ALS	ALS Laboratory Group
AMD	Air Monitoring Directive
AMP	access management plan
ANC	acid-neutralizing capacity
anion	*A negatively charged ion.*
ANPC	Alberta Native Plant Council
anthropogenic	*Human-made or caused*
anuran	*Vertebrate species such as frogs and toads that have long legs specialized for hopping and no tail.*
AOGCM	Atmosphere-Ocean General Circulation Model
AOP	annual operating plan
AOSA	Athabasca Oil Sands Area
AOSERP	Alberta Oil Sands Environmental Research Program
APEGGA	Association of Professional Engineers, Geologists and Geophysicists of Alberta
Application Case	*Assessment case that includes developments and activities in the Base Case with the Frontier Project added.*
AQA	air quality assessment
AQG	air quality guideline
AQHI	Air Quality Health Index
aquiclude	*An impermeable stratum or material that acts as a barrier to the flow of groundwater.*

aquifer	*A rock mass or layer containing saturated permeable material that can yield useable quantities of water to wells and springs (i.e., that can both store and transmit water). Aquifers are generally thought of as groundwater reservoirs that are extensive and that may be overlain or underlain by a confining layer.*
aquifuge	*A geologic unit that does not transmit or contain water.*
aquitard	*A material of intermediate permeability between an aquifer and an aquiclude. An aquitard allows some measure of leakage between the aquifers it separates.*
arboreal	*Species that are adapted to living and moving in trees.*
ARC	Alberta Research Council
archaeological potential	The likelihood that unrecorded archaeological sites are present in a given area. Its determination is often used to guide field studies.
areal evapotranspiration	*The amount of water that evapotranspirates to the atmosphere from a specified area, in a given time interval, and under specific energy and climatic conditions.*
argillaceous	*Rocks or sediments made of (or largely composed of) clay-sized particles or clay minerals.*
ARM	Athabasca River Model
ash	*Non-combustible residue from the combustion of coal.*
ASIR	Age-standardized incidence rates
ASL	ambient sound level – *Background sound or noise that includes transportation sources, animals, nature and non-ERCB regulated industrial facilities. It does not include industrial noise subject to* Directive 038. *The ASL does not include any energy-related industrial component and must be measured without it.*
ASL	acid-sensitive lakes
ASMR	Age-standardized mortality rates
ASP	area structure plan
asphaltenes	*A component of crude oil, heavy oil or bitumen that is insoluable in paraffinic solvents and is soluble in carbon disulphide.*
ASRD	Alberta Sustainable Resource Development
assessment case	*A description of environmental and development conditions at certain times that provides context from which to evaluate the environmental effects of the Project. For this assessment, three development scenarios are considered: Base Case, Application Case and Planned Development Case.*

assessment node	*A specific geographical site selected to quantify changes in watercourses and waterbodies in the local and regional study areas.*
ATC	Athabasca Tribal Council
atm-m³	atmospheres metres cubed
ATPRC	Alberta Tourism, Parks, Recreation and Culture
ATSDR	Agency for Toxic Substances and Disease Registery
attenuation	*A reduction of an effect (e.g., sound intensity or streamflow) by various means.*
ATV	all-terrain vehicle
AVI	Alberta Vegetation Inventory
avulsion event	*A rapid abandonment of an existing river channel and a formation of a new river channel.*
AWG	Air Working Group
AWI	Alberta Wetland Inventory
B/L	battery limit
bajada	*A broad, gently inclined, alluvial piedmont slope extending from the base of a mountain to a basin and formed by the lateral coalescence of a series of alluvial fans. The term is usually restricted to constructional slopes of intermontane basins.*
bankfull condition	*The water level or stage when a stream, river or lake is at the top of its banks.*
basal aquifer	*Water-bearing strata located at the lowest portion of a stratigraphic unit.*
Base Case	*Assessment case that includes developments that are currently operating or under construction, activities approved but not yet constructed, or those likely to be approved in the near future.*
baseflow	*That part of river flow that is not attributable to direct runoff from rainfall or from melting snow.*
baseline	*Conditions at a reference point in time with which later conditions are compared to assess the degree and character of change.*
BATEA	Best Available Technology Economically Achievable
bbl	barrel, petroleum (42 U.S. gallons)
bbl/cd	barrels per calendar day

bbl/sd	barrels per stream day
BC	base cation
BCF	bioconcentration factor
bcm	bank cubic metres
BCS	Bureau of Chemical Safety
benthic	*The ecological region at the lowest level of a sea or lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are called benthos.*
BFW	boiler feed water
bitumen	*A naturally occurring viscous mixture of complex hydrocarbons, with a specific gravity of about 1.0, that in its naturally occurring state will not flow to a well.*
bitumen froth	*Air-entrained bitumen with a froth-like appearance that is the product of the primary extraction and flotation bitumen recovery steps in the water-based extraction process.*
bitumen grade	*The amount of bitumen in oil sands usually expressed as a percentage by weight.*
BLM	Biotic Ligand Model
blowdown	*Water drained from the cooling tower basin to ensure, through make-up, that the circulating water quality remains acceptable.*
BMC	benchmark concentration
BMD	benchmark dose
BOD	biochemical oxygen demand
BOF	base of feed – *the bottom of the mineable ore zone based on the TV:BIP cut-off ratio applied such that each ore zone in the vertical column passes the cut-off ratio on an incremental and cumulative basis.*
bog	*Mineral-poor, acidic and peat-forming wetlands that receive water only from precipitation.*
boiler feed water	*Water that meets required purity specifications and is used in a steam generator to produce steam.*
BP	before present
braid delta	*A flat-topped and triangular or fan-shaped landform, made up of gravel, sand and finer sediment deposited by a glacial meltwater river discharging into a lake or the ocean. Commonly grades into a braidplain.*

breccia	*A rock composed of angular fragments of broken previously existing rocks. These lithic fragments are typically held together by a mineral cement or by a fine-grain matrix.*
brunisols	*Upland forest soils that have a thin leaf litter layer overlying reddish brown, sandy materials. They generally are prone to drought due to coarse texture and have low fertility levels.*
BTEX	benzene, toluene, ethylbenzene and xylenes
BTF	Biotransfer factor
bw/d	body weight per day
BWS	basal water sands – *McMurray Formation sand layers that are water saturated, and which occur in the interval between Devonian surface and oil sands.*
CAC	criteria air contaminant – *contaminants for which there are provincial or federal air quality objectives or standards.*
$CaCO_3$	calcium carbonate
CAEAL	Canadian Association for Environmental Analytical Laboratories
CALA	Canadian Association for Laboratory Accreditation Inc.
calendar day rate	*The average daily rate achieved (typically over a one-year period), determined by multiplying stream day rate (the maximum sustainable rate) by the process system availability factor.*
Cambrian	*Rocks that were laid down or otherwise formed between 570 and 510 Ma are assigned to a chronostratigraphic unit known as the Cambrian System.*
Canadian Shield	*Also known as the Precambrian Shield, it is an ancient platform of impermeable rock occurring in the Fort McMurray region.*
CANMET	Canada Centre for Mineral and Energy Technology
CAPEX	capital equipment expenditure
CAPP	Canadian Association of Petroleum Producers
Carboniferous	*Rocks that were laid down or otherwise formed in the timespan between approximately 360 Ma (end Devonian) and 290 Ma (begin Permian) are assigned to a chronostratigraphic unit known as the Carboniferous System.*
CASA	Clean Air Strategic Alliance
$CaSO_4$	calcium sulphate, gypsum
cation	*A positively charged ion.*

CC&R	closure, conservation and reclamation
CCAB	Canadian Council for Aboriginal Business
CCC	criterion continuous concentration
CCEMA	*Climate Change and Emissions Management Act*
CCL	compacted clay liner
CCME	Canadian Council of Ministers of the Environment
cd	calendar day
CEA	cumulative effects assessment
CEAA	*Canadian Environmental Assessment Act*
CEB	chronic effects benchmarks
CEM	continuous environmental monitoring
CEMA	Cumulative Environmental Management Association
CEMS	continuous emissions monitoring system
center reject	*Lean oil sand waste located below top of ore and above base of feed.*
CEPA	*Canadian Environmental Protection Act*
CFA	consolidated frequency analysis
CFHCP	conceptual fish habitat compensation plan
CFT	centrifuged fluid tailings – *a process whereby fluid fine tailings, to which flocculent has been added, is processed in centrifuges to produce a partially dewatered underflow and an overflow containing mostly water. Nominal underflow solids concentration from the centrifuges is 55% on a mass basis.*
CGKN	Canadian Geoscience Knowledge Network
CH_4	methane
CHD	closed hydrocarbon drain
CHRS	Canadian Heritage Rivers System
CL	critical load
clast	*An individual constituent or fragment of a sediment or rock, produced by the weathering of a larger rock mass.*

clastic	*Relates to a sediment or sedimentary rock whereby the particles (e.g. sand grains) have been derived from pre-existing rocks or minerals and have been transported some distance from their place of origin.*
CLI	Canada Land Inventory
closed-circuit operation	*A system in which potentially contaminated water is not discharged into a receiving stream but is reused (recycled).*
closure	*The Project phase after shutdown of operations and the site is remediated to a stable productive condition. Also used to describe the point when regulatory certification is received and the area is returned to the crown.*
cm/s	centimetres per second
CMC	criterion maximum concentration
CMS	Completions Management System (software)
CMT	construction management team
CNR	Canadian National Railway
CNRL	Canadian Natural Resources Limited
CNS	central nervous system
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COD	chemical oxygen demand
cogeneration	*The co-production of electricity and steam from the same unit or plant.*
coke	*A high-carbon byproduct produced by delayed or fluid coking in the process to upgrade heavy hydrocarbons to useable products.*
colluvium	*Materials deposited as a result of downslope movements due to gravity (e.g., rockfalls, landslides and debris flows). Colluvial deposits are composed of rock fragments of all sizes. Deposits are generally poorly sorted and poorly consolidated.*
compaction	*The process of pore space reduction in soil or sediments from heavier overlying material weighing the soil down.*
condensate extraction pump	*A pump that conveys the water out of the condenser hotwell and through the low pressure feed water system to the deaerator*

conductivity	*Measure of the ability of water to carry an electrical charge, determined by the concentration of dissolved substances. The major ions associated with conductivity are bicarbonate, carbonate, magnesium, calcium, sodium, chloride, potassium and sulphate.*
cone of depression	*A depression in the groundwater surface created when groundwater is pumped from a well. It is typically shaped as an inverted cone.*
confined aquifer	*Where an aquifer is encased above and below by a layer of comparatively low hydraulic conductivity.*
connate water	*Water entrapped in the pore space of a sedimentary deposit.*
CONRAD	Canadian Oil Sands Network for Research and Development
Consortium	Alberta Oil Sands Tailings Consortium
constructed reclamation lake	*A lake associated with external tailings areas and closure seepage remediation systems. For the location of constructed reclamation lakes for the Frontier Project, see Volume 1, Figure 13.6-4.*
COPC	chemical(s) of potential concern
COPD	Chronic Obstructive Pulmonary Disease
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPDFN	Chipewyan Prairie Dené First Nation
CPLA	central pit lake A
CPLB	central pit lake B
CPUE	catch-per-unit-effort
CR	carcinogenic risk
Cretaceous Period	*A period of geologic time 145 to 65 million years before present.*
CRISP	Comprehensive Regional Infrastructure Sustainability Plan
critical load	*The highest annual input of a pollutant that, at steady-state, does not cause unacceptable ecological or human health effects.*
CSE	culturally significant ecosystem – *Those areas within Fort McKay First Nation traditional lands that exhibit high value for renewable resource harvesting.*
CSL	comprehensive sound level – *The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement; used to determine whether a facility is complying with Directive 038*.

CSM	cutter soil mixing
CSSC	Canadian System of Soil Classification
CST	coarse sand tailings – *A coarse tailings stream from the cyclone underflow, consisting predominantly of water and sand but including a fluid fine tailings component. Fines content of CST deposits is typically in the 4-5% range, corresponding to a sand-to-fines ratio of about 20:1. CST is a segregating stream which produces FFT. Fines content of the CST stream is about 9%, corresponding to a sand-to-fines ration of about 10:1.*
CSTA	coarse sand tailings area
CT	consolidated tailings – *A mixture of sand and fines to which a coagulant has been added. Upon deposition, the sand and fines do not segregate and water is released.*
CTL	coniferous timber licence
CV	coefficient of variation
CWP	construction work package
CWS	Canada-wide standard
D/S	downstream
d50	*The average particle size is defined as the diameter when 50% mass of the material particles have a larger climate.*
dam^3	*Equals 1,000 cubic metres.*
daytime adjustment	*An adjustment that allows a 10 dBA increase because daytime sound levels are generally about 10 dBA higher than nighttime values.*
dB	decibel – *Logarithmic units associated with sound pressure level, sound power level or acceleration level.*
dBA	*A-weighted sound level expressed in decibels; where the sound pressure signal has been filtered using a frequency weighting that mimics the response of the human ear to quiet sound levels. The resultant sound pressure level is representative of the subjective response of the human ear.*
dBC	*C-weighted sound level expressed in decibels; often used in low-frequency noise analysis as the filtering effect is nearly flat at lower frequencies.*
DCS	distributed control system
DDA	dedicated disposal area – *An area dedicated solely to the deposition of captured fines using a technology or a suite of technologies.*

deaerator	*A device in which entrained air, oxygen, carbon dioxide and other non-condensable gases are removed from a process stream, such as bitumen froth, boiler feed water and steam condensate.*
dean stark	*A laboratory procedure used to determine the bitumen, water and solids content of oil sands.*
deep-seated	*Large landslide with a slide plane located at depth, rather than near the landslide surface. The slide moves as a coherent unit along this slide plane.*
deglaciation	*The uncovering of an area from glacier ice as a result of melting of the glacier.*
DEM	Digital Elevation Model
depositional habitat	*Still or slow-moving water where substrate consists of fine sediments such as sand, silt or clay. Organisms in these environments mostly live on top of the substrate or burrow into it.*
depressurization	*The process of reducing the pressure in an aquifer, by withdrawing water.*
development area	*Any area altered to an unnatural state. This represents all land and water areas altered by activities associated with the development of the Project oil sand leases.*
Devonian Period	*A period of geologic time 400 Ma to 360 million years before present.*
dewatering	*Removal of groundwater from a geological formation using wells or drainage ditch systems. The sediment is thus drained to an unsaturated condition.*
DFO	Fisheries and Oceans Canada
diagenesis	*The historical sequence of all chemical, physical and biological changes experienced by a sediment after its initial deposition and during and after it becomes a rock.*
diamicton	*Very poorly sorted sediment, composed of a particle sizes ranging from silt/clay to boulders. Coarse fragments are contained in a fine earth matrix.*
dilbit	*Diluted bitumen*
diluent	*A light liquid hydrocarbon added to bitumen to lower viscosity and density for the purpose of pipeline transportation.*
disconformity	*A significant interruption in the sequence of sedimentary rocks, generally by a considerable interval of erosion (or sometimes of nondeposition), and usually marked by a visible and irregular or uneven erosion surface.*

dispersivity	*Represents the mechanical mixing caused by groundwater velocity variations associated with the pores. Mixing that occurs along the flowpath is called longitudinal dispersion. Likewise, divergence across the flowpath results in transverse mixing, and this dilution effect is called transverse dispersion. Dispersion can be caused by mechanical mixing of groundwater flow through a porous medium and by chemical diffusion.*
disposal area	*An area dedicated to disposal of overburden and interburden. The disposal area can be located either inpit or expit.*
disturbed land	*Area where vegetation, topsoil or overburden is removed, or where topsoil, overburden and tailings are placed (as in mining).*
DL	detection limit
DLN	Dry low NO_x technology
DO	dissolved oxygen – *The amount of oxygen that is dissolved in a liquid, usually represented in parts per million (ppm).*
DOAG	Delegation of Authority Guideline
DOC	dissolved organic carbon
DQRA	detailed quantitative risk assessment
drawdown	*The amount that the groundwater level is lowered when water is pumped from a well.*
dried fines	*Materials created by the treatment of fluid fine tailings (FFT) in the thin-lift drying (TLD) process.*
drill hole	*A hole drilled into the ground using a drilling rig; used to determine the surficial geological stratigraphy.*
dS/m	decisiemen per metre (a measure of soil salinity)
DTED	daily threshold exposure dose
DUA	domestic use aquifer (or domestically useable aquifer)
dustfall	*The total amount of fine particles deposited by the atmosphere and falling onto the surface.*
dv	deciview
E	Simpson’s evenness index
EC	Eymundson Creek
EC_{25}	Effective concentration (25% test population); a measure of chronic toxicity

EC_{50}	Effective concentration (50% test population); a measure of chronic toxicity
echolocation	*Process by which bats emit high-frequency sound waves to search for food and navigate at night. It involves sensing the pattern of the reflected sound waves.*
Eco-SSL	ecological soil screening level
ETDA	external tailings disposal area – *An area dedicated solely to deposition of captured fines.*
EDI	estimated daily intake
EDP	emergency dump pond
EH&S	environment, health and safety
EIA	environmental impact assessment – *A review of the effects or changes that a proposed development will have on the local and regional environment.*
ELC	ecological land classification
EMB	energy and mass balance
emergency pond	*A pond located in the main plant facilities or along a pipe corridor to accommodate the emergency dumping of vessels or pipelines (mainly slurry containing) in the event of a plant upset or shutdown.*
energy equivalent sound level (L_{eq})	*An energy-average sound level taken over a specified period of time. It represents the average sound pressure encountered for the period. The time period is often added as a suffix to the label (e.g., L_{eq}(24) for the 24-hour equivalent sound level). L_{eq} is usually A-weighted. An L_{eq} value expressed in dBA is a good, single value descriptor of the annoyance of noise.*
entrainment	*Occurs when a fish is drawn into a water intake and cannot escape.*
entrenchment ratio	*A measure of the vertical confinement (bank height) of the stream.*
eolian	*Pertaining to sediment deposited by wind. Dunes and sheet sand deposits are made of sand, while silt forms blankets called loess.*
EP	engineer/procurement
EPA	(U.S.) Environmental Protection Agency
EPC	engineer/ procure/construct (subcontractor)
EPCM	engineer/procure/construction management (subcontractor)
EPEA	*Environmental Protection and Enhancement Act*

epicontinental sea	*A sea on a continental shelf or within a continent.*
EPT	Ephemeroptera, Plecoptera, Trichoptera (community)
ERA	ecological risk assessment
ERCB	Alberta Energy Resources Conservation Board (formerly the Energy Utilities Board or EUB) – *The agency responsible for deciding whether proposed oil, gas and oil sands projects should be approved and for many aspects of energy industry regulation*.
erosion risk	*An expression of the inherent sensitivity of a soil to erosion or its maximum erosion potential. Infiltration capacity and structural stability are considered the most important factors in controlling water erosion. Soil erosion risk increases as fine sand or silt content increases. As organic matter depth and vegetation cover increases, erosion risk decreases.*
ERP	emergency response plan
ERT	electrical resistivity tomography
ESL	effects screening level
ESA	environmentally significant area (*also*: environmental site assessment)
esker	*A long, narrow ridge-like body of stratified sand and gravel that was deposited by a subglacial or englacial steam.*
ET	extraction and tailings – *An area in the main plant facilities that deals with initial bitumen extraction, tailings processing, and tailings lines to the external tailings areas.*
ETA	external tailings area - *Tailings deposition area external to pit 1 and 2. Typically required in the initial years of mining and then as water clarification or storage facilities for longer term.*
EUB	[Alberta] Energy Utilities Board
euphotic	*The upper portion of the water column in a lake or river where light can still be found and photosynthesis can occur.*
evaporite	*A sedimentary rock composed of minerals produced by evaporation of a saline solution.*
evapotranspiration	*The combined losses of water from the earth's surface to the atmosphere through evaporation and transpiration. A major climatic process that return precipitated water to the earth's atmosphere as vapour.*
evenness	*Degree to which taxa of the same level are equal in abundance; a measure of biodiversity.*
existing conditions	*A reference condition or reference snapshot that approximately represents the conditions present today. This snapshot is characterized by baseline studies that were undertaken for the Project.*

F1	fraction 1 (of a petroleum hydrocarbon target and scan), also F2, F3, F4
FAA	U.S. Federal Aviation Administration
facies	*An observable characteristic of a rock or stratigraphic unit, such as overall appearance or composition.*
fairway	*The main channel of a river or bay.*
false negative	*The probability of concluding that a substance is absent when it is actually present.*
false positive	*The probability of concluding that a substance is present when it is actually absent.*
fan	*A gently sloping, fan-shaped mass of detritus forming a section of a low-angle cone; common where there is a notable decrease in gradient.*
FAT	factory acceptance testing
fault zone	*A fault where the displacement between two main rock masses occurs via several contributory minor faults rather than one single or main dislocation.*
FB	fractional bias
FCSS	family and community support services
FCV	final chronic value
feed water heater	*A heat exchanger used to increase the temperature of the condensate and feed water.*
FFT	fluid fine tailings – *Any fluid discard from bitumen extraction facilities containing more than 1 mass percent suspended solids and which behaves like a fluid. FFT comprises both thin fine tailings (TFT) and mature fine tailings (MFT).*
FGA	Facies Group Association
FHCL	fish habitat compensation lake – acronym only refers to the Frontier Project FHCL
FHOSP	Fort Hills Oil Sands Project
FHP	final harvest plan
fibric	*A textural descriptor applied to organic materials. The least decomposed organic material: it consists largely (>40%) of fibres whose botanical origin are readily identifiable; they retain their character when rubbed.*
field parameter	*Parameters that are routinely measured in the field using calibrated meters (e.g., pH, dissolved oxygen, temperature and conductivity).*

fines	*Mineral solids with particle sizes equal to or less than 44 microns based on sieve-hydrometer analysis or a method approved by the ERCB. (ERCB Directive 074).*
fines cake	*Any concentrated fines material, with low SFR, that is produced by application of fines management technology such as CFT, MFTD, PATLD or TLED.*
fines content	*Ratio of fines to total mineral solids on a mass basis.*
flocculant	*A chemical agent that enhances the solids removal rate by increasing the particle size; used to aid in the settling or consolidation of suspended material and the clarification of water and wastewater.*
fluid tailings	*Any fluid discard from bitumen extraction facilities containing more than 1 mass percent suspended solids and having less than an undrained shear strength of 5 kPa. (ERCB Directive 074).*
fluvial deposits	*Sediment transported and deposited by streams and rivers, including floodplain deposits, river terraces and alluvial fans.*
fluvial outwash sands	*Sand that is removed or washed out from a glacier by meltwater streams (i.e. a fluvial process) and deposited in front of or beyond the margin of a glacier.*
Fm	(Geological) formation – *A formally named and defined body of rock strata.*
FMA	forest management agreement
FMFN	Fort McKay First Nation
FMP	Forest Management Plan
FMU	forest management unit
FMZ	fish management zone
fossiliferous	*Sedimentary rocks containing fossils.*
FRD	Fire Road
freshet	*A sudden rise in the level of a stream caused by heavy rains or the rapid melting of snow and ice.*
froth	*Air-entrained bitumen with a froth-like appearance; the product of primary extraction and flotation bitumen recovery in the water-based extraction process.*
FRQ	frequency analysis
fry	*The period from hatching until one year; also referred to as young-of-the-year.*

FSMB	fish scale marker bed – *A regional stratigraphic marker in the western interior of Canada.*
FSU	froth separation unit
FT	froth treatment – *An area in the main plant facilities that receives froth generated in the extraction area and further treats it by adding solvent and heat to separate the bitumen from the water and solids, recover the solvent and send the treated tailings to the external tailings area.*
FTT	froth treatment tailings
fugitive emissions	*Trace amounts of uncombusted hydrocarbon substances that are released into the atmosphere during normal operations (except those from stacks and vents). Typical sources include gaseous leakage from valves, flanges, drains and volatilization from ponds.*
FVC	forced vital capacity
FWMIS	Fish and Wildlife Information Management System
g/cc	grams per cubic centimetre
g/s	grams per second
GCL	geosynthetic clay liner
GCM	global climate model
GCOS	Great Canadian Oil Sands
GDP	gross domestic product
geomorphic survey	*A survey of the earth’s shape, surface configuration and material.*
geomorphology	*The scientific study of the formation, alteration and configuration of landforms and their relationship with underlying structures.*
GHG	greenhouse gas – *Any gas in the atmosphere that absorbs infrared radiation (e.g., water vapour, carbon dioxide, methane, nitrous oxide, halogenated fluorocarbons, ozone, perfluorinated carbons and hydrofluorocarbons). GHGs are transparent to incoming solar radiation, but absorb outgoing terrestrial (infrared) radiation, and in turn re-emit it into the atmosphere. The net effect is a trapping of energy and a tendency to warm the earth's atmosphere, land and water surfaces.*
GIR	government and industrial relations
GIS	geographic information system
GJ	gigajoule (109 Joules)
GJ/h	gigajoules per hour

GJ/MWh	gigajoules per megawatt hour
GJ/sd	gigajoules per stream day
glacial till	*Unsorted and unstratified material deposited by a glacier; consists of a mixture of clay, silt, sand, gravel and boulders.*
glaciofluvial deposits	*Sediment formed by meltwater issuing from or within a glacier. The deposits are stratified and can occur in the form of outwash plains, deltas, kame terraces and eskers.*
glaciogenic	*A sediment or terrain feature that owes its origin to glacial processes.*
glaciolacustrine deposit	*Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes by water originating mainly from the melting of glacial ice.*
glauconitic	*Containing glauconite, a blue-green or yellow-green mineral, typically found in shallow marine sedimentary rocks.*
gleysols	*Mineral soils formed in wet areas with a water table within 1 m of the surface. These soils exhibit characteristics caused by chemical reducing conditions and tend to be too wet for good tree growth.*
glide	*Shallow (less than 0.3 m deep), wide, slow-flowing (less than 0.2 m/s), non-turbulent water lacking a defined thalweg. Substrate is usually silt/sand but may sometimes consist of gravel to small cobble.*
gneiss	*A rock that is formed by regional metamorphism. Bands of granular minerals alternate with bands of flake-like minerals showing a planar parallelism.*
GPS	global positioning system
ground truthing	*Field observations and measurements done to determine whether a map or interpretation of an aerial or satellite image accurately represents features on the surface of the earth.*
groundwater	*Subsurface water that occurs beneath the water table, in sediments or soils and geologic formations that are fully saturated.*
GTG	gas turbine generator
GWC	general works contractor (all construction disciplines)
H	horizontal
H_2S	hydrogen sulphide
ha	hectare
habitat potential	*The likelihood that a particular habitat can satisfy the requirements of a given life stage of a species.*

HADD	harmful alteration, disruption and destruction
hardness	*Measure of the amount of calcium and magnesium compounds in water, and other dissolved minerals (usually combined with carbonates or sulphates). Expressed as milligrams per litre (mg/L) calcium carbonate ($CaCO_3$).*
haze	*A general reduction in visibility over a wide geographic area that cannot be attributable to a single source and is usually due to cumulative emissions from multiple sources.*
HAZOP	hazard & operability (study)
HC_5 Value	*Concentration that is hazardous to no more than five percent of species in the community*
HD-MAPP	high-definition mapping and applications
HDPE	high-density polyethylene
HEC	human equivalent concentration
HEMP	human exposure monitoring program
HEP	habitat evaluation procedure
heritage value	*A measure of the relative importance of a palaeontological or archaeological resource, collection or site as determined by the palaeontological consultant during the palaeontological assessment.*
HHRA	human health risk assessment
historic archaeological sites	*Can be Aboriginal or non-Aboriginal and date from the time of European contact until approximately 1960.*
historic period sites	*Can include structures (e.g., homesteads, cabins, and forts), artifacts (e.g., industrial and folk-manufactured items made of metal, glass, ceramic, stone and other materials) or features (e.g., trails, foundations and campsites).*
historical resources	*Works of nature or of man, valued for their paleontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.*
HMW	high molecular weight
Holocene Epoch	The epoch of the Quaternary Period of geologic time following the Pleistocene Epoch (from present to about 10,000 to 12,000 years ago).
Hp	horsepower
HRIA	historical resources impact assessment – *A review of the effects that a proposed development will have on the local and regional historic and prehistoric heritage of an area.*

HRMB	Historic Resources Management Branch
HRSG	heat recovery steam generation
HRV	historic resource value
HSI	habitat suitability index
HSPF	Hydrologic Simulation Program – FORTRAN model
HTFT	high temperature froth treatment
HU	habitat unit
hummocky	*Irregular hillocks and hollows with slopes generally steeper than 10%; a landscape formed of small hills and depressions created by glacial deposition.*
HVAC	heating, ventilation, air conditioning
Hz	Hertz – *Unit of measurement of frequency, numerically equal to cycles per second.*
hydraulic conductivity (K)	*The permeability of soil or rock to water.*
hydrocyclone	*A device for separating sand from extraction tailings slurry using a rotating (cyclone) action. Water, fine tailings and residual bitumen separate to the overflow, and sand flows out the bottom of the device in a dense slurry.*
hydrogeology	*The science dealing with the occurrence of surface and groundwater and the related geologic aspects of surface water.*
hydrology	*The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings.*
hygric	*Soil moisture conditions where water is removed slowly enough to keep the soil wet for most of the growing season.*
IARC	International Agency for Research on Cancer
I/O	input/output
IC_{25}	inhibitory concentration (25% of test animals)
IC_{50}	inhibitory concentration (50% of test animals)
ID	interim directive
IDA	internal disposal area
IDF	intensity-duration-frequency

IFD	issued for design
IFE	issued for estimate
IFN	instream flow needs – *Minimum flow of water required for river habitat; used to define periods when river water withdrawls are not permitted*
IFR	issued for review
igpm	Imperial gallons per minute
IHS	inclined heterolithic stratification
ILCR	Incremental Lifetime Cancer Risk
ILM	integrated land management
impingement	*Occurs when an entrapped fish is help in contact with a water intake screen and is unable to free itself.*
interbedded	*Beds lying between or alternating with others of different character; especially rock material or sediment laid down in sequence between other beds, such as interbedded sands and gravels.*
interburden	*Formation material located between layers of oil sands ore that is removed for disposal to a waste area.*
interfingering	*Contrasting rock types that change laterally from one type to another, forming interpenetrating wedges.*
interflow	*A lateral movement of water that directly enters a stream channel or other body of water without having occurred first as surface flow. Usually measured in cubic metres per second.*
interfluve	*The area between rivers, especially the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction.*
intra-orebody aquifer	*Water-containing sand lenses (i.e., water-wet sand with little or no oil) commonly present within the oil sands.*
IOB	intra-orebody
IPCC	Intergovernmental Panel on Climate Change
IR	Indian Reserve
IRC	Industry Relations Corporation
IRP	Integrated Resource Plan
ISO	International Organization for Standardization

isopach map	*A map that shows the thickness distribution of a geologic unit by means of contour lines of thickness.*
isopleth	*A line on a map connecting locations having the same value of a given parameter.*
isostatic rebound	*The gradual upward recovery of continents that have been depressed under the weight of continental ice sheets. This happens once the ice melts and continues for some time afterward.*
ISQG	Interim Sediment Quality Guidelines
ITA	internal tailings area
JME	Jackpine Mine Expansion
joint	*A planer fracture in a rock; across the fracture, there is no displacement.*
Jurassic	*Rocks that were laid down or otherwise formed between 200 Ma to 210 Ma (end Triassic) and 135 Ma to 145 Ma (early Cretaceous).*
juvenile stage (fish)	*From one year old until a fish becomes sexually mature.*
ka	kilo annum (1,000 years before present)
K_{eq} H+/ha/a	kiloequivalents of hydrogen ions (protons) per hectare per annum (a measure of acid deposition)
kettle	*Steep-sided depressions formed by ice melt beneath sediment (most commonly beneath glaciofluvial sediment). A kettle with water in it is called a kettle lake.*
kg/a	kilogram per annum
kg/h	kilogram per hour
kg/MWh	kilogram per megawatt-hour
kJ	kilojoule
kJ/h	kilojoules per hour
kJ/kg	kilojoules per kilogram
kJ/kWh	kilojoules per kilowatt-hour
K_{ow}	octonol-water partition coefficient
kPa	kilopascal
kV	kilovolt
kW	kilowatt

kWh	kilowatt hour
L/d	litres per day
L/s	litres per second
Lacustrine	*A surficial geologic formation produced by, related to or formed in a lake.*
lamination	*A discrete layer of sedimentary rock less than 1 cm thick, differing from other layers in colour, composition or particle size.*
LAR	Lower Athabasca Region
LARP	*Draft Lower Athabasca Regional Plan*
LC_{25}	lethal concentration (25% test animals); a measure of acute toxicity
LC_{50}	lethal concentration (50% of test animals); a measure of acute toxicity
LCC	land capability class
LCCS	land capability classification system
LEE	low energy extraction
L_{eq}	energy equivalent sound level
LFN	low frequency noise – *Noise that ranges from infrasonic sounds (<20 Hz) up to 100 Hz.*
LIDAR	light detecting and ranging
lineament	*A geological feature that displays a line-like character.*
LIS	low impact seismic
lithology	*Defining characteristics of rocks, granular soil or sediment (e.g., mineralogy, grain size, texture and other physical properties).*
littoral	*The zone in a lake that extends from the shoreline to the maximum water depth where rooted aquatic plants have sufficient light to become established.*
LLD	legal land description
LLDPE	liner low-density polyethylene
LMW	low molecular weight
LOAEL	lowest-observed-adverse-effect level
LOC	license of occupation

LOEC	lowest-observed-effects concentration
lower heating value	*The heating value of a fuel that does not account for the effects of water vapour formed during the combustion process.*
low-flow event	*A period when low-flow conditions occur in a watercourse for a defined period of time.*
lowstand	*A geologic system where the sea level is below the shelf edge.*
LSA	local study area – *The maximum area where project-specific environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. Different LSAs are defined for each discipline.*
LSAS	Land Status Automated System
LSD	legal subdivision
LTFT	low-temperature froth treatment
LTRN	Long-Term River Network
luvisols	*Upland forest soils with a leaf litter layer over a gray washed-out layer, 15 to 20 cm thick, over grayish brown clayey subsoil. These are normal soils with respect to moisture and nutrient supply.*
m amsl	metres above mean sea level
m bgl	metres below ground level
m/s	metres per second
m^3/d	cubic metres per day
m^3/s	cubic metres per second
m^3/sd	cubic metres per stream day
Ma	mega annum (millions of years before present)
macrophyte	*An aquatic plant that grows in or near water and is either emergent, submergent or floating.*
MAH	Municipal Affairs and Housing
make-up water	*The process water required to replace that lost by evaporation or leakage in a closed-circuit, recycle operation.*
maltene	*A component of bitumen that is not associated with asphaltenes.*

mass movement	*Any process or sediment resulting from dislodging and downslope transport of soil and rock material as a unit under direct gravitational stress. The process may include slow displacement (e.g., creep, solifluction) or rapid movement (e.g., landslides, rock slides and falls, avalanches).*
MATC	maximum allowable toxicant concentration
matrix	*The groundmass of smaller grains in which larger particles are supported.*
MAWP	maximum allowable working pressure
maximum build-out	*All planned disturbances for a development.*
MBCA	*Migratory Birds Convention Act*
Mbcm	million bank cubic metres
MCFN	Mikisew Cree First Nation
MCR	maximum continuous rating
MD	municipal district
MDA	main development area – *Includes the North pit, Main pit and other main development facilities and landforms*.
MDA-SDA Corridor	Area connecting the main development area (MDA) with the south development area (SDA).
MDL	method detection limit
MDP	Municipal Development Plan
measureable parameter	*The metric used to measure and evaluate a key indicator.*
MeHg	methyl mercury
member	*A formally defined portion of a geological formation.*
m_{eq}/L	milliequivalents per litre (or molar equivalent per litre)
merchantable timber	*Trees that are cut down during clearing and can be marketed.*
mesic	*A descriptor of soil texture or moisture regime; organic material that is at a stage of decomposition that is intermediate between fibric and humic.*
metamorphism	*The process by which a pre-existing rock derives a new form that reflects mineralogical, chemical or meso to micro structural changes. The change(s) are usually promoted by temperature, pressure, shearing stresses and geochemical conditions.*

meta-sedimentary rocks	*Sedimentary rocks that were altered by metamorphic processes in Precambrian times.*
MFT	mature fine tailing
MFTD	mature fine tailings drying – *A process whereby fine fluid tailings, to which a flocculent has been added, is spread in thin lifts and then worked with large equipment using land-farming techniques to achieve a solids concentration in the 60% to 80% range by weight.*
MGA	*Municipal Government Act*
MIE	municipal impact exploration
mineral soil	*A soil consisting predominantly of, and having its properties determined predominately by, mineral matter. Usually contains less than 30% organic matter, but may contain an organic surface layer up to 0.4 m thick.*
MIP	mixed-in-place
MISAC	minimal impact seismic and access construction
mist net	*Refers to a net suspended between two poles made out of fine nylon mesh that is used to capture flying bats.*
MJ/h	megajoule per hour
MLL	miscellaneous land lease
MLP	miscellaneous lease permit
Mm^3	million cubic metres
mm Hg	millimetre of mercury
MOA	memorandum of agreement
model domain	*The region of interest for a numerical model (e.g., groundwater flow or air quality).*
MODFLOW	regional groundwater flow model
moisture regime	*The supply of moisture available for plant growth at a site.*
mol	mole
moraine	*An accumulation of earth, generally with stones, carried and finally deposited by a glacier.*
MOSA	Mineable Oil Sands Area
MPa	megapascal

MPMO	major project management office
MPOI	maximum point of impingement
MRL	minimum risk level
MSL	mineral surface lease (also maximum sound level)
$MtCO_2e/a$	million tonnes carbon dioxide equivalent per annum
muskeg	*A soil type comprised primarily of decayed vegetation prevalent in wet boreal regions.*
mustelid	*Mammals belonging to the weasel family (e.g., fisher, marten, otter and wolverine).*
MVA	megavolt ampere
MW	megawatt
MWh	megawatt-hour
NA	naphthenic acids
NAABA	Northeastern Alberta Aboriginal Business Association
NAAQO	National Ambient Air Quality Objective
NAAQS	National Ambient Air Quality Standard
NAD	North American Datum
NEB	National Energy Board
NFC	no fish captured
NFPA	National Fire Prevention Association
NG	natural gas
ng/L	nanograms per litre
NGO	nongovernmental organization
NIA	Noise Impact Assessment - *Identifies the expected sound level emanating from a facility*
NLP	Northern Lights project
nm	nanometre
NO	nitrogen oxide

NO_2	nitrogen dioxide
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
non-sport fish	species not specifically targeted by sport fishers, including species such as white and longnose suckers.
NO_X	oxides of nitrogen (NO, NO_2) (gas), or all nitrogen species (e.g., NO_x, N_2O, N_3O)
NPRI	National Pollutant Release Inventory
NPV	net present value
NRBS	Northern River Basins Study
NRC	National Research Council
NSMWG	NO_x-SO_x Management Working Group
NTP	National Toxicology Program
NTS	National Topographic System
NTU	nephelometric turbidity unit
nutrient regime	*The relative supply of nutrients available for plant growth at a given site.*
NWPA	*Navigable Waters Protection Act*
O_3	ozone
O & M	operation and maintenance
obliquity	*The tilt of earth's axis of rotation. It is one of three parameters that contribute to major ice age fluctuations of climate.*
OEHHA	California Office of Environmental Health Hazard Assessment
OHS	occupational health and safety
oil sands	*A sand deposit containing a heavy hydrocarbon (bitumen) in the pore space of sands and fine-grained particles.*
OLM	ozone limiting method
OMF	Ozone Management Framework
OMOE	Ontario Ministry of the Environment
OPEX	operating expenditure(s)

OPP	ore preparation plant – C*onsists of: truck dump, crusher, surge bin (stockpile) conveyors, rotary breakers and conditioning line.*
Ordovician	*Rocks that were laid down or otherwise formed between 510 Ma (end Cambrian) and 440 Ma (begin Silurian).*
organic compound	*Includes petroleum hydrocarbons, phenols, PAHs and naphthenic acids; these may originate from natural sources, such as eroding oil sands deposits (e.g., PAHs) or released from industrial sources.*
organic soil	*Soils with peat accumulations of 40 cm or more, found in bogs, fens and swamps. Water tables are commonly shallow or at the surface.*
orogency	*The process of generation of mountains.*
orthogonal joint sets	*Two sets of systematic joints that have propagated at right angles.*
OSCA	*Oil Sands Conservation Act*
OSDG	Oil Sands Developers Group
OSL	oil sands lease
OSRIN	Oil Sands Research and Information Network
OSSP	off-stream storage pond
OSTC	Oil Sands Tailings Consortium
OTHWG	once-through hot water generator
OTSG	once-through steam generator
overburden	*The soil, sand, silt or clay that overlies an oil sands deposit and must be removed to expose ore.*
P&ID	piping & instrument diagrams
PA/GA	public address/general alarm
PAA	Project assessment area – Includes the Project disturbance area (PDA) and areas where vegetation clearing may occur but is not currently planned.
PAC	polycyclic aromatic compounds
PAD	Peace-Athabasca Delta
PADD	Petroleum Administration for Defence District
PAH	polycyclic aromatic hydrocarbons
PAI	potential acid input

PAL	protection of aquatic life
palaeoclimate	*The prevailing climate at a given point in time in Earth's geologic past.*
palaeontological potential	*The likelihood of encountering fossils of high heritage value in a particular geological unit.*
palaeosol	*A soil that was formed in the past. Paleosols are usually buried beneath a layer of sediments and are thus no longer being actively created by soil formation processes like organic decay.*
palaeotopography	*The landscape or topographic relief of an area at a particular time in Earth's geologic past.*
PANH	polycyclic aromatic nitrogen heterocycles
parabolic dune	*A sand dune with a long, scoop-shaped form, convex in the downwind direction so that its horns point upwind, whose ground plan, when perfectly developed, approximates the form of a parabola.*
parent material	*The unconsolidated and more or less chemically weathered mineral or organic matter from which a soil's solum is developed by pedogenic processes.*
PCB	polychlorinated biphenyl
PCN	primary care network
PDA	Project disturbance area – Includes the Project area and reflects the anticipated limit of disturbance at the completion of operations in 2057. It includes *all lands subject to direct disturbance from the Frontier Project and associated infrastructure. This includes the surface ground area within the Project site that has either been previously cleared and/or disturbed (brownfield) or will be cleared and/or disturbed for construction and operation of the mine.*
PDC	Planned Development Case – *Assessment case that includes developments and activities included in the Application Case with other planned developments that are reasonably foreseeable added.*
PDD	public disclosure document
PDS	plant design system (drafting software by Intergraph)
peat	*Unconsolidated soil material consisting largely of undecomposed, or slightly decomposed, organic matter accumulated under conditions of excessive moisture.*
PEF	potency equivalence factor
PEL	probable effects level
pelagic	*Of or relating to the open ocean.*

PEP	project execution plan
Permian	*Rocks that were laid down or otherwise formed between 290 Ma (end Carboniferous) and 245 Ma (begin Triassic) are assigned to a chronostratigraphic unit known as the Permian System.*
PFD	process flow diagrams
Phanerozoic	*All rocks that were laid down or otherwise formed between end Precambrian and present are assigned to a chronostratigraphic unit known as the Phanerozoic Eon.*
PHC	petroleum hydrocarbon
piezometer	*A slimline (small diameter, e.g. 52 mm) well used to obtain information about groundwater surface elevations, hydraulic gradients and direction of flow, and hydraulic conductivity.*
pit lake	*A man-made lake used to fill a mine pit area.*
PLA	public land area
PLC	programmable logic control
Pleistocene Epoch	*The epoch of the Quaternary Period of geologic time (from about 10 to 12,000 to 1.6 million years ago), following the Pliocene Epoch and preceding the Holocene.*
plume blight	*Visual impairment of air quality that manifests itself as a coherent plume.*
PM_{10}	particulate matter less than 10 µm in diameter
$PM_{2.5}$	particulate matter less than 2.5 µm in diameter
PMF	predicted maximum flow
PO	purchase order
POI	point of impingement
polishing pond	*Pond designed to remove suspended sediment from waters before discharge into a receiving environment.*
ponding	*The natural formation of a pond by an interruption of the normal runoff.*
POP	preferred operating procedure (*also*: persistent organic pollutants)
porewater	*Water contained between grains of a soil or rock.*
porosity	*The percentage of the bulk volume of a rock or soil that is occupied by interstices minute openings or crevices), whether isolated or connected.*

post-glacial	*Pertaining to the time interval since the disappearance of glaciers or ice sheets from a particular area; similar to the Holocene Epoch.*
potential evapotranspiration	*The maximum quantity of water capable of being evaporated from the soil and transpired from the vegetation of a specified area, in a given time interval, under existing climatic conditions, and without limiting available surface moisture.*
power generator	*A device that converts rotational energy into electricity*
ppb	parts per billion
PPC	plume path coefficient
ppm	parts per million
PPRTV	Provisional Peer Reviewed Toxicity Value
PQRA	preliminary quantitative risk assessment
PR	piperock
Precambrian	*Rocks formed before the start of the Cambrian Period (540 million years ago). It covers about 90% of all geologic time.*
precession	*The trend in the direction of the Earth's axis of rotation, with a period of roughly 26,000 years. It is one of three parameters that contribute to important climatic and geologic cycles.*
precontact archaeological sites	*Include remains (e.g., stone tools, butchered bones, fire-broken rock and features such as hearths) resulting from the traditional occupation of Alberta by Aboriginal people before contact with European traders in the late 1700s.*
predevelopment	*A reference condition or reference snapshot, pre-1965, used to describe conditions and provide a reference from which to assess Project effects. Pre-1965 was chosen as a period prior to oil sands development activity*
PRM	Pierre River Mine
proglacial	*Immediately in front of or just beyond the limit of a glacier or ice sheet.*
Project area	*Includes all major works, such as mine pits, reclamation material storage, external tailings areas and bitumen processing.*
PSC	primary separation cell
PSD	particle size distribution – *The relative amounts of particles present, sorted according to size.*
PSL	permissible sound level – *The maximum sound level that a facility should not exceed at a point 15 m from the nearest or most affected dwelling unit.*

PSV (or PSC)	primary separation vessel (or cell) – *Primary extraction process equipment used in the first stage of separation of bitumen from the mineral solids contained in the oil sands feed. The PSV is generally situated after size-reduction equipment, such as rotary breakers, and before froth flotation equipment.*
PSV U/F	primary separation vessel underflow – *Also referred to a "coarse tailings", PSV U/F is a mixture of sand, fines, water and bitumen that can be used for sand dyke or beach construction*.
PT	proficiency testing
pulverizer	*Grinding machine used to crush coal to a very fine powder.*
PWMP	process water management pond
QA	quality assurance
QC	quality control
quartzose	*A substance which contains quartz as a principal constituent.*
Quaternary Period	*The most recent geologic time period, encompassing the last 2.6 million years. The Quaternary includes the Pleistocene and Holocene epochs.*
RAC	Regional Advisory Committee
RADS	Reactive Airway Dysfunction Syndrome
rain shadow	*An area having relatively low precipitation because a barrier causes prevailing winds to lose part or most of their moisture.*
RAM analysis	reliability, availability and maintainability analysis
RAMP	Regional Aquatics Monitoring Program
rankine cycle	*A thermodynamic cycle which converts heat into work. The heat is supplied externally to a closed loop, which usually uses water as the working fluid.*
RCM	regional climate model
RCT	recombined tailings – *A tailings stream formed by the recombination of coarse sand tailings and thickened tailings.*
RCTA	recombined tailings area
RCW	reclaim water – *Water recovered from the tailings. Reclaim water will be pumped from external tailings area to recycle water pond.*
receptor	*A permanent or seasonally occupied human dwelling that is regularly in use for at least six weeks per year.*

recharge	*When water is added to an aquifer directly (i.e., rainfall or snowmelt enters the subsurface and moves downward) or indirectly (i.e., following runoff to low lying areas, lakes or rivers with subsequent infiltration of water into the subsurface).*
recharge zone	*An area where geologic conditions are favourable for an infiltrating rainfall and snowmelt component to enter an aquifer, coinciding with a prevailing downward component of hydraulic head.*
reclamation	*The process of stabilizing and returning disturbed land to a state of equivalent or better capability, compared to predisturbance conditions.*
recycle water	*Recycle water is a combination of reclaim water and river water makeup. Recycle water is used for process water needs, especially slurry preparation.*
regeneration wastewater	*Water that is rejected from the water treatment process.*
regolith	*A general term for the blanket of fragmental and unconsolidated material that nearly everywhere forms the surface of the land.*
regosols	*Young soils with minimal soil formation and weakly developed horizons or layers.*
REL	Reference Exposure Level
relative humidity	*The ratio of actual water vapour in the air to the amount needed to saturate the air at the same temperature. Evaporation and evapotranspiration rates depend on the relative humidity of the air.*
RENEW	Recovery of Nationally Endangered Wildlife Initiative
RfC	reference concentration
RfD	reference dose
RFMA	Registered Fur Management Area
RFO	ready for operations
RFP	request for proposal
RFQ	request for quotation
Rge	range
riffle	*Partially to totally submerged pebble to cobble substrate, causing moderate turbulence and ripples in watercourses, with little to no whitewater*
riparian	*Of, relating to, or located on the banks of a river or stream.*
RIVM	Netherlands National Institute of Public Health and the Environment

RIWG	Regional Issues Working Group
RMA	resource management area
RMS	reclamation material stockpile – *An area for storing materials to be used during reclamation operations.*
RMWB	Regional Municipality of Wood Buffalo
RNV	range of natural variability
RO	reverse osmosis – *A method of water treatment.*
RoC	record of communication
Roche Moutonnee	*A glacially moulded rock mound exhibiting an asymmetrical form with a gently sloping and smoothly abraded, up-valley face contrasting with the steeper, broken, ice-plucked, down-valley face.*
rotary dump unloading	*A system used to unload coal railcars by rotating them upside down.*
ROW	right of way
RPD	relative percent difference – *A measure of precision.*
rpm	revolutions per minute
RQ	risk quotient
rs	Spearman rank order correlation coefficient
RSA	regional study area – *The area within which cumulative environmental effects are likely to occur, depending on physical and biological conditions (e.g., air sheds, watersheds, seasonal range of movements, population unit), and the type and location of other past, present or reasonably foreseeable projects or activities. Different RSAs are defined for different valued environmental components.*
RsC	risk-specific concentration
RSC	reduced sulphur compound
RsD	risk-specific dose
RSDS	Regional Sustainable Development Strategy
RTMP	Royal Tyrrell Museum of Palaeontology
runoff	*Water from rain or snow that flows over land to waterbodies or watercourses.*
run-on	*Similar to runoff, but referring to water that flows onto a property or any piece of land of interest.*

RUS	resource user survey
RUSLEFAC	revised universal soil loss equation for application in Canada
RWG	Reclamation Working Group (of the Cumulative Environmental Management Association)
RWI	river water intake
S	storativity
SAGD	steam-assisted gravity drainage
salinity	*The amount of soluble salts (for soil, it is expressed as electrical conductivity in dS/m).*
SAR	sodium adsorption ratio
SARA	*Species at Risk Act*
SCA	soil correlation area
SCADA	supervisory control and data acquisition
SCO	synthetic crude oil – *A mixture of hydrocarbons, similar to crude oil, derived from upgrading bitumen from oil sands.*
SCR	selective catalytic reduction – *A method of removing NOx from a flue gas stream.*
SCRAM	U.S. Support Centre for Regulatory Air Models
SCS	soil conservation service
SD	standard deviation
SDA	south development area – *Includes the Equinox pit and other south development facilities and landforms.*
sediment yield	*The volume or weight of sediment transported from a watershed per unit area in one year.*
seepage	*The slow movement of water or other fluid through a porous material, such as soil. Also refers to an area where water oozes from the ground.*
segregation	*Separation of fine and coarse fractions in tailings, during or after deposition. (ERCB Directive 074).*
SEIA	Socio-economic Impact Assessment
sep cells	separation cells – *Large, cylindrical open-top vessels that are used as the primary bitumen extraction device in water-based extraction processes.*

SEWG	Sustainable Ecosystems Working Group
SF	slope factor
SFR	sand-to-fines ratio
SIL	soil intensity level
Silurian	*Rocks that were laid down or otherwise formed between 440 Ma (end Ordovician) and 440 Ma (begin Devonian).*
sinkhole	*A depression in the landscape in a karst region. Drainage is subterranean, and a funnel shape is common.*
sinuosity	*Ratio of stream length to valley length.*
SIRs	supplemental information requests
SL	sound level – *the A-weighted sound pressure level expressed in dBA.*
SLERA	screening-level environmental risk assessment
slope stability	*The susceptibility of slope to landslides and the likelihood of slope failure.*
slump	*Material that has been deposited at the base of the slope by gravity during an event where part of the hillside has collapsed.*
SLWRA	screening-level wildlife risk assessment
SMA	surface mineable area
SMC	surface material licence
SME	surface material exploration
SML	surface mineral lease
SMP	stormwater management plan
SMV	species mean value
snapshot	*A point in time, often defined by a specific project milestone, and serving as a specific reference point to assess environmental conditions.*
SO_2	sulphur dioxide
SO_4	sulphate
soil moisture deficit	*The difference between the amount of water in the soil and the amount of water that the soil can hold.*

soil profile	*A vertical section of the soil through all its horizons and extending into the parent material.*
soil series	*Subdivisions of soil families based upon relatively detailed properties, including colour, texture, structure, consistence, thickness, abundance of coarse fragments, depth, concentration of soluble salts, pH, and lithology.*
SOPC	substance of potential concern
SO_X	sulphur oxide
species occurrence	*Refers to the presence of a species. It indicates the use of the area by a species for all or part of its life cycle. Species occurrence can be used to confirm presence; however, a species not detected does not confirm species absence.*
species richness	*The number of species or genera in a given area.*
sport fish	*Species which are actively sought by sport or recreational fishers, including northern pike, whitefish, walleye, arctic grayling and trout.*
SQG	soil quality guideline
SQS	supplier quality surveillance – *Specific QA criteria inspections and tests executed on behalf of Owner.*
SSD	Species Sensitivity Distribution – *A statistical extrapolation method that uses data from multiple species to derive a guideline.*
SSHE	safety, security, health & environment
STEL	short-term exposure limit
STG	steam turbine generator
storativity	*The volume of water an aquifer releases from or takes into storage due to pressure change.*
stormwater	*Water that is generated by rainfall and is often routed into drain or retention systems in order to prevent flooding.*
stratification	*The horizontal or inclined layered or bedded nature of a sequence of sedimentary strata.*
stratigraphy	*The succession and age of strata of rock and unconsolidated material. Also concerns the form, distribution, lithologic composition, fossil content and other properties of the strata.*
stratum	*A sheet-like body or layer of sedimentary rock.*
stream day rate	*The maximum sustainable daily rate (design capacity) for a process system.*

stream seomorphology	*The study of the shape, form and bed material of watercourses and their interpretation based on geology, climate and hydrology.*
streamflow	*The movement of surface water in a stream channel, usually measured in cubic metres per second (m^3/s). It describes the rate of flow past a specific location along the watercourse.*
subglacial	*Processes that occur in the bottom part of a glacier or ice sheet or immediately beneath a glacier.*
subhygric	*Soil moisture conditions where water is removed slowly enough to keep the soil wet for a significant part of the growing season.*
sublimation	*The transfer of frozen water (i.e., ice, snow and frost) from the land surface to the gas phase in the atmosphere without passing through an intermediate liquid phase.*
subnivean	*Small mammals such as mice, voles and shrews that rely on winter snow cover for survival.*
subsoil	*The B horizon of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equal of surface soil) in which roots normally grow.*
sub-watershed	*A smaller geographic section of a larger watershed unit, generally corresponding to an area drained by a small tributary.*
subxeric	*Soil moisture conditions where water is removed rapidly in relation to supply.*
surface flow	*A portion of water from precipitation that flows over a land to watercourse or waterbody, usually measured in cubic metres per second (m^3/s).*
surficial aquifer	*A deposit containing water at or near the surface of the earth.*
surrogate substance	*A parameter that has conservative attributes relative to the substance of interest. Typical attributes of a surrogate are that it (i) is more persistent in groundwater than the chemical of more direct interest, (ii) will be conveyed by the groundwater without retardation, and therefore it will arrive first, and (iii) is present at comparatively high concentrations, and therefore a high level of laboratory accuracy is better assured. The surrogate should be present in the same source as the substance or substances of direct interest. Chloride is a key surrogate for the oil sands region.*
suspended sediments	*Particles of matter such as sand or silt, often originating from the streambed, which become suspended in the water column as the water flows downstream. This is usually reported as total suspended solids (TSS).*
SVOC	semi-volatile organic compounds
SWMF	Surface Water Quality Management Framework

SWQG	surface water quality guideline
SWWG	Surface Water Working Group
t	Tonne – a metric ton (1,000 kg)
t/a	tonnes per annum
t/cd	tonnes per calendar day
t/d	tonnes per day
t/d/MWh	tonne per day per megawatt-hour
t/h or tph	tonnes per hour
t/sd	tonnes per stream day
t/sh	tonnes per stream hour
tailings	*A byproduct of the bitumen extraction process composed of water, sand, fines and residual bitumen. (ERCB Directive 074).*
tailings ponds	*Man-made impoundments structures used to contain tailings.*
tailings release water	*Water expelled from tailings during the course of consolidation.*
T-Alkalinity	total alkalinity
taxonomic richness	*The number of different species or genera within a community.*
TC	tolerable concentration
TCEQ	Texas Commission on Environmental Quality
TCU	total colour unit
TDGR	*Transportation of Dangerous Goods Act and Regulation*
TDI	tolerable daily intake
TDP	total dissolved phosphorous
TDS	total dissolved solids – *Measure of the combined content of all inorganic and organic substances contained in a liquid in a molecular, ionized or colloidal form; usually defined as a measure of all solids small enough to pass through a filter of two micrometres.*
TEEM	Terrestrial Environmental Effects Monitoring Program
TEF	toxic equivalency factor
TEH	total extractable hydrocarbons

TEMF	Terrestrial Ecosystem Management Framework
TEQ	toxic equivalency quotient
terrain integrity	*The stability of the landscape over time with respect to such factors as mass wasting (including erosion), settlement, seismic motion, tsunami activity and acid rock drainage. The capacity of the soils, surficial materials and bedrock to resist potential failure along a slope.*
TFA	temporary field authorizations
TFT	thin fine tailings – *A tailings product which forms from the segregation of tailings streams upon or after deposition. A portion of the fines from the tailings stream is trapped in coarse beach deposits but the remaining fines are dispersed and remain in suspension in water. TFT typically has a solids concentration of between 1% and 30% by weight.*
thalweg	*Path of the deepest thread of water in a watercourse.*
THC	total hydrocarbon compound
till	*Unsorted, unstratified glacial drift, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel and boulders.*
tillite	*A consolidated or indurated sedimentary rock formed by lithification of till, especially pre Pleistocene till.*
TJ	terajoule
TK	traditional knowledge – *Aboriginal knowledge and understanding of traditional resource and land use, harvesting and special places. May also be referred to as traditional ecological knowledge (TEK).*
TKN	Total Kjeldahl nitrogen
TLD	thin lift drying – *The process used to increase the solids concentration of fluid fine tailings (FFT) through a combination of drainage and evaporation to create a material capable of supporting terrestrial reclamation.*
TLDA	thin lift drying area
TLED	thin lift evaporative drying – *A process whereby mature fine tailings (MFT) is spread in thin layers and allowed to dry prior to placement of another lift over the first. TLED does not use flocculent.*
TLU	traditional land use – *Activities involving the harvest of traditional resources including hunting and trapping,* fishing, *plant harvesting, cultural activities, or any travel related to these activities.* Land *use maps document locations where the activities occur or are occurring.*
TLUOS	traditional land use and occupancy study
TLV	threshold limit value

TMAC	Trace Metals and Air Contaminants Group
TN	total nitrogen
TOC	total organic carbon
top of ore	*For each column of blocks in the three-dimensional geology and mining models, the top of the first zone passing ore cut-off grade (7 wt% bitumen) and minimum mining thickness (3 m) criteria.*
top reject	*Lean oil sand waste (below ore grade) located above the top of ore and below top of McMurray Formation.*
top waste	*Mine waste located above the top of McMurray Formation (i.e. above the top reject).*
TOR	terms of reference
total alkalinity	*Measure of the ability of water to neutralize acids to the equivalence point of carbonate or bicarbonate (pH 4.5).*
Total P	total phosphorous
total particulate matter	*Airborne particulate matter with an upper size limit of approximately 100 micro metre (µm) in aerodynamic equivalent diameter.*
toxicity	*Relating to harmful effects caused by a chemical substance present in water or sediments.*
TPA	trapline agreement
TPU	tainting potential units
traditional trail	*A trail identified as an historic or current travel route by Aboriginal peoples.*
trafficable deposit	*A deposit typically created through a process involving self-weight consolidation, enhanced drainage and/or capping, with minimum shear strength of 5 kPa one year after deposition. The trafficable surface layer must have a minimum undrained shear strength of 10 kPa five years after active deposition. (ERCB Directive 074)*
transmissivity	*The volume of water that will move in a porous medium per unit time under a unit hydraulic gradient through a unit width (at right angles to flow) over the whole thickness of the aquifer (e.g., m^3 per m per day, or simply m^2/day).*
Triassic	*Rocks that were laid down or otherwise formed between 245 Ma (end Permian) and 200Ma to 210 Ma (begin Jurassic).*
tributary	*A watercourse that flows into a larger (parent) watercourse or a waterbody.*
trophic level	*A group of organisms that occupy the same position in a food chain.*

TRS	total reduced sulphur
TRU	true colour unit
TRV	toxicological reference value
TSP	total suspended particulates
TSRU	tailings solvent recovery unit – *A process unit designed to remove solvent from the froth treatment plant tailings stream.*
TSRUT	tailings solvent recovery unit tailings - *Tailings generated by the froth treatment process. The stream consists of fine and coarse solids, water, rejected asphaltenes, and low levels of process solvent.*
TSS	total suspended solids – *Solid particles in a water sample that do not pass through a standard size filter. Usually measured in milligrams per litre (mg/L).*
TT	thickened tailings – *tailings produced using a thickener with the assistance of a flocculant acting on a hydrocyclone overflow stream in the tailing preparation process. The TT stream is designed to contain a high concentration of fines and to form a non-segregating deposit that releases additional water and consolidates to form a reclaimable surface over time.*
TTA	thickened tailings area (associated with ETA 1)
TU_a	acute toxicity unit CO_2e
TU_c	chronic toxicity unit
turbidity	*The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye; The measurement of turbidity is a key test of water quality.*
TUS	traditional use study
TV:BIP Ratio	total volume to bitumen in place – *The ratio of the total volume mined to the bitumen-in-place in the mined ore (m^3/m^3).*
Twp	township
U.S EPA OSW	United States Environmental Protection Agency Office of Solid Waste
U.S. EPA	United States Environmental Protection Agency
U/S	upstream
unconformity	*A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic succession, such as an interruption in the continuity of a depositional sequence of sedimentary rocks.*

upgraded product	*Often referred to as synthetic crude oil, upgraded product is bitumen that has undergone alteration to improve its hydrogen-carbon balance to a lighter specific gravity product.*
upgrader	*A facility for processing heavy oil or bitumen to reduce the density and viscosity of oil, and otherwise improve the value of the oil.*
URE	unit risk estimates
US NRC	United States National Research Council
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
V	volt
VCE	vegetation control easement
VFD	variable frequency drive – *A method of controlling an electric motor by controlling the frequency of the electric power supplied to it.*
viewshed	*A binary raster indicating the visibility of a viewpoint for or from an area of interest. A pixel with a value of unity indicates that the viewpoint is visible from that pixel, while a value of zero indicates that the viewpoint is not visible from the pixel.*
visual aesthetics	*A perception of visual beauty based on character, quality and scenic value.*
visual receptor	*An area of interest that could be adversely affected by visual changes caused by development. Receptors are used to measure change and evaluate potential visual effects.*
VOC	volatile organic compound
VRU	vapour recovery unit
Vug	*A small cavity in rock.*
W/m^2	watt per square metre
W4M	West of the Fourth Meridian
water yield	*Runoff contributed by the entire land area to a watercourse, including groundwater outflow that appears in the watercourse. Water yield is the volume of runoff from a watershed per unit area in one year.*
WBEA	Wood Buffalo Environmental Association
WBNP	Wood Buffalo National Park

WBS	work breakdown structure
WCR	[Alberta] Waste Control Regulation
WDS	[Alberta Environment's] Water Data System
wetted width	*The area in which water touches a stream channel's walls.*
WFP	work face planning
WHMIS	Workplace Hazardous Materials Information System
WHO	World Health Organization
winterkill	*When decomposition of organic material and use by fish and other organisms depletes oxygen to a point where fish begin to die.*
WMF	Water Management Framework
WMP	waste management plan
WMU	wildlife management unit
WQG	Water Quality Guideline
WRLIC	water resources licence
WSC	Water Survey of Canada
WT	whole tailings
wt%	weight-percent
WTA	waste transfer area
ZOI	zone(s) of influence