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This Environmental Impact Assessment and associated Baseline Reports were prepared for EnCana FCCL Ltd. by Golder Associates Ltd. (Golder Associates), Matrix Solutions Inc. and Nichols Applied Management as part of the Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G. The following Golder personnel (unless affiliations otherwise indicated) were responsible for completing the assessments as well as writing and editing these documents:

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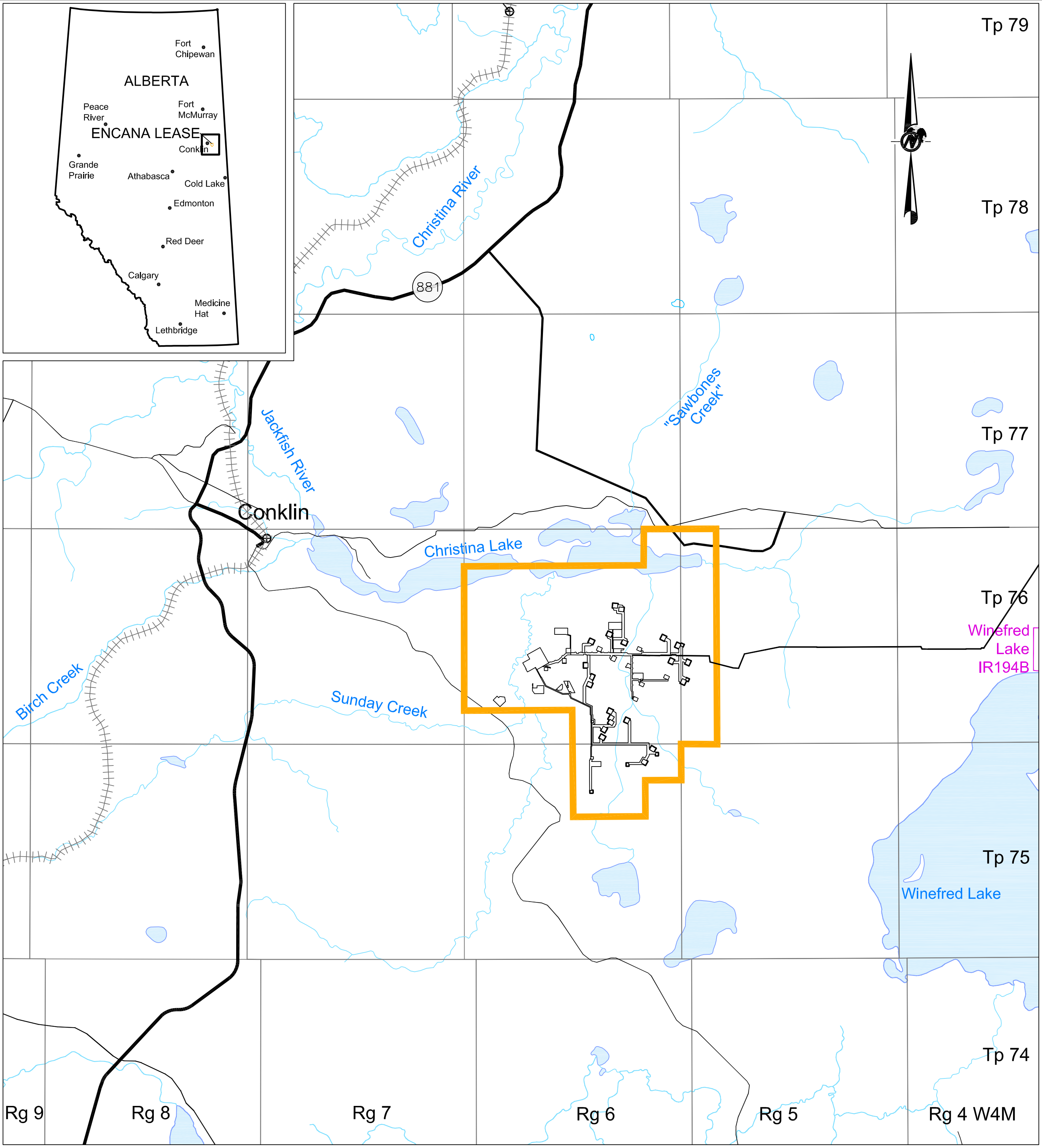
1 INTRODUCTION

EnCana FCCL Ltd. (EnCana) as operator for FCCL Partnership has been developing and operates a commercial scheme for the recovery of bitumen from the McMurray Formation at Christina Lake located in Section 16, Township 76, Range 6, West of the Fourth Meridian (W4M) (Figure 1-1). This scheme, including the use of in-situ Steam Assisted Gravity Drainage (SAGD) extraction well pairs and an on-site plant, operates under approvals issued by the Energy Resources Conservation Board (ERCB), No. 8591 and Alberta Environment (AENV), No. 48522-00-09. The Christina Lake Thermal Project (CLTP) is located about 20 km southeast of the community of Conklin, Alberta.

The original application for the CLTP was submitted to AENV and the ERCB formally known as Alberta Energy and Utilities Board in March 1998. In 2000, the CLTP was approved by the ERCB and AENV for production of 70,000 bbl/d (11,200 m^3/d) of bitumen over three phases of development (Phases 1, 2 and 3) each with a separate plant site.

Through a series of approval amendments the CLTP has been approved by the ERCB and AENV for a production of 98,800 bbl/d (15,709 m^3/d) of bitumen through the construction, operation and reclamation of Phases 1A, 1B, 1C and 1D. The amendments have involved expanding the original CLTP plant site instead of building three separate plant sites as originally proposed. Incremental production capacity originally envisioned from Phases 2 and 3 will still occur within the development area in a staged approached, increasing production at the Phases 1A and 1B site by 40,000 bbl/d (6,360 m^3/d) per phase via addition of Phases 1C and 1D. Overall surface disturbance has been reduced by combining the originally proposed three-phase (Phases 1, 2 and 3) into one larger expanded plant at a central location (Phases 1A to 1D).

The Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project) involves modifications and additions to the existing Christina Lake Phases 1A to 1D facilities to increase oil treating capacity to 218,800 bbl/d (34,789 m^3/d). This amendment involves expanding the approved Christina Lake facilities at the Phase 1 site by building three additional 40,000 bbl/d (6,360 m^3/d) phases, namely 1E, 1F and 1G. This will bring the cumulative production to 218,800 bbl/d (34,789 m^3/d) and a total of 23 Once Through Steam Generators (OTSG's) for Phases 1A to 1G the (Expanded CLTP).



LEGEND

- ROAD
- RAILWAY
- RIVER OR STREAM
- OPEN WATER
- INDIAN RESERVE
- ENCANA LEASE BOUNDARY
- PROJECT FOOTPRINT

5 0 5

SCALE 1:250,000 KILOMETRES

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001.
DATUM: NAD 83 PROJECTION: UTM ZONE 12

PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

PROJECT LOCATION

Golder Associates
Calgary, Alberta

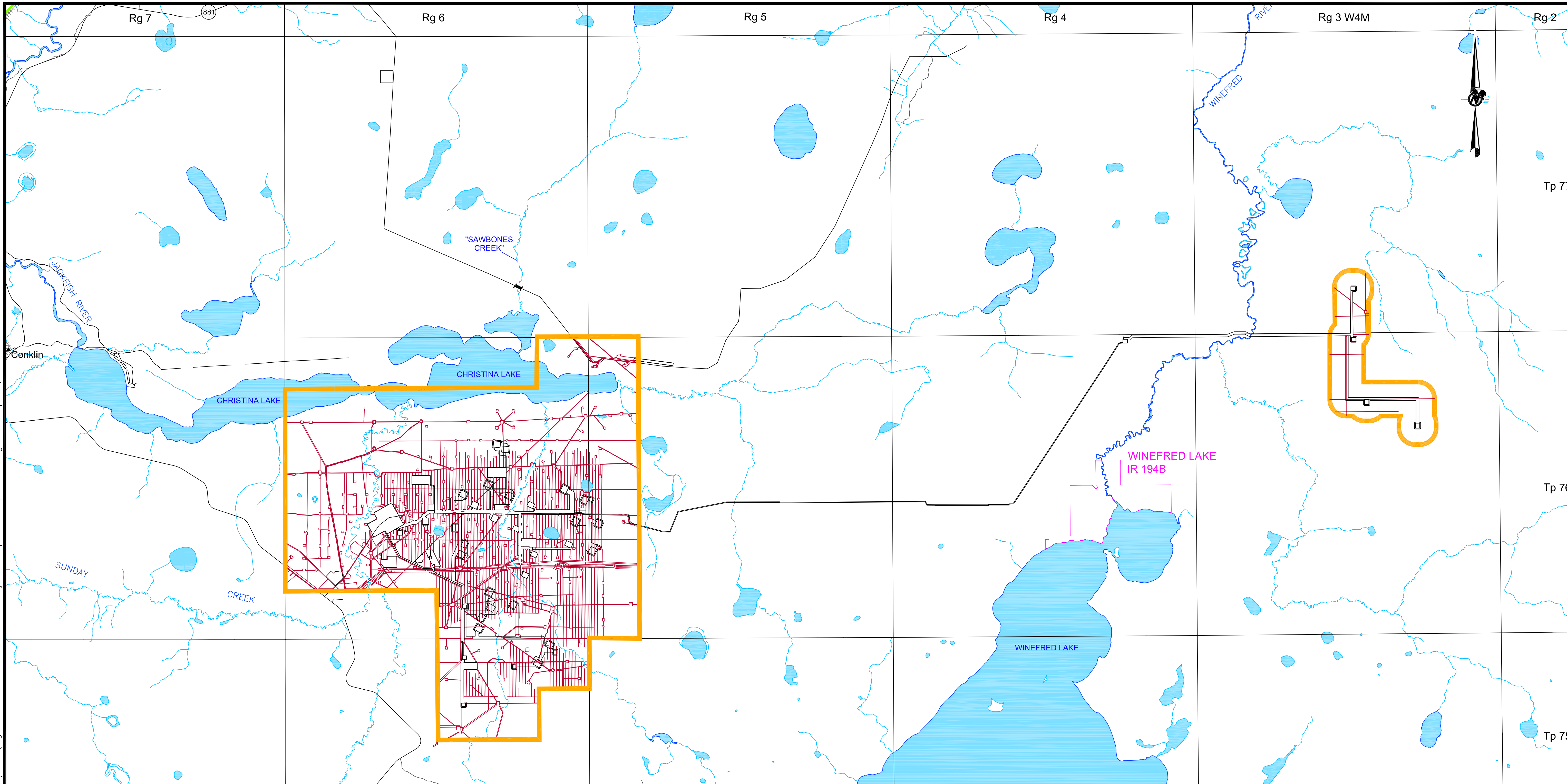
PROJ 09.1346.003.5100.9000			FILE No. 06134600390000A001	
DESIGN	LD	01/07/09	SCALE AS SHOWN	REV. 0
CADD	TRE	01/07/09	FIGURE: 1-1	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

L:\2006\1344-OIL SANDS\1346\06-1346-003\9000\9010\Fig 1-1 06134600390000A001 Project location.dwg Sep 18, 2009 - 3:33pm

In addition to the central plant modifications up to 19 well pads and 141 well pairs will be added. As well, up to 12 remote water disposal wells (located in Township 77, Range 3, W4M) and up to 11 saline water source wells on five well pads (located in Township 75, Range 6, W4M) will be added. Other supporting infrastructure modifications which are not part of the ERCB scheme such as diluent pipelines and Enbridge storage terminal tank, road upgrades, utilities, offices and camps will be applied for separately as appropriate.

Currently Phase 1C is under construction. The facility is designed to produce a maximum dry steam rate of 10,977 t/d for injection. This will require the installation of four new OTSGs. The steam injection capacity will be further increased by 10,977 t/d in Phase 1D by adding four more OTSGs. The facility will have a fixed maximum steam rate based on the number of steam generators available, while the maximum bitumen production rate will depend on the actual dry Steam-Oil Ratio (SOR) achieved. With the increase in oil production sulphur recovery will be required for Phases 1C and 1D. The design sulphur recovery criteria for production cumulative to Phase 1D will be 70% as required by ERCB regulations.

EnCana will develop Phases 1C and 1D within the approved Christina Lake oil sands development area. The Phases 1C and 1D developments can proceed in one of two ways. Under Option A there will be a total of 72 SAGD well pairs on nine new well pads; under Option B there will be a total of 66 well pairs on nine new well pads and two existing well pads. EnCana's preference is to use Option A; however that approach is conditional on the success of the ongoing re-pressurization project at CLTP. Option B will only be developed if the ongoing re-pressurization project is not successful.



LEGEND

- ROAD
- RIVER OR STREAM
- OPEN WATER
- INDIAN RESERVE
- PROJECT AREA
- PROJECT FOOTPRINT
- EXISTING AND APPROVED FOOTPRINT

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

2.5 0 2.5

SCALE 1:125,000 KILOMETRES

PROJECT

ENCANA.

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

PROJECT FOOTPRINT COMPONENTS

Golder Associates
Calgary, Alberta

PROJ	06.1346.003.9000		FILE No. 061346003900A002	
DESIGN	LD	01/07/09	SCALE AS SHOWN	REV. 0
CADD	TRE	17/08/09	**FIGURE: 1-2**	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

L:\2006\1344-OIL SANDS\1346\06-1346-003\9000\9010\Fig 1-2 061346003900A002 Project Footprint Components.dwg Sep 18, 2009 - 3:39pm

2 TERMS OF REFERENCE

The Terms of Reference (TOR) for the Environmental Impact Assessment (EIA) were submitted to AENV in February 2009. Alberta Environment issued the final TOR for the Project in July 2009 (AENV 2009). A copy of the TOR is provided in Appendix 2-I.

This assessment was completed to meet the relevant TOR (AENV 2009) for the Project (Appendix 2-I). The TOR also includes the requirements of the *Canadian Environmental Assessment Act* (CEAA) (Government of Canada 1994) and other applicable federal legislation. Volume 1 provides additional detailed *Environmental Protection and Enhancement Act* (EPEA) information requirements. Concordance tables have been provided in Appendix 2-II.

3 ASSESSMENT APPROACH

To gain approval for this development, EnCana has developed an integrated application to the ERCB and AENV for the Project. This application will provide details on the Project and provide supporting information for additional approvals for the Project. The application and EIA have also been completed to conform to the requirements of applicable legislation. The integrated application fulfills the requirements of the following Acts:

- *Canadian Environmental Assessment Act* (CEAA; Government of Canada 1994);
- *Climate Change and Emission Management Act* (Government of Alberta 2006);
- *Electric Utilities Act* (Government of Alberta 2003);
- *Alberta Environmental Protection and Enhancement Act* (EPEA; Government of Alberta 2006);
- *Fisheries Act* (Government of Canada 1995);
- *Historical Resources Act*, for clearance to construct the facilities (Government of Alberta 2000);
- *Migratory Birds Convention Act* 1994 (Government of Canada 1994);
- *Navigable Waters Protection Act* (Government of Canada 1985);
- *Oil and Gas Conservation Act*, for well and water disposal licenses (Government of Alberta 1983);
- *Oil Sands Conservation Act* (Province of Alberta 2000);
- *Pipelines Act* (AENV 2001) and Alberta EPEA (Government of Alberta 2006), for the construction and operation of new pipeline tie-ins for the Phase 3 plants;
- *Public Lands Act*, for surface rights (AENV 2000);
- *Species at Risk Act* (Government of Canada 2003); and
- *Transportation of Dangerous Goods Act* 1992 (Government of Canada 1992).

3.1 IMPACT ASSESSMENT OVERVIEW

The assessment of environmental and social considerations for the Project is presented as an integration of two key components of the Project. As stated in the TOR for the Project (AENV 2009), the EIA report will identify Project development activities and describe the effects, mitigation options and residual effects of the Project.

Information on EnCana operations as well as the development details for the Project are provided in Volume 1. Details on the EIA completed for the Project are provided in Volumes 2 to 6. This section details the purpose and approach for the EIA, including a description of the methods used to complete the EIA. The EIA methods used to assess the effects of the Project are described in Section 4, while the developments included in the assessment are listed in Section 5. A complete list of common and scientific names used throughout the assessment sections can be found in Appendix 2-III.

This EIA builds on a variety of environmental information collected in the region, other regional EIAs and specific Project information. All relevant provincial and federal regulatory requirements were considered in the development of the Project application and completion of the EIA.

Data sources for the EIA include:

- data collected during baseline studies for the Project as well as other developments in the region;
- data collected for the CLTP Pre-disturbance Assessments (PDA);
- data collected for previous regulatory applications; original 1998 CLTP application (PanCanadian 1998) and 2005 expansion amendment (EnCana 2005);
- digital elevation data for the study area (from National Topographic Database [NTDB]);
- government resource agencies, such as Alberta Sustainable Resource Development (ASRD) and AENV;
- government statistics;
- interviews with local trappers;
- Light Detection and Ranging (LIDAR);
- literature (published and unpublished) on environmental parameters relevant to the Project;
- oil sands development EIAs and associated, public supporting data;
- Project design details;
- published literature on environmental assessment methods;
- socio-economic information collected specifically for the Project;

- socio-economics interviews;
- Traditional Land Use information; and
- vegetation data (Alberta Vegetation Inventory [AVI] data supplied by Alberta Pacific Forest Industries Inc.).

Existing regional data was also used for the initial Project design work. EnCana will continue to incorporate findings and recommendations from regional efforts as part of the adaptive management of the Project.

The Quality Assurance and Quality Control (QA/QC) program for the Project EIA is detailed in Appendix 2-IV.

3.2 REPORT ORGANIZATION

The Project application and EIA have been organized into six volumes as follows:

- Volume 1 includes:
  - the application for the Project including ERCB and EPEA applications;
  - a corporate overview of EnCana;
  - a summary of the current CLTP operations;
  - a geological description;
  - a description of the reservoir recovery process;
  - a description of the Project;
  - environmental management and controls;
  - a summary of the EIA;
  - a summary of public consultation activities;
  - the Conservation and Reclamation (C&R) Plan; and
  - waste management and contingency plans.
- Volume 2 includes:
  - an introduction to the EIA;
  - EIA assessment methods;
  - monitoring programs; and
  - concordance tables.

- Volumes 3 includes assessments of:
  - Air Quality;
  - Noise;
  - Environmental Health (including human and wildlife health risk assessments); and
  - Air Emissions Effects.
- Volume 4 is an integrated volume of the following assessments:
  - Hydrogeology;
  - Hydrology;
  - Water Quality; and
  - Fish and Fish Habitat.
- Volume 5 is an integrated volume of the following assessments:
  - Terrain and Soils;
  - Terrestrial Vegetation, Wetlands and Forestry;
  - Wildlife and Wildlife Habitat; and
  - Biodiversity.
- Volume 6 includes assessments of:
  - Traditional Land Use;
  - Resource Use;
  - Visual Resources;
  - Historical Resources; and
  - Socio-Economics.
- Each volume also includes:
  - a list of references, a glossary, and a list of abbreviations and acronyms;
  - discipline-specific baseline reports, where applicable; and
  - appendices containing relevant supporting and/or additional information.

4 ENVIRONMENTAL IMPACT ASSESSMENT METHODS

4.1 OVERVIEW

The Project EIA was completed employing accepted techniques and in compliance with the regulatory requirements. The EIA addresses the requirements of the Project TOR (AENV 2009) as well as additional information to address federal regulations. The Cumulative Effects Assessment (CEA) completed as an integral component of the Project EIA meets the requirements of Section 16 of the *Canadian Environmental Assessment Act* (Government of Canada 1994).

4.1.1 Information Used

The Project EIA used the following information:

- quantitative and qualitative information on the environmental and ecological processes in the study areas, including Traditional Ecological Knowledge (TEK), where available and relevant information presented in previous environmental assessments;
- current, publicly available information about the past, existing and planned human activities in the study areas and the nature, size, location and duration of their potential interactions with the environment;
- information about ecological processes and natural forces that are expected to produce changes in environmental conditions;
- existing and proposed industrial projects, as well as activities associated with land use and infrastructure, to the extent information is known and available to the public six months prior to the submission of the assessment; and
- information on regional monitoring, research and other strategies or plans to minimize, mitigate and manage potential adverse effects.

4.1.2 Assessments Conducted

The information was used to analyze and address potential environmental effects of the Project. The assessments include:

- quantitative and qualitative descriptions of effects, with consideration of trends and uncertainties for the available information used in the EIA;

- descriptions of any deficiencies or limitations in existing environmental databases;
  - how identified deficiencies and/or limitations were addressed, considering their potential impact on the analysis and discussion on any appropriate follow-up;
- the use of appropriate predictive tools and methods, to enable quantitative estimates of future conditions with the highest possible degree of certainty;
- an evaluation of the effects, employing a system that is in compliance with the provincial and federal guidelines;
  - the ranking of the consequences of effects measured quantitatively against management objectives or baseline conditions and described qualitatively with respect to the views of the proponent and stakeholders;
- a description of management plans to prevent, or mitigate adverse effects and to monitor and respond to expected or unexpected conditions;
- a description of follow-up plans to verify the accuracy of predictions or determine the effectiveness of mitigation plans;
- a discussion of the assumptions and confidence in data to support conclusions regarding reclamation and mitigation success; and
- a description of residual effects and their environmental consequences.

4.1.3 Content of Reports

The Project EIA and baseline reports include the following information for each discipline:

- a description of the existing conditions;
- the identification of environmental disturbances from previous activities that are considered part of baseline conditions;
- a description of the nature and significance of environmental effects associated with Project development activities;
- comments on whether available data are sufficient to assess effects and mitigative measures;
- the presentation of plans to minimize, mitigate or eliminate adverse effects and impacts, together with a discussion of the key elements of such plans;

- the identification of residual effects and the significance of those impacts;
- the presentation of a plan to monitor environmental effects and manage environmental change to demonstrate that the Project will be operated in an environmentally sound manner;
- the presentation of a plan that addresses the adverse effects associated with the Project that may require joint resolution by government, industry and the community; and
- a summation of the mitigative measures that will be implemented for the Project.

4.1.4 EnCana's Climate Action Plan

EnCana is developing a corporate strategy for management of Greenhouse Gas (GHG) emissions. EnCana is studying alternatives for Carbon Capture and Storage (CCS) and investigating methods for incorporation into the current SAGD equipment template to facilitate a "CCS-ready" status for the project design. EnCana has a task force conducting research into reducing the cost of carbon capture. The task force is researching pre-combustion and oxyfuel technologies tailored for SAGD CO_2 capture.

EnCana recognizes that a federal/provincial/territorial climate change and environmental assessment working group has developed a general guidance document *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners* (FPTC 2003). EnCana has utilized the guidance document to assist in the completion of the Project EIA.

4.1.5 Assessment Cases

The Project EIA does not assess the effects of the Project in isolation. The three development scenarios addressed in the EIA are the Baseline Case, the Application Case and the Planned Development Case (PDC).

The Baseline Case establishes the conditions that would exist if the Project were not developed. It describes environmental conditions that include the effects resulting from existing and approved projects or activities within the study areas.

The Application Case describes the Baseline Case with the effects of the Project added. The Application Case includes both existing oil sands and other regional resource development activities and is a CEA for the Project.

The PDC includes the Application Case developments plus other regionally planned projects. The methodology for completing this case is the same as for the Application Case. The PDC for the Project includes consideration of the following, as required by the TOR (AENV 2009):

- EnCana will conduct a cumulative environmental effects assessment of the Project based on the AENV/EUB/Natural Resources Conservation Board (NRCB) Information Letter *Cumulative Effects Assessment in Environmental Impact Assessment Reports under the Alberta Environmental Protection and Enhancement Act* June 2000 (AENV, EUB and NRCB 2000). EnCana will include a summary of all proposed monitoring, research and other strategies or plans to minimize mitigate and manage potential adverse effects.
- The identification and assessment of the likely cumulative effects of the Project will:
  - define the spatial and temporal study area boundaries, and provide the rationale for assumptions used to define those boundaries for each environmental component examined;
  - describe the current (baseline) state of the environment in the Regional Study Area (used for the cumulative effects assessment) and the activities that have created the current conditions;
  - assess the incremental consequences that are likely to result from the Project in combination with other existing, approved and planned projects in the region;
  - discuss how relevant information or data used from previous oil sands and other development projects is appropriate for use in this EIA report;
  - consider and describe deficiencies or limitations in the existing database for relevant components of the environment; and
  - explain the approach and methods used to identify and assess cumulative impacts, including co-operative opportunities and initiatives undertaken to further the collective understanding. EnCana participates in cooperative efforts to address industry issues where it determines that such endeavours are effective. EnCana re-visits its participation in such cooperative efforts on an ongoing basis.

A PDC assessment is only completed for a component when the Application Case assessment results in a rating for predicted residual effects greater than negligible. The PDC is considered a conservative assessment of social and environmental conditions, since the projects included in the assessment may or may not proceed. In addition, the scope and size of the planned developments may change once designs are finalized and approved.

For the purposes of the Project, the information used for "Planned Projects" is based on what was publicly available on April 2, 2009. Projects disclosed after that date, or projects where approvals were issued or plans were modified after April 2009 were considered in the Project EIA based on the relevant information available as of the cut-off date.

The Application Case and PDC are both CEAs, as they consider the effects of existing and approved developments in combination with the Project and in combination with other planned projects. The CEA aspect of the Project has been completed to comply with the provincial land federal requirements, as detailed in the document *Cumulative Effects Assessment in Environmental Impact Assessment Reports under the Alberta Environmental Protection and Enhancement Act* (AENV, EUB and NRCB 2000) and to meet the requirements of Section 16 of the *Canadian Environmental Assessment Act* Government of Canada 1994). The process for completing the CEA as part of the Project EIA included consideration of guideline information as provided in the *Athabasca Oil Sands Cumulative Effects Framework Report* (Golder 1999a), and the *Cumulative Effects Practitioners Guide* (Hegmann et al. 1999).

4.2 KEY ISSUES AND KEY QUESTIONS

The Project EIA is explicit in identifying the key issues by addressing key questions. These key questions frame the relationships between the Project and the potential environmental impacts. This transparency allows reviewers to understand the rationale and assumptions used to make conclusions.

4.2.1 Key Issues

A key component of the impact assessment process is to identify and focus on the issues that are of greatest concern to stakeholders and regulators. This process was initiated through evaluation of the issues and responses in recent oil sands EIAs, recent oil sands application regulatory hearings, the *Regional Sustainable Development Strategy* (RSDS) *for the Athabasca Oil Sands Area* (AENV 1999), other relevant documents and through information received during consultation with stakeholders on the Project.

Some of the key issues associated with oil sands projects identified through regional initiatives such as RSDS and through consultation sessions include:

- sustainable ecosystems and end land use;
- air emissions and their effects on human health, wildlife and vegetation;
- water quality and quantity;
- fish and fish habitat;
- vegetation diversity;
- wildlife and wildlife habitat; and
- traditional land use.

Some of the issues considered in association with the Project include:

- facilities location;
- climate change considerations;
- air quality and noise;
- aquatic resources;
- terrestrial resources; and
- socio-economics.

Several of the key issues applicable to the Project are presented below. Additional issues relevant to the Project are provided within the Project EIA (Volume 3 to 6).

4.2.1.1 Facilities Location

The location of facilities and infrastructure relative to Christina Lake and associated watercourses has been identified as a key issue for the Project.

4.2.1.2 Climate Change Considerations

The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment issued a general guidance document in November 2003 for practitioners to use when incorporating climate change issues into environmental assessments (FPTC 2003). The guidance document sets out the following two approaches for incorporating climate change considerations:

- Greenhouse Gas considerations where the Project may contribute to GHG emissions; and
- impact consideration where changing climates may have an impact on the Project.

The federal guidance document indicates that projects are typically more closely aligned with one type of consideration or the other, but provides for cases where both considerations could be addressed.

In this application, production and management of GHG emissions is addressed in the air quality section of the EIA (Volume 3, Section 1). Consideration and predictions of how changing climates may impact on the Project are addressed in Appendix 2-V.

The Project application and EIA provide the following information with respect to consideration of climate change in the assessment.

Quantification of Greenhouse Gas Emissions

The predicted GHG emissions associated with the construction and operation of the Project are assessed in Air Quality Key Question Air Quality Application Case (AQAC)-6 in Volume 3, Section 1.8.

Identification of Project Sensitivities to Climate Change

The design, operations and reclamation planning for oil sands operations in northeastern Alberta consider relatively extreme climate variables as an expectation for occurrence during the life of the Project. This includes design for operations under possible operating temperatures ranging from -40 to +35°C.

An evaluation of the historic changes in temperature and precipitation as well as the possible changes in the future was completed for the Project (Appendix 2-V). The results from that assessment indicate increases in temperature are expected, while changes in precipitation are less well defined but are within existing annual variation. The results of the evaluations showed that potential predicted changes in key climate variables are not predicted to adversely impact the planned construction, operation and reclamation of the Project.

4.2.1.3 Air Quality and Noise

Key issues include the following:

- emissions of oxides of sulphur dioxide (SO_2), nitrogen (NO_x), GHGs and Particulate Matter (PM), as well as other industrial emissions;
- effects of emissions on ecological receptors; and
- effects of sound levels on people, wildlife and local traditional land uses.

4.2.1.4 Aquatic Resources

Key issues include the following:

- groundwater withdrawals and potential effects on groundwater quality and quantity, as well as surface water flows and water levels;
- watercourse crossings and associated effects of suspended sediment entrainment and deposition;
- natural drainage and flow patterns;
- wastewater management;
- runoff management;
- spill management;
- acid deposition from air emissions;
- effects on fish and fish habitat, including benthic invertebrate communities; and
- effects of fishing pressure.

4.2.1.5 Terrestrial Resources

Key issues include the following:

- caribou habitat and movement (Christina Caribou Zone);
- old growth forest;
- rare plants;
- habitat fragmentation; and
- reclamation.

4.2.1.6 Traditional Land Use

Key issues include the following:

- medicinal plants;
- traplines; and
- trail access.

4.2.1.7 Resource Use

Key issues include the following:

- aggregate resources;
- berry picking;
- environmentally important areas;
- fishing;
- forestry;
- hunting and trapping; and
- recreation.

4.2.1.8 Socio-Economic

Key issues include the following:

- traditional use;
- job creation;
- regional infrastructure and services; and
- community, regional and provincial benefits.

4.2.2 Key Questions

Key questions have been identified for each EIA component to address the specific issues identified by the communities, stakeholders, regulators or technical experts. The key questions also address issues detailed in the EIA TOR as that document is designed to focus on the key issues associated with the Project. Although key questions are used to focus the impact assessment, issues over and above those captured in the key questions are also addressed.

Key questions are provided for both the Application Case and PDC. The PDC key questions are intended to focus the effects assessment on the primary cumulative effects issues associated with the Project in relation to other planned projects. Therefore, if the Application Case resulted in the determination that the Project had a negligible residual effect, the assessment under the PDC may not be completed as the effects of the Project are not expected to overlap with those of future planned projects.

Key questions for the Project are summarized in Table 4.2-1 and 4.2-2.

Table 4.2-1 Summary of Key Questions for the Project: Application Case

Number	Key Question
Air Emissions Effects	
AEEAC-1	What effects could air emissions from existing and approved developments and the Project have on waterbodies and the aquatic resources therein?
AEEAC-2	What effects could air emissions from existing and approved developments and the Project have on soils?
AEEAC-3	What effects could air emissions from existing and approved developments and the Project have on terrestrial vegetation and wetlands?
AEEAC-4	What effects could air emissions from existing and approved developments and the Project have on wildlife habitat?
Human Health	
HHAC-1	What effects could emissions from existing and approved developments and the Project have on long-term (chronic) exposure and human health?
HHAC-2	What effects could emissions from existing and approved developments and the Project have on short-term (acute) exposure and human health?
HHAC-3	What effects could emissions from existing and approved developments and the Project have on $PM_{2.5}$ emissions and human health?
Wildlife Health	
WHAC-1	What effects could emissions from existing and approved developments and the Project have on long-term wildlife health?
Air Quality	
AQAC-1	What effects could existing and approved developments and the Project have on ambient air quality in the region?
AQAC-2	What effects could existing and approved developments and the Project have on the deposition of acid-forming compounds in the region?
AQAC-3	What effects could existing and approved developments and the Project have on concentrations of ground-level ozone in the region?
AQAC-4	Will emissions from the Project be in compliance with relevant provincial and federal emission guidelines?
AQAC-5	What effects could existing and approved developments and the Project have on odours at the selected receptors?
AQAC-6	What is the contribution of the Project to greenhouse gas emissions?
Noise	
NAC-1	What effects could activities associated with the Project have on noise at nearby dwellings and local wildlife?
Hydrogeology	
HGAC-1	What effects could existing and approved developments and the Project have on groundwater quantities, levels and flow patterns?
HGAC-2	What effects could existing and approved developments and the Project have on groundwater quality?
Hydrology	
HAC-1	What effects could existing and approved developments and the Project have on open-water areas, flows and water levels in receiving and nearby waterbodies?

Table 4.2-1 Summary of Key Questions for the Project: Application Case (continued)

Number	Key Question
HAC-2	What effects could existing and approved developments and the Project have on the geomorphic conditions of watercourses and the concentration of suspended sediments in the watersheds and drainage systems?
Water Quality	
WQAC-1	What effects could existing and approved developments and the Project have on water quality?
Fish and Fish Habitat	
FAC-1	What effects could existing and approved developments and the Project have on fish habitat?
FAC-2	What effects could existing and approved developments and the Project have on fish health?
FAC-3	What effects could existing and approved developments and the Project have on fish abundance?
FAC-4	What effects could existing and approved developments and the Project have on fish and fish habitat diversity?
Terrestrial	
TRAC-1	What effects could existing and approved developments and the Project have on the quantity of terrain and soils, and soil quality/capability?
TRAC-2	What effects could existing and approved developments and the Project have on terrestrial vegetation, wetlands and forestry?
TRAC-3	What effects could existing and approved developments and the Project have on wildlife abundance and habitat?
TRAC-4	What effects could existing and approved developments and the Project have on biodiversity?
Historical Resources	
HRAC-1	What effects could existing and approved developments and the Project have on historical resources?
Resource Use	
RUAC-1	What effects could existing and approved developments and the Project have on environmentally important areas?
RUAC-2	What effects could existing and approved developments and the Project have on natural resources and non-traditional resource users?
Socio-Economic	
SEAC-1	What effects could existing and approved developments and the Project have on the regional and provincial economy?
SEAC-2	What effects could existing and approved developments and the Project have on the regional population?
SEAC-3	What effects could existing and approved developments and the Project, and associated population growth have on the regional services and infrastructure?
Traditional Land Use	
TLUAC-1	What effects could existing and approved developments and the Project have on traditional land uses?
Visual Resources	
VRAC-1	What effects could existing and approved developments and the Project have on visual resources?

Table 4.2-2 Summary of Key Questions for the Project: Planned Development Case

Number	Key Question
Air Emissions Effects	
AEEPDC-1	What effects could air emissions from existing and approved developments, the Project and planned developments have on waterbodies and the aquatic resources therein?
AEEPDC-2	What effects could air emissions from existing and approved developments, the Project and planned developments have on soils?
AEEPDC-3	What effects could air emissions from existing and approved developments, the Project and planned developments have on terrestrial vegetation and wetlands?

Table 4.2-2 Summary of Key Questions for the Project: Planned Development Case (continued)

Number	Key Question
AEEPDC-4	What effects could air emissions from existing and approved developments, the Project and planned developments have on wildlife habitat?
Air Quality	
AQPDC-1	What effects could existing and approved developments, the Project and planned developments have on ambient air quality in the region?
AQPDC-2	What effects could existing and approved developments, the Project and planned developments have on the deposition of acid-forming compounds in the region?
Human Health	
HHPDC-1	What effects could emissions from existing and approved developments, the Project and planned developments have on long-term (chronic) exposure and human health?
HHPDC-2	What effects could emissions from existing and approved developments, the Project and planned developments have on short-term (acute) exposure and human health?
HHPDC-3	What effects could emissions from existing and approved developments, the Project and planned developments have on exposure to $PM_{2.5}$ and human health?
Wildlife Health	
WHPDC-1	What effects could emissions from existing and approved developments, the Project and planned developments have on long-term wildlife health?
Hydrogeology	
HGPDC-1	What effects could existing and approved developments, the Project and planned developments have on groundwater quantities, levels and flow patterns?
HGPDC-2	What effects could existing and approved developments, the Project and planned developments have on groundwater quality?
Hydrology	
HPDC-1	What effects could existing and approved developments, the Project and planned developments have on open-water areas, flows and water levels in receiving and nearby waterbodies?
HPDC-2	What effects could existing and approved developments, the Project and planned developments have on the geomorphic conditions of watercourses and the concentration of suspended sediments in the watersheds and drainage systems?
Water Quality	
WQPDC-1	What effects could existing and approved developments, the Project and planned developments have on water quality?
Fish and Fish Habitat	
FPDC-1	What effects could existing and approved developments, the Project and planned developments have on fish habitat?
FPDC-2	What effects could existing and approved developments, the Project and planned developments have on fish health?
FPDC-3	What effects could existing and approved developments, the Project and planned developments have on fish abundance?
FPDC-4	What effects could existing and approved developments, the Project and planned developments have on fish and fish habitat diversity?
Terrestrial	
TRPDC-1	What effects could existing and approved developments, the Project and planned developments have on the quantity of terrain and soils, and soil quality/capability?
TRPDC-2	What effects could existing and approved developments, the Project and planned developments have on terrestrial vegetation, wetlands and forestry?
TRPDC-3	What effects could existing and approved developments, the Project and planned developments have on wildlife abundance and habitat?
TRPDC-4	What effects could existing and approved developments, the Project and planned developments have on biodiversity?
Historical Resources	
HRPDC-1	What effects could existing and approved developments, the Project and planned developments have on historical resources?

Table 4.2-2 Summary of Key Questions for the Project: Planned Development Case (continued)

Number	Key Question
Resource Use	
RUPDC-1	What effects could existing and approved developments, the Project, and planned developments have on environmentally important areas?
RUPDC-2	What effects could existing and approved developments, the Project, and planned developments have on natural resources and non-traditional resource users?
Socio-Economic	
SEPDC-1	What effects could existing and approved developments, the Project and planned developments have on the regional and provincial economy?
SEPDC-2	What effects could existing and approved developments, the Project and planned developments have on the regional population?
SEPDC-3	What effects could existing and approved developments, the Project and planned developments, and associated population growth have on the regional services and infrastructure?
Traditional Land Use	
TLUPDC-1	What effects could existing and approved developments, the Project and planned developments have on traditional land uses?
Visual Resources	
VRPDC-1	What effects could existing and approved developments, the Project and planned developments have on visual resources?

4.3 SPATIAL CONSIDERATIONS

The disturbance footprint for the Project, plus the existing and approved CLTP disturbances, is shown in Figure 1-2.

The total area for all the components of the Project, including plant sites, well pads, camps, potential borrow pits, access roads, utility corridors and pipelines is estimated to be 396 ha, which includes 41 ha of existing disturbance.

Study areas for the Project EIA were determined with consideration of the specific component of the EIA. The spatial approach defined for a component generally includes a Local Study Area (LSA) and a Regional Study Area (RSA). The LSA is used to focus on and evaluate areas that may be directly effected by the Project development. The RSA is generally used to evaluate the effects of the Project in the larger geographic and ecological contexts. The spatial extent of the EIA component study areas are described below, with additional details in the relevant EIA component sections.

4.3.1 Air Quality

As part of the dispersion modelling process, the spatial extent of the effects of the Project on ambient air quality determines the region over which modelling is conducted. Four regions defining this spatial extent were included in the assessment. These were defined as follows:

- The modelling domain defines the region within which emission sources were quantified and air quality predictions were performed. The modelling domain chosen for the air quality assessment is shown in Figure 4.3-1. It extends north of the Athabasca Oil Sands Region, south of Cold Lake, east into Saskatchewan and west to Ranges 22 and 23. It is large enough to encompass the effects related to air emissions from developments in the region. The modelling domain includes key communities in Alberta and Saskatchewan.
- The Air Quality RSA defines the region over which modelling results are presented and is typically smaller than the modelling domain. The RSA was sized to meet the requirements of the Project TOR (AENV 2009). The RSA for the Project is defined by a 125 by 176.5 km area. This area is sufficiently large to contain the 0.17 keq/ha/yr Potential Acid Input (PAI) isopleth, as per the Project TOR. The RSA is also large enough to capture the air quality effects associated with the Project. The RSA extends into the province of Saskatchewan to ensure that any potential air quality effects near the Alberta/Saskatchewan border are assessed.
- The Air Quality LSA defines the area in the immediate vicinity of the Project where the majority of air quality effects are expected to occur. The LSA represents a subset of the RSA and allows a more focused assessment of the effects associated with the Project. The LSA was sized to meet the AENV Air Quality Model Guideline requirements for study areas (AENV 2003). The LSA is defined by an area of about 30 by 30 km, encompassing the Project area.
- The Project footprint is an area outlined by the Project plant property boundary. The Alberta Ambient Air Quality Objectives (AAAQOs) are applicable outside the Project footprint.

One of the aims of the air quality evaluation is to put the potential effects into perspective for regional stakeholders. To facilitate this, maximum air quality concentrations were predicted for each of the receptors indicated in Table 4.3-1. The list includes a total of seven community locations; of these seven locations three locations in Alberta and one in Saskatchewan are of importance to First Nations.

Table 4.3-1 Selected Receptors Included in the Air Quality Assessment

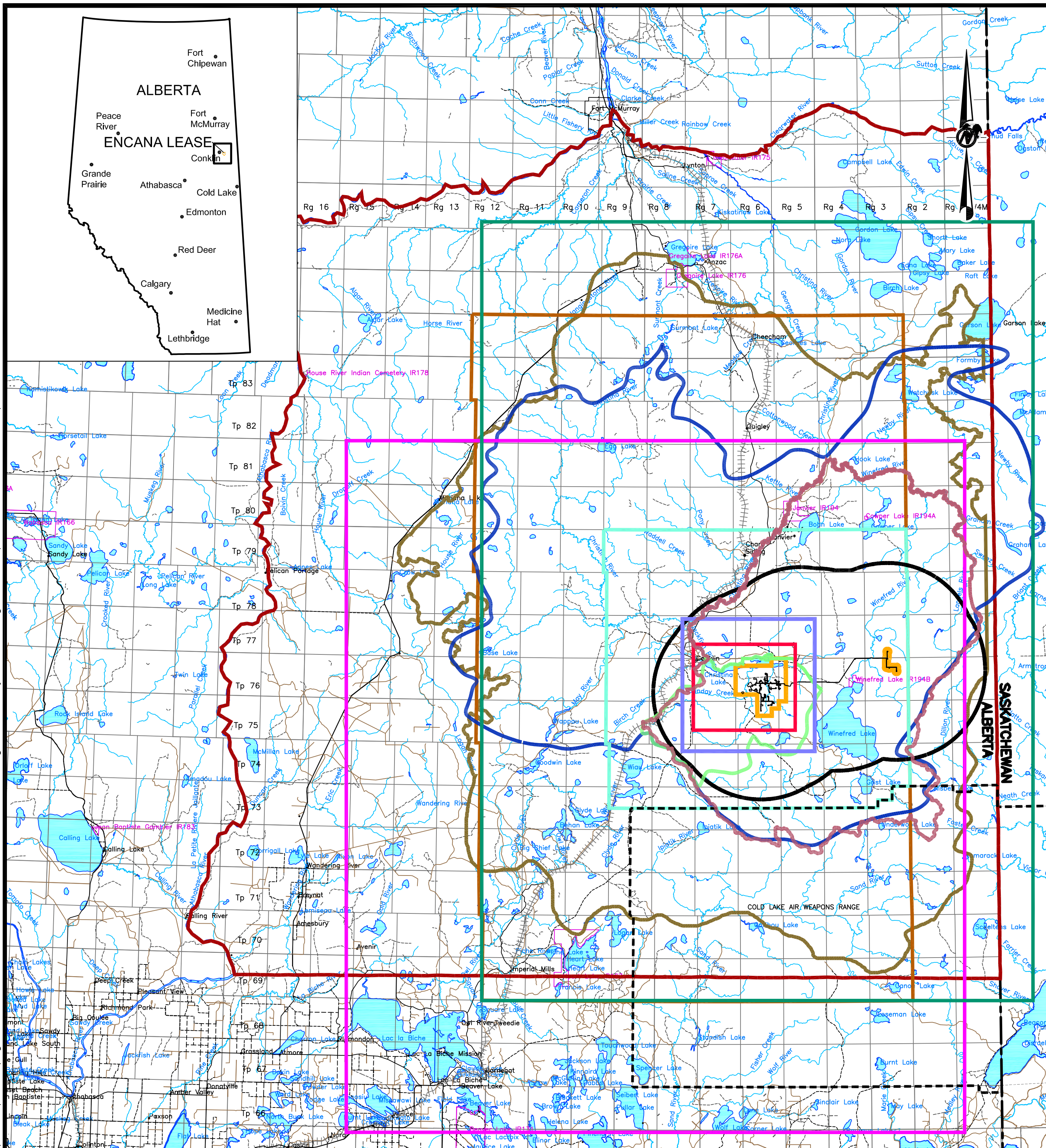
Receptors	Location[a]	
	Distance [km]	Direction
Aboriginal Communities		
Janvier (IR 194)	38.2	NNE
Winefred Lake (IR 194B)	22.6	E
Heart Lake (IR 167)	79.8	SSW
Peter Pond (IR 193), SK	125.5	ENE
Communities		
Conklin	13.9	WNW
Lac La Biche	114.3	SW
Cold Lake	132.2	SSE
Recreation Areas		
Fishing Camp (Christina Lake)	7.8	NE
Campground (Christina Lake)	11.7	WNW
Cabins[b]		
Cabin A	10.2	ENE
Cabin B	7.2	NE
Cabin C	8.5	NE
Cabin D	8.8	ENE
Cabin E	5.9	S
Cabin F	3.5	SSW
Cabin G	13.0	SSE
Cabin H	10.5	SSE
Cabin I	9.7	SSE
Cabin J	4.3	SW
Cabin K	3.6	SW
Cabin L	10.8	WNW
Cabin M	17.3	NW
Cabin N	19.6	NW
Cabin O	4.6	E
Cabin P	2.3	W
Cabin Q	3.6	N
Cabin R	15.1	SE
On-Site Worker Camp	0.7	NE
Maximum Property Boundary	–	–

[a] Distance and direction are relative to the centre of Plant.

[b] Only the cabin location with the maximum prediction is assessed in the EIA.

– = Maximum Property Boundary Receptors are spaced 20 m apart around Plant Boundary.

Concentrations were also predicted at the Christina Lake Lodge and the Christina Lake Campground recreational areas. In addition, concentrations were predicted at eighteen cabin locations around the Project. Of these only the location of maximum prediction was assessed in the EIA. Finally, concentrations were predicted at the on-site worker camp and along the plant property boundary where persons could experience prolonged exposure to air emissions. For the purposes of this assessment, these twelve receptors (i.e., seven communities, two recreation areas, maximum hunter/trapper/cabin location, on-site worker camp and maximum along property boundary) are referred to as the selected receptors. The relative locations of the selected receptors with respect to the Project are indicated in the table. The selected receptors located in the RSA are shown in Figure 4.3-1.



25 0 25

SCALE KILOMETRES

LEGEND

- ROAD
- RAILWAY
- RIVER OR STREAM
- OPEN WATER
- INDIAN RESERVE
- COLD LAKE AIR WEAPONS RANGE
- ENCANA LEASE BOUNDARY, HISTORICAL RESOURCES, TERRESTRIAL RESOURCES AND RESOURCE USE LOCAL STUDY AREA
- NOISE LOCAL STUDY AREA
- AIR LOCAL STUDY AREA
- AQUATIC RESOURCES LOCAL STUDY AREA
- HYDROGEOLOGY LOCAL STUDY AREA
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- AQUATIC RESOURCES REGIONAL STUDY AREA
- AIR REGIONAL STUDY AREA
- RESOURCE USE REGIONAL STUDY AREA
- HISTORICAL RESOURCES REGIONAL STUDY AREA
- VISUAL REGIONAL STUDY AREA
- HYDROGEOLOGY REGIONAL STUDY AREA

NOTE

* Locally known as Chard

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001. DATUM: NAD 83 PROJECTION: UTM ZONE 12

PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

LOCAL AND REGIONAL STUDY AREAS

Golder Associates
Calgary, Alberta

PROJ	06.1346.003.9000		FILE No. 06134600390000A003	
DESIGN	LD	01/07/09	SCALE AS SHOWN	REV. 0
CADD	TRE	17/08/09	FIGURE: 4.3-1	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

L:\2006\1344-OIL SANDS\1346\06-1346-003\9000\9010\Fig 4.3-1 06134600390000A003 Local AND Regional study areas.dwg Sep 18, 2009 - 3:41pm

4.3.2 Noise

The assessment and regulation of noise from energy resource projects in Alberta is the responsibility of the ERCB, which regulates noise from a receptor perspective. Noise-sensitive receptors are considered to be any permanent residences or seasonally occupied dwellings used at least six weeks out of the year outside the plant or project boundary that may be affected by the Project.

For the assessment of the noise resulting from the Project, four noise receptors were considered. Location details are provided in Table 4.3-2.

Table 4.3-2 Noise Receptor Locations, Christina Lake Thermal Expansion Project

Location	Easting [m]	Northing [m]
Hunter/Trapper Cabin A	506206	6158301
Hunter/Trapper Cabin B	506803	6163279
Conklin	494653	6164843
Christina Lake Lodge	497993	6165154

Note: Locations based on datum North American Datum (NAD) 83 and coordinate system Universal Transverse Mercator (UTM) Zone 12.

In addition to the discrete noise receptors identified in the Table 4.3-2, noise levels were also determined over a Noise LSA for each location assessed. Using the remote area 1.5 km criteria established in ERCB's Directive 038 (EUB 2007), the LSA was defined to assess the propagation of noise from the Project. The LSA is defined by a rectangle 7.5 by 10 km in size. The LSA was chosen to encompass potential noise effects of the Project. It encompasses the noise-sensitive receptors, the Expanded CLTP boundary and the ERCB 1.5 km criteria boundary. The ERCB 1.5 km criteria boundary is measured 1.5 km from the CLTP Development Area.

The noise assessment requires that the 'fenceline' for the application be established (EUB 2007). The 'fenceline' is defined by the Expanded CLTP boundary.

The Noise RSA is considered to be the same area as the LSA. In the area beyond the LSA, noise emission from the Expanded CLTP will attenuate a level well below the ambient sound level.

4.3.3 Human Health

Effects to human health were evaluated on a regional basis. The Air Quality RSA for the human health assessment includes the Regional Municipality of Wood Buffalo (RMWB), Alberta; however, communities in Lac La Biche County, the District of Bonnyville and the Peter Pond area (Saskatchewan) were also included. Eighteen hunter/trapper cabin locations were considered in the assessment.

No specific study area was defined for wildlife health. Rather, wildlife was assumed to live within areas where the maximum air concentrations were predicted. It was assumed that all wildlife species spent time in this maximally exposed area.

4.3.4 Air Emissions Effects

The aquatic resources analysis considered the effects of air emissions from the Project and regional developments on waterbodies in the air quality modelling domain, and streams located within the Aquatics LSA. The modelling domain includes the entire Oil Sands Region and extends into western Saskatchewan. Evaluating the effects of deposition within the entire modelling domain maximized the spatial coverage of the analysis. It also incorporated all waterbodies evaluated by similar assessments conducted recently.

The terrestrial resources analysis considered the effects of air emissions from the Project and regional developments on soils, vegetation and wildlife habitat in the Terrestrial Resources RSA.

4.3.5 Aquatic Resources

Four geographic areas have been identified for the Aquatic Resources assessment (Figure 4.3-1). The Aquatic Resources RSA includes the projects listed under the Baseline Case (Section 5) and numerous river basins shown in Figure 4.3-1. The Aquatic Resources LSA includes the Project Area south of Christina Lake and the drainage basins of two streams flowing into Christina Lake (Figure 4.3-1).

The Hydrogeology RSA and LSA are larger than the corresponding Aquatic Resources study areas (Figure 4.3-1). The rationale for the larger Hydrogeology study areas was to capture the lateral extent of potential Project-related effects within the LSA and potential regional cumulative effects with other projects within the RSA.

4.3.5.1 Regional Study Area

Aquatic Resources

The Aquatic Resources RSA was defined on the basis of potential effects of construction and operation of the Project on flows and water levels in regional rivers and lakes (including surface water/groundwater interactions) and on waterbodies supporting fish populations.

The Aquatic Resources RSA (Figure 4.3-1) includes the following major watersheds and lakes:

- Winefred River basin (effective drainage area of 4,270 km^2): The Winefred River originates from Grist Lake, and drains north before discharging to the Christina River about 50 km north of the Project site.
- Christina River basin upstream from the confluence of the Christina River and the Winefred River (effective drainage area of 5,630 km^2): The Christina River originates from the Stony Mountain Wildland and flows south before turning north near Chard and discharging into the Clearwater River about 130 km north of the Project site.
- Christina Lake (surface area of 21 km^2 and effective drainage area of 1,270 km^2): Christina Lake discharges to the Jackfish River, which discharges into the Christina River about 8 km northwest of the Christina Lake outlet.
- Winefred Lake (surface area of 127 km^2 and effective drainage area of 1,205 km^2): Winefred Lake is downstream of Grist Lake and receives inflows from small tributaries originating from south and southwest. Winefred Lake discharges to the Winefred River, which flows northeast.

The total area of the Aquatic Resources RSA is about 990,000 ha. Most of the Aquatic Resources RSA lies within Alberta, with about 2% extending into Saskatchewan within the Winefred River watershed. The Winefred River watershed within the Aquatic Resources RSA encompasses several regionally important lakes and groundwater resources.

Hydrogeology

The Hydrogeology RSA was defined primarily on the basis of interpreted regional geology and groundwater flow patterns and was selected to be of adequate areal extent to simulate cumulative effects of groundwater withdrawal and wastewater disposal. The extent of the Hydrogeology RSA is defined by the following (Figure 4.3-1):

- north – the eastward flowing section of the Athabasca River, to the confluence with the Clearwater River at Fort McMurray, and the Clearwater River, extending from Fort McMurray to the Saskatchewan border;
- east – the Saskatchewan border extending north from the centre of Township 69 to the Clearwater River;
- south – the centre of Township 69 extending west from the Saskatchewan border to the Athabasca River; and
- west – the northward flowing portion of the Athabasca River, extending north from the midpoint of Township 69 to Township 87.

4.3.5.2 Local Study Area

Aquatic Resources

The Aquatic Resources LSA was selected based on the Project lease area, local drainage basins and the requirements of the aquatics components including Water Quality, Hydrology, and Fish and Fish Habitat. The Aquatic Resources LSA was delineated mostly by watershed boundaries that may be directly or indirectly affected by the Project. In some cases, the Aquatic Resources LSA crosses watershed boundaries. In such cases, the Aquatic Resources LSA boundary was set sufficiently far away from the Project such that direct Project effects beyond the boundary were projected to be negligible. The Aquatic Resources LSA is independent of the Hydrogeology LSA because proposed Project activities within the deeper groundwater flow system are predicted to have negligible interaction with shallow water resources.

The Aquatic Resources LSA has a total area of about 680,000 ha and consists of three sub-basins draining into Christina Lake from the south, east and west (Figure 4.3-1). These include the following:

- Christina Lake sub-basin (drainage area of 72.7 km^2), including the lake surface area but excluding the drainage area north of the lake;
- Sunday Creek sub-basin (drainage area of 386 km^2); and

- unnamed tributaries to Christina Lake sub-basin (drainage area of 239 km^2), including South Unnamed Creek (Kirby and Hay lakes) and part of the East Unnamed Creek (i.e., excluding the majority of the East Unnamed Creek drainage area).

The Aquatic Resources LSA is comprised primarily of undulating terrain with extensive low-lying wetlands areas. Maximum relief is about 140 m, with elevations ranging from 554 metres above sea level (masl) at Christina Lake to about 696 masl within the Sunday Creek sub-basin. The average elevation of the Aquatic Resources LSA is about 625 masl.

Hydrogeology

The boundaries of the Hydrogeology LSA were defined based on watershed and shallow hydrogeologic boundaries. The Hydrogeology LSA was selected to encompass the anticipated lateral extent of potential Project effects due to groundwater withdrawal from Quaternary aquifers.

The Hydrogeology LSA is comprised of an irregular boundary extending from Townships 72 to 81, Ranges 1 to 9 W4M. The extent of the LSA is shown in Figure 4.3-1 and is defined by the following:

- north – the westward flowing section of Winefred River to the confluence with the Christina River and the north-eastward flowing section of the Christina River;
- east – a topographic high and shallow groundwater flow divide extending from the Mostoos Hills Upland area on the west side of Dillon River along the north and north-westward flowing sections of Landels River to the confluence with Winefred River;
- south – a shallow groundwater flow divide along a topographic high across the Mostoos Hills Upland area; and
- west – from Christina Lake along the north-eastward flowing Jackfish River to the confluence with Christina River and along Christina River to the confluence with Winefred River; south from Christina Lake along a topographic high between Birch and Sunday creeks.

The Hydrogeology LSA also includes most of the area for which detailed geologic mapping was completed (Figure 4.3-1). Potential effects to groundwater quantity are most likely to occur within the Hydrogeology LSA because this area contains the Project water supply and disposal wells. In addition, Project effects related to groundwater quality are more likely to occur within the Hydrogeology LSA because this area contains the Project facilities including the Central Plant Site and well pads.

4.3.6 Terrestrial Resources

4.3.6.1 Regional Study Area

The RSA was established to assess the contributions of the Project within the broader regional area (Figure 4.3-1). The RSA covers an area of 1,538,591 ha and is situated primarily within the Central Mixedwood and Lower Boreal Highlands natural subregions (NRC 2006). The RSA boundary was defined with consideration of the following parameters:

- ecodistrict and/or vegetation classification boundaries;
- geographic areas such as the Stony Mountain Uplands located northwest of the Project;
- defined woodland caribou habitat areas (e.g., Christina Caribou areas);
- one female woodland caribou home range diameter (30 km; Stuart-Smith et al. 1997); and
- the average size of two moose home range diameters (22 km; Hauge and Keith 1981).

The regional vegetation is represented by a mix of wetlands in poorly drained areas and terrestrial vegetation on better drained soils. Typical terrestrial communities are dominated by pure or mixed stands of aspen and white spruce, with minor inclusions of balsam poplar and/or white birch. On drier sites with coarse-textured soils, jack pine is the dominant tree species. Poorly drained areas of the regional landscape are characterized by a diverse array of forested and non-forested wetlands types. These include peatlands such as black spruce and tamarack-dominated bogs and fens, as well as non-peatland marshes, swamps and areas of shallow open water. Shallow groundwater characteristics vary considerably among these wetlands types, resulting in considerable differences in plant species composition and structure. Fire has also been a prevalent form of natural disturbance throughout the area and as a result, many parts of the RSA are characterized by young forests that have regenerated following fire.

Landforms in the subregion are comprised predominantly of ground moraine and hummocky moraine, interspersed with some areas of aeolian dunes, sandy outwash plains and glaciolacustrine plains (NRC 2006). Post-glacial organic deposits overlay glacial and post-glacial mineral deposits in many areas. Overall, the terrain has low relief and a level to undulating surface. Dominant soil orders in this region include Organic, Luvisolic, Brunisolic and Gleysolic.

Table 4.3-3 outlines the disturbance footprints associated with each development in the RSA included in the Application Case.

Table 4.3-3 Disturbance Areas of Existing and Approved Developments in the Regional Study Area

Developments	Terrain and Soils [ha]	Terrestrial Vegetation, Wetlands and Forestry, Wildlife and Wildlife Habitat, and Biodiversity [ha]
Baseline Case		
EnCana FCCL Ltd.: Christina Lake Thermal Project, Foster Creek Pilot and Foster Creek Phases 1 and 2	2,468	2,468
Canadian Natural Resources Limited: Kirby Pilot Project, Horizon Oil Sands Project, Burnt Lake Project, Primrose and Wolf Lake Project, Primrose East In-Situ Oil Sands Project	11	11
Connacher Oil and Gas Limited: Great Divide Oil Sands Project	14,363	14,363
ConocoPhillips Canada: Surmont Commercial SAGD	1,800	1,800
Devon Canada Corporation: Jackfish SAGD Project, Jackfish 2 Project	2,142	2,142
MEG Energy Corporation: Christina Lake Regional Project – Pilot, Christina Lake Regional Project – Commercial (Phase 2 and 2B)	232	297
OPTI Canada Inc./Nexen Canada Ltd.: Long Lake Pilot and Commercial Project	1	1
Petrobank Energy and Resources Ltd.: Whitesands Pilot Project, Whitesands Project Expansion	78	78
Petro-Canada: Dover SAGD Pilot, VAPEX Pilot, MacKay River In-Situ, Meadow Creek In-Situ	1,629	1,629
Forestry	n/a	17,958
Municipalities And Communities	428	428
Pipelines, Roadways, East Athabasca Highway, Others	12,872	56,524
Total Existing and Approved Developments	**36,025**	**97,700**
Application Case		
EnCana Christina Lake Thermal Project Phases 1E, 1F, 1G	137	396
Total Application Case Development	**137**	**396**
Planned Development Case		
EnCana FCCL Ltd.: Foster Creek Expansion, Narrows Lake	2,494	2,494
Connacher Oil and Gas Limited: Algar Oil Sands Project	144	144
Canadian Natural Resources Limited: Kirby In-Situ Oil Sands Project	327	327
EnerPLUS Resources Fund: Kirby Oil Sands Project	17,875	17,875
Excelsior Energy Limited: Hangingstone Pilot	3,482	3,482
Japan Canada Oil Sands Limited: Hangingstone SAGD Project	521	521
Korea National Oil Corporation: Black Gold Project	723	723
MEG Energy Corporation: Christina Lake Regional Project – Phase 3	2,028	2,028
OPTI Canada Inc./Nexen Canada Ltd: Long Lake Commercial Project Phase 2	13,834	13,834
Petrobank Energy and Resources: May River Project	2,718	2,718

Table 4.3-3 Disturbance Areas of Existing and Approved Developments in the Regional Study Area (continued)

Developments	Terrain and Soils [ha]	Terrestrial Vegetation, Wetlands and Forestry, Wildlife and Wildlife Habitat, and Biodiversity [ha]
Petro-Canada: Lewis SAGD Project, Meadow Creek Expansion SAGD Project, MacKay River Expansion SAGD project	4,929	4,929
Statoil Hydro: Kai Kos Dehseh SAGD Project	93,881	93,881
Forestry	n/a	59,531
Major Pipelines, Utility Corridors, Roadways And Others	249	249
Municipal Growth	221	221
Total Planned Developments Case	**143,460**	**202,946**

n/a = Not applicable because seismic and forestry activities are not considered to disturb terrain and soils.

Notes: Differences in areas of developments between the Terrain and Soils, and the remaining terrestrial components are due to the disturbance types such as seismic lines and forestry activity, which are not considered to disturb soils in the RSA.
Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

4.3.6.2 Local Study Area

The LSA was established to assess the effects of the Project on Terrestrial Resources at the local scale (Figure 4.3-1). Project activities will be contained within EnCana's lease boundaries with the exception of the Project's disposal wells. The final location of the disposal wells (Figure 4.3-1), about 22 km to the east of the CLTP lease in Section 26 and 27, Township 76, Range 3, W4M, was determined with assistance from local First Nations advisors.

A separate satellite study area was added to the LSA to address the potential effects of the disposal wells, because it was not appropriate to define a much larger LSA to include this relatively small, and remote, disturbance. The resulting LSA (Figure 4.3-1) encompasses 11,168 ha, and includes the CLTP lease area (10,305 ha) within Townships 75 and 76, Ranges 5 and 6, W4M, the small, disposal well area (863 ha) in Sections 26 and 27, Township 76, Range 3, W4M, and a small potential source well location extending outside the lease boundary to the southwest. The potential source well location was considered after the initial baseline work and baseline reports were completed. A different location was subsequently chosen, but the LSA was kept with this option still available. Therefore, there is a 868 ha difference in the LSA from that reported in the terrestrial baseline reports.

There is a minimum 500 m buffer between the Project footprint and the LSA boundary, representing a zone where potential indirect effects of the Project effects may occur. The described LSA approach satisfies the impact assessment methods for the individual terrestrial disciplines and the TOR, which requires an assessment of all Project-related facilities, such as disposal wells. The assessments for each discipline describe how the Project effects within the satellite study area were incorporated into the overall LSA assessment. The existing infrastructure connecting the two study areas (lease and satellite), and the associated impacts, are captured in the RSA.

The LSA falls completely within the Central Mixedwood Natural Subregion (NRC 2006) (Figure 4.3-1). The 11,168 ha LSA is comprised of 5,547 ha of wetlands vegetation (50%) and 3,102 ha of terrestrial vegetation (28%). Burns cover 587 ha (5%). The remainder of the LSA is associated with non-vegetated classes such as 46 ha of meadows and shrublands (less than 1%), 612 ha of waterbodies (5%) and 1,275 ha of disturbances (11%).

Physiographic subdivisions of Alberta describe the general landscape characteristics of a region. The LSA is situated in the Mostoos Hills Upland Section of the Eastern Alberta Plains Region (EUB and AGS 2002). The LSA is characterized as having generally subdued relief and nearly level to slightly hummocky topography on glaciofluvial over moraine surficial material. Elevations within the Eastern Plains Region range from about 500 to 800 masl. The lowland areas are dominated by peatlands (fens and bogs). Microrelief is generally undulating throughout the LSA (1 to 3 m height). Overall, the slopes in the LSA range from 0.5% on the peatlands to less than 10% in the morainal areas (Pettapiece 1986), although some steeper slopes were encountered.

4.3.7 Socio-Economics

The Socio-Economics RSA includes the following communities:

- Lac La Biche County, including Lac La Biche and Plamondon;
- The southern part of the RMWB around Conklin and Janvier/Chard; and
- First Nations reserves located within southern RMWB and Lac La Biche County:
  - Chipewyan Prairie Dené First Nation (CPDFN);
  - Beaver Lake Cree First Nation (BLCN);
  - Heart Lake First Nation (HLFN); and
  - Fort McMurray First Nation (FMFN).

The northern part of the RMWB around Fort McMurray and including Saprae Creek and Anzac is not included in the RSA. The economy of the northern part of the RMWB is dominated by mining- and upgrading-based oil sands developments. The rapid economic and population growth of the area around Fort McMurray starting in 1995 has focused supply relationships of oil sands facilities around Conklin away from Fort McMurray and towards Lac La Biche County and beyond. In addition, travel between Conklin and Fort McMurray was at times problematic until Secondary Highway 881 was paved in 2006.

For some effects, such as the effect on selected service providers and the Project's municipal fiscal effects, the study area includes the RMWB. Finally, the economic effects of the Project consider Alberta as a whole.

4.3.8 Traditional Land Use

4.3.8.1 Local Registered Fur Management Areas and Local Study Area

Figure 4.3-1 shows the TLU LSA and the RFMAs overlapped by the LSA. The LSA partially overlaps RFMA #s 616, 668, 1595, 2313, 2316 and 2322. These directly affected RFMAs provide an appropriate basis for assessing TLU since they provide an important location from which traditional activities are conducted.

4.3.8.2 Regional Study Area

The RSA is based on the Terrestrial Resources RSA and is shown in Figure 4.3-1 Traditional land use areas primarily include land that is used to collect traditional resources including hunted game and harvested berries or medicinal plants. They may also include cabins and other areas of spiritual or historical significance based on oral tradition. The Terrestrial Resources RSA considers potential effects on wildlife and vegetation, which are important components of TLU activities.

The RSA represents the joint use of a region and its resources by the members of nearby Aboriginal communities that practice relatively similar traditional pursuits. The objective of the TLU baseline study for the RSA was to summarize the historic and current use of the CPDFN, FMFN, HLFN and BLCN within the RSA (Appendix 6-I). It is also recognized that members of the Métis Nation of Conklin and Chard have similar ties to the land, pursue a traditional way of life within this area, and are long-standing residents of northeastern Alberta. No specific area was identified as representing their specific uses, but it is recognized that Métis people are participants in regional TLU patterns through active operation of RFMAs, as well as hunting, fishing and gathering throughout the RSA.

4.3.9 Historical Resources

The effects on historical resources that accompany the Project will occur directly within areas scheduled for land surface disturbance. The whole of the Project area ground surface will not be affected by construction activities due to the dispersed nature of the proposed developments. The LSA includes the Project areas that will be directly affected by construction activities as well as surrounding areas within the EIA area.

The Historical Resources Impact Assessment (HRIA) for Permit 07-186 was designed to assess the LSA for historical resources and to recommend mitigation for any sites within the LSA that might be affected by the Project (Blower 2007). This includes all or portions of 33 sections of land over an area of about 10,305 ha including: Sections 6, 7, 18, 19, 30 and 31-76-5 West of the Fourth Meridian (W4M); Sections 26, 27 34, 35 and 36-75-6 W4M; Sections 1, 2, 3, 7, 8, 9, 10, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 32 and 36-76-6 W4M.

The initial configuration of the areas to be examined during the field component was established by EnCana and Alberta Culture and Community Spirit (ACCS) in their review of the application for the permit to conduct these studies. After the HRIA was completed, Section 32-76-6 W4M was removed from the Project EIA; however, it had already been included in the *Historical Resources Act HRA* clearance application for the HRIA (Blower 2007). Sections 21 and 22-75-6 W4M were added after the HRIA was completed and will require further historical resource studies. The disposal wells cover an area of about 863 ha, which include all or portions of eight sections of land including: Sections 3 and 4-77-3 W4M; Sections 23, 26, 27, 28, 33 and 34-76-3 W4M. The HRIA for Permit 08-254 examined Sections 33 and 34-76-3 W4M and Sections 3 and 4-77-3 W4M (Balls 2009). The areas not covered by this HRIA will require further historical resource studies in the future.

The originally planned LSA target areas were modified after field observations were made during foot and vehicle traverses. The assessment of the direct and indirect effects of the Project is based on the results of the field studies conducted within this LSA.

An analysis of the effects of the Project in combination with existing, approved and planned developments within the general region was facilitated through definition of the Historical Resources RSA. The RSA covers an area of 1,491,839 ha or 160 townships surrounding the Project and includes all or portions of 89 archaeological national registry (Borden) blocks identified in Alberta. The RSA extends from the western boundary of Range 12 to the eastern edge of Range 3, W4M. The southern boundary of Township 69 forms the southern boundary of the RSA, while the northern boundary of Township 84 is its northern boundary.

4.3.10 Resource Use

Two areas have been delineated to facilitate data collection and presentation; a Resource Use RSA and a Resource Use LSA. The RSA encompasses resources that are potentially affected by the Project both directly and indirectly. The LSA encompasses resources that are potentially directly affected by the Project. For this assessment, the LSA has been determined to be the same boundary as the Terrestrial Resources LSA. In total, the LSA encompasses 11,168 ha.

4.3.11 Visual Resources

One study area was identified for the assessment of potential effects on visual resources: a Visual Resources RSA. The RSA includes all areas within 20 km of the Project. Areas beyond 20 km from the Project are likely to have poor or obstructed views due to distance, topography, atmospheric conditions and vegetation.

4.4 TEMPORAL CONSIDERATIONS

The temporal considerations for the EIA are based on the Project Description (Volume 1, Sections 1 and 3) and include unique conditions that may affect environmental components differently. The schedule for the Project is detailed in Volume 1, Section 1.

The Project increases in production and the associated facilities are scheduled to begin operations in 2014 (Phase 1E), 2015 (Phase 1F) and 2016 (Phase 1G). Front-end engineering and design work has begun. Construction will begin in 2011, pending regulatory approvals. Each of the three phases, namely 1E, 1F and 1G, will have four OTSGs adding 10,977 t/d of dry steam for injection per phase and 40,000 bbl/d (6,359 m^3/d) of oil treating capacity per phase. This will bring the cumulative dry steam for injection to 60,032 t/d dry steam and the cumulative production to 218,800 bbl/d (34,789 m^3/d) for Phases 1A to 1G. It is anticipated that reclamation of the Project will commence in 2025.

The main Project phases include construction, operations and reclamation. For most components, impact analyses considered construction and operations together. Construction is discussed separately, where that activity adds a measurable, short-term change to the component under consideration (e.g., the influence of the initial construction vehicles on air emissions).

Some EIA components, particularly the terrestrial components, examine the Project under three temporal conditions: construction, operation and reclamation activities. Although there will be some sequencing of both the removal and reclamation of terrestrial systems, this sequential development and reclamation process is not considered in the assessments. Assessments consider either that everything is undeveloped, developed or reclaimed. This is a conservative approach so that effects are not underestimated.

4.5 LINKAGE DIAGRAMS

The purpose of the EIA is to examine the relationships between the Project and its potential effects on human and natural environments. These relationships are defined in terms of linkage diagrams and revealed in the impact analyses. Linkage diagrams provide a means of defining the interaction between project activities, potential environmental change and the analysis of the key questions. The analysis of this interaction allows for assessment of effects in a broader ecological context.

Linkage diagrams are used to clearly describe how project activities could potentially lead to environmental changes, which in turn could affect specific components of the environment. Figure 4.5-1 illustrates the general format of the linkage diagrams. Symbols on the linkage diagrams include:

- ovals (project activities);
- rectangles (potential changes in the environment);
- diamonds (key questions); and
- triangles (connection to or from a different environmental or social component).

Linkage diagrams are used as tools to guide the impact analysis, which addresses each link on the diagram. They also show how the different environmental and social components are inter-related. The potential linkages between activities and impacts are evaluated to determine whether they apply to the Project.

The EIA considers each link on the component linkage diagram, with the analyses consisting of four main steps:

- identification of Project activities that could contribute to environmental change;
- analysis of potential linkages;

- analysis and classification of impacts; and
- identification and description of mitigation measures and monitoring for potential residual impacts.

When this evaluation indicates a potential impact, the linkage is ruled valid for assessment. When the evaluation does not indicate a potential impact, the linkage is ruled invalid for the Project and is not assessed in the EIA.

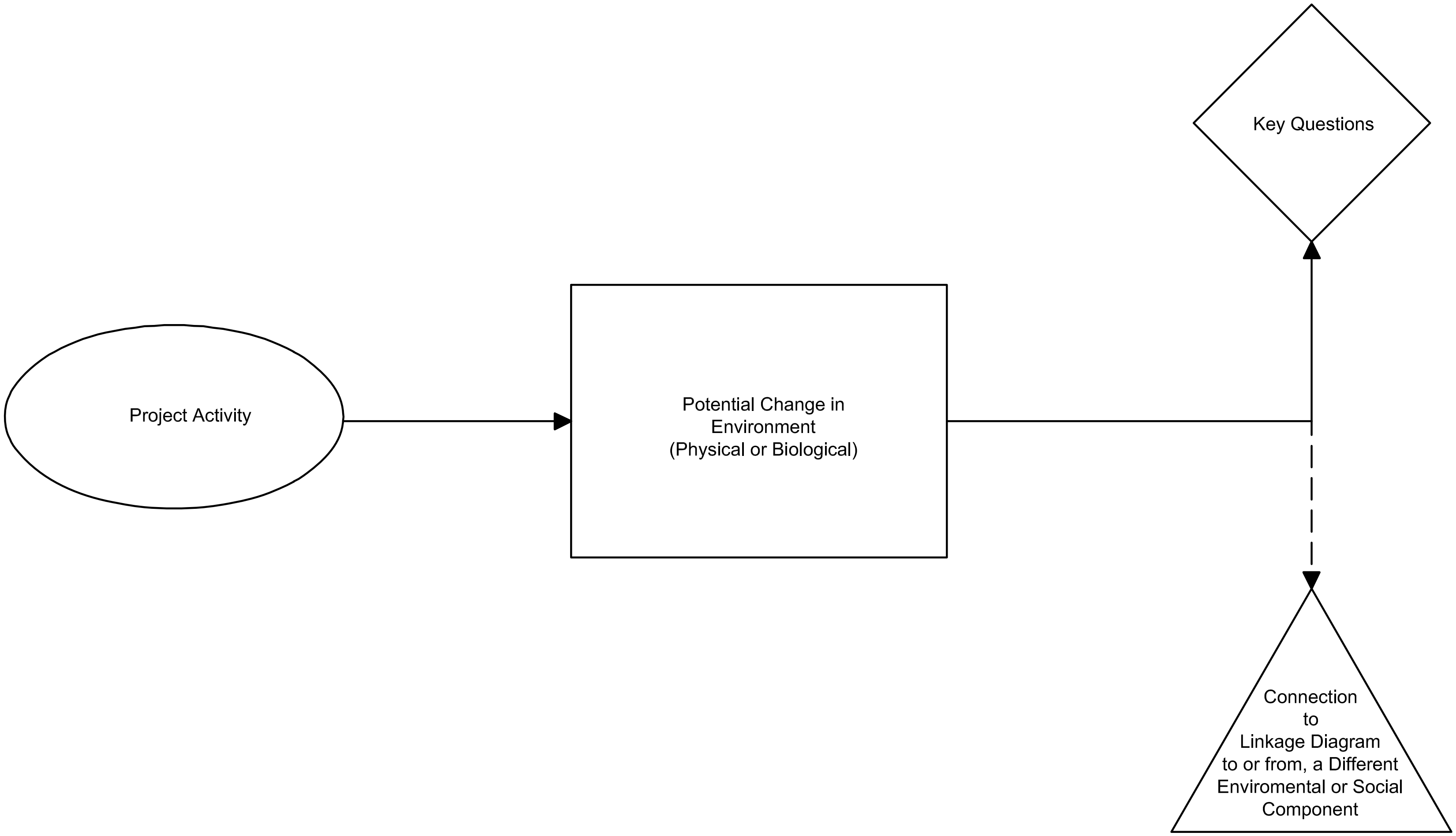
4.6 KEY INDICATOR RESOURCES

The linkage diagram analyses may also include consideration of Key Indicator Resources (KIRs) that provide definable assessment and measurement end points for some environmental components. These KIRs are representative species and/or communities that allow for a focused examination of the ways the Project may result in changes to the environment in terms of issues of importance to the species or communities.

Key Indicator Resources are the environmental attributes or components identified as having legal, scientific, cultural, economic or aesthetic value. The selection of KIRs is based on a process defined in detail by Golder (1999b) and a process used by the Cumulative Environmental Management Association (CEMA 2001). The Key Indicator Priority list of 2001 was revised in 2006 to focus more on ecosystem processes (CEMA 2006). In general, KIRs were selected based on:

- species presence/absence and abundance as determined during baseline surveys and/or historical studies;
- importance as a traditional resource;
- Cumulative Environmental Management Association indicator species or guild;
- Regional Aquatics Monitoring Program (RAMP) sentinel species (for aquatic resources);
- representation of aquatic sport, non-sport and forage species; and
- species status provincially or federally (e.g., ASRD 2006; COSEWIC 2007).

L:\2006\1344-OIL SANDS\1346\06-1346-003\9000\9010\Fig 4.5-1 0613460039000A005 Key to using linkage diagrams.dwg Sep 18, 2009 - 3:42pm



PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

KEY TO LINKAGE DIAGRAMS

Golder Associates
Calgary, Alberta

PROJ	06.1346.003.9000	
DESIGN	LD	01/07/09
CADD	TRE	02/07/09
CHECK	LD	18/09/09
REVIEW	IGG	18/09/09

FILE No. 0613460039000A005

SCALE AS SHOWN REV. 0

FIGURE: 4.5-1

The identification of KIRs is not universal throughout the EIA. Some components assess all relevant attributes (e.g., air quality looks at the effects of all relevant emissions related to the Project; the socio-economics assessment looks at key indicators for those aspects of the human environment that are directly affected by the Project and oil sands projects in general).

The KIRs selected for the Project are summarized in Table 4.6-1.

Table 4.6-1 Key Indicator Resources and Rationale for Selection

Resource	KIRs		Rationale
Aquatic Resources	**Waterbodies**		
	Christina Lake, Unnamed Waterbodies WB2 and WB6, WB12	walleye northern pike Arctic grayling brook stickleback (forage fish) benthic invertebrates	traditional resource, historical documentation, listed species
		northern pike benthic invertebrates	fish species captured during spring and/or late summer surveys, traditional resource
		northern pike brook stickleback (forage fish) benthic invertebrates	fish species captured during spring and/or late summer surveys, traditional resource
	Unnamed Waterbodies, WB11 and WB13	brook stickleback (forage fish) benthic invertebrates	brook stickleback were the only fish species captured during spring and/or late summer surveys
	Unnamed Waterbodies WB-1, WB-2, WB-3, and WB-4	benthic invertebrates	no fish were captured during spring and/or late summer baseline surveys, and there is no historical documentation of captured fish species
	Watercourses		
	Unnamed Tributary to the north bay of Christina Lake (“Sawbones Creek”)	walleye northern pike brook stickleback (forage fish) benthic invertebrates	fish species captured or observed during spring and/or late summer surveys, historical documentation, traditional resource
	Unnamed Tributary to the east shore of Christina Lake	white sucker brook stickleback (forage fish) benthic invertebrates	fish species captured during spring and/or late summer surveys
	Unnamed Tributaries to the Christina River	benthic invertebrates	no fish captured during spring and/or late summer surveys, no historical documentation of captured fish species

Table 4.6-1 Key Indicator Resources and Rationale for Selection (continued)

Resource	KIRs	Rationale
Terrestrial Vegetation and Wetlands	lichen jack pine (a1) communities	caribou habitat communities with restricted spatial distributions
	riparian communities	highly productive areas with high rare plant potential; form important wildlife habitat and corridor areas
	old growth forests	mature forest within the boreal forest with restricted distribution because of the fire regime
	peatlands (bogs and fens)	important boreal forest ecosystems that cannot be reclaimed because of the complex interrelated hydrological, chemical and biotic conditions
	patterned fens	rare wetlands type with high rare plant potential; susceptible to physical disturbance; communities with restricted spatial distributions
	rare and special plant communities	plant communities with restricted spatial distributions
	productive forests	important to the forest industry
	rare plants	federally and/or provincially recognized plants with restricted spatial, ecological and temporal distributions
	traditional plants	plants traditionally used by Aboriginal peoples for food, medicine or spiritual purposes
Wildlife	woodland caribou	Cumulative Environmental Management Association (CEMA) Sustainable Ecosystems Working Group (SEWG) environmental indicator, ecological importance(prey species), ease of monitoring, traditional importance, abundant information
	moose	CEMA SEWG environmental indicator, economic importance, recreational importance, ecological importance (primary prey species), ease of monitoring, traditional importance, abundant information
	Canada lynx	provincial status, ecological importance (carnivore, predator/prey relationship), traditional and economic importance
	black bear	traditional importance, ecological importance (carnivore), CEMA SEWG environmental indicator
	fisher	provincial status, ecological importance (carnivore), traditional and economic importance, CEMA SEWG environmental indicator
	beaver	traditional and economic importance, ecological importance (keystone species)
	barred owl	ecological importance (carnivore), provincial status, member of the CEMA SEWG environmental indicator bird community, old growth forest birds
	black-throated green warbler	provincial status, member of the CEMA SEWG environmental indicator bird community, old growth forest birds
	yellow rail	federal status, representative of the marsh bird community, riparian health indicator
	Canadian toad	provincial status, riparian health indicator

Table 4.6-1 Key Indicator Resources and Rationale for Selection (continued)

Resource	KIRs	Rationale
Socio-economics	employment	address different aspects of people's lives, including people as economic and social beings
	income	
	population change	
	services and infrastructure	
	provincial corporate tax and resource royalty income	traces the taxation consequences of the Project
	federal corporate tax income	
Resource Use	aggregates	limited resource, high demand
	agriculture	commercial use, high importance
	berry picking	traditional subsistence and recreational importance
	environmentally important areas	designated as protected or environmentally important areas, recreational importance
	fishing	recreational importance
	forestry	economic importance
	hunting and trapping	economic and recreation importance, trapping is of importance to community subsistence
	land use policies	development requirements and guidelines
	recreation	recreational importance
	traditional use	subsistence and recreational importance
	visual resources	aesthetic importance

4.7 IMPACT ANALYSES

Impact analyses focus on assessment of potential changes to receptors within the environment due to the construction, operation and reclamation of the Project. Not all key questions used in the Project result in completion of an impact assessment, because the answer to the question may be information on environmental change that passes to another component where the effect on receptors is evaluated and an impact analyses completed.

The impact analysis includes validation of causal linkages between particular Project activities and potential environmental impacts, as described in Section 4.5. These potential linkages between Project activities and environmental change were considered for each EIA component. Where the changes in an environmental component are effected by changes in another environmental component, the linkages are represented as triangles (Figure 4.5-1). Sub-headings are provided for each link on the linkage diagram. Within each of the sub-headings, the potential for the Project to result in an environmental change is determined and the link is classified as valid or invalid.

The process of evaluating potential effects of the Project on receptors may result in the identification of opportunities for project re-design to eliminate or minimize a potential effect. This iterative process is an integral component of the project design engineering team working with those completing environmental and social impact assessments. Through this process, many potential effects of the Project were eliminated during the process of designing the Project.

Validation of the link includes consideration of the mitigation measures. Mitigation, within the context of this EIA, is defined as follows: "the application of design, construction or scheduling principles to minimize or eliminate potential adverse impacts and, where possible, enhance environmental quality" (Sadar 1994). For certain activities, ongoing mitigation (e.g., changes in operating practices) can minimize or eliminate physical or chemical stresses, thereby rendering invalid the link between a Project activity and an environmental change.

If a link between a Project activity and an environmental change is considered valid, the key question under consideration is examined. Where the environmental component has defined KIRs, the impacts on each KIR are evaluated separately.

Quantitative methods of assessment are used where possible. Predictive modelling is used as a tool in the Air Quality, Hydrogeology, Hydrology, Water Quality, Fish and Fish Habitat, and Wildlife and Wildlife Habitat Assessments. Risk assessment techniques are used to assess impacts to human and wildlife health. Geographic Information Systems were used to help develop qualitative measures to assess impacts on terrestrial resources and resource use. The detailed assessment techniques are described in the EIA component sections.

4.8 IMPACT DESCRIPTION CRITERIA

The environmental and socio-economic impacts are assessed in terms of quantitative impact criteria that are defined in this section of the EIA. These impact criteria are based on attributes such as direction, magnitude, geographic extent, duration, reversibility and frequency. An important component is the degree of confidence in the data and analysis. The outcome is a rating system of the environmental consequences of the Project on specific environmental or socio-economic resources.

Residual impacts are classified using quantification criteria to determine environmental consequence. Components where the potential change in a parameter results in an effect on another component do not provide an environmental consequence. For example, a change in water quality can result in an effect on fish and fish habitat. Therefore, water quality does not present an environmental consequence. Each impact is first described in terms of the following criteria: direction, magnitude, geographic extent, duration, reversibility and frequency (including seasonal effects). These criteria are defined and considered as per guidelines in the *Canadian Environmental Assessment Act Responsible Authorities Guide* (FEARO 1994).

Direction of an impact may be positive, neutral or negative with respect to the key question (e.g., a habitat gain for a KIR would be classed as positive, whereas a loss in habitat would be considered negative).

Magnitude describes the intensity, or severity of an effect. It is often described as the amount of change in a measurable parameter or variable relative to the baseline condition, guideline value or other defined standard. The specific definition used to determine the magnitude rating (negligible, low, moderate or high) is defined by each component. The ratings are relative to the characteristics being investigated, the methods available to measure the effect, and the accepted practice in each component. Definitions of magnitude are unique to the characteristics of the measured parameter or variable. The criteria are defined in detail in each component in specific sections describing the assessment methods.

Geographic extent is the spatial area that is affected by the Project in combination with other developments. It will generally be based on the local and regional study areas developed by each component, although some, such as terrestrial resources, may have a single study area. The choice of study area strongly influences the final classification of the residual effect; therefore, the size of the study area is an important consideration (i.e., is it too small or large). The general principle followed in determining study areas follows the guidelines outlined in the *Cumulative Effects Assessment Practitioners Guide* (Hegmann et al. 1999). That document suggests that consideration of a "zone-of-influence" beyond which the effects of the action have diminished to an acceptable or trivial state (i.e., a very low probability of occurrence or acceptably small magnitude) is an acceptable approach.

Duration refers to the length of time over which an environmental impact occurs. It considers the various phases of the Project, including construction, operation and reclamation during which the effects may occur as well as the length of time for the environmental component to recover from the disturbance.

Reversibility indicates the potential for recovery of the ecological endpoint. An effect is defined as irreversible if the resource element cannot be restored to pre-impact condition within the long-term as defined under duration. Because ecosystems are dynamic, a site is considered to be restored if natural succession processes are re-established. Reversibility does not necessarily require the establishment of a mature stage, but can be achievement of a development stage that is capable of sustaining the pre-development successional pattern.

Frequency describes how often the effect occurs within a given time period and is classified as low, medium or high in occurrence. Discussions on seasonal considerations are made when they are important in the evaluation of the impact.

Table 4.8-1 details the impact description criteria for each of the Project EIA components that determine an environmental consequence. Criteria for direction, reversibility and frequency are the same for all environmental components. Magnitude, geographic extent and duration vary depending on the component. The impact description criteria table also provides numerical scores that are used to determine environmental consequence.

Table 4.8-1 Impact Description Criteria and Numerical Scores for the Project

Resource	Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]	Reversibility[e]	Frequency[f][g]
Noise	positive: a decrease in noise levels neutral: no change in noise levels negative: an increase in noise levels	negligible: no projected increase in ambient sound levels low: increased noise levels do not exceed the ERCB nighttime requirements moderate: increased noise levels exceed the ERCB nighttime requirements by <5 dB high: increased noise levels exceed the ERCB daytime requirements by more than 5 dB	local (0): occurring up to 1.5 km from the lease regional (+1): outside the limit of 1.5 km from the Project boundary	short-term (0): <3 years medium-term (+1): 3 to 30 years long-term (+2): >30 years	reversible (-3) or irreversible (+3)	low (0): occurs once medium (+1): occurs intermittently high (+2): occurs continuously
Hydrogeology/Groundwater	positive, negative or neutral for the measurement endpoints	negligible: no change from the Baseline Case low: near (i.e., slightly above) Baseline Case moderate: above Baseline Case high: substantially above Baseline Case	local: effect restricted to the LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Hydrology	positive, negative or neutral for the measurement endpoints	negligible: <1% change low: 1 to 5% change moderate: 5 to 15% change high : >15% change	local: effect restricted to the LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently (1 to 10 times per year) high: occurs frequently (>10 times per year)
Water Quality	positive, negative or neutral for the measurement endpoints	negligible: releases do not cause exceedance of guidelines low: releases contribute slightly to existing background exceedances moderate: releases cause exceedance of guidelines (where guidelines were not previously exceeded) high: releases cause substantial exceedance of guidelines	local: effect restricted to the LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously

Table 4.8-1 Impact Description Criteria and Numerical Scores for the Project (continued)

Resource	Direction[(a)]	Magnitude[(b)]	Geographic Extent[(c)]	Duration[(d)]	Reversibility[(e)]	Frequency[(f)(g)]
Fish and Fish Habitat	positive, negative or neutral for the measurement endpoints	negligible: no measurable change low: <10% change in measurement endpoint moderate: 10 to 20% change in measurement endpoint high: >20% change in measurement endpoint where guidelines or criteria[(h)] exist: negligible: releases do not cause exceedance of guidelines low: releases contribute slightly to existing background exceedances moderate: releases cause marginal exceedance of guidelines (where guidelines were not previously exceeded) high: releases cause substantial exceedance of guidelines	local: effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Soil and Terrain	positive, negative or neutral for the measurement endpoints	negligible: no measurable effect (<1%) on the measurement endpoint low: <10% change in measurement endpoint moderate: 10 to 20% change in measurement endpoint high: >20% change in measurement endpoint	local: effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Terrestrial Vegetation, Wetlands and Forestry	positive, negative or neutral for the measurement endpoints	negligible: no measurable effect to <1% low: 1 to <10% change in measurement endpoint moderate: 10 to 20% change in measurement endpoint high: >20% change in measurement endpoint	local : effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Wildlife	positive, negative or neutral for the measurement endpoints	negligible: no measurable effect low: <10% change in measurement endpoint moderate: 10 to 20% change in measurement endpoint high: >20% change in measurement endpoint	local : effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously

Table 4.8-1 Impact Description Criteria and Numerical Scores for the Project (continued)

Resource	Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]	Reversibility[e]	Frequency[f][g]
Air Emission Effects on Ecological Receptors – Water Quality and Aquatic Biota	positive: a decrease in acid deposition negative: an increase in acid deposition	negligible (0): no measurable effect (<1%) on the measurement end point low (+5): <10% change in measurement end point moderate (+10): 10 to 20% change in measurement end point high (+15): >20% change in measurement end point	local: effect restricted to the Project lease area regional: effect restricted to the Air Quality RSA beyond regional: effect extends beyond the Air Quality RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once medium: occurs intermittently high: occurs continuously
Air Emission Effects on Ecological Receptors – Soil	positive, negative or neutral for the measurement endpoints	negligible: <1% change in areas exceeding the critical loads low: <10% change in areas exceeding critical loads moderate: 10 to 20% change in areas exceeding critical loads high: >20% change in areas exceeding critical loads	local: effect restricted to around emission source regional: effect extends throughout the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Biodiversity	positive, negative or neutral for the measurement endpoints	negligible: no measurable effect low: <10% change in measurement endpoint moderate : 10 to 20% change in measurement endpoint high : >20% change in measurement endpoint	local : effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously
Resource Use	positive, negative or neutral for the measurement endpoints	negligible: <1% low: <10% change in measurement endpoint moderate : 10 to 20% change in measurement endpoint high: >20% change in measurement endpoint	local: effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs more than once high: occurs continuously
Resource Use – Visual Quality	positive, negative or neutral for the measurement endpoints	negligible: plant site not visible low: plant site visible from a small number of locations moderate: plant site visible from many locations high: plant site visible from all locations	local: effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5 to 30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs more than once high: occurs continuously

Table 4.8-1 Impact Description Criteria and Numerical Scores for the Project (continued)

Resource	Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]	Reversibility[e]	Frequency[f][g]
Historical Resources	positive: increase in information negative: loss of resources and/or contextual information	negligible (0): no physical impact occurs or no historical sites are expected to be present low (+5): minimal impact to valuable resources, or resources are few and of low value moderate (+10): moderate or partial impact to resources of high to moderate historical value high (+15): severe physical impact to resources of high historical value	local (0): effect restricted to areas of direct physical disturbance (LSA) regional (+1): effect extends to indirect effects of increased access/use in the region	short-term (0): <5 years medium-term (+1): 5-20 years long-term (+2): >20 years	reversible (-3) or irreversible (+3)	n/a
Human Health	positive, negative or neutral for the measurement endpoints	negligible: ER[i] <1 and no data gaps or 1<ER<10 due to naturally elevated background exposures and/or conservative exposure assumptions low: no ER due to lack of data, but anecdotal data suggests low hazard additional information necessary to characterize potential impact moderate: 10<ER<20 high: ER>20	local: effect restricted to LSA regional: effect extends beyond the LSA into the RSA beyond regional: effect extends beyond the RSA	short-term: <5 years medium-term: 5-30 years long-term: >30 years	reversible or irreversible	low: occurs once moderate: occurs intermittently high: occurs continuously

(a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.
(b) Magnitude: degree of change to analysis endpoint.
(c) Geographic Extent: area affected by the impact.
(d) Duration: length of time over which the environmental effect occurs.
(e) Reversibility: effect on the resource (or resource capability) can or cannot be reversed.
(f) Frequency: how often the environmental effect occurs.
(g) Season effects are assessed when relevant for a specific component as Spring, Summer, Fall or Year-Round.
(h) Criteria can include acute and chronic aquatic life as well as No Observed Effects Concentration (NOEC).
(i) ER: exposure ratio, the predicted exposure divided by the exposure limit.
n/a = Not applicable.

4.8.1 Certainty and Prediction Confidence

The purpose of an EIA is to predict the future conditions of dynamic environmental and social components that are, by their very nature, continuously changing. As a result, within every EIA there is a degree of confidence (certainty or uncertainty) associated with the predictions therein.

The degree of confidence in predictions is assessed for each residual effect predicted in the EIA. Each component uses quantitative methods such as sensitivity analyses or semi-quantitative methods to assess prediction confidence to the extent reasonable. Other sources of information, such as the conservative nature of assumptions and experience gained from other projects, are also included when available.

Assumptions for statistical tests as well as details on models employed as part of the EIA are discussed within the applicable components. This information will generally be provided in the Baseline Reports or appendices to the EIA. The intent of the review is to show that the data meets statistical requirements and that models employed are justified for use in the EIA. Specific information provided for models includes:

- a pictorial representation for all model compartments and linkages including all subroutines and modules;
- a list of all parameters incorporated in the model (reference to pictorial representation above) with a brief description of their purpose, known range of values, whether set from literature, calibrated, or measured (derived from local data) and the value(s) used in the EIA predictions;
- a sensitivity analysis demonstrating which parameters have the largest influence on model output; and
- a discussion of error for the parameters to which the model is most sensitive and for the final model output.

Uncertainty in the Project EIA is also managed through use of assessment scenarios that evaluate what is often referred to as being a worst-case scenario. This conservatism is based on the fact that all developments considered in the completed impact assessments are assumed to be at the maximum extent in terms of surface disturbance and operational emissions. However, the vast majority of projects in the region will be operated in phases with progressive reclamation throughout the project's life. Therefore, the actual extent of these developments during operation and reclamation at any one time is overestimated. The application of conservative assumptions means that predicted effects will likely be greater than the observed effects in the study area.

Based on the results of these methods, confidence is ranked qualitatively based on the following criteria and ranking system:

- quality and quantity of baseline information;
- confidence in measurements or analytical techniques (e.g., modelling) used to assess resource effects; and
- confidence in the success of mitigation and predicted residual effects after mitigation.

Each criterion receives a confidence rating from low to high. The three assigned rankings are then discussed to provide a rationale for the overall confidence rating.

4.8.2 Environmental Consequence

The environmental consequence rating has been developed to provide a measurement that consolidates the results of five criteria: magnitude, duration, frequency, geographic extent and reversibility. The purpose of assigning an environmental consequence is to provide a transparent process that consolidates the results of the criteria into one rating. The consolidation allows the effects from different components to be compared using a common rating so that areas of greatest potential concern can be identified.

Although a numerical system has been developed, the numbers are not an end in themselves. The intention is to use these numbers to provide a rating system that facilitates discussion and decision-making for the Project. Table 4.8-2 shows the screening system used to estimate an environmental consequence for residual impacts. The screening system details a numerical score for each of the parameters considered in evaluating an impact. The total is then used as a guide to assign environmental consequence of residual impacts as follows:

- negligible 0 to 5
- low 6 to 10
- moderate 11 to 15
- high greater than 15

Table 4.8-2 Screening System for Environmental Consequences

Magnitude (Severity)	Geographic Extent	Duration	Reversibility	Frequency
negligible (0)	local (0)	short-term (0)	yes (-3)	low (0)
low (+5)	regional (+1)	medium-term (+1)		moderate (+1)
moderate (+10)	beyond regional (+2)	long-term (+2)	no (+3)	high (+2)
high (+15)				

In some cases, the level of confidence on a prediction is low such that an estimate of environmental consequence cannot be made with a sufficient degree of certainty. Undetermined ratings are accompanied by recommendations for monitoring predictions and adaptive management success. Recommended follow-up activities are detailed within each of the EIA component sections.

4.8.3 Management and Monitoring

EnCana uses the environmental consequence ratings to define the management approaches to be implemented for the predicted environmental effect. The management for the predicted effects could include:

- re-engineering of systems;
- redesign of operational plans;
- enhancement of mitigation plans or processes;
- improvements in monitoring systems to enhance information on effects; or
- collection of additional information to reduce levels of uncertainty in the assessment.

EnCana views the definition of environmental consequences of Project impacts as an important step to ensure sustainability of the environment, and uses this information to guide development of its Environmental Management System, detailed in Volume 1. EnCana's current or planned monitoring activities are detailed in Appendix 2-VI.

5 PROJECTS CONSIDERED IN THE ASSESSMENT CASES

The assessment cases for the Project EIA include the Baseline Case, the Application Case and the PDC. The Application Case includes the Baseline Case and the Project. The PDC considers any project or activity that has been publicly disclosed up to six months prior to the submission of the Project application and EIA report. Table 5-1 overviews the cases and the developments included in the three cases. Figure 5-1 shows the locations of developments included in the assessment cases.

The EIA considers the effects of the developments included in each of the assessment cases, and predicts changes as a result of the addition of projects. Details on regional developments are provided in Appendix 2-VII. The data available for these developments are taken from project applications, EIAs, update reports and other project-specific information that is publicly available. In addition, the potential effects of Baseline Case developments are monitored through the actions of project-specific and regional monitoring programs such as the Wood Buffalo Environmental Association (WBEA) and RAMP.

The only development added to the Baseline Case for consideration under the Application Case is the Project. The result of this focusing of the assessment is that any changes in environmental or social components identified from those reported for the Baseline Case are thereby directly associated with the Project. The data for the potential effects of the Project are based on the project design and operational information, as provided in Volume 1 of the application.

The PDC adds the potential effects of a number of possible developments to the effects predicted for the Project in combination with the existing and approved developments. The determination of projects to be added in the PDC was made in compliance with the TOR conditions (AENV 2009) that stated that a planned project was one that had been publicly disclosed up to six months prior to the submission of the Project application and EIA (AENV 2009). Data used for the planned developments are based on:

- information provided by the developer in its public disclosure document;
- data that has been shown to be typical of similar types of operations in the Oil Sands Region;
- information from Planned Development project applications and EIAs if such documents are available; and
- specific information provided by the developer on its proposed development, where available.

Table 5-1 Assessment Cases

Developments Included in Assessment Cases	
Baseline Case (Existing + Approved Developments)	• **EnCana FCCL Ltd.:** Christina Lake Thermal Project, Foster Creek Pilot and Foster Creek Phases 1 and 2 • **Albian Sands Energy Inc.:** Muskeg River Mine and Muskeg River Mine Expansion • **Canadian Natural Resources Limited:** Kirby Pilot Project, Horizon Oil Sands Project, Burnt Lake Project, Primrose and Wolf Lake In-Situ Project, Primrose East In-Situ Oil Sands Project • **Connacher Oil and Gas Limited:** Great Divide Oil Sands Project • **ConocoPhillips Canada:** Surmont Commercial SAGD • **Devon Canada Corporation:** Jackfish SAGD Project, Jackfish 2 Project • **Husky Energy Inc.:** Tucker Thermal Project, Sunrise Thermal Project, Caribou Lake Thermal Project • **Imperial Oil Resources Limited:** Cold Lake In-Situ Project, Nabiye Expansion and Mahihkan North Expansion • **Imperial Oil Resources Ventures Limited:** Kearl Oil Sands Project • **Japan Canada Oil Sands Limited:** Hangingstone – In-Situ Pilot • **MEG Energy Corporation:** Christina Lake Regional Project – Phase 1, 2 and 2B • **OPTI Canada Inc./Nexen Canada Ltd.:** Long Lake Pilot and Commercial Project • **Petrobank Energy and Resources Ltd.:** Whitesands Pilot Project, Whitesands Project Expansion • **Petro-Canada:** Dover SAGD Pilot, VAPEX Pilot, MacKay River In-Situ, Meadow Creek In-Situ • **Petro-Canada Oil Sands Inc.:** Fort Hills Mining Project • **Shell Canada Limited:** Orion EOR Project, Jackpine Mine – Phase 1 • **Suncor Energy Inc.:** South Tailings Pond, Lease 86/17, Steepbank Mine, Millennium Mine, Voyageur Upgrader, Upgrader Complex, North Steepbank Extension Mine, Millennium Coker Unit (MCU), Millennium Vacuum Unit (MVU), Firebag Enhanced Thermal Solvent (ETS) Pilot Project and Firebag SAGD Project • **Syncrude Canada Ltd.:** Mildred Lake Mining and Upgrading, Mildred Lake Upgrader Expansion and Emissions Reduction Program, Aurora South Mine, Aurora North Mine • **Total E&P Joslyn Ltd.:** Joslyn Creek SAGD Project – Phase 1 and Commercial • **Aggregate Resources:** Birch Mountain Resources Ltd. Muskeg Valley Quarry • **Forestry** • **Fort McKay/Firebag Aerodrome** • **East Athabasca Highway** • **Williams Liquids Extraction and Storage Facilities** • **Gas Plants and Compressors** • **Municipalities and Communities** • **Pipelines, Roadways and Others**
Application Case (Existing + Approved Development + EnCana Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G)	• **EnCana FCCL Ltd.:** EnCana Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G

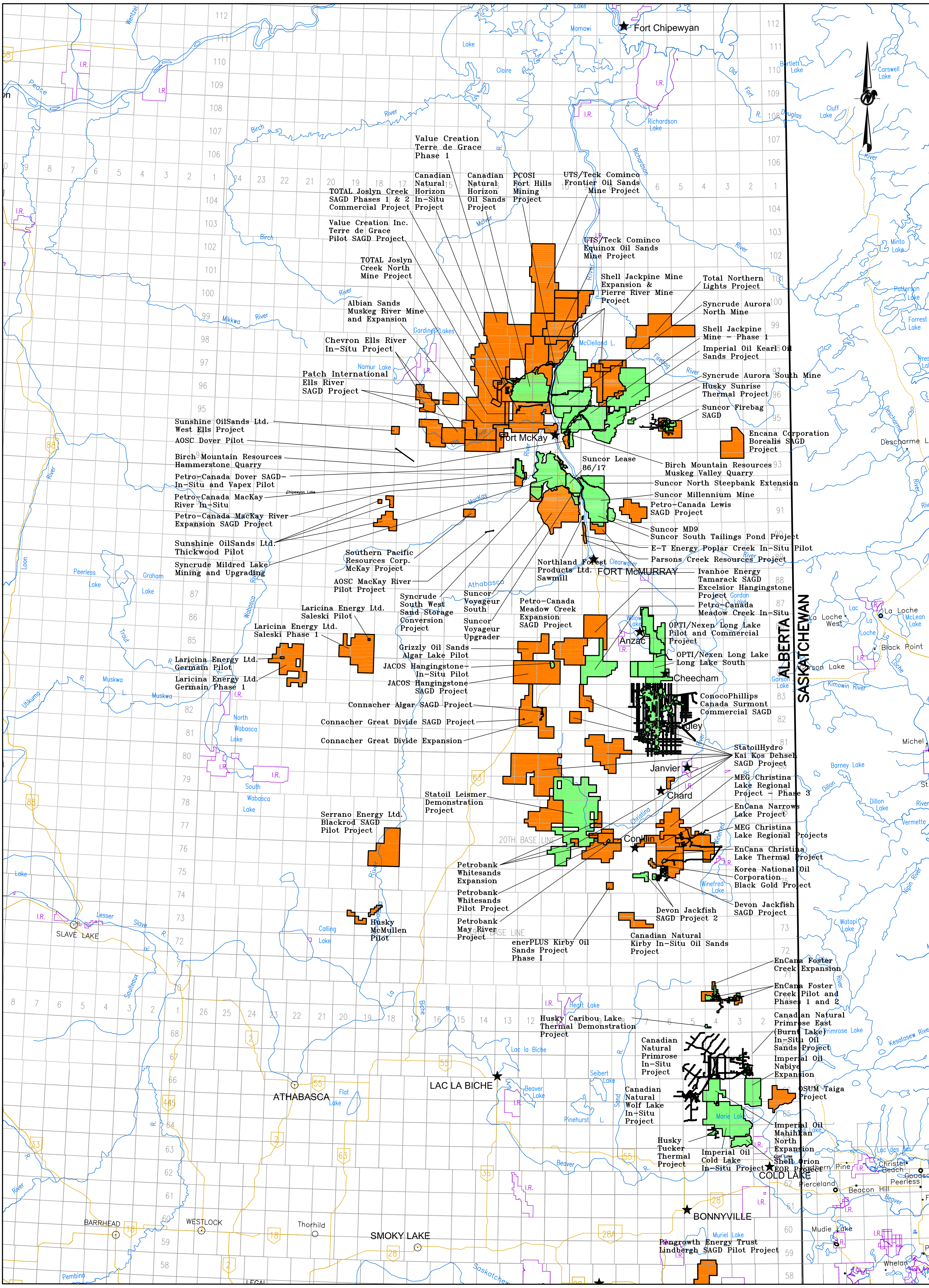
Table 5-1 Assessment Cases (continued)

Developments Included in Assessment Cases	
Planned Development Case (Existing + Approved Developments + EnCana Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G + Planned Developments)	• **EnCana FCCL Ltd.:** Foster Creek Expansion, Narrows Lake • **EnCana Corporation.:** Borealis SAGD Project • **Athabasca Oil Sands Corporation:** Dover Pilot, Thickwood Pilot • **Canadian Natural Resources Limited:** Horizon In-Situ Project, Kirby In-Situ Oil Sands Project • **Connacher Oil and Gas Limited:** Algar Oil Sands Project • **E-T Energy:** Field Test • **EnerPLUS:** Kirby Oil Sands Project • **Excelsior Energy Limited:** Hangingstone Pilot • **Grizzly Oil Sands:** Algar Lake Pilot • **Japan Canada Oil Sands Limited:** Hangingstone SAGD Project • **Korea National Oil Corporation:** Black Gold Project • **Laricina Energy Ltd.:** Germain Pilot, Saleski Pilot • **MEG Energy Corporation:** Christina Lake Regional Project – Phase 3 • **OPTI Canada Inc./Nexen Canada Ltd**: Long Lake Commercial Project Phase 2 • **Pengrowth Energy Trust:** Lindbergh SAGD Pilot Project • **Petrobank Energy and Resources:** May River Project • **Petro-Canada:** Lewis SAGD Project, Meadow Creek Expansion SAGD Project, MacKay River Expansion SAGD Project • **Serrano Energy Ltd.:** Blackrod SAGD Pilot Project • **Shell Canada Limited:** Jackpine Mine Expansion, Pierre River Mine • **Southern Pacific Resources Corporation:** McKay Project • **Statoil Hydro:** Kai Kos Dehseh SAGD Project • **Suncor Energy Inc.:** Voyageur South Project, Millennium Mine Dump 9 Project, Firebag Stages 4 to 6 • **Sunshine Oilsands Limited:** West Ells Pilot • **Syncrude Canada Ltd.:** South West Sand Storage Conversion Project • **Synenco Energy:** Northern Lights Project • **Total E&P Canada Ltd.:** Joslyn Creek SAGD Expansion, Joslyn North Mine Project • **Value Creation Inc.:** Terre de Grace Pilot SAGD Project • **Aggregate Resources:** Birch Mountain Resources Ltd.: Hammerstone Project, Parsons Creek Resources Project • **Forestry** • **Major Pipelines, Utility Corridors, Roadways And Others** • **Municipal Growth**

Note: Planned Developments include projects publicly disclosed 6 months before the writing of this report.

A summary of the developments considered in the Project EIA and the environmental or social components in which each development were specifically considered is provided in Table 5-2 for the Application Case and Table 5-3 for the PDC. Where a project is shown not to be considered by a component; that means there is no measurable overlap of potential effects of that project with the Project.

L:\2006\1344-OIL SANDS\1346\06-1346-003\9000\9010\ Drawing file: Fig 5-1 0613460039000A006 Oil Sands Basemap-Current.dwg Sep 18, 2009 - 3:50pm



LEGEND

- EXISTING AND APPROVED DEVELOPMENTS
- PLANNED DEVELOPMENTS

30 0 30

SCALE KILOMETRES

REFERENCE

AltaLIS

"Source: Information Services Corporation of Saskatchewan, (1:2,000,000 Base Data); Reproduced with the permission of Information Services Corporation of Saskatchewan

PROJECT

ENCANA

CHRISTINA LAKE THERMAL EXPANSION PROJECT PHASES 1E, 1F AND 1G

TITLE

OIL SANDS DEVELOPMENTS - EXISTING, APPROVED AND PLANNED

Golder Associates
Calgary, Alberta

PROJECT No.	06.1346.003.9000	FILE No. 0613460039000A006	
DESIGN	LD	01/07/09	SCALE AS SHOWN REV. 0
CADD	TRE	02/07/09	
CHECK	LD	18/09/09	FIGURE: 5-1
REVIEW	IGG	18/09/09	

Table 5-2 Developments Included and Components Considered in the Baseline and Application Cases

Development	EIA Component											
	Air Quality	Noise	Health	Air Emission Effects	Hydrogeology	Aquatic Resources	Terrestrial Resources	Traditional Land Use	Resource Use	Historical Resources	Visual Resources	Socio-Economics
EnCana Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (Application Case only)	●	●	●	●	●	●	●	●	●	●	●	●
EnCana FCCL Ltd.												
Christina Lake Thermal Project	●	●	●	●	●	●	●	●	●	●	●	●
EnCana Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G	●	●	●	●	●	●	●	●	●	●	●	●
Foster Creek Pilot	●	n/a	●	●	n/a	n/a	●	●	n/a	●	n/a	●
Foster Creek Phases 1 and 2	●	n/a	●	●	n/a	n/a	●	●	n/a	●	n/a	●
Albian Sands Energy Inc.												
Muskeg River Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Muskeg River Mine Expansion	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Canadian Natural Resources Limited												
Kirby Pilot Project	●	n/a	●	●	●	n/a	●	●	●	●	n/a	●
Horizon Oil Sands Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Burnt Lake Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Primrose and Wolf Lake In-Situ Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Primrose East In-Situ Oil Sands Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Connacher Oil and Gas Limited												
Great Divide Oil Sands Project	●	n/a	●	●	●	●	●	●	n/a	●	n/a	●
ConocoPhillips Canada												
Surmont Commercial SAGD	●	n/a	●	●	●	●	●	●	n/a	●	n/a	●
Devon Canada Corporation												
Jackfish SAGD Project	●	●	●	●	●	●	●	●	●	●	●	●
Jackfish 2 Project	●	●	●	●	●	●	●	●	●	●	●	●
Husky Energy Inc.												
Tucker Thermal Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Sunrise Thermal Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Caribou Lake Thermal Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	●	n/a	●
Imperial Oil Resources Limited												
Cold Lake In-Situ Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Nabiye Expansion	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Mahihkan North Expansion	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Imperial Oil Resources Ventures Limited												
Kearl Oil Sands Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Japan Canada Oil Sands Limited												
Hangingstone – In-Situ Pilot	●	n/a	●	●	●	n/a	n/a	n/a	n/a	●	n/a	●
MEG Energy Corporation												
Christina Lake Regional Project – Phase 1, 2 and 2B	●	n/a	●	●	●	●	●	●	●	●	●	●
OPTI Canada Inc./Nexen Canada Ltd.												
Long Lake Pilot	●	n/a	●	●	●	n/a	●	●	n/a	n/a	n/a	●
Long Lake Pilot Commercial Project	●	n/a	●	●	●	n/a	●	●	n/a	n/a	n/a	●
Petrobank Energy and Resources Ltd.												
Whitesands Pilot Project	●	n/a	●	●	●	●	●	●	●	●	n/a	●
Whitesands Project Expansion	●	n/a	●	●	●	●	●	●	n/a	●	n/a	●
Petro-Canada												
Dover SAGD Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
VAPEX Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
MacKay River In-Situ	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●

Table 5-2 Developments Included and Components Considered in the Baseline and Application Cases (continued)

Development	EIA Component											
	Air Quality	Noise	Health	Air Emission Effects	Hydrogeology	Aquatic Resources	Terrestrial Resources	Traditional Land Use	Resource Use	Historical Resources	Visual Resources	Socio-Economics
Meadow Creek In-Situ	●	n/a	●	●	●	n/a	●	●	n/a	●	n/a	●
Petro-Canada Oil Sands Inc.												
Fort Hills Mining Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Shell Canada Limited												
Orion EOR Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Jackpine Mine – Phase 1	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Suncor Energy Inc.												
South Tailings Pond	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Lease 86/17	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Steepbank Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Millennium Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Voyageur Upgrader	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Upgrader Complex	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
North Steepbank Extension Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Millennium Coker Unit (MCU)	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Millennium Vacuum Unit (MVU)	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Firebag SAGD Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Syncrude Canada Ltd.												
Mildred Lake Mining and Upgrading	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Mildred Lake Upgrader Expansion and Emissions Reduction Program	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Aurora South Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Aurora North Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Total E&P Joslyn Ltd.												
Joslyn Creek SAGD Project – Phase 1 and Commercial	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Aggregate Resources												
Birch Mountain Resources Ltd. Muskeg Valley Quarry	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Forestry	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Fort McKay/Firebag Aerodrome	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
East Athabasca Highway	●	n/a	●	●	n/a	●	●	●	●	●	●	●
Williams Liquids Extraction and Storage Facilities	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Gas Plants and Compressors	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Municipalities and Communities	●	n/a	●	●	n/a	●	●	●	●	●	●	●
Pipelines, Roadways and Others	●	n/a	●	●	n/a	●	●	●	●	●	●	●

n/a = Not applicable.
● = Included in assessment.

Table 5-3 Developments Included and Components Considered in the Planned Development Case

Developments	EIA Component											
	Air Quality	Noise	Health	Air Emission Effects	Hydrogeology	Aquatic Resources	Terrestrial Resources	Traditional Land Use	Resource Use	Historical Resources	Visual Resources	Socio-Economics
EnCana FCCL Ltd.												
Foster Creek Expansion	●	n/a	●	●	n/a	n/a	●	●	n/a	●	n/a	●
Narrows Lake	●	n/a	●	●	●	●	●	●	●	●	●	●
EnCana Corporation												
Borealis SAGD Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Athabasca Oil Sands Corporation												
Dover Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Thickwood Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Canadian Natural Resources Limited												
Horizon In-Situ Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Kirby In-Situ Oil Sands Project	●	n/a	●	●	●	●	●	●	●	●	n/a	●
Connacher Oil and Gas Limited												
Algar Oil Sands Project	●	n/a	●	●	n/a	●	●	●	n/a	●	n/a	●
E-T Energy												
Field Test	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
EnerPLUS												
Kirby Oil Sands Project	●	n/a	●	●	n/a	●	●	●	n/a	●	n/a	●
Excelsior Energy Limited												
Hangingstone Pilot	●	n/a	●	●	n/a	n/a	●	●	n/a	n/a	n/a	●
Grizzly Oil Sands												
Algar Lake Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Japan Canada Oil Sands Limited												
Hangingstone SAGD Project	●	n/a	●	●	●	n/a	●	●	n/a	●	n/a	●
Korea National Oil Corporation												
Black Gold Project	●	n/a	●	●	n/a	●	●	●	●	●	●	●
Laricina Energy Ltd.												
Germain Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Saleski Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
MEG Energy Corporation												
Christina Lake Regional Project – Phase 3	●	n/a	●	●	●	●	●	●	●	●	●	●
OPTI Canada Inc./Nexen Canada Ltd												
Long Lake Commercial Project Phase 2	●	n/a	●	●	●	n/a	●	●	n/a	●	n/a	●
Pengrowth Energy Trust												
Lindbergh SAGD Pilot Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Petrobank Energy and Resources												
May River Project	●	n/a	●	●	n/a	●	●	●	●	●	n/a	●
Petro-Canada												
Lewis SAGD Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Meadow Creek Expansion SAGD Project	●	n/a	●	●	n/a	n/a	●	●	n/a	●	n/a	●
MacKay River Expansion SAGD Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●

Table 5-3 Developments Included and Environmental Components Considered in the Planned Development Case (continued)

Developments	EIA Component											
	Air Quality	Noise	Health	Air Emission Effects	Hydrogeology	Aquatic Resources	Terrestrial Resources	Traditional Land Use	Resource Use	Historical Resources	Visual Resources	Socio-Economics
Serrano Energy Ltd.												
Blackrod SAGD Pilot Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Shell Canada Limited												
Jackpine Mine Expansion	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Pierre River Mine	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Southern Pacific Resources Corporation												
McKay Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Statoil Hydro												
Kai Kos Dehseh SAGD Project	●	n/a	●	●	●	●	●	●	●	●	●	●
Suncor Energy Inc.												
Voyageur South Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Millennium Mine Dump 9 Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Firebag Stages 4 to 6	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Sunshine Oilsands Limited												
West Ells Pilot	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Syncrude Canada Ltd.												
South West Sand Storage Conversion Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Synenco Energy												
Northern Lights Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Total E&P Canada Ltd.												
Joslyn Creek SAGD Expansion	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Joslyn North Mine Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Value Creation Inc.												
Terre de Grace Pilot SAGD Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Aggregate Resources												
Birch Mountain Resources Ltd.	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Hammerstone Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Parsons Creek Resources Project	●	n/a	●	●	n/a	n/a	n/a	n/a	n/a	n/a	n/a	●
Forestry	●	n/a	●	●	n/a	●	●	●	●	●	●	●
Major Pipelines, Utility Corridors, Roadways And Others	●	n/a	●	●	n/a	●	●	●	●	●	●	●
Municipal Growth	●	n/a	●	●	n/a	●	●	●	●	●	●	●

n/a = Not applicable.
● = Included in assessment.

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7 GLOSSARY

Alberta Ambient Air Quality Objective (AAAQO)	Alberta Ambient Air Quality Objective levels are established for several air compounds under Section 14 of the *Environmental Protection and Enhancement Act* (EPEA). The AAAQOs form an integral part of the management of air quality in the province, and are used for reporting the state of the environment, establishing approval conditions, evaluating proposed facilities with air emissions, assessing compliance near major air emission sources and guiding monitoring programs.
Alberta Energy and Utilities Board (EUB) now the Energy Resources Conservation Board (ERCB)	An independent, quasi-judicial agency of the Government of Alberta, the EUB was created in February 1995 by the amalgamation of the Energy Resources Conservation Board and the Public Utilities Board. The purpose of the EUB is to ensure that the discovery, development, and delivery of Alberta's resources take place in a manner that is fair, responsible and in the public interest.
Alberta Environment (AENV)	Provincial ministry that looks after the following: establishes policies, legislation, plans, guidelines and standards for environmental management and protection; allocates resources through approvals, dispositions and licenses, and enforces those decisions; ensure water infrastructure and equipment are maintained and operated effectively; and prevents, reduces and mitigates floods, droughts, emergency spills and other pollution-related incidents.
Alberta Sustainable Resource Development (ASRD)	Alberta Sustainable Resource Development (ASRD) is one of the Alberta Ministries whose mission is to encourage balanced and responsible use of Alberta's natural resources through the application of leading practices in management, science and stewardship. ASRD works with Albertans across the province to ensure a balance between the economic, environmental and social values of our province. They fight forest fires, manage fish and wildlife, oversee the development of Alberta's forests, and manage the use of public lands.
Ambient Sound Level	Background sound level: the sound level that is present in the acoustic environment of a defined area. Ambient sound can include sources from transportation equipment, animals and nature.

Benthic Invertebrates Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their life stages dwelling on bottom sediments in the waterbody.

These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.

Biodiversity The variety of plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected.

Biotic The living organisms in an ecosystem.

Bitumen A highly viscous, tarry, black hydrocarbon material having an API gravity of about 9 (specific gravity about 1.0). It is a complex mixture of organic compounds. Carbon accounts for 80 to 85% of the elemental composition of bitumen, hydrogen 10%, sulphur 5%, and nitrogen, oxygen and trace elements form the remainder.

Bog Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks.

Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.

Borden Block Map units of 10’ latitude by 10’ longitude used to facilitate site designation.

Boreal Forest The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.

Borrow Pit	A bank or pit from which earth is taken for use in filling or embanking. Often used in the construction of roads.
Brackish Water	Water with total dissolved solids concentration ranging from 1,000 to 10,000 g/m3.
Carnivore	Any of an order of mammals that feed chiefly on flesh or other animal matter rather than plants.
Critical Load	A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge. For waterbody acidification, the critical load represents an estimate of the amount of acidic deposition below which significant adverse changes are not expected to occur in a lake's ecosystem.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.
Exposure Ratio (ER) or Hazard Quotient (HQ)	A comparison between total exposure from all predicted routes of exposure and the exposure limits for chemicals of concern. This comparison is calculated by dividing the predicted exposure by the exposure limit. Also referred to as hazard quotient (HQ).
Fen	Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters. Minerotropic peat-forming wetlands that receive surface moisture from precipitation and groundwater. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.
Footprint	The proposed development area that directly affects the soil and vegetation components of the landscape.
Forage Fish	Small fish that provide food for larger fish (e.g., longnose sucker, fathead minnow).

Fragmentation	The process of breaking into pieces or sections. For example, dividing contiguous tracts of land into smaller and less connected sections through site clearing (e.g., for roads).
Geographic Information System (GIS)	Computer software designed to develop, manage, analyze and display spatially referenced data.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Guild	A set of co-existing species that share a common resource.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Historical/Heritage Resources	Works of nature or of humans, valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.
Hydrogeology	The study of the factors that deal with subsurface water (groundwater) and the related geologic aspects of surface water. Groundwater as used here includes all water in the zone of saturation beneath the earth's surface, except water chemically combined in minerals.
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.
In-Situ	Also known as "in place". Refers to methods of extracting deep deposits of oil sands without removing the groundcover. The in-situ technology in oil sands uses underground wells to recover the resources with less impact to the land, air and water than for oil sands mining.
Isopleth	A line on a map connecting places sharing the same feature (e.g., ground-level concentrations).
Key Indicator Resources (KIRs)	Environmental attributes or components identified as a result of a social scoping exercise as having legal, scientific, cultural, economic or aesthetic value.
Keystone Species	A species that is of particular importance to community integrity and function, without which significant changes to the community would occur.

Local Study Area (LSA)	Defines the spatial extent directly or indirectly affected by the project.
Oil Sands Region	The Oil Sands Region includes the Fort McMurray – Athabasca Oil Sands Subregional Integrated Resource Plan (IRP), the Lakeland Subregional IRP and the Cold Lake – Beaver River Subregional IRP.
Old Growth Forest	An ecosystem distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species, composition, and ecosystem function. Old growth forests are those forested areas where the annual growth equals annual losses, or where the mean annual increment of timber volume equals zero. They can be defined as those stands that are self-regenerating (i.e., having a specific structure that is maintained).
Particulate Matter	A mixture if small particles and liquid droplets, often including a number of chemicals, dust and soil particles.
Patterned Fen	Peatlands that display a distinctive pattern due to alterations between open wet areas (flarks) and drier shrubby to wooded areas (strings).
Peatland	Areas where there is an accumulation of peat material at least 40 cm thick. These are represented by bog and fen wetlands types.
Potential Acid Input (PAI)	A composite measure of acidification determined from the relative quantities of deposition from background and industrial emissions of sulphur, nitrogen and base cations.
Rare Plants	A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory or country.
Receptor	The person or organism subjected to exposure to chemicals or physical agents.
Regional Aquatics Monitoring Program (RAMP)	RAMP was established to determine, evaluate and communicate the state of the aquatic environment in the Athabasca Oil Sands Region.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.

Riparian Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.

Risk The likelihood or probability that the toxic effects associated with a chemical or physical agent will be produced in populations of individuals under their actual conditions of exposure. Risk is usually expressed as the probability of occurrence of an adverse effect, i.e., the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to the factor. Risk is expressed as a fraction without units and takes values from 0 (absolute certainty that there is no risk, which can never be shown) to 1.0, where there is absolute certainty that a risk will occur.

Risk Assessment Process that evaluates the probability of adverse effects that may occur, or are occurring on target organism(s) as a result of exposure to one or more stressors.

Runoff The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.

Sediment Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope soil characteristics, land usage and quantity and intensity of precipitation.

Sentinel Species Species that can be used as an indicator of environmental conditions.

Species A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.

Sport / Game Fish Large fish caught for food or sport (e.g., northern pike, Arctic grayling).

Steam Assisted Gravity Drainage (SAGD)	An in-situ oil sands recovery technique that involves the use of two horizontal wells, one to inject steam and a second to produce the bitumen.
Suspended Sediments	Particles of matter suspended in the water. Measured as the oven dry weight of the solids, in mg/L, after filtration through a standard filter paper. Less than 25 mg/L would be considered clean water, while an extremely muddy river might have 200 mg/L of suspended sediments.
Traditional Environmental (or Ecological) Knowledge (TEK)	Knowledge and understanding of traditional resource and land use, harvesting and special places.
Traditional Land Use (TLU)	Activities involving the harvest of traditional resources such as hunting and trapping, fishing, gathering medicinal plants and travelling to engage in these activities. Land use maps document locations where the activities occur or are occurring.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams and rivers.
Wetlands	Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or "peatlands," and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.
Wildlife	Under the *Species at Risk Act*, wildlife is defined as a species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus that is wild by nature and is native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.

Worst-Case A semi-quantitative term referring to the maximum possible exposure, dose or risk that can conceivably occur, whether or not this exposure, dose, or risk actually occurs or is observed in a specific population. It should refer to a hypothetical situation in which everything that can plausibly happen to maximize exposure, dose, or risk does happen. The worst-case may occur in a given population, but since it is usually a very unlikely set of circumstances in most cases, a worst-case estimate will be somewhat higher than what occurs in a specific population.

8 ABBREVIATIONS

%	Percent
<	Less than
>	More than
°C	Temperature in degrees Celsius
AAAQO	Alberta Ambient Air Quality Objectives
ACCS	Alberta Culture and Community Spirit (formerly Alberta Tourism, Parks, Recreation and Culture)
AENV	Alberta Environment
ASRD	Alberta Sustainable Resource Development
AVI	Alberta Vegetation Inventory
bbl/d	Barrels per day
C&R	Conservation and Reclamation
CEA	Cumulative Effects Assessment
CEAA	*Canadian Environmental Assessment Act*
CEMA	Cumulative Environmental Management Association
CLTP	Christina Lake Thermal Project
dB	Decibel, a measure of sound power
E	East
e.g.	For example
EIA	Environmental Impact Assessment
EnCana	EnCana FCCL Ltd.
EPEA	*Environmental Protection and Enhancement Act*
ER	Exposure ratio
ERCB	Energy Resources Conservation Board
EUB	Alberta Energy and Utilities Board (predecessor to the Energy Resources Conservation Board [ERCB])
GHG	Greenhouse Gas
GIS	Geographic Information System
ha	Hectare
HRIA	Historical Resources Impact Assessment
i.e.	That is
keq/ha/yr	Kiloequivalent per hectares per year
KIRs	Key Indicator Resources
km	Kilometre
km^2	Square
LIDAR	Light Detection and Ranging
LSA	Local Study Area

m	Metre
m^3/d	Cubic metres per day
masl	metres above sea level
MEG	MEG Energy Corp.
N	North
NAD	North American Datum
NOEC	No Observed Effects Concentration
NO_X	Oxides of nitrogen (NO, NO_2) (gas), or all nitrogen species (e.g., NO_X, N_2O, N_3O)
NRCB	Natural Resources Conservation Board
NTDB	National Topographic Database
OTSG	Once Through Steam Generator
PAI	Potential Acid Input
PDA	Pre-Disturbance Assessment
PDC	Planned Development Case
PM	Particulate matter
$PM_{2.5}$	Particulate matter with a mean aerodynamic diameter of 2.5 microns (µm) or smaller
QA/QC	Quality Assurance/Quality Control
RAMP	Regional Aquatics Monitoring Program
RMWB	Regional Municipality of Wood Buffalo
RSA	Regional Study Area
RSDS	Regional Sustainable Development Strategy for the Athabasca Oil Sands
S	South
SAGD	Steam Assisted Gravity Drainage
SEWG	Sustainable Ecosystems Working Group
SK	Saskatchewan
SO_2	Sulphur dioxide
SOR	Steam to oil ratio
t/d	Tonnes per day
TEK	Traditional Ecological Knowledge
TOR	Terms of Reference
TLU	Traditional Land Use
UTM	Universal Transverse Mercator
W	West
W4M	West of the Fourth Meridian
WBEA	Wood Buffalo Environmental Association

APPENDIX 2-I

TERMS OF REFERENCE

THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.

TERMS OF REFERENCE

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR THE

ENCANA FCCL OIL SANDS LTD.

CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASE E, F AND G

Approximately 150 km South of Fort McMurray, Alberta

ISSUED BY: **ALBERTA ENVIRONMENT**

DATE: **JULY 23, 2009**

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PURPOSE OF THE TERMS OF REFERENCE

The purpose of this document is to identify for EnCana FCCL Oil Sands Ltd. (EnCana FCCL), aboriginal communities and appropriate stakeholders the information required by government agencies for an Environmental Impact Assessment (EIA) report prepared under the *Environmental Protection and Enhancement Act* (EPEA) for the Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project).

EnCana plans to develop its commercial-scale bitumen production project on its Oil Sands Development Leases located in Townships 75 and 76, Ranges 5 and 6, W4M, in the area south of Christina Lake, Alberta. The Project will be based on steam assisted gravity drainage (SAGD) thermal technology. EnCana, FCCL Oil Sands Ltd. has been developing and operating its Christina Lake Thermal Project in phases since receiving approvals in 2000. The facility currently produces approximately 14,000 barrels per day (bbl/d) and is approved up to phase D (98,800 bbl/d). We are seeking regulatory approval for a proposed expansion, phases 1E, 1F and 1G, that would take production to 218,800 bbl/d over the next decade. This expansion will continue to use steam-assisted gravity drainage (SAGD) thermal oil recovery technology to recover the bitumen (thick oil).

SCOPE OF THE EIA REPORT

EnCana FCCL shall prepare and submit an EIA report that examines the environmental and socio-economic effects of the Project.

The EIA report shall be prepared with consideration to all applicable provincial and federal legislation, codes of practice, guidelines, standards and directives. EnCana FCCL shall identify the legislation, policies, approvals, and current multi-stakeholder planning initiatives applicable to the Project.

The EIA report shall be prepared in accordance with these Terms of Reference and the environmental information requirements prescribed under EPEA and associated regulations, and the *Canadian Environmental Assessment Act*, if applicable. The EIA report will form part of EnCana FCCL' application to the Energy Resources Conservation Board (ERCB). An EIA report summary will also be included as part of the ERCB Application.

EnCana FCCL shall refer to the Guide to Preparing Environmental Impact Assessment Reports in Alberta published by Alberta Environment (the Guide) and these Terms of Reference when preparing the EIA report. In any case where there is a difference in requirements between the Guide and these Terms of Reference, the Terms of Reference shall take precedence.

The EIA report will include a glossary of terms and a list of abbreviations to assist the reader in understanding the material presented. It will also include concordance tables that cross-reference the EIA report to the sub-section level (lower case letters) of the Terms of Reference.

EnCana FCCL will prepare a summary of the EIA report that will provide the reader with sufficient information to obtain a general understanding of the Project and its potential positive and negative effects. The summary report shall be a stand-alone document; however, it can reference more detailed information presented in the EIA report itself.

[A] The summary report shall provide an overview of the EIA report including:

a) the Project components and development activities which have the potential to affect the environment;
b) existing conditions in the Study Area, including existing uses of lands, resources and other activities which have potential in combination with proposed development activities, to affect the environment;

c) the environmental, cultural, and socio-economic impacts of the Project including the regional, temporal, and cumulative effects which are anticipated;
d) impact significance in terms of magnitude, extent, duration, frequency, and reversibility;
e) residual effects; and
f) an overview of modeling techniques used.

The summary report shall include suitable maps, charts and other illustrations to identify the components of the Project, the existing conditions, and the environmental and socio-economic implications of the development.

CONTENT OF THE EIA REPORT

1 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION

[A] Document the public engagement program implemented for the Project including:
a) list of all meetings and the specific comments or issues raised at the meetings;
b) description and documentation of concerns and issues expressed by the public, EnCana FCCL analysis of those concerns and issues, and the actions taken to address those concerns and issues; and
c) how public input was incorporated into the Project development, impact mitigation and monitoring plans.

[B] Document the aboriginal consultation program implemented for the Project including:
a) list of all meetings and the specific comments or issues raised at the meetings;
b) description and documentation of concerns and issues expressed by aboriginal communities and groups EnCana FCCL analysis of those concerns and issues, and the actions taken to address those concerns and issues;
c) how aboriginal input was incorporated into the Project development, impact mitigation and monitoring plans; and
d) consultation undertaken with aboriginal communities and groups with respect to traditional ecological knowledge and traditional use of land.

[C] Describe plans to maintain the public engagement and aboriginal consultation process following completion of the EIA report review to ensure that the public and aboriginal peoples will have an appropriate forum for expressing their views on the ongoing development, operation and reclamation of the Project.

2 PROJECT DESCRIPTION

2.1 THE PROPONENT

[A] Provide:
a) a corporate profile; and
b) the name of the legal entity that will develop, manage and operate the Project and hold the operating approvals.

[B] Describe EnCana FCCL and its history in Alberta’s oil and gas industry, with specific reference to existing operations, proposed operations, mineral resources, environmental studies and community involvement.

2.2 PROJECT DEVELOPMENT

[A] Provide a development plan that includes:
a) the phases of development;
b) bitumen/heavy oil recovery facilities;
c) processing facilities;
d) steam and/or power generation facilities;

e) infrastructure (pipelines, access roads and power lines);
f) other buildings and structures;
g) field maintenance operations; and
h) activities associated with each stage of the Project.

[B] Provide a schedule outlining the proposed phases of development and the sequence and duration of key project components, including the timing of key steps in the construction, operation, decommissioning and reclamation stages of each phase.

[C] Discuss the key factors controlling the schedule, restrictions for conducting certain development activities, and uncertainties.

2.3 EVALUATION OF ALTERNATIVES

2.3.1 Project Alternatives

[A] Discuss the need for the Project including:

a) any alternative means of carrying out the Project that are technically and economically feasible and where applicable indicate their potential environmental effects and impacts;
b) a comparison of identified alternatives to the Project or components of the Project and the anticipated effects and impacts of the alternatives. Discuss how environmental, socio-economic and traditional use criteria influenced the selection of the proposed alternatives. Discuss reasons for not selecting any identified alternatives;
c) implications resulting from a delay in proceeding with the Project, or any phase of the Project; and
d) potential cooperative development opportunities (e.g., shared infrastructure).

[B] Discuss the implications of not going ahead with the Project.

2.3.2 Process and Infrastructure Alternatives

[A] Describe the process and criteria used to select sites for facilities and infrastructure.

[B] Discuss the route or site selection criteria for any linear or other infrastructure development or modification and provide the rationale for selecting the proposed alignment and design.

[C] Discuss the options considered for supplying the thermal energy and electric power required for the Project and their environmental implications. Discuss the implications that alternate fuel sources may have on the selection of pollution abatement equipment or technologies.

[D] Describe the criteria and rationale for selecting the preferred water supply sources. Include options for using saline groundwater and the criteria used to assess the feasibility of its use.

[E] Discuss the potential for new or additional technology to increase resource recovery at later times in the field development and to affect the number of wells required.

[F] Discuss options and technologies considered for wastewater treatment, wastewater management and wastewater disposal and reasons, including water quality and environmental considerations for selecting the preferred options in the context of best management practices and best available technologies.

[G] Discuss options and technologies considered for air emission and air quality management and the evaluation of emission minimization options, including air emission control technology considerations, for selecting the preferred options in the context of best management practices and best available technologies.

[H] Discuss the waste disposal options. Discuss the strategy for on-site waste disposal versus off-site waste disposal and identify:

a) the location of on-site waste disposal, including landfills, if applicable;

b) the availability of off-site waste disposal facilities;
c) site suitability from a groundwater protection perspective;
d) site suitability from a geo-technical perspective; and
e) site suitability with regard to existing and potential human activities in the area.

2.4 PROJECT PROCESSES AND FACILITIES

[A] Provide maps and/or drawings of the Project components and activities including:
a) existing infrastructure, leases and clearings, including exploration clearings;
b) proposed central processing/treatment and field facilities;
c) other buildings and infrastructure (pipelines and utilities);
d) temporary structures;
e) transportation and access routes;
f) on-site hydrocarbon storage;
g) containment structures such as retention ponds and storage ponds (e.g., lime sludge, stormwater runoff, boiler blow-down);
h) water wells/intakes, pipelines, and storage structures;
i) sources of aggregate resources, borrow material and other construction material and locations of any stockpiles that will be developed; and
j) waste storage area and disposal sites.

[B] Provide a list of facilities for which locations will be determined later.

[C] Describe the primary resource recovery process, any proposed follow-up recovery process and other related processes and process facilities of the Project.

[D] Discuss the amount and source of energy required for the Project.

[E] Describe the proposed method to transport product to markets.

[F] Provide a listing of chemical products to be manufactured, processed or otherwise used for the Project and describe, in general terms, how these products will be stored and managed. Identify products containing substances that are:
a) *Canadian Environmental Protection Act*, 1999 toxics;
b) listed on the National Pollutant Release Inventory;
c) dangerous goods as defined by the federal *Transportation of Dangerous Goods Act*; and
d) on the Domestic Substances List and categorized as requiring further assessment under Canada's Chemicals Management Plan.

[G] Describe the nature and amount of on-site hydrocarbon storage. Discuss containment and other environmental protection measures.

2.5 TRANSPORTATION INFRASTRUCTURE

[A] Provide a summary of any Traffic Impact Assessment study carried out for the Project, or where no Traffic Impact Assessment study has been conducted, describe the anticipated changes to traffic (e.g., type, volume) on highways, including an assessment of impacts for all stages of the Project. Consider other existing and planned uses of the same highways.

[B] Describe and map the locations of any new road or intersection construction, or any improvements to existing roads or intersections, related to the development of the Project, from the boundary of the Project Area up to and including the highway access point, and
a) discuss the alternatives and the rationale for selection of the preferred alternative;
b) describe the impacts to local communities of the changes in transportation infrastructure;
c) provide a proposed schedule of work;
d) provide an estimated cost of the work; and

e) provide a summary of the consultation with Alberta Transportation and the local authority, including their views on the compatibility of the proposed work with their own local or regional infrastructure development plans.

[C] Identify the type, volume, location and availability of road construction and road improvement work, related to the development of the Project, within the outside of the Project Area

[D] Describe the access corridors needed and/or planned by other resource stakeholders including those responsible for Forest Management Areas and other timber quota holders, and

a) describe how their needs are accommodated to reduce overall environmental impact from resource development; and
b) describe opportunities for cooperation in access development.

[E] Indicate where Crown land dispositions may be needed for roads or other infrastructure for the Project.

[F] Describe crossings of watercourses or waterbodies required and provide example diagrams of each type of crossing. Discuss:

a) timing,
b) construction standards or methods, and
c) environmental protection plans.

2.6 LAND MANAGEMENT

[A] Provide a description and timing of land clearing activities.

[B] Provide a timber salvage plan, highlighting end users and identifying proposed volumes for removal (by species and year) for all stages of the Project.

[C] Identify any access restrictions including where appropriate, measures taken to control access to the Project Area while ensuring continued access to adjacent wildland areas.

[D] Provide a fire control plan highlighting:

a) measures taken to ensure continued access for firefighters to adjacent wildland areas;
b) forest fire prevention, detection, reporting, and suppression measures, including proposed fire equipment;
c) measures for determining the clearing width of power line rights-of-way; and
d) required mitigative measures for areas adjacent to the Project Area based on the FireSmart Wildfire Assessment System.

2.7 AIR EMISSIONS MANAGEMENT

[A] Provide emission profiles (type, rate and source) for the Project's operating and construction emissions including point and non-point sources and fugitive emissions. Consider both normal and upset conditions. Discuss:

a) odorous or visible emissions from the proposed facilities;
b) annual and total greenhouse gas emissions during all stages of the Project. Identify the primary sources and provide examples of calculations;
c) the intensity of greenhouse gas emissions per unit of bitumen produced and discuss how it compares with similar projects;
d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;
e) EnCana FCCL overall greenhouse gas management plans;
f) the amount and nature of Criteria Air Contaminant emissions;
g) the amount and nature of acidifying emissions, probable deposition patterns and rates;
h) control technologies used to minimize air emissions such as sulphur dioxide (SO_2), hydrogen sulphide (H_2S), oxides of nitrogen (NO_X), greenhouse gases, volatile organic compounds

(VOC), polycyclic aromatic hydrocarbons (PAH), particulate matter (PMx), carbon monoxide (CO) and ammonia (NH_3);

i) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized;
j) upset condition scenarios (e.g., frequency and duration) and proposed measures to ensure upset conditions are minimized;
k) gas collection and conservation, and the applicability of vapour recovery technology;
l) fugitive emissions control technology to detect, measure and control emissions and odours from equipment leaks; and
m) the applicability of sulphur recovery, acid gas re-injection, or flue gas desulphurization to reduce sulphur emissions.

2.8 WATER MANAGEMENT

[A] Discuss potential cooperation with other parties regarding water related infrastructure and management including, but not limited to, water intakes, pipelines, water storage and withdrawals, flow monitoring and reporting and ecological monitoring.

2.8.1 Water Supply

[A] Describe the water supply requirements for the Project, including:

a) the expected water balance during the life of the Project. Discuss assumptions made or methods chosen to arrive at the water balances;
b) the process, potable and non-potable water requirements and sources for construction, start-up, normal and emergency operating situations, decommissioning and reclamation. Identify the volume of water to be withdrawn from each source, considering plans for wastewater reuse;
c) the location of sources and associated infrastructure (e.g., pipelines for water supply);
d) the variability in the amount of water required on an annual and seasonal basis as the Project is implemented;
e) the expected cumulative effects on water losses/gains due to the Project operations;
f) potable water treatment systems all stages of the Project;
g) type and quantity of potable water treatment chemicals used; and
h) measures for ensuring efficient use of water including alternatives to reduce the consumption of non-saline water such as water use minimization, recycling, conservation, and technological improvements.

2.8.2 Surface Water

[A] Describe the surface water management strategy for all stages of the Project, including:

a) design factors considered, such as:
    i) site drainage,
    ii) run-on management,
    iii) road, well pad and plant run-off,
    iv) erosion and sediment control,
    v) groundwater and surface water protection,
    vi) groundwater seepage,
    vii) produced water management,
    viii) flood protection, and
    ix) geotechnical stability concerns; and
b) permanent or temporary alterations or realignments of watercourses, wetlands and other waterbodies.

[B] Describe realignments of Crown bed and shore and proposed compensation.

[C] Provide a description of navigable waterways and the results of navigability assessment(s) waterways that may be affected by the Project.

2.8.3 Wastewater Management

[A] Describe the wastewater management strategy, including:

a) the source, quantity and composition of each wastewater stream from each component of the proposed operation (e.g., bitumen extraction and associated facilities) for all Project conditions, including normal, start-up, worst-case and upset conditions;
b) the proposed disposal locations and methods for each wastewater stream, and the measures taken to prevent impacts on potable groundwater, aquatic ecosystems and vegetation;
c) formations for the disposal of wastewaters;
d) design of facilities that will collect, treat, store and release wastewater streams;
e) type and quantity of chemicals used in wastewater treatment; and
f) sewage treatment and disposal.

2.9 WASTE MANAGEMENT

[A] Characterize and quantify the anticipated dangerous goods, and hazardous, non-hazardous, and recyclable wastes generated by the Project, and:

a) describe the composition and volume of specific waste streams and discuss how each stream will be managed;
b) identify the amount of drilling wastes and the options considered for disposal and the option(s) chosen;
c) describe how the disposal sites and sumps will be constructed; and
d) describe plans for pollution prevention, waste minimization, recycling, and management to reduce waste quantities for all stages of the Project.

2.10 CONSERVATION AND RECLAMATION

[A] Provide a conceptual conservation and reclamation plan for the Project considering:

a) any existing Conservation and Reclamation Plan;
b) pre-development information with respect to land capability, vegetation, commercial forest land base by commercialism class, forest productivity, recreation, wildlife, aquatic resources, aesthetics, traditional land uses and land use resources;
c) integration of operations, decommissioning, reclamation planning and reclamation activities.
d) discuss anticipated timeframes for completion of reclamation stages and release of lands back to the Crown including an outline of the key milestone dates for reclamation and how progress to achieve these targets will be measured;
e) constraints to reclamation such as timing of activities, availability of reclamation materials and influence of natural processes and cycles including natural disturbance regimes;
f) post-development land capability with respect to:
    i) self-sustaining topography, drainage and surface watercourses representative of the surrounding area,
    ii) pre-development traditional use with consideration for traditional vegetation and wildlife species in the reclaimed landscape,
    iii) wetlands,
    iv) self-sustaining vegetation communities representative of the surrounding area, and
    v) reforestation and forest productivity;
g) a revegetation plan for the disturbed terrestrial and aquatic areas, identifying the species types that will be used for seeding or planting, and the vegetation management practices to return disturbed areas to a state capable of supporting a self-sustaining vegetative community capable of ecological succession equivalent to pre-disturbance conditions, considering factors such as biological capability and diversity, natural disturbance regimes and end land use objectives;

h) reclamation material salvage, storage areas and handling procedures;
i) reclamation material replacement indicating depth, volume and type;
j) pre-development and final reclaimed site drainage plans;
k) integrating surface and near-surface drainage within the Project Area; and
l) promotion of biodiversity.

[B] Provide a predicted Ecological Land Classification map for the post-reclamation landscape considering potential land uses, including traditional uses, and how the landscape and soils have been designed to accommodate future land use.

[C] Provide a conceptual plan to monitor reclamation performance and success (including soils, vegetation, wildlife and aquatic resources).

[D] Discuss uncertainties related to the conceptual reclamation plan.

2.11 ENVIRONMENTAL MANAGEMENT SYSTEMS

[A] Summarize key elements of EnCana FCCL existing or proposed environment, health and safety management system.

[B] Describe adaptive management plans that minimize the impact of the Project. Describe the flexibility built into the Project to accommodate future modifications as a result of:
a) any change in environmental standards, limits and guidelines; or
b) findings from Project-specific or regional monitoring.

[C] Describe EnCana FCCL current and proposed source monitoring programs with respect to:
a) source air emissions, including fugitive emissions;
b) wastewater treatment and release; and
c) hazardous and non-hazardous waste treatment and storage.

[D] Discuss:
a) how monitoring data will be disseminated to the public or other interested parties; and
b) how the results of monitoring programs and publicly available monitoring information will be integrated with EnCana FCCL environmental management system.

2.12 REGIONAL AND COOPERATIVE INITIATIVES

[A] Discuss EnCana FCCL's involvement in regional and cooperative efforts to address environmental and socio-economic issues associated with regional development, including:
a) potential cooperative ventures that EnCana FCCL has initiated, could initiate or could develop with other operators and other resource users;
b) how EnCana FCCL will work to develop and implement such cooperative opportunities;
c) EnCana FCCL participation in any regional forums;
d) how EnCana FCCL would design and implement research programs; and
e) how regional environmental management initiatives will be incorporated into EnCana FCCL's management practices.

[B] Discuss EnCana FCCL regional monitoring activities including:
a) monitoring that will be undertaken to assist in managing environmental effects, confirm performance of mitigative measures and improve environmental protection strategies;
b) monitoring done independently by EnCana FCCL;
c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups; and
d) new monitoring initiatives that may be required as a result of the Project.

3 ENVIRONMENTAL ASSESSMENT

3.1 ASSESSMENT REQUIREMENTS

3.1.1 Scenarios

[A] Define assessment scenarios including:

a) a Baseline Case, which includes existing environmental conditions, existing and approved projects or activities;
b) an Application Case, which includes the Baseline Case plus the Project; and
c) a Planned Development Case, which includes past, existing and anticipated future environmental conditions, based on existing and approved projects or activities, plus planned projects or activities reasonably expected to occur.

For the purposes of defining the assessment scenarios, *approved* means approved by any federal, provincial or municipal regulatory authority. *Planned* means any project or activity that has been publicly disclosed up to six months prior to the submission of EnCana FCCL's Application and EIA report.

3.1.2 Study Areas

3.1.2.1 Project Area

[A] The Project Area includes all lands subject to direct disturbance from the Project and associated infrastructure. For the Project Area, provide:

a) the legal land description;
b) the boundaries of the land under EnCana FCCL's control (this may include lands under the public land disposition or private lands leased or owned by EnCana FCCL);
c) the proposed ERCB approval area;
d) a map that shows the status of land tenure/ownership and identifies the locations of all proposed development activities and facilities; and
e) a topographic map of appropriate scale showing the area proposed to be disturbed in relation to existing township grids, wetlands, watercourses, and waterbodies.

3.1.2.2 Local and Regional Study Areas

[A] The Local Study Area (LSA) is the area existing outside the boundaries of the Project Area, where there is a reasonable potential for immediate environmental impacts due to ongoing Project activities.

[B] The Regional Study Area (RSA) is the area within which there is the potential for cumulative and socio-economic effects, and that may be relevant to the assessment of any wider-spread effects of the Project.

[C] The Study Area for the EIA report shall include the Project Area as well as the spatial and temporal limits of individual environmental components outside of the Project Area boundaries where an effect can be reasonably expected. The Study Area includes both the Local and Regional Study Areas.

[D] For each LSA and RSA:

a) provide the scientific rationale used to define the spatial and temporal aspects considering the location and range of probable Project and cumulative effects;
b) identify LSA and RSA boundaries on maps of appropriate scale that show existing township grids, wetlands, watercourses, waterbodies and other topographic features.

[E] Identify the traditional land use areas within the Study Area, as provided by aboriginal communities and groups.

3.1.3 Cumulative Environmental Effects

[A] EnCana FCCL will assess cumulative environmental effects in accordance with the ERCB/AENV/Natural Resources Conservation Board Information Letter *Cumulative Effects Assessment* *in Environmental Impact Assessment Reports under the Alberta Environmental Protection and Enhancement Act*, June 2000. EnCana FCCL will include a summary of all proposed monitoring, research and other strategies or plans to minimize, mitigate and manage any potential adverse effects.

[B] Explain the approach and methods used to identify and assess cumulative impacts, including cooperative opportunities and initiatives undertaken to further the collective understanding of cumulative effects. Provide a record of relevant assumptions, confidence in data and analysis to support conclusions.

3.1.4 Information Requirements

[A] EnCana FCCL shall include the following environmental information for each assessment scenario:

- a) a description of and rationale for the selection of environmental attributes, parameters, or properties examined;
- b) for each selected environmental attribute, parameter, or property:
  - i) describe existing conditions. Comment on whether the available data are sufficient to assess impacts and mitigative measures. Identify environmental disturbance from previous, current, and approved activities that have become part of the baseline conditions,
  - ii) describe the environmental effects associated with the development activities,
  - iii) provide plans to minimize, mitigate or eliminate negative effects and impacts. Discuss the key elements of such plans,
  - iv) provide a description of the process and criteria used to determine the significance of environmental effects,
  - v) provide a plan to manage environmental changes and identify and follow-up programs necessary to verify the accuracy of the environmental assessment and to determine effectiveness of measures taken to mitigate adverse environmental effects, and
  - vi) describe residual effects and their significance;
- c) a discussion of the sources of information used in the assessment including:
  - i) a summary of previously conducted environmental assessments related to EnCana FCCL's operations,
  - ii) literature and previous EIA reports and environmental studies; operating experience from current, similar operations; industry study groups; traditional knowledge; and government sources, and
  - iii) limitations or deficiencies that the information may place on the analysis or conclusions in the EIA report. Discuss how these limitations or deficiencies may be addressed within the EIA report; and
- d) description of the techniques used to identify and evaluate the environmental impacts and effects resulting from the Project.

[B] The EIA report shall:

- a) identify where deficiencies in information exist and describe EnCana FCCL's plan, including a rationale, for providing the necessary information. Where required undertake studies and investigations to obtain additional information to address the information deficiencies;
- b) provide a sufficient base for the prediction of positive and negative impacts and the extent to which negative impacts may be mitigated by planning, Project design, construction techniques, operational practices and reclamation techniques. Impact significance will be quantified where possible and assessed including consideration of spatial, temporal and cumulative aspects;
- c) provide a plan that addresses the adverse impacts associated with the Project that may require joint resolution by government, industry and the community. Describe how this plan might be implemented and how it would incorporate the participation of government, industry and the community; and
- d) present biophysical information in a manner that enables ecological land classification maps to be completed to the ecosite classification level.

3.1.5 Modeling

[A] For those models or modeling techniques used that are not prescribed by regulators to predict Project impacts provide:

a) the justification for the model used;
b) documentation of the calibration process, the validation process and the assumptions used and data sets used to obtain the modeling predictions in the EIA report;
c) discussion of the limitations of the models, including sources of error and relative accuracy, and how these limitations were addressed in the EIA report.

[B] Air quality modeling shall be conducted in accordance with the latest edition of the *Air Quality Modeling Guidelines* published by Alberta Environment.

3.2 AIR QUALITY, CLIMATE AND NOISE

3.2.1 Baseline Information

[A] Discuss the baseline climatic and air quality conditions including:

a) the type and frequency of meteorological conditions that may result in poor air quality; and
b) appropriate ambient air quality parameters such as SO_2, CO, H_2S, total hydrocarbons (THC), NOX, VOC, PAH, individual hydrocarbons of concern in the THC and VOC mixtures, ground-level ozone (O_3), visibility, representative heavy metals, and particulates (road dust, PM_{10} and $PM_{2.5}$).

[B] Provide representative baseline noise levels at receptor locations.

3.2.2 Impact Assessment

[A] Identify components of the Project that will affect air quality, and:

a) describe the potential for reduced air quality (including odours and visibility) resulting from the Project and discuss any implications of the expected air quality for environmental protection and public health, including the local residents and actively used cabins;
b) estimate ground-level concentrations of appropriate air quality parameters;
c) discuss any expected changes to particulate deposition, nitrogen deposition, and acidic deposition patterns;
d) identify areas that exceed Potential Acid Input (PAI) critical loading criteria;
e) discuss interactive effects that may occur as a result of co-exposure of a receptor to all emissions; and
f) describe air quality impacts resulting from the Project, and their implications for other environmental resources, including habitat diversity and quantity, soil resources, vegetation resources, and water quality.

[B] Identify stages or elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events. Discuss what impacts the change to climate parameters may have on elements of the Project that are sensitive to climate parameters.

[C] Identify components of the Project that have the potential to increase noise levels and discuss the implications. Present the results of a noise assessment. Include:

a) potentially-affected people and wildlife;
b) an estimate of the potential for increased noise resulting from the development; and
c) the implications of any increased noise levels, including the implications for local residents and any actively used cabins.

[D] Describe how air quality and noise impacts resulting from the Project will be mitigated.

[E] Describe the residual air quality and noise effects of the Project and EnCana FCCL's plans to manage those effects.

3.2.3 Monitoring

[A] Describe the monitoring programs proposed to assess any impacts to air quality and noise and to measure the effectiveness of mitigation.

[B] Describe any monitoring programs proposed to monitor the effects of acid deposition.

3.3 HYDROGEOLOGY

3.3.1 Baseline Information

[A] Provide an overview of the existing geologic and hydrogeologic setting from the ground surface down to, and including, the oil producing zones and wastewater disposal zones, and if applicable, to the base of any deeper strata that would be potentially impacted by wastewater disposal. Document any new hydrogeological investigations, including methodology and results, undertaken as part of the EIA study, and:

a) present regional and Project Area geology using structure contour maps, geologic cross-sections and isopach maps to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features;
b) present regional and Project Area hydrogeology describing:
    i) the major aquifers, aquitards and aquicludes (Quaternary and bedrock), their spatial distribution, properties, hydraulic connections between aquifers, hydraulic heads, gradients, groundwater flow directions and velocities. Include maps and cross sections,
    ii) the chemistry of groundwater aquifers including baseline concentrations of major ions, metals and hydrocarbon indicators,
    iii) the potential discharge zones, potential recharge zones and sources, areas of groundwater-surface water interaction and areas of Quaternary aquifer-bedrock groundwater interaction,
    iv) water well development and groundwater use, including an inventory of groundwater users,
    v) the recharge potential for Quaternary aquifers,
    vi) potential hydraulic connection between bitumen production zones, deep disposal formations and other aquifers due to Project operations,
    vii) the characterization of formations chosen for deep well disposal, including chemical compatibility and containment potential, injection capacity, hydrodynamic flow regime, and water quality assessments, and
    viii) the locations of major facilities associated with the Project including facilities for waste storage, treatment and disposal (e.g., deep well disposal) and describe site-specific aquifer and shallow groundwater conditions beneath these proposed facilities. Provide supporting geological information.

3.3.2 Impact Assessment

[A] Describe Project components and activities that have the potential to affect groundwater resource quantity and quality during the life of the Project.

[B] Describe the nature and significance of the potential Project impacts on groundwater with respect to:

a) inter-relationship between groundwater and surface water in terms of surface water quantity and quality;
b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands;
c) changes in groundwater quality and quantity;

d) conflicts with other groundwater users, and proposed resolutions to these conflicts;
e) potential implications of seasonal variations; and
f) groundwater withdrawal for Project operations including any expected alterations in the groundwater flow regime during and following Project operations.

[C] Describe programs to manage and protect groundwater resources including:
a) the early detection of potential contamination;
b) groundwater remediation options in the event that adverse effects are detected.

[D] Identify measures to reduce the environmental risks from casing failures.

[E] Describe the residual effects of the Project on groundwater quality and quantity and EnCana FCCL's plans to manage those effects.

3.3.3 Monitoring

[A] Describe any monitoring programs proposed to asses any Project impacts to groundwater quality and quantity and to measure the effectiveness of mitigation plans.

3.4 HYDROLOGY

3.4.1 Baseline Information

[A] Describe and map the surface hydrology. Include flow regimes of streams in the Project Area.

[B] Provide surface flow baseline data, including:
a) seasonal variation, low, average and peak flows for watercourses, and
b) low, average and peak levels for waterbodies.

[C] Identify any surface water users who have existing approvals, permits or licenses.

3.4.2 Impact Assessment

[A] Discuss changes to watersheds, including surface and near-surface drainage conditions, potential flow impediment, and potential changes in open-water surface areas caused by the Project.

[B] Describe the extent of hydrological changes that will result from disturbances to groundwater and surface water movement:
a) include changes to the quantity of surface flow, water levels and channel regime in watercourses (during minimum, average and peak flows) and water levels in waterbodies;
b) assess the potential impact of any alterations in flow on the hydrology and identify all temporary and permanent alterations, channel realignments, disturbances or surface water withdrawals;
c) discuss both the Project and cumulative effect of these changes on hydrology (e.g., timing, volume, peak and minimum flow rates, river regime and lake levels), including the significance of effects for downstream watercourses; and
d) identify any potential erosion problems in watercourses due to the Project.

[C] Discuss changes in sedimentation patterns in receiving waters resulting from the Project.

[D] Describe impacts on other surface water users due to the Project. Identify any potential water use conflicts.

[E] Describe potential downstream impact if surface water is removed.

[F] Discuss the impact of low flow conditions and in-stream flow needs on water supply and water and wastewater management strategies.

[G] Discuss how potential impacts of temporary and permanent roads and well pads on the wetland hydrology will be minimized and mitigated.

[H] Describe mitigation measures to address impacts during all stages of the Project, including:
a) alteration in flow regimes;
b) potential water use conflicts; and
c) increased sediment loadings.

[I] Describe residual effects of the Project on hydrology and EnCana FCCL's plans to manage those effects.

3.4.3 Monitoring

[A] Describe any monitoring programs proposed to assess the impacts of changes in surface water flows and levels on aquatic resources, wildlife and vegetation and to measure the effectiveness of mitigation plans.

3.5 SURFACE WATER QUALITY

3.5.1 Baseline Information

[A] Describe the baseline water quality of watercourses and waterbodies. Discuss the effects of seasonal variations, flow and other factors on water quality.

3.5.2 Impact Assessment

[A] Identify Project components that may influence or impact surface water quality.

[B] Describe the potential impacts of the Project on surface water quality:
a) discuss any changes in water quality resulting from the Project that may exceed the *Surface Water Quality Guidelines for Use in Alberta* or the *Canadian Water Quality Guidelines*;
b) discuss the significance of any impacts on water quality and implications to aquatic resources (e.g., biota, biodiversity and habitat);
c) discuss seasonal variation and potential effects on surface water quality;
d) assess the potential Project related and cumulative impacts of acidifying and other air emissions on surface water quality; and
e) discuss the effect of changes in surface runoff or groundwater discharge on water quality in surface waterbodies.

[C] Describe proposed mitigation measures to maintain surface water quality at all stages of the Project.

[D] Describe the residual effects of the Project on surface water quality and EnCana FCCL's plans to manage those effects.

3.5.3 Monitoring

[A] Describe any monitoring programs proposed to assess surface water quality impacts from the Project and to measure the effectiveness of mitigation plans. Discuss the location of monitoring sites, the frequency of monitoring, the parameters to be monitored, the implementation of quality assurance programs, and the numerical methodology.

[B] Describe how continuous monitoring will be used to evaluate Project effects, and how such monitoring will be used to identify the need for mitigation.

3.6 AQUATIC ECOLOGY

3.6.1 Baseline Information

[A] Describe the existing fish and other aquatic resources (e.g., benthic invertebrates). Identify species composition, distribution, relative abundance, movements and general life history parameters.

[B] Describe and map, as appropriate, the fish habitat and aquatic resources of the lakes, rivers, ephemeral water bodies and other waters and identify:

a) key indicator species and provide the rationale and selection criteria used;
b) critical or sensitive areas such as spawning, rearing, and over-wintering habitats. Discuss seasonal habitat use including migration and spawning routes; and
c) current and potential use of the fish resources by aboriginal, sport or commercial fisheries.

3.6.2 Impact Assessment

[A] Describe the potential impacts to fish, fish habitat, and other aquatic resources (e.g., stream alterations and changes to substrate conditions, water quality and quantity) considering:

a) fish tainting, survival of eggs and fry, chronic or acute health effects, and increased stress on fish populations from release of contaminants, sedimentation, flow alterations, temperature and habitat changes;
b) potential impacts on riparian areas that could impact aquatic biological resources and productivity;
c) the potential for increased fishing pressures in the region that could arise from the increased workforce and improved access as a result of the Project. Identify the implications on the fish resource and describe any mitigation strategies that might be planned to minimize these effects, including any plans to restrict employee and visitor access; and
d) changes to benthic invertebrate communities that may affect food quality and availability for fish.

[B] Discuss the design, construction and operational factors to be incorporated into the Project to minimize effects to fish and fish habitat and protect aquatic resources.

[C] Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat including the development of a “No Net Loss” fish habitat objective.

[D] Describe the effects of any surface water withdrawals considered including cumulative effects on aquatic resources.

[E] Describe the residual effects of the Project on fish, fish habitat, and other aquatic resources and discuss their significance in the context of local and regional fisheries. Describe EnCana FCCL’s plans to manage those effects.

3.6.3 Monitoring

[A] Describe any monitoring programs proposed to assess any Project impacts to fish, fish habitat and other aquatic resources and to measure the effectiveness of mitigation plans.

3.7 VEGETATION

3.7.1 Baseline Information

[A] Describe and map vegetation communities for each ecosite phase.

[B] Describe and map wetlands, and discuss the distribution and relative abundance of wetlands.

[C] Identify, verify and map the relative abundance of species of rare plants and the ecosite phases where they are found.

[D] Identify key indicators and discuss the rationale for their selection. Identify composition, distribution, relative abundance, and habitat requirements. Address those species listed as “at Risk, May be at Risk and Sensitive” in *The Status of Alberta Species* (Alberta Sustainable Resource Development) and all species listed in Schedule 1 of the federal *Species at Risk Act*.

[E] Discuss the potential of each ecosite phase to support rare plant species, plants for traditional, medicinal and cultural purposes, old growth forests and communities of limited distribution. Consider their importance for local and regional habitat, sustained forest growth, rare plant habitat and the hydrologic regime.

[F] Describe the regional relevance of landscape units that are identified as rare.

[G] Provide Timber Productivity Ratings for both the Project Area and the Local Study Area, including identification of productive forested, non-productive forested and non-forested lands.

3.7.2 Impact Assessment

[A] Identify the amount of vegetation and wetlands to be disturbed during the life of the Project.

[B] Discuss any potential effects the Project may have on rare plants or endangered species.

[C] Discuss temporary (include timeframe) and permanent changes to vegetation and wetland communities and comment on:

a) the effects and their implications for other environmental resources (e.g., habitat diversity and quantity, water quality and quantity, erosion potential)
b) the effects and their implications to recreation, aboriginal and other uses; and
c) the sensitivity to disturbance (including acid deposition), as well as the techniques used to estimate sensitivity to disturbance and reclamation, of each vegetation community.

[D] Describe the regional impact of any ecosite phase to be removed.

[E] Discuss from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and the expected differences in the resulting vegetative community structures.

[F] Provide an Ecological Land Classification map that shows the reclaimed vegetation. Comment on the importance of the size, distribution and variety of the reclaimed landscape units from both a local and regional perspective.

[G] Compare the pre-disturbance and reclaimed percentages and distribution of all forested communities in the Project Area and determine the amount of commercial and non-commercial forest land base that will be disturbed by the Project.

[H] Discuss the impact of any loss of wetlands, as well as how this will affect land use, fragmentation and biodiversity. Discuss measures and techniques that will be used to minimize the impact.

[I] Provide a mitigation strategy that will minimize Project impacts addressing:

a) mitigation of the adverse effects of site clearing on rare plants, plant communities and plants for traditional, medicinal and cultural purposes. Identify any setbacks proposed around environmentally-sensitive areas such as surface waterbodies, riparian areas, traditional use sites and wetlands; and
b) measures and techniques that will be used to minimize the impact of loss of wetlands on land use, fragmentation and biodiversity.

[J] Discuss weeds and non-native invasive species and describe how these species will be assessed and controlled prior to and during operation and reclamation.

[K] Describe the residual effects of the Project on vegetation and EnCana FCCL’s plans to manage those effects.

3.7.3 Monitoring

[A] Describe any monitoring programs proposed to assess vegetation impacts from the Project and to measure the effectiveness of mitigation plans.

3.8 WILDLIFE

3.8.1 Baseline Information

[A] Describe and map existing wildlife resources (amphibians, reptiles, birds and terrestrial and aquatic mammals) and their use and potential use of habitats.

[B] Identify key indicator species and discuss the rationale for their selection. Identify composition, distribution, relative abundance, seasonal movements, movement corridors, habitat requirements, key habitat areas, and general life history. Address those species:

a) listed as “at Risk, May be at Risk and Sensitive” in *The Status of Alberta Species* (Alberta Sustainable Resource Development);
b) listed in Schedule 1 of the federal *Species at Risk Act*; and
c) listed as “at risk” by COSEWIC.

[C] Describe, quantify and map all existing habitat disturbance (including exploration activities) and identify those habitat disturbances that are related to existing and approved Project operations.

3.8.2 Impact Assessment

[A] Describe Project components and activities that may affect wildlife and wildlife habitat.

[B] Describe and assess the potential impacts of the Project on key indicator species and relate those impacts to wildlife populations and wildlife habitats, addressing:

a) how the Project will affect wildlife relative abundance, movement patterns, distribution and recruitment into regional populations for all stages of the Project;
b) how improved or altered access may affect wildlife including potential obstruction of daily and seasonal movements, increased vehicle-wildlife collisions, and increased hunting pressure;
c) how increased habitat fragmentation may affect wildlife considering edge effects, the availability of core habitat, and the influence of linear features and infrastructure on wildlife movements and other population parameters;
d) the spatial and temporal changes to habitat availability and habitat effectiveness (types, quality, quantity, diversity and distribution);
e) potential effects on wildlife as a result of changes to air and water quality, including both acute and chronic effects on animal health;
f) potential effects on wildlife from EnCana’s proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic;
g) the resilience and recovery capabilities of wildlife populations and habitats to disturbance; and
h) the potential for the Project Area to be returned to its existing state with respect to wildlife populations and their habitats;

[C] Comment on the availability of species for traditional use considering habitat loss, habitat avoidance, vehicle-wildlife collisions, increased non-aboriginal hunting pressure and other Project related effects to wildlife populations.

[D] Provide a strategy and mitigation plan to minimize impacts on wildlife and wildlife habitat during all stages of the Project and to return productive wildlife habitat to the area, considering:

a) consistency of the plan with applicable regional, provincial and federal wildlife habitat objectives and policies;
b) a schedule for the return of habitat capability to areas impacted by the Project;
c) the use of setbacks to protect riparian habitats, interconnectivity of such habitat and the unimpeded movement by wildlife species using the habitat;
d) anticipated access controls or other management strategies to protect wildlife during and after Project operations;

e) measures to prevent habituation of wildlife, minimize the potential for human-wildlife encounters and consequent destruction of wildlife, including any staff training program, fencing camps, garbage containment measures or regular follow-up;
f) measures to mitigate habitat fragmentation considering impacts to habitat connectivity and wildlife movements resulting from linear features (e.g., above ground pipelines, roads, etc.) and other Project infrastructure and activities; and
g) measures to minimize the effects of light on wildlife.

[E] Describe the residual effects of the Project on wildlife and wildlife habitat and EnCana FCCL's plans to manage those effects.

3.8.3 Monitoring

[A] Describe the monitoring programs proposed to assess any Project impacts to wildlife and to measure the effectiveness of mitigation plans, giving special attention to species:
a) listed as "at Risk, May be at Risk, and Sensitive" in The Status of Alberta Species (Alberta Sustainable Resource Development);
b) listed in Schedule 1 of the federal *Species at Risk Act*; and
c) listed as "at risk" by COSEWIC.

3.9 BIODIVERSITY AND FRAGMENTATION

3.9.1 Baseline Information

[A] Describe the terrestrial and aquatic biodiversity metrics that will be used to characterize the existing ecosystems and probable effects of Project development, and:
a) describe the process and rationale used to select biotic and abiotic indicators for biodiversity within selected taxonomic groups;
b) determine the relative abundance of species in each ecosite phase;
c) provide species locations, lists and summaries of observed and estimated species richness and evenness for each ecosite phase;
d) provide a measure of biodiversity on baseline sites that are representative of the proposed reclamation ecosites; and
e) rank each ecological unit for biodiversity potential. Describe the techniques used in the ranking process.

[B] Describe the current level of habitat fragmentation.

3.9.2 Impact Assessment

[A] Describe the metrics used to assess the probable effects of the Project. Discuss the contribution of the Project to any anticipated changes in regional biodiversity and the potential impact to local and regional ecosystems.

[B] Identify and evaluate the extent of potential effects from fragmentation that may result from the Project.

[C] Discuss the measures to minimize any anticipated changes in regional biodiversity.

[D] Describe the residual effects of the Project on biodiversity and fragmentation and EnCana FCCL's plans to manage those effects.

3.9.3 Monitoring

[A] Describe any monitoring programs proposed to assess any Project impacts on biodiversity and fragmentation and to measure the effectiveness of mitigation plans.

3.10 TERRAIN AND SOILS

3.10.1 Baseline Information

[A] Provide descriptions and maps of the terrain and soils conditions, including:

a) surficial geology and topography;
b) the soil types and their distribution. Provide an ecological context to the soil resource by supplying a soil survey report and maps to include Survey Intensity Level 2 for the Project Area;
c) the suitability and availability of soils within the Project Area for reclamation;
d) soils that could be affected by the Project with emphasis on potential acidification (by soil type); and
e) descriptions and locations of erosion sensitive soils.

3.10.2 Impact Assessment

[A] Describe Project activities and other related issues that could affect soil quality (e.g., compaction, contaminants) and:

a) indicate the amount (ha) of surface disturbance from plant, field (pads, pipelines, access roads), aggregate and borrow sites, construction camps, drilling waste disposal and other infrastructure-related construction activities;
b) provide an inventory of the pre- and post-disturbance land capability classes for soils in both the Project Area and Local Study Area and describe Project impacts to land capability. Indicate the size and location of soil types and land capability classes that will be disturbed;
c) discuss the relevance of any changes for the local and regional landscapes, biodiversity, productivity, ecological integrity, aesthetics and future use resulting from disturbance for all stages of the Project;
d) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions resulting from the Project;
e) describe potential sources of soil contamination;
f) describe the impact of the Project development on soil types and reclamation suitability and the approximate volume of soil materials for reclamation. Discuss any constraints or limitations to achieving vegetation/habitat reclamation based on anticipated soil conditions (e.g., compaction, contaminants, salinity, soil moisture, nutrient depletion, erosion, etc.);

[B] Discuss:

a) discuss the potential for soil erosion during the life of the Project;
b) the environmental effects of proposed drilling methods on the landscape and surficial and bedrock geology;
c) the potential for casing and pipeline failures and their environmental effects;
d) the potential for changes in the ground surface during steaming and recovery operations (e.g., ground heave and/or subsidence) and their environmental implications; and
e) the potential impacts caused by the mulching and storage of woody debris considering, but not limited to vulnerability to fire, degradation of soil quality and increased footprint.

[C] Provide a mitigation plan, including:

a) possible measures to minimize surface disturbance including the use of existing clearings for Project development;
b) possible actions to address potential effects of acid deposition;
c) possible actions to mitigate effects of any constraint or limitation to habitat reclamation such as compaction, contaminants, salinity, soil moisture, erosion, nutrient regime, etc.;
d) possible measures to mitigate changes to ground surface (temperature, heave and subsidence) during operations;
e) possible actions to address impacts to land capability; and

f) any other measures to reduce or eliminate the potential impacts that the Project may have on soil capability and/or quality.

[D] Describe the residual effects of the Project on terrain and soils and EnCana FCCL's plans to manage those effects.

3.10.3 Monitoring

[A] Describe any monitoring programs proposed to assess any Project impacts on terrain and soils and to measure the effectiveness of mitigation plans.

3.11 LAND USE

3.11.1 Baseline Information

[A] Identify the current land uses, including oil and gas development, agriculture, forestry, tourism, cultural use, food collection, trapping, fishing, hunting, any other aboriginal uses and other outdoor recreational activities.

[B] Identify and map all Crown land and Crown Reservations (Holding Reservation, Protective Notation, Consultative Notation).

[C] 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).

[D] 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.

3.11.2 Impact Assessment

[A] Identify the potential impact of the Project on land uses, including:

a) impacts to unique sites or special features;
b) impacts caused by changes in public access arising from linear development, including secondary effects related to increased hunter, angler and other recreational access, decreased access to traditional use sites, and facilitated predator movement;
c) the implications of relevant land use policies and resource management initiatives for the Project, including any constraints to development;
d) potential impacts to aggregate reserves that may be located on land under EnCana FCCL's control and reserves in the region;
e) 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;
f) 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;
g) how the Project disturbance impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;
h) 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
i) impacts of the Project on regional recreational activities, public access, aboriginal land use and other land uses during and after development activities.

[B] Discuss possible mitigation strategies to address:

a) the need for, and plans to address, access management during and after Project operations;
b) the process for addressing the needs of other land users in both the Project Area and the Local Study Area;

c) measures to mitigate impacts on land use; and
d) how potentially-affected aggregate reserves will be salvaged and stockpiled with input provided by Alberta Transportation and Alberta Sustainable Resource Development.

[C] Describe the residual effects of the Project on land use and EnCana FCCL's plans to manage those effects.

3.11.3 Monitoring

[A] Describe any monitoring programs proposed to assess any Project impacts on land use and to measure the effectiveness of mitigation plans.

4 HISTORIC RESOURCES

[A] Describe consultation with Alberta Culture and Community Spirit (ACCS) concerning the need for a Historic Resource Impact Assessment (HRIA) for the Project, and:

a) provide a general overview of the results of any previous historic resource studies that have been conducted, including archaeological resources, palaeontological resources, historic period sites, and any other historic resources as defined within the *Historical Resources Act*;
b) summarize the results from the field program performed to assess archaeological, palaeontological and historic significance of both the Project Area and the Local Study Area;
c) provide a summary of the results of the HRIA conducted to assess the potential impact of the Project on archaeological, palaeontological and historic resources;
d) provide an outline of the program and schedule of field investigations that ACCS may require EnCana FCCL to undertake to further assess and mitigate the effects of the Project on historic resources; and
e) document any historic resources concerns during consultation on the Project.

5 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE

[A] Provide:

a) a map of traditional land use areas (if the aboriginal community or group is willing to have this information disclosed);
b) a map of cabin sites, spiritual sites, graves and other traditional use sites considered as 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;
c) a description of the extent of traditional use of land in both the Project Area and the Local Study Area, including fishing, hunting, trapping, nutritional or medicinal plant harvesting, and cultural use by affected aboriginal peoples;
d) a discussion of:
    i) access to traditional lands in the Project Area during all stages of the Project;
    ii) the vegetation and wildlife used for traditional, food, ceremonial, medicinal and other purposes;
    iii) aboriginal views on land reclamation.

[B] Determine the impact of the Project on traditional uses and identify possible mitigation strategies.

6 PUBLIC HEALTH AND SAFETY ASSESSMENT

[A] Describe those aspects of the Project that may have implications for public health or the delivery of regional health services. Determine whether there may be implications for public health arising from the Project. Specifically:

a) assess the potential health implications of the compounds that will be released to the environment from the Project in relation to exposure limits established to prevent acute and chronic adverse effects on human health;

b) provide the data, exposure modeling calculations, and describe the methods EnCana FCCL used to assess impacts of the Project on human health and safety;
c) provide information, including chemical analyses and modeling results, on samples of selected environmental media (e.g., soil, water, air, vegetation, wild game, etc.) used in the assessment;
d) discuss the potential for changes to water quality, air quality and soil quality to increase human exposure to contaminants taking into consideration all Project activities;
e) identify the human health impact of the potential contamination of country foods and natural food sources taking into consideration all Project activities;
f) document any health concerns raised by stakeholders during consultation on the Project;
g) document any health concerns identified by aboriginal communities or groups resulting from impacts of existing development and of the Project specifically on their traditional lifestyle and include an aboriginal receptor type in the assessment;
h) assess the cumulative human health effects to receptors, including First Nations and Métis receptors;
i) as appropriate, describe anticipated follow-up work, including regional cooperative studies. Discuss how such work will be implemented and coordinated with ongoing air, soil and water quality initiatives;
j) describe the potential health impacts due to higher regional traffic volumes and the increased risk of accidental leaks and spills; and
k) discuss mitigation strategies to minimize the potential impact of the Project on human health.

[B] Describe those aspects of the Project that may have implications for public safety. Determine whether there may be implications for public safety arising from the Project. Specifically:

a) describe EnCana FCCL's emergency response plan, including public notification protocol and safety procedures, to minimize adverse environmental effects, including emergency reporting procedures for spill containment and management;
b) document any safety concerns raised by stakeholders during consultation on the Project;
c) describe how local residents will be contacted during an emergency and the type of information that will be communicated to them;
d) describe the existing agreements with area municipalities or industry groups such as safety cooperatives, emergency response associations, regional mutual aid programs and municipal emergency response agencies;
e) describe the potential safety impacts due to higher regional traffic volumes; and
f) discuss mitigation plans to ensure workforce and public safety during the life of the Project. Include prevention and safety measures for wildfire occurrences, water saturated plume from cooling towers, icy roads in the winter months, accidental release or spill of chemicals to the environment and failures of structures retaining water or fluid wastes.

7 SOCIO-ECONOMIC ASSESSMENT

7.1 BASELINE INFORMATION

[A] Describe the existing socio-economic conditions in the region, including for the communities in the region.

[B] Describe factors that may affect existing socio-economic conditions including:

a) population changes;
b) EnCana FCCL's policies and programs regarding the use of regional and Alberta goods and services;
c) a project schedule and a general description of the overall engineering and contracting plan for the Project;
d) workforce requirements for the Project, including a description of when peak activity periods will occur; and

e) planned accommodations for the workforce during the life of the Project.

7.2 IMPACT ASSESSMENT

[A] Describe the socio-economic effects of construction and operation of the Project, including:

a) impacts related to:
   i) local training, employment and business opportunities,
   ii) regional and provincial economic benefits,
   iii) housing,
   iv) recreational activities,
   v) trapping, hunting and fishing, and
   vi) effects on First Nations and Métis (e.g., traditional land use and social and cultural implications);

b) estimated total Project cost, including a breakdown for engineering and project management, equipment and materials, and labour for both construction and operation stages. Indicate the percentage of expenditures expected to occur in the region, Alberta, Canada outside of Alberta, and outside of Canada;

c) impacts of the Project on the availability of affordable housing and the quality of health care services. Provide a summary of any discussions that have taken place with the local municipalities and the local environmental public health office of Alberta Health Services concerning housing availability and health care services respectively;

d) discuss any effects expected on primary and secondary highway systems and other regional roads caused by anticipated traffic changes;

[B] Describe the socio-ecomonic effects of any construction camp required for the Project and identify:

   i) its location,
   ii) the number of workers it is intended to house,
   iii) whether the camp will service the Project only or other clients,
   iv) the length of time the camp will be in service, and
   v) describe what services will be provided in the camp (e.g., security, recreation and leisure, medical services);

a) the impact on local and regional infrastructure and community services, including consideration of municipal "hard services", education/training services, social services, urban and regional recreation services, law enforcement and emergency services; and

b) describe municipal growth pressures as they relate to the Project and the need for additional Crown land to meet these needs.

[C] Discuss options for mitigating impacts including:

a) EnCana FCCL's policies and programs regarding the use of regional and Alberta goods and services;

b) plans to work with First Nations and Métis communities and groups and other local residents and businesses regarding employment, training needs, and other economic development opportunities arising from the Project;

c) steps that have been undertaken by industry, the municipality, provincial government or through regional and cooperative initiatives to address socio-economic concerns and impacts to local and regional transportation infrastructure;

d) the potential to avoid overlap with other Projects that are reasonably anticipated during all stages of the Project;

e) mitigation plans that will be undertaken to address issues related to the availability of affordable housing and the quality of health care services; and

f) strategies to mitigate socio-economic concerns raised by the local municipality and other stakeholders in the region.

[D] Describe the residual effects of the Project on socio-economic conditions and EnCana FCCL's plans to manage those effects.

7.3 MONITORING

[A] Describe any monitoring plans proposed to assess and Project socio-economic impacts and to measure the effectiveness of mitigation plans.

APPENDIX 2-II

CONCORDANCE TABLES

LIST OF TABLES

Table 1 Final Terms of Reference Issued by Alberta Environment - Concordance

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
1.0 INTRODUCTION		
Background	The purpose of this document is to identify for EnCana FCCL Ltd. (EnCana FCCL), aboriginal communities and appropriate stakeholders the information required by government agencies for an Environmental Impact Assessment (EIA) report prepared under the *Environmental Protection and Enhancement Act* (EPEA) for the Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project). EnCana plans to develop its commercial-scale bitumen production project on its Oil Sands Development Leases located in Townships 75 and 76, Ranges 5 and 6, W4M, in the area south of Christina Lake, Alberta. The Project will be based on steam assisted gravity drainage (SAGD) thermal technology. EnCana, FCCL Ltd. has been developing and operating its Christina Lake Thermal Project in phases since receiving approvals in 2000. The facility currently produces approximately 14,000 barrels per day (bbl/d) and is approved up to phase D (98,800 bbl/d). We are seeking regulatory approval for a proposed expansion, phases 1E, 1F and 1G, that would take production to 218,800 bbl/d over the next decade. This expansion will continue to use steam-assisted gravity drainage (SAGD) thermal oil recovery technology to recover the bitumen (thick oil).	Volume 1, Section 1 Introduction
Scope of Environmental Impact Assessment Report	EnCana FCCL shall prepare and submit an EIA report that examines the environmental and socio-economic effects of the Project. The EIA report shall be prepared with consideration to all applicable provincial and federal legislation, codes of practice, guidelines, standards and directives. EnCana FCCL shall identify the legislation, policies, approvals, and current multi-stakeholder planning initiatives applicable to the Project. The EIA report shall be prepared in accordance with these Terms of Reference and the environmental information requirements prescribed under EPEA and associated regulations, and the *Canadian Environmental Assessment Act*, if applicable. The EIA report will form part of EnCana FCCL' application to the Energy Resources Conservation Board (ERCB). An EIA report summary will also be included as part of the ERCB Application. EnCana FCCL shall refer to the Guide to Preparing Environmental Impact Assessment Reports in Alberta published by Alberta Environment (the Guide) and these Terms of Reference when preparing the EIA report. In any case where there is a difference in requirements between the Guide and these Terms of Reference, the Terms of Reference shall take precedence.	Volumes 2 to 6
	The EIA report will include a glossary of terms and a list of abbreviations to assist the reader in understanding the material presented. It will also include concordance tables that cross-reference the EIA report to the sub-section level (lower case letters) of the Terms of Reference.	Volumes 1 to 6

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
Scope of Environmental Impact Assessment Report (continued)	EnCana FCCL will prepare a summary of the EIA report that will provide the reader with sufficient information to obtain a general understanding of the Project and its potential positive and negative effects. The summary report shall be a stand-alone document; however, it can reference more detailed information presented in the EIA report itself. [A] The summary report shall provide an overview of the EIA report including: (a) the Project components and development activities which have the potential to affect the environment; (b) existing conditions in the Study Area, including existing uses of lands, resources and other activities which have potential in combination with proposed development activities, to affect the environment; (c) the environmental, cultural, and socio-economic impacts of the Project including the regional, temporal, and cumulative effects which are anticipated; (d) impact significance in terms of magnitude, extent, duration, frequency, and reversibility; (e) residual effects; and (f) an overview of modeling techniques used. The summary report shall include suitable maps, charts and other illustrations to identify the components of the Project, the existing conditions, and the environmental and socio-economic implications of the development.	[A] Volume 1, Section 13 Summary of Environmental Impact Assessment
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION		
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION	[A] Document the public engagement program implemented for the Project including: (a) list of all meetings and the specific comments or issues raised at the meetings; (b) description and documentation of concerns and issues expressed by the public, EnCana FCCL analysis of those concerns and issues, and the actions taken to address those concerns and issues; and (c) how public input was incorporated into the Project development, impact mitigation and monitoring plans.	[A] Volume 1, Section 2 Public Consultation

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION (continued)	[B] Document the aboriginal consultation program implemented for the Project including: (a) list of all meetings and the specific comments or issues raised at the meetings; (b) description and documentation of concerns and issues expressed by aboriginal communities and groups EnCana FCCL analysis of those concerns and issues, and the actions taken to address those concerns and issues; (c) how aboriginal input was incorporated into the Project development, impact mitigation and monitoring plans; and (d) consultation undertaken with aboriginal communities and groups with respect to traditional ecological knowledge and traditional use of land.	[B] Volume 1, Section 2 Public Consultation; Volume 6, Section 2 Traditional Land Use
	[C] Describe plans to maintain the public engagement and aboriginal consultation process following completion of the EIA report review to ensure that the public and aboriginal peoples will have an appropriate forum for expressing their views on the ongoing development, operation and reclamation of the Project.	[C] Volume 1, Section 2 Public Consultation
2.0 PROJECT DESCRIPTION		
2.1 The Proponent	[A] Provide: (a) a corporate profile; and (b) the name of the legal entity that will develop, manage and operate the Project and hold the operating approvals. [B] Describe EnCana FCCL and its history in Alberta's oil and gas industry, with specific reference to existing operations, proposed operations, mineral resources, environmental studies and community involvement.	[A] and [B] Volume 1, Section 1 Introduction
2.2 Project Development	[A] Provide a development plan that includes: (a) the phases of development;	[A] Volume 1, Section 1 Introduction
	(b) bitumen/heavy oil recovery facilities;	(b) Volume 1, Section 4 Bitumen Recovery Process
	(c) processing facilities;	(c) Volume 1, Section 6 Facilities
	(d) steam and/or power generation facilities;	(d) Volume 1, Section 6 Facilities
	(e) infrastructure (pipelines, access roads and power lines);	(e) Volume 1, Section 6 Facilities
	(f) other buildings and structures;	(f) Volume 1, Section 6 Facilities

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.2 Project Development (continued)	(g) field maintenance operations; and	(g) Volume 1, Section 6 Facilities
	(h) activities associated with each stage of the Project.	(h) Volume 1, Section 14 Conservation and Reclamation Plan
	[B] Provide a schedule outlining the proposed phases of development and the sequence and duration of key project components, including the timing of key steps in the construction, operation, decommissioning and reclamation stages of each phase.	[B] Volume 1, Section 1.6 Project Schedule
	[C] Discuss the key factors controlling the schedule, restrictions for conducting certain development activities, and uncertainties.	[C] Volume 1, Section 1.6 Project Schedule
2.3 Evaluation Alternatives		
2.3.1 Project Alternatives	[A] Discuss the need for the Project including: (a) any alternative means of carrying out the Project that are technically and economically feasible and where applicable indicate their potential environmental effects and impacts; (b) a comparison of identified alternatives to the Project or components of the Project and the anticipated effects and impacts of the alternatives. Discuss how environmental, socio-economic and traditional use criteria influenced the selection of the proposed alternatives. Discuss reasons for not selecting any identified alternatives; (c) implications resulting from a delay in proceeding with the Project, or any phase of the Project; and (d) potential cooperative development opportunities (e.g., shared infrastructure). [B] Discuss the implications of not going ahead with the Project.	[A] and [B] Volume 1, Section 11 Alternatives Considered
2.3.2 Process and Infrastructure Alternatives	[A] Describe the process and criteria used to select sites for facilities and infrastructure.	[A] Volume 1, Section 5.7 Surface Disturbance; Volume 1, Section 11.7 Off-Site Pipeline Routing and Well Pad Surface Locations
	[B] Discuss the route or site selection criteria for any linear or other infrastructure development or modification and provide the rationale for selecting the proposed alignment and design.	[B] Volume 1, Section 5.7 Surface Disturbance; Volume 1, Section 11.7 Off-Site Pipeline Routing and Well Pad Surface Locations
	[C] Discuss the options considered for supplying the thermal energy and electric power required for the Project and their environmental implications. Discuss the implications that alternate fuel sources may have on the selection of pollution abatement equipment or technologies.	[C] Volume 1, Section 4 Bitumen Recovery Process; Volume 1, Section 9.3 Greenhouse Gas Management

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.3.2 Process and Infrastructure Alternatives (continued)	[D] Describe the criteria and rationale for selecting the preferred water supply sources. Include options for using saline groundwater and the criteria used to assess the feasibility of its use.	[D] Volume 1, Section 5.5 Water Source Wells
	[E] Discuss the potential for new or additional technology to increase resource recovery at later times in the field development and to affect the number of wells required.	[E] Volume 1, Section 11.10 Future Production Enhancements
	[F] Discuss options and technologies considered for wastewater treatment, wastewater management and wastewater disposal and reasons, including water quality and environmental considerations for selecting the preferred options in the context of best management practices and best available technologies.	[F] Volume 1, Section 6.6 Make-up Water and Produced Water Treatment
	[G] Discuss options and technologies considered for air emission and air quality management and the evaluation of emission minimization options, including air emission control technology considerations, for selecting the preferred options in the context of best management practices and best available technologies.	[G] Volume 1, Section 6.11 Sulphur Recovery Facility
	[H] Discuss the waste disposal options. Discuss the strategy for on-site waste disposal versus off-site waste disposal and identify: (a) the location of on-site waste disposal, including landfills, if applicable; (b) the availability of off-site waste disposal facilities; (c) site suitability from a groundwater protection perspective; (d) site suitability from a geo-technical perspective; and (e) site suitability with regard to existing and potential human activities in the area.	[H] Volume 1, Section 9.4 Waste Management
2.4 Project Process and Facilities	[A] Provide maps and/or drawings of the Project components and activities including: (a) existing infrastructure, leases and clearings, including exploration clearings;	[A] Volume 1, Section 1.3 Project Location
	(b) proposed central processing/treatment and field facilities;	(b) Volume 1, Appendix 1-III Plot Plan and Equipment List
	(c) other buildings and infrastructure (pipelines and utilities);	(c) Volume 1, Appendix 1-III Plot Plan and Equipment List
	(d) temporary structures;	(d) Volume 1, Appendix 1-III Plot Plan and Equipment List
	(e) transportation and access routes;	(e) Volume 1, Section 1.3 Project Location
	(f) on-site hydrocarbon storage;	(f) Volume 1, Appendix 1-III Plot Plan and Equipment List
	(g) containment structures such as retention ponds and storage ponds (e.g. lime sludge, stormwater runoff, boiler blow-down);	(g) Volume 1, Appendix IX Surface Water Management Plan Summary
	(h) water wells/intakes, pipelines and storage structures;	(h) Volume 1, Section 1.3 Project Location

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.4 Project Process and Facilities (continued)	(i) sources of aggregate resources, borrow material and other construction material and locations of any stockpiles that will be developed; and	(i) Volume 1, Appendix 1-IX Surface Water Management Plan Summary
	(j) waste storage area and disposal sites.	(j) Volume 1, Appendix 1-IX Surface Water Management Plan Summary
	[B] Provide a list the facilities for which locations will be determined later.	[B] n/a
	[C] Describe the primary resource recovery process, any proposed follow-up recovery process and other related processes and process facilities of the Project.	[C] Volume 1, Section 4 Bitumen Recovery Process
	[D] Discuss the amount and source of energy required for the Project.	[D] Volume 1, Appendix IV Block Flow Diagrams, Energy Balance, Simplified Water Balances and Development Profile with ERCB Water Usage Formulas
	[E] Describe the proposed method to transport product to markets.	[E] Volume 1, Section 6.3.3 Gathering/Distribution System
	[F] Provide a listing of chemical products to be manufactured, processed or otherwise used for the Project and describe, in general terms, how these products will be stored and managed. Identify products containing substances that are: (a) Canadian *Environmental Protection Act*, 1999 toxics; (b) listed on the National Pollutant Release Inventory; (c) dangerous goods as defined by the federal *Transportation of Dangerous Goods Act*; and (d) on the Domestic Substances List and categorized as requiring further assessment under Canada's Chemicals Management Plan.	[F] Volume 1, Section 9.4 Waste Management
	[G] Describe the nature and amount of on-site hydrocarbon storage. Discuss containment and other environmental protection measures.	[G] Volume 1, Section 6.8 Fluid Storage

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.5 Transportation Infrastructure	[A] Provide a summary of any Traffic Impact Assessment study carried out for the Project, or where no Traffic Impact Assessment study has been conducted, describe the anticipated changes to traffic (e.g., type, volume) on highways, including an assessment of impacts for all stages of the Project. Consider other existing and planned uses of the same highways.	[A] Volume 6, Section 6.8 Transportation
	[B] Describe and map the locations of any new road or intersection construction, or any improvements to existing roads or intersections, related to the development of the Project, from the boundary of the Project Area up to and including the highway access point, and (a) discuss the alternatives and the rationale for selection of the preferred alternative; (b) describe the impacts to local communities of the changes in transportation infrastructure; (c) provide a proposed schedule of work; (d) provide an estimated cost of the work; and (e) provide a summary of the consultation with Alberta Transportation and the local authority, including their views on the compatibility of the proposed work with their own local or regional infrastructure development plans.	[B] Volume 1, Section 6.13 Roads; Volume 6, Section 6.8 Transportation
	[C] Identify the type, volume, location and availability of road construction and road improvement work, related to the development of the Project, within the outside of the Project Area	[C] Volume 1, Section 1.3 Project Location
	[D] Describe the access corridors needed and/or planned by other resource stakeholders including those responsible for Forest Management Areas and other timber quota holders, and (a) describe how their needs are accommodated to reduce overall environmental impact from resource development; and (b) describe opportunities for cooperation in access development.	[C] Volume 1, Section 1.3 Project Location
	[E] Indicate where Crown land dispositions may be needed for roads or other infrastructure for the Project.	[E] Volume 1, Section 1.3 Project Location
	[F] Describe crossings of watercourses or waterbodies required and provide example diagrams of each type of crossing. Discuss: (a) timing, (b) construction standards or methods, and (c) environmental protection plans.	[F] Volume 4, Section 3.2.3 Watercourse Crossings

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.6 Land Management	[A] Provide a description and timing of land clearing activities.	[A] Volume 1, Section 14.4 Detailed Conservation and Reclamation Plan
	[B] Provide a timber salvage plan, highlighting end users and identifying proposed volumes for removal (by species and year) for all stages of the Project.	[B] Volume 1, Section 14.4.1.1 Timber Salvage Plan
	[C] Identify any access restrictions including where appropriate, measures taken to control access to the Project Area while ensuring continued access to adjacent wildland areas.	[C] Volume 6, Section 3.5.2 Effects on Environmentally Important Areas
	[D] Provide a fire control plan highlighting: (a) measures taken to ensure continued access for firefighters to adjacent wildland areas; (b) forest fire prevention, detection, reporting, and suppression measures, including proposed fire equipment; (c) measures for determining the clearing width of power line rights-of-way; and (d) required mitigative measures for areas adjacent to the Project Area based on the FireSmart Wildfire Assessment System.	[D] Volume 1, Section 9.2 Wildfire Risk Assessment
2.7 Air Emissions Management	[A] Provide emission profiles (type, rate and source) for the Project's operating and construction emissions including point and non-point sources and fugitive emissions. Consider both normal and upset conditions. Discuss: (a) odorous or visual emissions from the proposed facilities;	[A] Volume 3, Section 1.8 Application Case; Volume 3, Appendix 3-I Emission Source Details; Volume 3, Appendix 3-II Upset Conditions
	(b) annual and total greenhouse gas emissions during all stages of the Project. Identify the primary sources and provide examples of calculations;	(b) Volume 3, Section 1.8 Application Case
	(c) the intensity of greenhouse gas emissions per unit of bitumen produced and discuss how it compares with similar projects;	(c) Volume 3, Section 1.8 Application Case
	(d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;	(d) Volume 3, Section 1.8 Application Case
	(e) EnCana FCCL overall greenhouse gas management plans;	(e) Volume 3, Section 1.8.8.3 Approach to Managing Greenhouse Gases
	(f) the amount and nature of Criteria Air Contaminant emissions;	(f) Volume 3, Section 1.6 Baseline Case; Volume 3, Section 1.8 Application Case; Volume 3, Section 1.9 Planned Development Case; Volume 3, Appendix 3-I Emission Source Details

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.7 Air Emissions Management (continued)	(g) the amount and nature of acidifying emissions, probable deposition patterns and rates;	(g) Volume 3, Section 1.6 Baseline Case; Volume 3, Section 1.8 Application Case; Volume 3, Section 1.9 Planned Development Case; Volume 3, Appendix 3-I Emission Source Details
	(h) control technologies used to minimize air emissions such as sulphur dioxide (SO2), hydrogen sulphide (H_2S), oxides of nitrogen (NO_X), greenhouse gases, volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), particulate matter (PMx), carbon monoxide (CO) and ammonia (NH_3);	(h) Volume 3, Section 1.1.2.1 Project Air Quality Management Initiatives
	(i) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized;	(i) Volume 3, Appendix 3-II Upset Conditions
	(j) upset condition scenarios (e.g., frequency and duration) and proposed measures to ensure upset conditions are minimized;	(j) Volume 3, Appendix 3-II Upset Conditions
	(k) gas collection and conservation, and the applicability of vapour recovery technology;	(k) Volume 1, Section 6.10 Vapour Recovery System
	(l) fugitive emissions control technology to detect, measure and control emissions and odours from equipment leaks; and	(l) Volume 3, Section 1.1.2.1 Project Air Quality Management Initiatives
	(m) the applicability of sulphur recovery, acid gas re-injection, or flue gas desulphurization to reduce sulphur emissions.	(m) Volume 3, Appendix 3-I Emission Source Details
2.8 Water Management		
2.8 Water Management	[A] Discuss potential cooperation with other parties regarding water related infrastructure and management including, but not limited to, water intakes, pipelines, water storage and withdrawals, flow monitoring and reporting and ecological monitoring.	[A] Volume 1, Section 7 Water Source Management
2.8.1 Water Supply	[A] Describe the water supply requirements for the Project, including: (a) the expected water balance during the life of the Project. Discuss assumptions made or methods chosen to arrive at the water balances;	[A] Volume 1, Appendix 1-VII Detailed Water Balances
	(b) the process, potable and non-potable water requirements and sources for construction, start-up, normal and emergency operating situations, decommissioning and reclamation. Identify the volume of water to be withdrawn from each source, considering plans for wastewater reuse;	(b) Volume 1, Appendix 1-IV Block Flow Diagrams, Energy Balance, Simplified Water Balances and Development Profile with ERCB Water Usage Formulas
	(c) the location of sources and associated infrastructure (e.g., pipelines for water supply);	(c) Volume 1, Section 5.5 Water Source Wells

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.8.1 Water Supply (continued)	(d) the variability in the amount of water required on an annual and seasonal basis as the Project is implemented;	(d) Volume 1, Appendix 1-IV Block Flow Diagrams, Energy Balance, Simplified Water Balances and Development Profile with ERCB Water Usage Formulas
	(e) the expected cumulative effects on water losses/gains due to the Project operations;	(e) Volume 4, Section 5 Application Case
	(f) potable water treatment systems all stages of the Project;	(f) Volume 1, Section 6.6 Make-Up Water and Produced Water Treatment
	(g) type and quantity of potable water treatment chemicals used; and	(h) Volume 1, Section 6.6 Make-Up Water and Produced Water Treatment
	(h) measures for ensuring efficient use of water including alternatives to reduce the consumption of non-saline water such as water use minimization, recycling, conservation, and technological improvements.	(h) Volume 1, Section 7.3 Saline Source Water
2.8.2 Surface Water	[A] Describe the surface water management strategy for all stages of the Project, including: (a) Design factors considered, such as; i) site drainage; ii) run-on management; iii) road, well pad and plant run-off; iv) erosion and sediment control; v) groundwater and surface water protection; vi) groundwater seepage; vii) produced water management; viii) flood protection, and ix) geotechnical stability concerns; and (b) permanent or temporary alterations or realignments of watercourses, wetlands and other waterbodies.	[A] Volume 1, Appendix 1-IX Surface Water Management Plan Summary
	[B] Describe realignments of Crown bed and shore and proposed compensation.	n/a
	[C] Provide a description of navigable waterways and the results of navigability assessment(s) waterways that may be affected by the Project.	[C] Volume 4, Section 3.2.3 Water Course Crossings

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.8.3 Wastewater Management	[A] Describe the wastewater management strategy, including: (a) the source, quantity and composition of each wastewater stream from each component of the proposed operation (e.g., bitumen extraction and associated facilities) for all Project conditions, including normal, start-up, worst-case and upset conditions;	[A] Volume 1, Section 7 Water Source Management
	(b) the proposed disposal locations and methods for each wastewater stream, and the measures taken to prevent impacts on potable groundwater, aquatic ecosystems and vegetation;	(b) Volume 1, Section 3.8 Deep Well Disposal; Volume 1, Section 5.4 Water Disposal Wells
	(c) formations for the disposal of wastewaters;	(c) Volume 1, Section 3.8 Deep Well Disposal
	(d) design of facilities that will collect, treat, store and release wastewater streams;	(d) Volume 1, Section 6.6 Make-up Water and Produced Water Treatment
	(e) type and quantity of chemicals used in wastewater treatment; and	(e) Volume 1, Section 6.6 Make-up Water and Produced Water Treatment
	(f) sewage treatment and disposal.	(f) Volume 1, Section 6.6.1 Sanitary System
2.9 Waste Management	[A] Characterize and quantify the anticipated dangerous goods, and hazardous, non-hazardous, and recyclable wastes generated by the Project, and: (a) describe the composition and volume of specific waste streams and discuss how each stream will be managed; (b) identify the amount of drilling wastes and the options considered for disposal and the option(s) chosen; (c) describe how the disposal sites and sumps will be constructed; and (d) describe plans for pollution prevention, waste minimization, recycling, and management to reduce waste quantities for all stages of the Project.	[A] Volume 1, Section 9.4 Waste Management
2.10 Conservation and Reclamation	[A] Provide a conceptual conservation and reclamation plan for the Project considering: (a) any existing Conservation and Reclamation Plan;	[A] Volume 1, Section 14.2.1 Christina Lake Thermal Project Conservation and Reclamation
	(b) pre-development information with respect to land capability, vegetation, commercial forest land base by commercialism class, forest productivity, recreation, wildlife, aquatic resources, aesthetics, traditional land uses and land use resources;	(b) Volume 1, Section 14.2 Existing Biophysical Environment; Volume 1, Section 14.3.6 Restoration and Equivalent Capability; Volume 5, Section 4 Baseline Case

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.10 Conservation and Reclamation (continued)	(c) integration of operations, decommissioning, reclamation planning and reclamation activities.	(c) Volume 1, Section 14.3.3.2 Well Pad Sequence; Volume 1, Section 14.4.3 Facility Decommissioning and Closure
	(d) discuss anticipated timeframes for completion of reclamation stages and release of lands back to the Crown including an outline of the key milestone dates for reclamation and how progress to achieve these targets will be measured;	(d) Volume 1, Section 14.4 Detailed Conservation and Reclamation Plan
	(e) constraints to reclamation such as timing of activities, availability of reclamation materials and influence of natural processes and cycles including natural disturbance regimes;	(e) Volume 1, Section 14.4.3 Facility Decommissioning and Closure
	(f) post-development land capability with respect to: (i) self-sustaining topography, drainage and surface watercourses representative of the surrounding area, (ii) pre-development traditional use with consideration for traditional vegetation and wildlife species in the reclaimed landscape, (iii) wetlands, (iv) self-sustaining vegetation communities representative of the surrounding area, and (v) reforestation and forest productivity;	(f) Volume 1, Section 14.4.3 Facility Decommissioning and Closure; Volume 1, Section 14.3.6 Restoration and Equivalent Capability
	(g) a revegetation plan for the disturbed terrestrial and aquatic areas, identifying the species types that will be used for seeding or planting, and the vegetation management practices to return disturbed areas to a state capable of supporting a self-sustaining vegetative community capable of ecological succession equivalent to pre-disturbance conditions, considering factors such as biological capability and diversity, natural disturbance regimes and end land use objectives;	(g) Volume 1, Section 14.4.3.2 Revegetation Plan
	(h) reclamation material salvage, storage areas and handling procedures;	(h) Volume 1, Section 14.4.1 Facility Construction
	(i) reclamation material replacement indicating depth, volume and type;	(i) Volume 1, Section 14.4.3 Facility Decommissioning and Closure
	(j) pre-development and final reclaimed site drainage plans;	(j) Volume 1, Section 14.4.3.3 Component-Specific Reclamation and Revegetation Plans
	(k) integrating surface and near-surface drainage within the Project Area; and	(k) Volume 1 Section 14.4.2.2 Water Management Plan
	(l) promotion of biodiversity.	(l) Volume 1 Section 14.4.3.2 Revegetation Plan; Volume 1, Section 14.3.6.3 Biodiversity
2.10	[B] Provide a predicted Ecological Land Classification map for the post-reclamation landscape	[B] Volume 1 Section 14.4.3 Facility

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
Conservation and Reclamation (continued)	considering potential land uses, including traditional uses, and how the landscape and soils have been designed to accommodate future land use.	Decommissioning and Closure
	[C] Provide a conceptual plan to monitor reclamation performance and success (including soils, vegetation, wildlife and aquatic resources).	[C] Volume 1 Section 14.6 Conservation and Reclamation Monitoring
	[D] Discuss uncertainties related to the conceptual reclamation plan.	[D] Volume 1 Section 14 Conservation and Reclamation Plan
2.11 Environmental Management System	[A] Summarize key elements of EnCana FCCL's existing or proposed environment, health and safety management system.	[A] Volume 1, Section 9.1 Environmental Health and Safety Management
	[B] Describe adaptive management plans that minimize the impact of the Project. Describe the flexibility built into the Project to accommodate future modifications as a result of: (a) any change in environmental standards, limits and guidelines; or (b) findings from Project-specific or regional monitoring.	[B] Volume 1, Section 9.1 Environmental Health and Safety Management; Volume 1, Section 12.1 Co-Operative Efforts
	[C] Describe EnCana FCCL current and proposed source monitoring programs with respect to: (a) source air emissions, including fugitive emissions; (b) wastewater treatment and release; and (c) hazardous and non-hazardous waste treatment and storage.	[C] Volume 2, Appendix 2-VI Monitoring Programs
	[D] Discuss: (a) how monitoring data will be disseminated to the public or other interested parties; and (b) how the results of monitoring programs and publicly available monitoring information will be integrated with EnCana FCCL's environmental management system.	[D] Volume 1, Section 2.4 Consultation; Volume 2, Appendix 2-VI Monitoring Programs
2.12 Regional and Cooperative Initiatives	[A] Discuss EnCana FCCL's involvement in regional and cooperative efforts to address environmental and socio-economic issues associated with regional development, including: (a) potential cooperative ventures that EnCana FCCL has initiated, could initiate or could develop with other operators and other resource users; (b) how EnCana FCCL will work to develop and implement such cooperative opportunities; (c) EnCana FCCL participation in any regional forums; (d) how EnCana FCCL would design and implement research programs; and (e) how regional environmental management initiatives will be incorporated into EnCana FCCL's management practices.	[A] Volume 1, Section 12,1 Co-Operative Efforts; Volume 2, Appendix 2-VI Monitoring Programs

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.12 Regional and Cooperative Initiatives (continued)	[B] Discuss EnCana FCCL regional monitoring activities including: (a) monitoring that will be undertaken to assist in managing environmental effects, confirm performance of mitigative measures and improve environmental protection strategies; (b) monitoring done independently by EnCana FCCL; (c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups; and (d) new monitoring initiatives that may be required as a result of the Project.	[B] Volume 2, Appendix 2-VI Monitoring Programs
3.0 ENVIRONMENTAL ASSESSMENT		
3.1 Assessment Requirements		
3.1.1 Scenarios	[A] Define assessment scenarios including: (a) a Baseline Case, which includes existing environmental conditions, existing and approved projects or activities; (b) an Application Case, which includes the Baseline Case plus the Project; and (c) a Planned Development Case, which includes past, existing and anticipated future environmental conditions, based on existing and approved projects or activities, plus planned projects or activities reasonably expected to occur. For the purposes of defining the assessment scenarios, *approved* means approved by any federal, provincial or municipal regulatory authority. *Planned* means any project or activity that has been publicly disclosed up to six months prior to the submission of EnCana FCCL's Application and EIA report.	[A] Volume 2, Section 4.1.5 Assessment Cases
3.1.2 Study Areas	***3.1.2.1 Project Area*** [A] The Project Area includes all lands subject to direct disturbance from the Project and associated infrastructure. For the Project Area, provide: (a) the legal land description;	[A] Volume 1, Section 1 Introduction
	(b) the boundaries of the land under EnCana FCCL's control (this may include lands under the public land disposition or private lands leased or owned by EnCana FCCL);	(b) Volume 1, Figure 5.1-1
	(c) the proposed ERCB approval area;	(c) Volume 1, Figure 3.1-1
	(d) a map that shows the status of land tenure/ownership and identifies the locations of all proposed development activities and facilities; and	(d) Volume 1, Figure 10.2-1
	(e) a topographic map of appropriate scale showing the area proposed to be disturbed in relation to existing township grids, wetlands, watercourses, and waterbodies.	(e) Volume 1, Figure 5.1-1; Volume 6, Figure 5.2-1

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.1.2 Study Areas (continued)	***3.1.2.2 Local and Regional Study Areas*** [A] The Local Study Area (LSA) is the area existing outside the boundaries of the Project Area, where there is a reasonable potential for immediate environmental impacts due to ongoing Project activities. [B] The Regional Study Area (RSA) is the area within which there is the potential for cumulative and socio-economic effects, and that may be relevant to the assessment of any wider-spread effects of the Project. [C] The Study Area for the EIA report shall include the Project Area as well as the spatial and temporal limits of individual environmental components outside of the Project Area boundaries where an effect can be reasonably expected. The Study Area includes both the Local and Regional Study Areas.	[A], [B] and [C] Volume 2, Section 4.3 Spatial Considerations
	[D] For each LSA and RSA: (a) provide the scientific rationale used to define the spatial temporal aspects, considering the location and range of probable Project and cumulative effects; and	[D] Volume 2, Section 4.3 Spatial Considerations
	(b) identify LSA and RSA boundaries on maps of appropriate scale that show existing township grids, wetlands, watercourses, waterbodies and other topographic features.	(b) Volume 2, Figure 4.3-1
	[E] Identify the traditional land use areas within the Study Area, as provided by aboriginal communities and groups.	(c) Volume 6, Appendix 6-I Traditional Land Use Baseline
3.1.3 Cumulative Environmental Effects	[A] EnCana FCCL will assess cumulative environmental effects in accordance with the ERCB/AENV/Natural Resources Conservation Board Information Letter *Cumulative Effects Assessment in Environmental Impact Assessment Reports under the Alberta Environmental Protection and Enhancement Act*, June 2000. EnCana FCCL will include a summary of all proposed monitoring, research and other strategies or plans to minimize, mitigate and manage any potential adverse effects.	[A] Volumes 3 to 6; Volume 2, Appendix 2-VI Monitoring Programs
	[B] Explain the approach and methods used to identify and assess cumulative impacts, including cooperative opportunities and initiatives undertaken to further the collective understanding of cumulative effects. Provide a record of relevant assumptions, confidence in data and analysis to support conclusions.	[B] Volume 2, Section 4 Environmental Impact Assessment Methods
3.1.4 Information Requirements	[A] EnCana FCCL shall include the following environmental information for each assessment scenario: (a) a description of and rationale for the selection of environmental attributes, parameters, or properties examined;	[A] Volumes 3 to 6

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.1.4 Information Requirements (continued)	(b) for each selected environmental attribute, parameter, or property: (i) describe existing conditions. Comment on whether the available data are sufficient to assess impacts and mitigative measures. Identify environmental disturbance from previous, current, and approved activities that have become part of the baseline conditions, ii) describe the environmental effects associated with the development activities, iii) provide plans to minimize, mitigate or eliminate negative effects and impacts. Discuss the key elements of such plans, iv) provide a description of the process and criteria used to determine the significance of environmental effects, v) provide a plan to manage environmental changes and identify and follow-up programs necessary to verify the accuracy of the environmental assessment and to determine effectiveness of measures taken to mitigate adverse environmental effects, and vi) describe residual effects and their significance;	(b) Volumes 3 to 6
	(c) discussion of the sources of information used in the assessment including: (i) a summary of previously conducted environmental assessments related to EnCana FCCL's operations, ii) literature and previous EIA reports and environmental studies; operating experience from current, similar operations; industry study groups; traditional knowledge; and government sources, and iii) limitations or deficiencies that the information may place on the analysis or conclusions in the EIA report. Discuss how these limitations or deficiencies may be addressed within the EIA report; and	(c) Volume 2, Section 3.1 Impact Assessment Overview
	(d) description of the techniques used to identify and evaluate the environmental impacts and effects resulting from the Project.	(d) Volume 2, Section 4.7 Impact Analyses; Volume 2, Section 4.8 Impact Description Criteria
	[B] The EIA report shall: (a) identify where deficiencies in information exist and describe EnCana FCCL's plan, including a rationale, for providing the necessary information. Where required undertake studies and investigations to obtain additional information to address the information deficiencies;	(a) Volumes 3 to 6
	(b) provide a sufficient base for the prediction of positive and negative impacts and the extent to which negative impacts may be mitigated by planning, Project design, construction techniques, operational practices and reclamation techniques. Impact significance will be quantified where possible and assessed including consideration of spatial, temporal and cumulative aspects;	(b) Volumes 3 to 6

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.1.4 Information Requirements (continued)	(c) provide a plan that addresses the adverse impacts associated with the Project that may require joint resolution by government, industry and the community. Describe how this plan might be implemented and how it would incorporate the participation of government, industry and the community; and	(c) Volume 2, Appendix 2-VI Monitoring Programs; Volumes 3 to 6
	(d) present biophysical information in a manner that enables ecological land classification maps to be completed to the ecosite classification level.	(d) Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline
3.1.5 Modeling	[A] For those models or modeling techniques used that are not prescribed by regulators to predict Project impacts provide: (a) the justification for the model used; (b) documentation of the calibration process, the validation process and the assumptions used and data sets used to obtain the modeling predictions in the EIA report; (c) discussion of the limitations of the models, including sources of error and relative accuracy, and how these limitations were addressed in the EIA report.	[A] Volume 3, Appendix 3-III Air Modelling Methods; Volume 3, Appendix 3-IV Noise Modelling Methods; Volume 3, Appendix 3-XII Air Emissions Effects Supplemental Information; Volume 4, Appendix 4-II Hydrogeology Groundwater Flow Model; Volume 5, Appendix 5-I Wildlife Habitat Modelling
	[B] Air quality modeling shall be conducted in accordance with the latest edition of the *Air Quality Modeling Guidelines* published by Alberta Environment.	[B] Volume 3, Appendix 3-III Air Modelling Methods
3.2 Air Quality, Climate and Noise		
3.2.1 Baseline Information	[A] Discuss the baseline climatic and air quality conditions including: (a) the type and frequency of meteorological conditions that may result in poor air quality; and	[A] Volume 3, Appendix 3-IV Existing Air Quality and Meteorology
	(b) appropriate ambient air quality parameters such as SO_2, CO, H_2S, total hydrocarbons (THC), NO_X, VOC, PAH, individual hydrocarbons of concern in the THC and VOC mixtures, ground-level ozone (O_3), visibility, representative heavy metals, and particulates (road dust, PM_{10} and $PM_{2.5}$).	(b) Volume 3, Appendix 3-IV Existing Air Quality and Meteorology
	[B] Provide representative baseline noise levels at receptor locations.	[B] Volume 3, Section 2.3 Baseline Summary; Volume 3, Appendix 3-VII Noise Baseline
3.2.2 Impact Assessment	[A] Identify components of the Project that will affect air quality, and:	[A] Volume 3, Appendix 3-I Emission Source Details
	(a) describe the potential for reduced air quality (including odours and visibility) resulting from the Project and discuss any implications of the expected air quality for environmental protection and public health, including the local residents and actively used cabins;	(a) Volume 3, Section 1.8 Application Case; Volume 6 Visual Resources Assessment; Volume 6, Section 4.2 Assessment Approach

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.2.2 Impact Assessment (continued)	(b) estimate ground-level concentrations of appropriate air quality parameters;	(b) Volume 3, Section 1.6 Application Case; Volume 3, Section 1.8 Application Case; Volume 3, Section 1.9 Planned Development Case; Volume 3, Appendix 3-V Ambient Air Quality Predictions
	(c) discuss any expected changes to particulate deposition, nitrogen deposition, and acidic deposition patterns;	(c) Volume 3, Section 1.6 Application Case; Volume 3, Section 1.8 Application Case; Volume 3, Section 1.9 Planned Development Case; Volume 3, Appendix 3-V Ambient Air Quality Predictions
	(d) identify areas that exceed Potential Acid Input (PAI) critical loading criteria;	(d) Volume 3, Section 4.5 Application Case;
	(e) discuss interactive effects that may occur as a result of co-exposure of a receptor to all emissions; and	(e) Volume 3, Section 1.8 Application Case
	(f) describe air quality impacts resulting from the Project, and their implications for other environmental resources, including habitat diversity and quantity, soil resources, vegetation resources, and water quality.	(f) Volume 3, Section 4.3 Baseline Case; Volume 3, Section 4.5 Application Case; Volume 3, Section 4.6 Planned Development Case
	[B] Identify stages or elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events. Discuss what impacts the change to climate parameters may have on elements of the Project that are sensitive to climate parameters.	[B] Volume 3, Appendix 2-V Climate Change Considerations
	[C] Identify components of the Project that have the potential to increase noise levels and discuss the implications. Present the results of a noise assessment. Include: (a) potentially-affected people and wildlife;	[C] Volume 2, Section 3.2 Human Health Risk Assessment; Volume 3, Section 3.3 Wildlife Health Assessment
	(b) an estimate of the potential for increased noise resulting from the development; and	(b) Volume 3, Section 2.7 Application Case
	(c) the implications of any increased noise levels, including the implications for local residents and any actively used cabins.	c) Volume 3, Section 2.7 Application Case

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.2.2 Impact Assessment (continued)	[D] Describe how air quality and noise impacts resulting from the Project will be mitigated.	[D] Volume 3, Section 1.1.2.1 Project Air Quality Management Initiatives Volume 3, Section 2.4 Mitigation; Volume 3, Section 2.7 Application Case
	[E] Describe the residual air quality and noise effects of the Project and EnCana FCCL's plans to manage those effects.	[E] Volume 3, Section 1.1.2 Air Quality Management and Commitments; Volume 3, Section 2.4 Mitigation Volume 3, Section 2.8 Monitoring and Follow-up; Volume 3, Section 2.10 Noise Conclusions Volume 6, Section 4.6 Application Case
3.2.3 Monitoring	[A] Describe the monitoring programs proposed to assess any impacts to air quality and noise and to measure the effectiveness of mitigation.	[A] Volume 3, Section 1.10 Monitoring Volume 3, Section 2.8 Monitoring and Follow-up
	[B] Describe any monitoring programs proposed to monitor the effects of acid deposition.	[B] Volume 3, Section 4.7 Monitoring
3.3 Hydrogeology		
3.3.1 Baseline Information	[A] Provide an overview of the existing geologic and hydrogeologic setting from the ground surface down to, and including, the oil producing zones and wastewater disposal zones, and if applicable, to the base of any deeper strata that would be potentially impacted by wastewater disposal. Document any new hydrogeological investigations, including methodology and results, undertaken as part of the EIA study, and: (a) present regional and Project Area geology using structure contour maps, geologic cross-sections and isopach maps to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features;	[A] Volume 4, Section 4.1 Hydrogeology (Baseline Case)

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.3.1 Baseline Information (continued)	(b) present regional and Project Area hydrogeology describing: i) the major aquifers, aquitards and aquicludes (Quaternary and bedrock), their spatial distribution, properties, hydraulic connections between aquifers, hydraulic heads, gradients, groundwater flow directions and velocities; include maps and cross-sections, ii) the chemistry of groundwater aquifers including baseline concentrations of major ions, metals and hydrocarbon indicators, iii) the potential discharge zones, potential recharge zones and sources, areas of groundwater-surface water interaction and areas of Quaternary aquifer-bedrock groundwater interaction, iv) water well development and groundwater use, including an inventory of groundwater users, v) the recharge potential for Quaternary aquifers, vi) potential hydraulic connection between bitumen production zones, deep disposal formations and other aquifers due to Project operations; vii) the characterization of formations chosen for deep well disposal, including chemical compatibility and containment potential, injection capacity, hydrodynamic flow regime, and water quality assessments, and viii) the locations of major facilities associated with the Project including facilities for waste storage, treatment and disposal (e.g., deep well disposal) and describe site-specific aquifer and shallow groundwater conditions beneath these proposed facilities. Provide supporting geological information.	(b) Volume 4, Section 4.1 Hydrogeology (Baseline Case)
3.3.2 Impact Assessment (continued)	[A] Describe Project components and activities that have the potential to affect groundwater resource quantity and quality during the life of the Project.	[A] Volume 4, Section 5.1 Hydrogeology (Application Case)
	[B] Describe the nature and significance of the potential Project impacts on groundwater with respect to: (a) inter-relationship between groundwater and surface water in terms of surface water quantity and quality; (b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands; (c) changes in groundwater quality and quantity; (d) conflicts with other groundwater users, and proposed resolutions to these conflicts; (e) potential implications of seasonal variations; and (f) groundwater withdrawal for Project operations including any expected alterations in the groundwater flow regime during and following Project operations.	[B] Volume 4, Section 5.1 Hydrogeology (Application Case)

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.3.2 Impact Assessment (continued)	[C] Describe programs to manage and protect groundwater resources including: (a) the early detection of potential contamination; (b) groundwater remediation options in the event that adverse effects are detected.	[C] Volume 4, Section 3.1 Subsurface Facilities and Infrastructure (Monitoring); Volume 4, Section 5.1 Hydrogeology (Application Case); Volume 4, Section 6.1 Hydrogeology (Planned Development Case)
	[D] Identify measures to reduce the environmental risks from casing failures.	[D] Volume 4, Section 3.1 Subsurface Facilities and Infrastructure
	[E] Describe the residual effects of the Project on groundwater quality and quantity and EnCana FCCL's plans to manage those effects.	[E] Volume 4, Section 5.1 Hydrogeology (Application Case)
3.3.3 Monitoring	[A] Describe any monitoring programs proposed to asses any Project impacts to groundwater quality and quantity and to measure the effectiveness of mitigation plans.	[A] Volume 4, Section 7.1 Hydrogeology (Monitoring)
3.4 Hydrology		
3.4.1 Baseline information	[A] Describe and map the surface hydrology. Include flow regimes of streams in the Project Area.	[A] Volume 4, Section 4.2 Hydrology (Baseline Case)
	[B] Provide surface flow baseline data, including; (a) seasonal variation, low, average and peak flows for watercourses; and (b) low, average and peak levels for waterbodies.	[B] Volume 4, Section 4.2 Hydrology (Baseline Case)
	[C] Identify any surface water users who have existing approvals, permits or licenses.	[C] Volume 4, Appendix 4-V Hydrology Baseline
3.4.2 Impact Assessment	[A] Discuss changes to watersheds, including surface and near-surface drainage conditions, potential flow impediment, and potential changes in open-water surface areas caused by the Project.	[A] Volume 4, Section 5.2 Hydrology (Application Case)
	[B] Describe the extent of hydrological changes that will result from disturbances to groundwater and surface water movement: (a) include changes to the quantity of surface flow, water levels and channel regime in local watercourses (during minimum, average and peak flows) and water levels in waterbodies; (b) assess the potential impact of any alterations in flow on hydrology and identify all temporary and permanent alterations, channel realignments, disturbances or surface water withdrawals; (c) discuss both the Project and cumulative effect of these changes on hydrology (e.g., timing, volume, peak and minimum flow rates, river regime and lake levels), including the significance of effects for downstream watercourses; and (d) identify any potential erosion problems in watercourses due to the Project.	[B] Volume 4, Section 5.2 Hydrology (Application Case)

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.4.2 Impact Assessment (continued)	[C] Discuss changes in sedimentation patterns in receiving waters resulting from the Project.	[C] Volume 4, Section 5.2 Hydrology (Application Case)
	[D] Describe impacts on other surface water users due to the Project. Identify any potential water use conflicts	[D] Volume 4, Section 5.2 Hydrology (Application Case)
	[E] Describe potential downstream impact if surface water is removed.	[E] Volume 4, Section 5.2 Hydrology (Application Case)
	[F] Discuss the impact of low flow conditions and in-stream flow needs (IFN) on water supply and water and wastewater management strategies.	[F] Volume 4, Section 6.2 Hydrology (Planned Development Case)
	[G] Discuss how potential impacts of temporary and permanent roads and well pads on wetland hydrology will be minimized and mitigated.	[G] Volume 4, Section 3.1 Subsurface Facilities and Infrastructure (Mitigation)
	[H] Describe mitigation measures to address impacts during all stages of the Project, including: (a) alteration in flow regimes; (b) potential water use conflicts; and (c) increased sediment loadings.	[H] Volume 4, Section 3 Mitigation
	[I] Describe residual effects of the Project on hydrology and EnCana FCCL's plans to manage those effects.	[I] Volume 4, Section 5.2 Hydrology (Planned Development Case)
3.4.3 Monitoring	[A] Describe any monitoring programs proposed to assess the impacts of changes in surface water flows and levels on aquatic resources, wildlife and vegetation and to measure the effectiveness of mitigation plans.	[A] Volume 4, Section 7.2 Hydrology (Monitoring)
3.5 Surface Water Quality		
3.5.1 Baseline Information	[A] Describe the baseline water quality of watercourses and waterbodies. Discuss the effects of seasonal variations, flow and other factors on water quality.	[A] Volume 4, Section 4.3 Water Quality (Baseline Case)
3.5.2 Impact Assessment	[A] Identify Project components that may influence or impact surface water quality.	[A] Volume 4, Section 5.3 Water Quality (Application Case)

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.5.2 Impact Assessment (continued)	[B] Describe the potential impacts of the Project on surface water quality: (a) discuss any changes in water quality resulting from the Project that may exceed the *Surface Water Quality Guidelines for Use in Alberta or Canadian Water Quality Guidelines*; (b) discuss the significance of any impacts on water quality and implications to aquatic resources (e.g., biota, biodiversity and habitat); (c) discuss seasonal variation and potential effects on surface water quality; (d) assess the potential Project related and cumulative impacts of acidifying and other air emissions on surface water quality; and (e) discuss the effect of changes in surface runoff or groundwater discharge on water quality in surface waterbodies.	[B] Volume 3, Section 4.5 Application Case; Volume 4, Section 5.3 Water Quality (Application Case)
	[C] Describe proposed mitigation measures to maintain surface water quality at all stages of the Project.	[C] Volume 4, Section 3.2 Surface Facilities and Infrastructure (Mitigation)
	[D] Describe the residual effects of the Project on surface water quality and EnCana FCCL's plans to manage those effects.	[D] Volume 4, Section 5.3 Water Quality (Application Case)
3.5.3 Monitoring	[A] Describe any monitoring programs proposed to assess surface water quality impacts from the Project and to measure the effectiveness of mitigation plans. Discuss the location of monitoring sites, the frequency of monitoring, the parameters to be monitored, the implementation of quality assurance programs, and the numerical methodology.	[A] Volume 4, Section 7.3 Water Quality (Monitoring)
	[B] Describe how continuous monitoring will be used to evaluate Project effects, and how such monitoring will be used to identify the need for mitigation.	[B] Volume 4, Section 7.3 Water Quality (Monitoring)
3.6. Aquatic Ecology		
3.6.1 Baseline Information	[A] Describe the existing fish and other aquatic resources (e.g., benthic invertebrates). Identify species composition, distribution, relative abundance, movements and general life history parameters.	[A] Volume 4, Section 4.4 Fish and Fish Habitat (Baseline Case)
	[B] Describe and map, as appropriate, the fish habitat and aquatic resources of the lakes, rivers, ephemeral water bodies and other waters and identify: (a) key indicator species and provide the rationale and selection criteria used; (b) critical or sensitive areas such as spawning, rearing, and over-wintering habitats. Discuss seasonal habitat use including migration and spawning routes; and (c) current and potential use of the fish resources by Aboriginal, sport or commercial fisheries.	[B] Volume 4, Section 4.4 Fish and Fish Habitat (Baseline Case)

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.6.2 Impact Assessment	[A] Describe the potential impacts to fish, fish habitat and other aquatic resources (e.g., stream alterations and changes to substrate conditions, water quality and quantity) considering: (a) fish tainting, survival of eggs and fry, chronic or acute health effects, and increased stress on fish populations from release of contaminants, sedimentation, flow alterations, temperature and habitat changes; (b) potential impacts on riparian areas that could impact aquatic biological resources and productivity; (c) the potential for increased fishing pressures in the region could arise from the increased workforce and improved access as a result of the Project. Identify the implications on the fish resource and describe any mitigation strategies that might be planned to minimize these effects, including any plans to restrict employee and visitor access; and (d) changes to benthic invertebrate communities that may affect food quality and availability for fish.	[A] Volume 4, Section 5.4 Fish and Fish Habitat (Application Case)
	[B] Discuss the design, construction and operational factors to be incorporated into the Project to minimize effects to fish and fish habitat and protect aquatic resources.	[B] Volume 4, Section 3.2 Surface Facilities and Infrastructure (Mitigation)
	[C] Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat including the development of a "No Net Loss" fish habitat objective.	[C] Volume 4, Section 5.4 Fish and Fish Habitat (Application Case)
	[D] Describe the effects of any surface water withdrawals considered including cumulative effects on aquatic resources.	[C] Volume 4, Section 5.3 Water Quality (Application Case)
	[E] Describe the residual effects of the Project on fish, fish habitat, and other aquatic resources and discuss their significance in the context of local and regional fisheries. Describe EnCana FCCL's plans to manage those effects.	[E] Volume 4, Section 5.4 Fish and Fish Habitat (Application Case)
3.6.3 Monitoring	[A] Describe any monitoring programs proposed to assess any Project impacts to fish, fish habitat and other aquatic resources and to measure the effectiveness of mitigation plans.	[A] Volume 4, Section 7.4 Fish and Fish Habitat (Monitoring)
3.7 Vegetation		
3.7.1 Baseline Information	[A] Describe and map vegetation communities for each ecosite phase.	[A] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline
	[B] Describe and map wetlands, and discuss the distribution and relative abundance of wetlands.	[B] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline; Volume 5, Section 4.4.3 Landscape-Level Biodiversity
	[C] Identify, verify and map the relative abundance of species of rare plants and the ecosite phases where they are found.	[C] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline; Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.7.1 Baseline Information (continued)	[D] Identify key indicators and discuss the rationale for their selection. Identify composition, distribution, relative abundance, and habitat requirements. Address those species listed as "at Risk, May be at Risk and Sensitive" in *The Status of Alberta Species* (Alberta Sustainable Resource Development) and all species listed in Schedule 1 of the federal *Species at Risk Act*.	[D] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
	[E] Discuss the potential of each ecosite phase to support rare plant species, plants for traditional medicinal and cultural purposes, old growth forests and communities of limited distribution. Consider their importance for local and regional habitat, sustained forest growth, rare plant habitat and the hydrologic regime.	[E] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline
	[F] Describe the regional relevance of landscape units that are identified as rare.	[F] Volume 5, Appendix 5-III Biodiversity Baseline
	[G] Provide Timber Productivity Ratings for both the Project Area and the Local Study Area, including identification of productive forested, non-productive forested and non-forested lands.	[G] Volume 5, Appendix 5-IV Forestry Baseline
3.7.2 Impact Assessment	[A] Identify the amount of vegetation and wetlands to be disturbed during the life of the Project.	[A] Volume 5, Section 6.2.2. Terrestrial Vegetation, Wetlands and Forestry Impact Analysis.
	[B] Discuss any potential effects the Project may have on rare plants or endangered species.	[B] Volume 5, Section 6.2.3.9 Rare Plants
	[C] Discuss temporary (include timeframe) and permanent changes to vegetation and wetlands communities and comment on:	[C] Volume 5, Section 6.2.2. Terrestrial Vegetation, Wetlands and Forestry Impact Analysis
	(a) the effects and their implications for other environmental resources (e.g., habitat diversity and quantity, water quality and quantity, erosion potential)	(a) Volume 5, Section 6.1 Terrain and Soils; Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
	(b) the effects and their implications to recreation, aboriginal and other uses; and	(b) Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry; Volume 6, Section 2 Traditional Land Use Assessment; Volume 6, Section 3 Resource Use
	(c) the sensitivity to disturbance (including acid deposition), as well as the techniques used to estimate sensitivity to disturbance and reclamation, of each vegetation community.	(c) Volume 3, Section 4.5 Application Case; Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
	[D] Describe the regional impact of any ecosite phase to be removed.	[D] Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
	[E] Discuss from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and the expected differences in the resulting vegetative community structures.	[E] Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
3.7.2	[F] Provide an Ecological Land Classification map that shows the reclaimed vegetation.	[F] Volume 5, Appendix 5-II Terrestrial

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
Impact Assessment (continued)	Comment on the importance of the size, distribution and variety of the reclaimed landscape units from both a local and regional perspective.	Vegetation and Wetlands Baseline; Volume 5, Section 4.4.3 Landscape-Level Biodiversity
	[G] Compare the pre-disturbance and reclaimed percentages and distribution of all forested communities in the Project Area and determine the amount of commercial and non-commercial forest land base that will be disturbed by the Project.	[G] Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry
	[H] Discuss the impact of any loss of wetlands, as well as how this will affect land use, fragmentation and biodiversity. Discuss measures and techniques that will be used to minimize the impact.	[H] Volume 5, Section 6.2 Terrestrial Vegetation, Wetlands and Forestry; Volume 5, Section 3 Mitigation
	[I] Provide a mitigation strategy that will minimize Project impacts addressing: (a) mitigation of the adverse effects of site clearing on rare plants, plant communities and plants for traditional, medicinal and cultural purposes. Identify any setbacks proposed around environmentally-sensitive areas such as surface waterbodies, riparian areas, traditional use sites and wetlands; and (b) measures and techniques that will be used to minimize the impact of loss of wetlands on land use, fragmentation and biodiversity.	(I) Volume 5, Section 3 Mitigation
	[J] Discuss weeds and non-native invasive species and describe how these species will be assessed and controlled prior to and during operation and reclamation.	[J] Volume 1, Section 14.4, Detailed Conservation and Reclamation Plan; Volume 5, Section 3.2 Operations; Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline
	[K] Describe the residual effects of the Project on vegetation and EnCana FCCL's plans to manage those effects.	[K] Volume 5, Section 6.2.5 Terrestrial Vegetation, Wetlands and Forestry Residual Impact Classification
3.7.3 Monitoring	[A] Describe any monitoring programs proposed to assess vegetation impacts from the Project and to measure the effectiveness of mitigation plans.	[A] Volume 5, Section 8 Monitoring

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.8 Wildlife		
3.8.1 Baseline Information	[A] Describe and map existing wildlife resources (amphibians, reptiles, birds and terrestrial and aquatic mammals) and their use and potential use of habitats.	[A] Volume 5, Appendix 5-V Wildlife and Wildlife Habitat Baseline
	[B] Identify key indicator species and discuss the rationale for their selection. Identify composition, distribution, relative abundance, seasonal movements, movement corridors, habitat requirements, key habitat areas, and general life history. Address those species: (a) listed as "at Risk, May be at Risk and Sensitive" in *The Status of Alberta Species* (Alberta Sustainable Resource Development); (b) listed in Schedule 1 of the federal *Species at Risk Act*; and (c) listed as "at risk" by COSEWIC.	[B] Volume 5, Appendix 5-V Wildlife and Wildlife Habitat Baseline; Volume 5, Appendix 5-I Wildlife Habitat Modelling; Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife
	[C] Describe, quantify and map all existing habitat disturbance (including exploration activities) and identify those habitat disturbances that are related to existing and approved Project operations.	[C] Volume 5, Section 4.2 Terrestrial Vegetation, Wetlands and Forestry
3.8.2 Impact Assessment	[A] Describe Project components and activities that may affect wildlife and wildlife habitat.	[A] Volume 5, Section 6.3 Wildlife (Application Case) Volume 5, Section 7.3 Wildlife (Planned Development Case) Volume 5, Appendix 5-I Wildlife Habitat Modelling
	[B] Describe and assess the potential impacts of the Project on key indicator species and relate those impacts to wildlife populations and wildlife habitats, addressing: (a) how the Project will affect wildlife relative abundance, movement patterns, distribution and recruitment into regional populations for all stages of the Project;	[B] Volume 5, Section 6.3 Wildlife (Application Case) Volume 5, Section 7.3 Wildlife (Planned Development Case); Volume 5, Appendix 5-I Wildlife Habitat Modelling
	(b) how improved or altered access may affect wildlife including potential obstruction of daily and seasonal movements, increased vehicle-wildlife collisions, and increased hunting pressure;	(b) Volume 5, Section 6.3 Wildlife; Volume 5, Appendix 5-I Wildlife Habitat Modelling

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.8.2 Impact Assessment (continued)	(c) how increased habitat fragmentation may affect wildlife considering edge effects, the availability of core habitat, and the influence of linear features and infrastructure on wildlife movements and other population parameters;	(c) Volume 5, Section 6.3 Wildlife (Application Case); Volume 5, Section 7.3 Wildlife (Planned Development Case); Volume 5, Appendix 5-I Wildlife Habitat Modelling
	(d) the spatial and temporal changes to habitat availability and habitat effectiveness (types, quality, quantity, diversity and distribution);	(d) Volume 5, Section 6.3 Wildlife (Application Case); Volume 5, Section 7.3 Wildlife (Planned Development Case); Volume 5, Appendix 5-I Wildlife Habitat Modelling
	(e) potential effects on wildlife as a result of changes to air and water quality, including both acute and chronic effects on animal health;	(e) Volume 3 Section 3.3.4 Application case; Volume 5, Appendix 3-VIII Human and Wildlife Health Risk Assessment Methods
	(f) potential effects on wildlife from EnCana's proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic;	(f) Volume 5, Section 6.3 Wildlife (Application Case); Volume 5, Section 7.3 Wildlife (Planned Development Case)
	(g) the resilience and recovery capabilities of wildlife populations and habitats to disturbance; and	(g) Volume 5, Section 6.3 Wildlife (Application Case); Volume 5, Section 7.3 Wildlife (Planned Development Case); Volume 5, Appendix 5-I Wildlife Habitat Modelling; Volume 1, Section 14 Conservation and Reclamation Plan
	(h) the potential for the Project Area to be returned to its existing state with respect to wildlife populations and their habitats;	(h) Volume 5, Section 6.3 Wildlife (Application Case); Volume 5, Appendix 5-I Wildlife Habitat Modelling
	[C] Comment on the availability of species for traditional use considering habitat loss, habitat avoidance, vehicle-wildlife collisions, increased non-aboriginal hunting pressure and other Project related effects to wildlife populations.	[C] Volume 5, Section 4.3 Wildlife; Volume 5, Section 6.3 Wildlife
	[D] Provide a strategy and mitigation plan to minimize impacts on wildlife and wildlife habitat during all stages of the Project and to return productive wildlife habitat to the area, considering: (a) consistency of the plan with applicable regional, provincial and federal wildlife habitat objectives and policies;	[D] Volume 5, Section 8.3 Wildlife (Monitoring); Volume 5, Section 3 Mitigation

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.8.2 Impact Assessment (continued)	(b) a schedule for the return of habitat capability to areas impacted by the Project;	(b) Volume 5, Section 3 Mitigation; Volume 5, Section 8.1 Soil and Reclamation (Monitoring)
	(c) the use of setbacks to protect riparian habitats, interconnectivity of such habitat and the unimpeded movement by wildlife species using the habitat;	(c) Volume 5, Section 3 Mitigation; Volume 5, Section 8.3 Wildlife (Monitoring)
	(d) anticipated access controls or other management strategies to protect wildlife during and after Project operations;	(d) Volume 5, Section 3 Mitigation; Volume 5, Section 8.3 Wildlife (Monitoring)
	(e) measures to prevent habituation of wildlife, minimize the potential for human-wildlife encounters and consequent destruction of wildlife, including any staff training program, fencing camps, garbage containment measures or regular follow-up;	(e) Volume 5, Section 3 Mitigation; Volume 5, Section 8.3 Wildlife (Monitoring)
	(f) measures to mitigate habitat fragmentation considering impacts to habitat connectivity and wildlife movements resulting from linear features (e.g., above ground pipelines, roads, etc.) and other Project infrastructure and activities; and	(f) Volume 5, Section 3 Mitigation; Volume 5, Section 8.3 Wildlife (Monitoring)
	(g) measures to minimize the effects of light on wildlife.	(g) Volume 5, Section 3 Mitigation; Volume 5, Section 8.3 Wildlife (Monitoring)
	[E] Describe the residual effects of the Project on wildlife and wildlife habitat and EnCana FCCL's plans to manage those effects.	[E] Volume 5, Section 6.3 Wildlife; Volume 5, Section 8.3. Wildlife (Monitoring)
3.8.3 Monitoring	[A] Describe the monitoring programs proposed to assess any Project impacts to wildlife and to measure the effectiveness of mitigation plans, giving special attention to species: (a) listed as "at Risk, May be at Risk, and Sensitive" in The Status of Alberta Species (Alberta Sustainable Resource Development); (b) listed in Schedule 1 of the federal *Species at Risk Act*; and (c) listed as "at risk" by COSEWIC.	[A] Volume 5, Section 6.3 Wildlife; Volume 5, Section 8.3. Wildlife (Monitoring)
3.9 Biodiversity and Fragmentation		
3.9.1 Baseline Information	[A] Describe the terrestrial and aquatic biodiversity metrics that will be used to characterize the existing ecosystems and probable effects of Project development, and:	[A] Volume 5, Appendix 5-II Terrestrial Vegetation and Wetlands Baseline; Volume 5, Appendix 5-III Biodiversity Baseline
	(a) describe the process and rationale used to select biotic and abiotic indicators for biodiversity within selected taxonomic groups;	(a) Volume 5, Appendix 5-III Biodiversity Baseline
	(b) determine the relative abundance of species in each ecosite phase;	(b) Volume 5, Appendix 5-III Biodiversity Baseline

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.9.1 Baseline Information (continued)	(c) provide species locations, lists and summaries of observed and estimated species richness and evenness for each ecosite phase;	(c) Volume 5, Appendix 5-III Biodiversity Baseline
	(d) provide a measure of biodiversity on baseline sites that are representative of the proposed reclamation ecosites; and	(d) Volume 5, Appendix 5-III Biodiversity Baseline; Volume 5, Section 6.4 Biodiversity
	(e) rank each ecological unit for biodiversity potential. Describe the techniques used in the ranking process.	(e) Volume 5, Appendix 5-III Biodiversity Baseline; Volume 5, Section 6.4 Biodiversity
	[B] Describe the current level of habitat fragmentation.	[B] Volume 5, Appendix 5-III Biodiversity Baseline; Volume 5, Section 6.4 Biodiversity
3.9.2 Impact Assessment	[A] Describe the metrics used to assess the probable effects of the Project. Discuss the contribution of the Project to any anticipated changes in regional biodiversity and the potential impact to local and regional ecosystems.	[A] Volume 5, Section 6.4 Biodiversity; Volume 5, Appendix 5-I Wildlife Habitat Modelling
	[B] Identify and evaluate the extent of potential effects from fragmentation that may result from the Project.	[B] Volume 5, Section 6.4 Biodiversity
	[C] Discuss the measures to minimize any anticipated changes in regional biodiversity.	[C] Volume 5, Section 3 Mitigation
	[D] Describe the residual effects of the Project on biodiversity and fragmentation and EnCana FCCL's plans to manage those effects.	[D] Volume 5, Appendix 5-II Biodiversity Baseline; Volume 5, Section 6.4.2 Biodiversity Impact Analysis
3.9.3 Monitoring	[A] Describe any monitoring programs proposed assess any Project impacts on biodiversity and fragmentation and to measure the effectiveness of mitigation plans.	[A] Volume 5, Section 3 Mitigation; Volume 5, Section 8.4 Biodiversity (Monitoring)
3.10 Terrain and Soils		
3.10.1 Baseline Information	[A] Provide descriptions and maps of the terrain and soils conditions, including: (a) surficial geology and topography;	[A] Volume 5, Appendix 5-VI Terrain and Soils Baseline
	(b) the soil types and their distribution. Provide an ecological context to the soil resource by supplying a soil survey report and maps to include Survey Intensity Level (SIL) 2 for the Project Area;	(b) Volume 5, Appendix 5-VI Terrain and Soils Baseline
	(c) the suitability and availability of soils within the Project Area for reclamation;	(c) Volume 5, Appendix 5-VI Terrain and Soils Baseline
	(d) soils that could be affected by the Project with emphasis on potential acidification (by soil type); and	(d) Volume 5, Appendix 5-VI Terrain and Soils Baseline
	(e) descriptions and locations of erosion sensitive soils.	(e) Volume 5, Appendix 5-VI Terrain and Soils Baseline

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10.2 Impact Assessment	[A] Describe Project activities and other related issues that could affect soil quality (e.g., compaction, contaminants) and:	[A] Volume 5, Section 3 Mitigation; Volume 5, Section 5 Linkage Analysis
	(a) indicate the amount (ha) of surface disturbance from plant, field (pads, pipeline, access roads), aggregate and borrow sites, construction camps, drilling waste disposal and other infrastructure-related construction activities;	(a) Volume 5, Section 6.1 Terrain and Soils; Volume 1, Section 1.1 Overview; Volume 1, Section 9.4 Waste Management
	(b) provide an inventory of the pre- and post-disturbance land capability classes for soils in both the Project Area and Local Study Area and describe Project impacts to land capability. Indicate the size and location of soil types and land capability classes that will be disturbed;	(b) Volume 5, Section 6.1.3. Soil Impact Analysis
	(c) discuss the relevance of any changes for the local and regional landscapes, biodiversity, productivity, ecological integrity, aesthetics and future use resulting from disturbance for all stages of the Project;	(c) Volume 5, Section 5 Linkage Analysis
	(d) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions resulting from the Project;	(d) Volume 2, Appendix 2-V Climate Change Considerations; Volume 3, Section 1.1.2.1 Project Air Quality Initiatives; Volume 3, Section 4.3 Baseline Case; Volume 3, Section 4.5 Application Case; Volume 3, Section 4.6 Planned Development Case
	(e) describe potential sources of soil contamination;	(e) Volume 5, Section 3.2 Mitigation (Operations); Volume 1, Section 5 Drilling and Completion; Volume 1, Section 9 Environmental Management
	(f) describe the impact of the Project development on soil types and reclamation suitability and the approximate volume of soil materials for reclamation. Discuss any constraints or limitations to achieving vegetation/habitat reclamation based on anticipated soil conditions (e.g., compaction, contaminants, salinity, soil moisture, nutrient depletion, erosion, etc.);	(f) Volume 5, Section 6.1 Terrain and Soils; Volume 1, Section 14 Conservation and Reclamation Plan
	[B] Discuss: (a) discuss the potential for soil erosion during the life of the Project;	[B] Volume 5, Section 2.6.2.1Terrain and Soils; Volume 5, Appendix 5-VI Terrain and Soils Baseline

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10.2 Impact Assessment (continued)	(b) the environmental effects of proposed drilling methods on the landscape and surficial and bedrock geology;	(b) Volume 5, Section 5 Linkage Analysis; Volume 5, Section 3.2 (Operations); Volume 1, Section 5 Drilling and Completion; Volume 1, Section 9 Environmental Management
	(c) the potential for casing and pipeline failures and their environmental effects;	(c) Volume 5, Section 3.2 Mitigation (Operations); Volume 1, Section 5 Drilling and Completion; Volume 1, Section 9 Environmental Management
	(d) the potential for changes in the ground surface during steaming and recovery operations (e.g., ground heave and/or subsidence) and their environmental implications; and	(d) Volume 5, Section 5 Linkage Analysis; Volume 5, Section 6.1.2 Terrain Impact Analysis; Volume 1, Section 5.7 Surface Disturbance
	(e) the potential impacts caused by the mulching and storage of woody debris considering, but not limited to vulnerability to fire, degradation of soil quality and increased footprint.	(e) Volume 5, Section 3.1 Construction (Mitigation)
	[C] Provide a mitigation plan, including: (a) possible measures to minimize surface disturbance including the use of existing clearings for Project development;	[C] Volume 5, Section 3.1 Construction (Mitigation); Volume 1, Section 14 Conservation and Reclamation Plan
	(b) possible actions to address potential effects of acid deposition;	(b) Volume 3, Section 1.1.2.1 Project Air Quality Initiatives
	(c) possible actions to mitigate effects of any constraint or limitation to habitat reclamation such as compaction, contaminants, salinity, soil moisture, erosion, nutrient regime, etc.;	(c) Volume 1, Section 9.4 Waste Management
	(d) possible measures to mitigate changes to ground surface (temperature, heave and subsidence) during operations;	(d) Volume 5, Section 5 Linkage Analysis; Volume 5, Section 6.1.2 Terrain Impact Assessment; Volume 1, Section 5 Surface Disturbance
	(e) possible actions to address impacts to land capability; and	(e) Volume 5, Section 3 Mitigation; Volume 5, Section 8.1 Soil and Reclamation; Volume 1, Section 14.6 Conservation and Reclamation Monitoring

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10.2 Impact Assessment (continued)	(f) any other measures to reduce or eliminate the potential impacts that the Project may have on soil capability and/or quality.	(f) Volume 5, Section 3 Mitigation; Volume 5, Section 8.1 Soil and Reclamation; Volume 1, Section 14.6 Conservation and Reclamation Monitoring
	[D] Describe the residual effects of the Project on terrain and soils and EnCana FCCL's plans to manage those effects.	[D] Volume 5, Section 6.1 Terrain and Soils
3.10.3 Monitoring	[A] Describe any monitoring programs proposed to assess any Project impacts on terrain and soils and to measure the effectiveness of mitigation plans.	[A] Volume 1, Section 14.6 Conservation and Reclamation Monitoring; Volume 5, Section 8.1 Soil and Reclamation
3.11 Land Use		
3.11.1 Baseline Information	[A] Identify the current land uses, including oil and gas development, agriculture, forestry, tourism, cultural use, food collection, trapping, fishing, hunting, any other aboriginal uses and other outdoor recreational activities.	[A] Volume 6, Appendix 6-II Resource Use Baseline Report
	[B] Identify and map all Crown land and Crown Reservations (Holding Reservation, Protective Notation, Consultative Notation).	[B] Volume 5, Appendix 5-IV Forestry Baseline Figure 1; Volume 6, Appendix 6-II Resource Use Baseline Report ; Volume 6, Section 3.1 Land Use Plans and Zoning; Volume 6, Section 3.5 Land Use Dispositions
	[C] 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).	[C] Volume 6, Appendix 6-II Resource Use Baseline Report; Volume 6, Section 3.8 Environmentally Important Areas
	[D] Identify any land use policies and resource management initiatives that pertain to the Project, and discuss how the Project will be consistent with these initiatives.	[D] Volume 6, Appendix 6-II Resource Use Baseline Report; Volume 6, Section 3.1 Land Use Plans and Zoning
3.11.2 Impact Assessment	[A] Identify the potential impact of the Project on these land uses, including: (a) impacts to unique sites or special features;	[A] Volume 6, Section 3.5.2 Effects on Environmentally Important Areas
	(b) impacts caused by changes in public access arising from linear development, including secondary effects related to increased hunter, angler and other recreational access, decreased access to traditional use sites, and facilitated predator movement;	(b) Volume 6, Section 3.5.3 Effects on Resource Use and Users

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.11.2 Impact Assessment (continued)	(c) the implications of relevant land use policies and resource management initiatives for the Project, including any constraints to development;	(c) Volume 6, Appendix 6-II Resource Use Baseline Report; Volume 6, Section 3.1 Land Use Plans and Zoning
	(d) potential impacts to aggregate reserves that may be located on land under EnCana FCCL's control and reserves in the region;	(d) Volume 6, Section 3.5.3 Effects on Resource Use and Users
	(e) 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;	(e) Volume 6, Section 3.5.3 Effects on Resource Use and Users; Volume 6, Section 3.5.2.2 Mitigation
	(f) 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;	(f) Volume 6, Section 3.5.2.3 Effects Analysis and Table 3.5-7
	(g) how the Project disturbance impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;	(g) Volume 5, Section 6.2.3.5 Annual Allowable Cut; Volume 6, Section 3.5.2.3 Effects Analysis
	(h) 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	(h) Volume 5, Section 6.2.2 Terrestrial Vegetation, Wetlands and Forestry Impact Analysis; Volume 4, Section 5.2.4 Summary of Hydrology Assessment
	(i) impacts of the Project on regional recreational activities, public access, aboriginal land use and other land uses during and after development activities.	(i) Volume 6, Section 3.5.3 Effects on Resource Use and Users
	[B] Discuss possible mitigative strategies to address: (a) the need for, and plans to address, access management during and after Project operations; (b) the process for addressing the needs of other users in both the Project Area and the Local Study Area; (c) measures to mitigate impacts on land use; and (d) how potentially-affected aggregate reserves will be salvaged and stockpiled with input provided by Alberta Transportation and Alberta Sustainable Resource Development.	[B] Volume 6, Section 3.5.2.2 Mitigation
	[C] Describe the residual effects of the Project on land use and EnCana FCCL's plans to manage those effects.	[C] Volume 6, Section 3.5.3.4 Residual Impact Classification; Volume 6, Section 3.5.2.5 Monitoring
3.11.3 Monitoring	[A] Describe any monitoring programs proposed to assess any Project impacts on land use and to measure the effectiveness of mitigation plans.	[A] Volume 6, Section 3.5.2.5 Monitoring

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.0 HISTORIC RESOURCES		
4.0 HISTORIC RESOURCES	[A] Describe consultation with Alberta Culture and Community Spirit (ACCS) concerning the need for a Historic Resource Impact Assessment (HRIA) for the Project, and:	[A] Volume 6, Section 5.1 Introduction; Volume 6, Section 5.2.5.1 Historical Resources Impact Assessment Process
	(a) provide a general overview of the results of any previous historic resource studies that have been conducted including archaeological resources, palaeontological resources, historical period sites, and any other historical resources as defined within the *Historical Resources Act*	(a) Volume 6, Section 5.4.2 Regional Study Area
	(b) summarize the results from the field program performed to assess archaeological, palaeontological and historical significance of both the Project Area and the Local Study Area;	(b) Volume 6, Section 5.2.5 Assessment Methodology; Volume 6, Section 5.4.1 Local Study Area
	(c) provide a summary of the results of the HRIA conducted to assess the potential impact of the Project on archaeological, palaeontological and historical resources;	(c) Volume 6, Section 5.2.5 Assessment Methodology; Volume 6, Section 5.4.1 Local Study Area
	(d) provide an outline of the program and schedule of field investigations that ACCS may require EnCana FCCL to undertake to further assess and mitigate the effects of the Project on historical resources; and	(d) Volume 6, Section 5.9 Conclusions; Volume 6, Section 5.10 Follow-up Prior to Construction
	(e) document any historic resources concerns during consultation on the Project.	(e) Volume 6, Section 2 Traditional Land Use Assessment
5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE		
5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE	[A] Provide: (a) a map of traditional land use areas (if the aboriginal community or group is willing to have this information disclosed);	[A] Volume 6, Appendix 6-I Traditional Land Use Baseline Figure 3
	(b) a map of cabin sites, spiritual sites, graves and other traditional use sites considered as 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;	(b) Volume 6, Appendix 6-I Traditional Land Use Baseline Figure 3; Volume 6, Section 5.6 Application Case
	(c) a description of the extent of traditional use of land in both the Project Area and the Local Study Area, including fishing, hunting, trapping, nutritional or medicinal plant harvesting, and cultural use by affected aboriginal peoples;	(c) Volume 6, Appendix 6-I Traditional Land Use Baseline

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE (continued)	(d) a discussion of: (i) access to traditional lands in the Project Area during all stages of the Project; (ii) the vegetation and wildlife used for traditional, food, ceremonial, medicinal and other purposes; (iii) aboriginal views on land reclamation.	(d) Volume 6, Appendix 6-I Traditional Land Use Baseline; Volume 6, Section 2.7 Application Case
	[B] Determine the impact of the Project on traditional uses and identify possible mitigation strategies.	[B] Volume 6, Section 2.4 Mitigation; Volume 6, Section 2.7 Application Case; Volume 6, Section 2.8 Planned Development Case
6.0 PUBLIC HEALTH AND SAFETY ASSESSMENT		
6.0 PUBLIC HEALTH AND SAFETY ASSESSMENT	[A] Describe those aspects of the Project that may have implications for public health or the delivery of regional health services. Determine whether there may be implications for public health arising from the Project. Specifically: (a) assess the potential health implications of the compounds that will be released to the environment from the Project in relation to exposure limits established to prevent acute and chronic adverse effects on human health;	[A] Volume 3, Section 3.2.3 Baseline Case; Volume 3, Section 3.2.4 Application Case; Volume 3, Section 3.2.5 Planned Development Case
	(b) provide the data, exposure modelling calculations, and described the methods EnCana FCCL used to assess impacts of the Project on human health and safety;	(b) Volume 3, Appendix 3-VIII Human and Wildlife Health Risk Assessment Methods
	(c) provide information, including chemical analysis and modelling results, on samples of selected environmental media (e.g. soil, water, air, vegetation, wild game) used in the assessment;	(c) Volume 3, Appendix 3-IX Health Assessment Sources of Data; Volume 3, Appendix 3-XI Regional Environmental Sampling Data
	(d) discuss the potential for changes to water quality, air quality and soil quality to increase human exposure to contaminants taking into consideration all Project activities;	(d) Volume 3, Section 3.2.6 Human Health Conclusions
	(e) identify the human health impact of the potential contamination to country foods and natural food sources taking into consideration all Project activities;	(e) Volume 3, Appendix 3-VIII Human and Wildlife Health Risk Assessment Methods
	(f) document any health concerns raised by stakeholders during consultation on the Project;	(f) Volume 3, Section 3.1.4 Consultation and Assessment Focus
	(g) document any health concerns identified by aboriginal communities or groups resulting from impacts of existing development and of the Project specifically on their traditional lifestyle and include an aboriginal receptor type in the assessment;	(g) Volume 3, Section 3.14 Consultation and Assessment Focus

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
6.0 PUBLIC HEALTH AND SAFETY ASSESSMENT (continued)	(h) assess the cumulative human health effects to receptors, including First Nations and Métis receptors;	(h) Volume 3, Section 3.2.5 Planned Development Case; Volume 3, Appendix 3-VIII Human and Wildlife health Risk Assessment Methods
	(i) as appropriate, describe anticipated follow-up work, including regional cooperative studies. Discuss how such work will be implemented and coordinated with ongoing air, soil and water quality initiatives;	(i) Volume 3, Section 3.3.6 Mitigation and Monitoring
	(j) describe the potential health impacts due to higher regional traffic volumes and the increased risk of accidental leaks and spills; and	(j) Volume 6, Section 6.8 Transportation
	(k) discuss mitigation strategies to minimize the potential impact of the Project on human health.	(k) Volume 3, Section 3.3.6 Mitigation and Monitoring
	[B] Describe those aspects of the Project that may have implications for public safety. Determine whether there may be implications for public safety arising from the Project. Specifically: (a) describe EnCana FCCL's emergency response plan, including public notification protocol and safety procedures, to minimize adverse environmental effects, including emergency reporting procedures for spill containment and management;	[B] Volume 1, Section 9 Environmental Management
	(b) document the safety concerns raised by stakeholders during consultation on the Project;	(b) Volume 1, Section 2.4 Consultation
	(c) describe how local residents will be contacted during an emergency and the type of information that will be communicated to them;	(c) Volume 1, Section 9 Environmental Management
	(d) describe the existing agreements with area municipalities or industry groups such as safety cooperatives, emergency response associations, regional mutual aid programs and municipal emergency response agencies;	(d) Volume 1, Section 9 Environmental Management
	(e) describe the potential safety impacts due to higher regional traffic volumes; and	(e) Volume 6, Section 6.8 Transportation
	(f) discuss mitigation plans to ensure workforce and public safety during the life of the Project. Include prevention and safety measures for wildfire occurrences, water saturated plume from the cooling towers, icy roads in the winter months, accidental release or spill of chemicals to the environment and failures of structures retaining water or fluid wastes.	(f) Volume 1, Section 9 Environmental Management; Volume 6, Section 6.8 Transportation; Volume 6, Section 6.9 Mitigation and Enhancement
7.0 SOCIO-ECONOMIC ASSESSMENT		
7.1 Baseline Information	[A] Describe the existing socio-economic conditions in the region, including for the communities in the region.	[A] Volume 6, Section 5 Socio-Economic Assessment

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
7.1 **Baseline Information (continued)**	[B] Describe factors that may affect existing socio-economic conditions including: (a) population changes; (b) EnCana FCCL's policies and programs regarding the use of regional and Alberta goods and services; (c) a Project schedule and a general description of the overall engineering and contracting plan for the Project; (d) workforce requirements for the Project including a description of when peak activity periods will occur; and (e) planned accommodations for the workforce during the life of the Project.	[B] Volume 6, Section 5 Socio-Economic Assessment
7.2 **Impact Assessment**	[A] Describe the socio-economic effects of construction and operation of the Project, including: (a) impacts related to: i) local training, employment and business opportunities, ii) regional and provincial economic benefits, iii) housing, iv) recreational activities, v) trapping, hunting and fishing, and vi) effects on First Nations and Métis (e.g., traditional land use and social and cultural implications); (b) estimated total Project cost including a breakdown for engineering and project management, equipment and materials, and labour for both construction and operations stages. Indicate the percentage of expenditures expected to occur in the region, Canada outside Alberta, and outside Canada; (c) impacts of the Project on the availability of affordable housing and the quality of health care services. Provide a summary of any discussions that have taken place with the local municipalities and the local environmental public health office of Alberta Health Services concerning housing availability and health care services respectively; (d) discuss any effects expected on primary and secondary highway systems and other regional roads caused by anticipated traffic changes;	[A] Volume 6, Section 5 Socio-Economic Assessment

Table 1 Final Terms of Reference Issued by Alberta Environment – Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
7.2 Impact Assessment (continued)	[B] Describe the socio-economic effects of any construction camp required for the Project and identify: (i) its location, (ii) the number of workers it is intended to house, (iii) whether the camp will service the Project only or other clients, (iv) the length of time the camp will be in service, and (v) describe what services will be provided in the camp (e.g., security, recreation and leisure, medical services); (a) the impact on local and regional infrastructure and community services, including consideration of municipal "hard services", education/training services, social services, urban and regional recreation services, law enforcement and emergency services; and (b) describe municipal growth pressures as they relate to the Project and the need for additional Crown land to meet these needs.	[B] Volume 6, Section 5 Socio-Economic Assessment
	[C] Discuss options for mitigating impacts including: (a) EnCana FCCL's policies and programs regarding the use of regional and Alberta goods and services; (b) plans to work with First Nations and Métis communities and groups and other local residents and businesses regarding employment, training needs, and other economic development opportunities arising from the Project; (c) steps that have been undertaken by industry, the municipality, provincial government or through regional and cooperative initiatives to address socio-economic concerns and impacts to local and regional transportation infrastructure; (d) the potential to avoid overlap with other Projects that are reasonably anticipated during all stages of the Project; (e) mitigation plans that will be undertaken to address issues related to the availability of affordable housing and the quality of health care services; and (f) strategies to mitigate socio-economic concerns raised by the local municipality and other stakeholders in the region.	[C] Volume 6, Section 5 Socio-Economic Assessment
	[D] Describe the residual effects of the Project on socio-economic conditions and EnCana FCCL's plans to manage those effects.	[D] Volume 6, Section 5 Socio-Economic Assessment
7.3 Monitoring	[A] Describe any monitoring plans proposed to assess and Project socio-economic impacts and to measure the effectiveness of mitigation plans.	[A] Volume 6, Section 5 Socio-Economic Assessment; Volume 6, Section 6.9 Mitigation and Enhancement

Table 2 Energy Resources Conservation Board Directive 023 Information Requirements (EUB 1991)

Directive 023 Section	Requirement (abridged)	Locations in Volume 1 unless otherwise noted
1.0 GENERAL INFORMATION		
1.5	**Project description**	
1.5.1	Applicable Acts and Sections under which the application is made	Volume 1, Section 1.4
1.5.2	Name and address of the application and any partners involved and the details of company incorporation	Volume 1, Section 1.6
1.5.3	Statement of need and project timing	Volume 1, Section 1
1.5.4	Overall project description and discussion of schedule Including: location, size and scope, schedule of preconstruction, construction, start up, duration of operations, and a discussion of the reasons for selecting the proposed schedule.	Volume 1, Section 1
1.5.5	Regional setting and reference to existing and proposed land use	Volume 1, Section 1
1.5.6	a. Maps showing freehold, leasehold, mineral and surface rights of the proposed scheme and surrounding area. b. Maps with legal descriptions showing the locations of landowners and their dwellings in relation to the proposed oil sands site	Volume 1, Figure 10.2-1; Volume 1, Figure 10.2-2
1.5.7	Map showing topography, exiting areas of habitation, industry, the proposed site and any development in the Project area	Volume 1, Figure 5.1-1; Volume 1, Figure 3
1.5.8	Aerial photomosaic at an appropriate scale to illustrate the locations of the Project components including the mine area, wells, extraction plant, upgrader unit, tanks, discard storage sites including tailing ponds, access roads, railways, pipelines and utility corridors.	Volume 1, Figure 3
1.5.9	Description of storage and transportation facilities of the final hydrocarbon product, including detail of size and ownership of any pipeline which may be utilized	Volume 1, Section 6.14
1.5.10	Proposed rate of production over the life of the Project	Volume 1, Section 1.2
1.5.11	Description of the subject oil sands	Volume 1, Section 3.5
1.5.12	Status of negotiations held or to be held with the freehold, leasehold, mineral surface rights owners	Volume 1, Section 10
1.5.13	Proposed energy source, alternatives, resource use, sources and supply	Volume 1, Appendix 1-IV
1.5.14	Description and results of public information program	Volume 1, Section 2
1.5.15	The term of the approval sought, including expected project start and completion dates	Volume 1, Section 1
1.5.16	Name of responsible person to contact	Volume 1, Section 1.6

Table 2 Energy Resources Conservation Board Directive 023 Information Requirements (EUB 1991) (continued)

Directive 023 Section	Requirement (abridged)	Locations in Volume 1 unless otherwise noted
2.0 TECHNICAL INFORMATION		
2.1	Surface mining operations	n/a
2.2	Underground access and development	n/a
2.3	In-situ operations	Volume 1, Section 4
2.4	**Processing Plant**	
2.4.1	A separate description of the bitumen extraction, upgrading, utilities, refining and sulphur recovery facilities, including; a discussion of the process process flow diagrams indicating major equipment, stream rates and composition, and the proposed production measurement devices, characteristics and locations chemical and physical characteristics and properties of feeds and product materials	Volume 1, Section 4; Volume 2, Section 6; Volume 1, Appendix 1-V
2.4.2	Overall material and energy balances, including information with respect to hydrocarbon and sulphur recoveries, water use and energy efficiency	Volume 1, Appendix 1-IV; Volume 1, Appendix 1-VI
2.4.3	Quantity of products, by-products and waste and their disposition	Volume 1, Section 6; Volume 1, Section 9.4.3
2.4.4	Surface drainage within the areas of the processing plant, product storage and waste treatment and disposal	Volume 1, Section 9.4; Volume 4, Section 5.2.3; Volume 4, Section 7.2.1
2.4.5	Comparison of proposed process to alternatives considered on the basis of overall recovery, energy efficiency, cost, commercial availability and environmental considerations and the reasons for selecting the proposed process	Volume 1, Section 11
2.4.6	This number has been omitted from Directive 023	
2.4.7	Example of production accounting reports	Volume 1, Section 8
2.5	**Electrical Utilities and External Energy Sources**	
2.5.1	A description of any facilities to be provided for the generation of electricity to be used by the Project.	n/a
2.5.2	Identification of the source, quantity and quality of any fuel, electricity or steam to be obtained from sources beyond the Project site	Volume 1, Section 6.3
2.5.3	Where energy resources from outside the Project boundaries are to be supplied to the Project, a detailed appraisal of the options available to eliminate the need for such resources, with consideration for overall recovery, energy balance, costs, technical limitations and environmental implications	Volume 1, Section 6.3

Table 2 Energy Resources Conservation Board Directive 023 Information Requirements (EUB 1991) (continued)

Directive 023 Section	Requirement (abridged)	Locations in Volume 1 unless otherwise noted
2.6	**Environmental Control**	
2.6.1	A description of air and water pollution control and monitoring facilities, as well as a liquid spill contingency plan	Volume 1, Section 9; Volume 4, Section 7
2.6.2	A description of the water management program, including the proposed water source and expected withdrawal the source-water quality control the waste-water disposal program water balance for the proposed scheme the produced-water clean-up/recycle program	Volume 1, Appendix 1-VII; Volume 1, Appendix 1-IX; Volume 4, Section 5.1.1; Volume 4, Section 3.2
2.6.3	The manner in which surface water drainage within the Project area would be collected, treated and disposed	Volume 1, Section 6.7.4, Volume 1, Appendix 1-IX; Volume 4, Section3.2; Volume 4, Section 5.2.3; Volume 4, Section 7.2.1
2.6.4	A description of the air and water pollution control and monitoring facilities	Volume 1, Section 9.4; Volume 3, Section 1; Volume 4, Section 3.2; Volume 1, Section 7.3
2.6.5	A description of the emission control system, including stack design criteria and process data any additions of residue gas or natural gas to the flare system to ensure combustion of hydrogen sulphide for both normal operating conditions and maximum emission conditions methods proposed for the control of all air pollutants from all potential or actual emission sources at the operation (including all vents, stacks, flares, product storage tanks, sulphur handling areas, ponds, wells and other fugitive emission sources) during normal, emergency and maximum operating conditions monitoring program for hydrogen sulphide, sulphur dioxide, total sulphation, hydrogen sulphide sulphation, soil pH, nitrogen oxides and hydrocarbons in the surrounding area	Volume 1, Section 9; Volume 3, Appendix 3-I; Volume 3, Section 1.10
3.1	**Commercial Viability**	
3.1.1	An appraisal and projections, on an annual basis of revenues, capital and operating costs (including a breakdown of fuel costs and non-fuel operating costs), royalties and taxes, net cash flow, marketing arrangements, fuel and electric power arrangements	Volume 6, Section 6

Table 2 Energy Resources Conservation Board Directive 023 Information Requirements (EUB 1991) (continued)

Directive 023 Section	Requirement (abridged)	Locations in Volume 1 unless otherwise noted
3.1.2	A description of project costs which include capital and operating cost, including a breakdown of capital and operating costs for each component of the Project including site preparation, well drilling and completion, central processing facilities (including steam generation, waster treatment and recycling), satellite and surface facilities, production/injection distribution system, upgrading, utilities and off-sites depreciation	Volume 6, Section 6
3.2	**Benefit-Cost Analysis**	
3.2.1	A summary of quantifiable public benefits and costs incurred during the construction and operation of the Project	Volume 6, Section 6
3.2.2	A summary of non-quantifiable public benefits and costs incurred each year during construction and operation of the Project	Volume 6, Section 6
3.3	**Economic Impact**	
3.3.1	An appraisal of the economic impact of the Project on the region, province and nation	Volume 6, Section 6
3.3.2	A discussion of any initiatives undertaken to accommodate regional economic priorities and interests	Volume 6, Section 6
3.3.3	An assessment of direct and indirect employment opportunities for all groups associated with the Project including projected max and min workforce demand by skill categories in the construction and operating phases and an analysis of how these demands shall be met an analysis of the indirect and induced employment generated by the Project due to employment multiplier effects a discussion of the employment and training arrangements provided by applicant that would enable residents of the region to participate in meeting the workforce demands	Volume 6, Section 6
4.0	Environmental Impact Assessment	Volumes 2 to 6
5.0	Biophysical Impact Assessment	Volume 5
6.0	Social Impact Assessment	Volume 6, Section 6
7.0	Describe the environmental protection plan including mitigation measures, environmental monitoring and research	Volume 1, Section 13; Volumes 2 to 6; Volume 2, Appendix 2-VI
8.0	Conceptual Development and Reclamation Plan	Volume 1, Section 14
9.0	Solid Waste Management Plan	Volume 1, Section 9.4

APPENDIX 2-III

COMMON AND SCIENTIFIC NAMES

THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.

APPENDIX 2-III

COMMON AND SCIENTIFIC NAMES

Common Name	Scientific Name
Vegetation[(a)(b)]	
Tree	
aspen	*Populus tremuloides*
balsam fir	*Abies balsamea*
balsam poplar	*Populus balsamifera*
black spruce	*Picea mariana*
jack pine	*Pinus banksiana*
shining willow	*Salix lucida* (also *S. lasiandra*)
tamarack	*Larix laricina*
white birch	*Betula papyrifera*
white spruce	*Picea glauca*
willow	*Salix sp.*
Shrub	
alder	*Alnus sp.*
alder-leaved buckthorn	*Rhamnus alnifolia*
Arctic willow	*Salix arctica*
aspen	*Populus tremuloides*
autumn willow	*Salix serissima*
balsam fir	*Abies balsamea*
balsam poplar	*Populus balsamifera*
balsam willow	*Salix pyrifolia*
baneberry	*Actaea rubra*
basket willow	*Salix petiolaris*
bastard toadflax	*Comandra umbellatae*
beaked willow	*Salix bebbiana*
birch	*Betula sp.*
black spruce	*Picea mariana*
bog birch	*Betula glandulosa*
bog cranberry	*Vaccinium vitis-idaea*
bog rosemary	*Andromeda polifolia*
bog willow	*Salix pedicellaris*
bracted honeysuckle	*Lonicera involucrata*
bristly black currant	*Ribes lacustre*
buckbrush	*Symphoricarpos occidentalis*
Canada buffaloberry	*Shepherdia canadensis*
choke cherry	*Prunus virginiana*
cloudberry	*Rubus chamaemorus*
common bearberry	*Arctostaphylos uva-ursi*
common blueberry	*Vaccinium myrtilloides*
common Labrador tea	*Ledum groenlandicum*
common wild rose	*Rosa woodsii*
crowberry	*Empetrum nigrum*
current/gooseberry	*Ribes sp.*
dwarf bilberry	*Vaccinium caespitosum*
dwarf birch	*Betula pumila*
dwarf raspberry	*Rubus arcticus (also R. acaulis)*
false mountain willow	*Salix pseudomonticola (also S. monticola)*
flat-leaved willow	*Salix planifolia*
fly honeysuckle	*Lonicera caerulea (also L. villosa)*
green alder	*Alnus viridis ssp crispa*
high-bush cranberry	*Viburnum opulus*
hoary willow	*Salix candida*
honeysuckle	*Lonicera sp.*

Common Name	Scientific Name
jack pine	*Pinus banksiana*
leatherleaf	*Chamaedaphne calyculata*
low-bush cranberry	*Viburnum edule*
mountain laurel	*Kalmia microphylla*
myrtle-leaved willow	*Salix myrtillifolia*
northern bastard toadflax	*Geocaulon lividum*
northern black currant	*Ribes hudsonianum*
northern gooseberry	*Ribes oxyacanthoides*
northern laurel	*Kalmia polifolia*
prickly rose	*Rosa acicularis*
pussy willow	*Salix discolor*
red-osier dogwood	*Cornus stolonifera*
river alder	*Alnus incana* ssp *tenuifolia* (also *A. rugosa*)
sandbar willow	*Salix exigua*
saskatoon	*Amelanchier alnifolia*
Scouler's willow	*Salix scouleriana*
shining willow	*Salix lucida (also S. lasiandra)*
shrubby cinquefoil	*Potentilla fruticosa*
shrubby willow	*Salix arbusculoides*
silverberry	*Elaeagnus commutata*
silverweed	*Potentilla anserinae*
skunk currant	*Ribes glandulosum*
small bog cranberry	*Oxycoccus microcarpus*
smooth willow	*Salix glauca*
snowberry	*Symphoricarpos albus*
tamarack	*Larix laricina*
three-toothed cinquefoil	*Potentilla tridentatae*
twinflower	*Linnaea borealis*
twining honeysuckle	*Lonicera dioica*
velvet-fruited willow	*Salix maccalliana*
water birch	*Betula occidentalis*
white birch	*Betula papyrifera*
white spruce	*Picea glauca*
wild black currant	*Ribes americanum*
wild red currant	*Ribes triste*
wild red raspberry	*Rubus idaeus*
willow	*Salix sp.*
yellow willow	*Salix lutea*
Forb	
–	*Brassica sp.*
–	*Aster sp.*
–	*Campanula sp.*
–	*Corallorhiza sp.*
–	*Delphinium sp.*
–	*Epilobium sp.*
–	*Equisetum sp.*
–	*Erigeron sp.*
–	*Galium sp.*
–	*Geum sp.*
–	*Hypericum sp.*
–	*Lemna sp.*
–	*Mentha sp.*
–	*Mertensia sp.*

Common Name	Scientific Name
–	*Myriophyllum sp.*
–	*Nuphar sp.*
–	*Parnassia sp.*
–	*Pedicularis sp.*
–	*Petasites frigidus*
–	*Platanthera sp. (also Habenaria sp.)*
–	*Potamogeton sp.*
–	*Potentilla sp.*
–	*Pyrola sp.*
–	*Ranunculus sp.*
–	*Rumex sp.*
–	*Sagittaria sp.*
–	*Thalictrum sp.*
–	*Triglochin sp.*
–	*Utricularia sp.*
–	*Valeriana sp.*
–	*Vicia sp.*
–	*Viola sp.*
alpine goldenrod	*Solidago multiradiata*
alsike clover	*Trifolium hybridumhybrdium*
American brooklime	*Veronica americana*
American winter cress	*Barbarea orthoceras*
annual hawk's beard	*Crepis tectorum*
arrow-leaved coltsfoot	*Petasites frigidus var sagittatus*
arum-leaved arrowhead	*Sagittaria cuneata*
Bicknell's geranium	*Geranium bicknellii*
bishop's-cap	*Mitella nuda*
bitter cress	*Cardamine pensylvanica*
blunt-leaved bog orchid	*Platanthera obtusata (also Habenaria obtusata)*
blunt-leaved sandwort	*Moehringia lateriflora*
bog violet	*Viola nephrophylla*
bracted bog orchid	*Coeloglossum viride (also Habenaria viridis)*
broad-leaved arrowhead	*Sagittaria latifolia*
broad-leaved everlasting	*Antennaria neglecta*
buck-bean	*Menyanthes trifoliata*
bulb-bearing water-hemlock	*Cicuta bulbifera*
bunchberry	*Cornus canadensis*
Canada anemone	*Anemone canadensis*
Canada goldenrod	*Solidago canadensis*
Canadian milk vetch	*Astragalus canadensis*
celery-leaved buttercup	*Ranunculus sceleratus*
cloudberry	*Rubus chamaemorus*
common bladderwort	*Utricularia vulgaris*
common cattail	*Typha latifolia*
common dandelion	*Taraxacum officinale*
common duckweed	*Lemna minor*
common fireweed	*Epilobium angustifolium*
common groundsel	*Senecio vulgaris*
common horsetail	*Equisetum arvense*
common mare's-tail	*Hippuris vulgaris*
common nettle	*Urtica dioica*
common pink wintergreen	*Pyrola asarifolia*
common plantain	*Plantago major*

Common Name	Scientific Name
common scouring-rush	*Equisetum hyemale*
common yarrow	*Achillea millefolium*
cow parsnip	*Heracleum lanatum*
cow-wheat	*Melampyrum lineare*
cream-colored vetchling	*Lathyrus ochroleucus*
creeping thistle	*Cirsium arvense*
dewberry	*Rubus pubescens*
dwarf raspberry	*Rubus arcticus (also R. acaulis)*
dwarf scouring-rush	*Equisetum scirpoides*
early blue violet	*Viola adunca*
elephant's-head	*Pedicularis groenlandica*
field mouse-ear chickweed	*Cerastium arvense*
flat-leaved bladderwort	*Utricularia intermedia*
fleshy stitchwort	*Stellaria crassifolia*
floating marsh-marigold	*Caltha natans*
fringed milkwort	*Polygala paucifolia*
golden dock	*Rumex maritimus*
golden saxifrage	*Chrysosplenium iowense*
goldthread	*Coptis trifolia*
graceful cinquefoil	*Potentilla gracilis*
green saxifrage	*Chrysosplenium tetrandrum*
green sorrel	*Rumex acetosa*
greenish-flowered wintergreen	*Pyrola chlorantha (also Pyrola virens)*
ground-cedar	*Diphasiastrum complanatum (also Lycopodium complanatum)*
ground-pine	*Lycopodium obscurum*
harebell	*Campanula rotundifolia*
heart-leaved arnica	*Arnica cordifolia*
hedysarum	*Hedysarum sp.*
hemp-nettle	*Galeopsis tetrahit*
hooded ladies'-tresses	*Spiranthes romanzoffiana*
hornwort	*Ceratophyllum demersum*
kidney-leaved violet	*Viola renifolia*
Labrador bedstraw	*Galium labradoricum*
Labrador lousewort	*Pedicularis labradorica*
Lapland buttercup	*Ranunculus lapponicus*
large yellow lady's-slipper	*Cypripedium parviflorum var pubescens (also C. calceolus)*
large-leaved yellow avens	*Geum macrophyllum*
leafy arnica	*Arnica chamissonis*
lesser rattlesnake plantain	*Goodyera repens*
lesser wintergreen	*Pyrola minor*
Lindley's aster	*Aster ciliolatus*
long-leaved chickweed	*Stellaria longifolia*
long-stalked chickweed	*Stellaria longipes*
long-stalked mouse-ear chickweed	*Cerastium nutans*
Macoun's buttercup	*Ranunculus macounii*
many-flowered yarrow	*Achillea sibirica*
marsh aster	*Aster borealis*
marsh cinquefoil	*Potentilla palustris*
marsh hedge-nettle	*Stachys palustris*
marsh horsetail	*Equisetum palustre*
marsh skullcap	*Scutellaria galericulata*
marsh willowherb	*Epilobium palustre*

Common Name	Scientific Name
marsh yellow cress	*Rorippa palustris*
marsh-marigold	*Caltha palustris*
meadow bitter cress	*Cardamine pratensis*
meadow horsetail	*Equisetum pratense*
mountain valerian	*Valeriana sitchensis*
narrow spinulose shield fern	*Dryopteris carthusiana (also D. austriaca)*
narrow-leaved collomia	*Collomia linearis*
narrow-leaved dock	*Rumex triangulivalvis*
narrow-leaved hawkweed	*Hieracium umbellatum*
narrow-leaved willowherb	*Epilobium leptophyllum*
nodding beggarticks	*Bidens cernua*
northern bastard toadflax	*Geocaulon lividum*
northern bedstraw	*Galium boreale*
northern grass-of-parnassus	*Parnassia palustris*
northern green bog orchid	*Platanthera hyperborea (also Habenaria hyperborea)*
northern slender ladies'-tresses	*Spiranthes lacera*
northern starflower	*Trientalis borealis*
northern stitchwort	*Stellaria calycantha*
northern twayblade	*Listera borealis*
northern valerian	*Valeriana dioica*
northern water-horehound	*Lycopus uniflorus*
northern willowherb	*Epilobium ciliatum*
northern yellow lady's-slipper	*Cypripedium parviflorum var makasin*
oak fern	*Gymnocarpium dryopteris*
oblong-leaved sundew	*Drosera anglica*
one-flowered wintergreen	*Moneses uniflora*
one-sided wintergreen	*Orthilia secunda (also Pyrola secunda)*
pale coralroot	*Corallorhiza trifida*
palmate-leaved coltsfoot	*Petasites frigidus var palmatus*
perennial sow-thistle	*Sonchus arvensis*
Philadelphia fleabane	*Erigeron philadelphicus*
pink corydalis	*Corydalis sempervirens*
pitcher-plant	*Sarracenia purpurea*
prairie cinquefoil	*Potentilla pensylvanica*
purple avens	*Geum rivale*
purple peavine	*Lathyrus venosus*
purple-stemmed aster	*Aster puniceus*
rattlesnake plantain	*Goodyera oblongifolia*
red and white baneberry	*Actaea rubra*
red clover	*Trifolium pratense*
rough cinquefoil	*Potentilla norvegica*
round-leaved bog orchid	*Platanthera orbiculata (also Habenaria orbiculata)*
round-leaved orchid	*Amerorchis rotundifolia (also Orchis rotundifolia)*
round-leaved sundew	*Drosera rotundifolia*
running club-moss	*Lycopodium clavatum*
scheuchzeria	*Scheuchzeria palustris*
seaside arrow-grass	*Triglochin maritima*
silverweed	*Potentilla anserina*
slender arrow-grass	*Triglochin palustris*
slender-leaved sundew	*Drosera linearis*
small bedstraw	*Galium trifidum*
small-flowered buttercup	*Ranunculus abortivus*
small-leaved everlasting	*Antennaria parvifolia*

Common Name	Scientific Name
spreading sweet cicely	*Osmorhiza depauperata*
star-flowered Solomon's-seal	*Smilacina stellata*
sticky false asphodel	*Tofieldia glutinosa*
stiff club-moss	*Lycopodium annotinum*
swamp horsetail	*Equisetum fluviatile*
swamp lousewort	*Pedicularis parviflora*
sweet-scented bedstraw	*Galium triflorum*
tall anemone	*Anemone riparia*
tall larkspur	*Delphinium glaucum*
tall lungwort	*Mertensia paniculata*
tall meadow rue	*Thalictrum dasycarpum*
three-flowered avens	*Geum triflorum*
three-leaved Solomon's-seal	*Smilacina trifolia*
three-toothed cinquefoil	*Potentilla tridentata (also P. tridentata)*
tufted loosestrife	*Lysimachia thyrsiflora*
variegated horsetail	*Equisetum variegatum*
various-leaved pondweed	*Potamogeton gramineus*
veiny meadow rue	*Thalictrum venulosum*
Virginia grape fern	*Botrychium virginianum*
water arum	*Calla palustris*
water parsnip	*Sium suave*
water smartweed	*Polygonum amphibium*
water smartweed	*Polygonum coccineum*
water-hemlock	*Cicuta maculata*
western Canada violet	*Viola canadensis*
western dock	*Rumex occidentalis*
western water-horehound	*Lycopus asper*
western willow aster	*Aster hesperius*
western wood lily	*Lilium philadelphicum*
white clover	*Trifolium repens*
white sweet-clover	*Melilotus alba*
white-stem pondweed	*Potamogeton praelongus*
wild chive	*Allium schoenoprasum*
wild lily-of-the-valley	*Maianthemum canadense*
wild mint	*Mentha arvensis*
wild sarsaparilla	*Aralia nudicaulis*
wild strawberry	*Fragaria virginiana*
wild vetch	*Vicia americana*
wood anemone	*Anemone quinquefolia*
woodland horsetail	*Equisetum sylvaticum*
woodland strawberry	*Fragaria vesca*
wormseed mustard	*Erysimum cheiranthoides*
yellow avens	*Geum aleppicum*
yellow pond-lily	*Nuphar lutea ssp variegata*
yellow rattle	*Rhinanthus minor*
yellow sweet-clover	*Melilotus officnalis*
yellow water crowfoot	*Ranunculus gmelinii*
Graminoid	
–	*Agropyron sp.*
–	*Calamagrostis sp.*
–	*Eleocharis sp.*
–	*Eriophorum sp.*
–	*Festuca hallii*

Common Name	Scientific Name
–	*Festuca sp.*
–	*Juncus sp.*
–	*Oryzopsis sp.*
–	*Poa sp.*
–	*Scirpus sp.*
alpine rush	*Juncus alpinoarticulatus*
awned sedge	*Carex atherodes*
beaked sedge	*Carex rostrata*
beautiful sedge	*Carex concinna*
Bebb's sedge	*Carex bebbii*
bent sedge	*Carex deflexa*
bluejoint	*Calamagrostis canadensis*
bog muhly	*Muhlenbergia glomerata*
bog sedge	*Carex paupercula*
bristle-stalked sedge	*Carex leptalea*
brownish sedge	*Carex brunnescens*
capitate sedge	*Carex capitata*
close-sheathed cotton grass	*Eriophorum brachyantherum*
common great bulrush	*Schoenoplectus tabernaemontani (also Scirpus validus)*
common tall manna grass	*Glyceria grandis*
drooping wood-reed	*Cinna latifolia*
few-flowered sedge	*Carex pauciflora*
fowl bluegrass	*Poa palustris*
fowl manna grass	*Glyceria striata*
foxtail barley	*Hordeum jubatum*
fringed brome	*Bromus ciliatus*
golden sedge	*Carex aurea*
graminoid sp.	–
green sedge	*Carex viridula*
hair-like sedge	*Carex capillaris*
hairy wild rye	*Leymus innovatus (also Elymus innovatus)*
hairy-fruited sedge	*Carex lasiocarpa*
hay sedge	*Carex siccata*
Hudson Bay bulrush	*Scirpus hudsonianus*
inland sedge	*Carex interior*
Kentucky bluegrass	*Poa pratensis*
knotted rush	*Juncus nodosus*
lakeshore sedge	*Carex lacustris*
livid sedge	*Carex livida*
mud sedge	*Carex limosa*
narrow reed grass	*Calamagrostis stricta*
northern bog sedge	*Carex gynocrates*
northern manna grass	*Glyceria borealis*
northern reed grass	*Calamagrostis inexpansa*
northern rice grass	*Oryzopsis pungens*
Norway sedge	*Carex norvegica*
orchard grass	*Dactylis glomerata*
prostrate sedge	*Carex chordorrhiza*
purple oat grass	*Schizachne purpurascens*
Raymond's sedge	*Carex raymondii*
Richardson's sedge	*Carex richardsonii*
rough hair grass	*Agrostis scabra*
russett cotton grass	*Eriophorum chamissonis*

Common Name	Scientific Name
rye-grass sedge	*Carex loliacea*
sand sedge	*Carex houghtoniana*
Sartwell's sedge	*Carex sartwellii*
sedge	*Carex sp.*
sheathed cotton grass	*Eriophorum vaginatum*
sheathed sedge	*Carex vaginata*
short sedge	*Carex canescens*
short sedge	*Carex canescens ssp canescens (also C. curta)*
short-awned foxtail	*Alopecurus aequalis*
silvery-flowered sedge	*Carex aenea*
slender cotton grass	*Eriophorum gracile*
slender rush	*Juncus tenuis*
slender wheat grass	*Elymus trachycaulus ssp trachycaulus (also Agropyron trachycaulum)*
slough grass	*Beckmannia syzigachne*
small bottle sedge	*Carex utriculata*
small-flowered wood-rush	*Luzula parviflora*
spike trisetum	*Trisetum spicatum*
Sprengel's sedge	*Carex sprengelii*
sweet grass	*Hierochloe hirta ssp arctica (also H. odorata)*
tall cotton-grass	*Eriophorum angustifolium*
thin-flowered sedge	*Carex tenuiflora*
thin-leaved cotton grass	*Eriophorum viridi-carinatum*
three-seeded sedge	*Carex trisperma*
timothy	*Phleum pratense*
tufted bulrush	*Scirpus cespitosus*
tufted hair grass	*Deschampsia cespitosa*
turned sedge	*Carex retrorsa*
two-seeded sedge	*Carex disperma*
two-stamened sedge	*Carex diandra*
water sedge	*Carex aquatilis*
western wheat grass	*Pascopyrum smithii (also A. smithii)Agropyron smithii*
white beakrush	*Rhynchospora alba*
white-grained mountain rice grass	*Oryzopsis asperifolia*
wire rush	*Juncus balticus*
Bryophyte	
–	*Abietinella abietina (also Thuidium abietinum)*
–	*Amblystegium serpens*
–	*Aulacomnium sp.*
–	*Brachythecium campestre*
–	*Brachythecium erythrorrhizon*
–	*Brachythecium mildeanum*
–	*Brachythecium rutabulum*
–	*Brachythecium salebrosum*
–	*Brachythecium turgidum*
–	*Bryohaplocladium sp.*
–	*Bryum argenteum*
–	*Bryum pseudotriquetrum*
–	*Bryum sp.*
–	*Calliergon sp.*
–	*Campylium hispidulum*
–	*Dicranum sp.*
–	*Drepanocladus sp.*

Common Name	Scientific Name
–	*Hamatocaulis lapponicus*
–	*Mnium sp.*
–	*Myurella tenerrima*
–	*Orthotrichum laevigatum*
–	*Orthotrichum obtusifolium*
–	*Plagiomnium sp.*
–	*Polytrichum sp.*
–	*Pseudobryum cinclidioides*
–	*Sphagnum sp.*
–	*Splachnum sp.*
–	*Thuidium philibertii*
–	*Thuidium recognitum*
–	*Thuidium sp.*
–	*Timmia megapolitana*
–	*Cetraria nivalis (also Flavocetraria nivalis)*
–	*Cladina stygia*
–	*Cladonia bacillaris*
–	*Cladonia cristatella*
–	*Cladonia macilenta*
–	*Cladonia mateocyatha*
–	*Cladonia phyllophora*
–	*Cladonia sobolescens*
–	*Cladonia sp.*
–	*Cladonia squamosa*
–	*Cladonia subulata*
–	*Peltigera kristinssonii (also Peltigera occidentalis)*
–	*Peltigera praetextata*
–	*Peltigera rufescens*
–	*Peltigera scabrosa*
–	*Peltigera sp.*
–	*Stereocaulon sp.*
acute-leaved peat moss	*Sphagnum capillifolium*
alpine flat moss	*Fissidens osmundioides*
bighorn cladonia	*Cladonia cornuta*
Blandlow's feather moss	*Helodium blandowii*
broom moss	*Dicranum scoparium*
brown moss	*Drepanocladus aduncus*
brown moss	*Hamatocaulis vernicosus (also Drepanocladus vernicosus)*
brown moss	*Limprichtia revolvens*
brown moss	*Sanionia uncinata (also Drepanocladus uncinatus)*
brown moss	*Warnstorfia exannulata*
brown tapering splachnum	*Tetraplodon mnioides*
campylium moss	*Campylium polygamum*
carpet pelt	*Peltigera neopolydactyla*
common hair-cap	*Polytrichum commune*
common northern lantern moss	*Cinclidium stygium*
common tree moss	*Climacium dendroides*
copper wire moss	*Pohlia nutans*
crowned pixie-cup	*Cladonia carneola*
cup lichen	*Cladonia coniocraea*
cushion moss	*Dicranum acutifolium*
cushion moss	*Dicranum fragilifolium*
dog lichen	*Peltigera canina*

Common Name	Scientific Name
Drummond's plagiomnium moss	*Plagiomnium drummondii*
elliptic plagiomnium moss	*Plagiomnium ellipticum*
eurhynchium moss	*Eurhynchium pulchellum*
flagon-fruited splachnum	*Splachnum ampullaceum*
fuscous moss	*Dicranum fuscescens*
giant water moss	*Calliergon giganteum*
Girgensohn's moss	*Sphagnum girgensohnii*
golden moss	*Tomentypnum falcifolium*
golden moss	*Tomentypnum nitens*
greater sulphur cup	*Cladonia sulphurina*
hypnum moss	*Hypnum pratense*
juniper hair-cap	*Polytrichum juniperinum*
knight's plume moss	*Ptilium crista-castrensis*
leptobryum moss	*Leptobryum pyriforme*
lesser sulphur-cup	*Cladonia deformis*
liverwort	*Blepharostoma trichophyllum*
liverwort	*Calypogeia sphagnicola*
liverwort	*Jamesoniella autumnalis*
liverwort	*Lepidozia reptans*
liverwort	*Lophocolea minor*
liverwort	*Lophozia collaris*
liverwort	*Marchantia polymorpha*
liverwort	*Mylia anomala*
liverwort	*Plagiochila asplenioides*
liverwort	*Ptilidium ciliare*
liverwort	*Ptilidium pulcherrimum*
mealy forked cladonia	*Cladonia scabriuscula*
mealy pixie-cup	*Cladonia chlorophaea*
meesia moss	*Meesia triquetra*
meesia moss	*Meesia uliginosa*
midway peat moss	*Sphagnum magellanicum*
moss species	–
mountain curved-back moss	*Oncophorus wahlenbergii*
myurella moss	*Myurella julacea*
narrow-leaved splachnum	*Tetraplodon angustatus*
organ-pipe lichen	*Cladonia crispata*
peat moss	*Sphagnum angustifolium*
plagiothecium moss	*Plagiothecium laetum*
powdered funnel lichen	*Cladonia cenotea*
purple horn-toothed moss	*Ceratodon purpureus*
pylaisiella moss	*Pylaisiella polyantha*
red collar moss	*Splachnum rubrum*
red leaf moss	*Bryoerythrophyllum recurvirostre*
red pixie-cup	*Cladonia borealis*
reindeer lichen	*Cladina arbuscula*
reindeer lichen	*Cladina mitis*
reindeer lichen	*Cladina rangiferina*
reindeer lichen	*Cladina stellaris*
rhizomnium moss	*Rhizomnium pseudopunctatum*
rusty peat moss	*Sphagnum fuscum*
Schreber's moss	*Pleurozium schreberi*
scorpidium moss	*Scorpidium scorpioides (also Drepanocladus revolvens)*
shore-growing peat moss	*Sphagnum riparium*

Common Name	Scientific Name
sieve lichen	*Cladonia multiformis*
slender hair-cap	*Polytrichum strictum*
smooth cladonia	*Cladonia gracilis*
smooth-footed powderhorn	*Cladonia ochrochlora*
speckled greenshield	*Flavopunctelia flaventior*
spraypaint	*Icmadophila ericetorum*
squarrose peat moss	*Sphagnum squarrosum*
stair-step moss	*Hylocomium splendens*
straw-coloured water moss	*Calliergon stramineum*
studded leather lichen	*Peltigera aphthosa*
Terrestrial Lichen	
thin-leafed peat moss	*Sphagnum teres*
thorn cladonia	*Cladonia uncialis*
toothed plagiomnium moss	*Plagiomnium cuspidatum*
trumpet lichen	*Cladonia fimbriata*
tufted moss	*Aulacomnium palustre*
veinless pelt	*Peltigera malacea*
Warnstorf's peat moss	*Sphagnum warnstorfii*
water hook moss	*Warnstorfia fluitans (also Drepanocladus fluitans)*
wavy dicranum	*Dicranum polysetum*
wavy dicranum	*Dicranum undulatum*
whip fork moss	*Dicranum flagellare*
wide-tongued peat moss	*Sphagnum russowii*
wooden soldiers	*Cladonia botrytes*
wooly foam lichen	*Stereocaulon tomentosum*
yellow star moss	*Campylium stellatum*
Epiphyte	
–	*Biatora vacciniicola*
–	*Bryoria sp.*
–	*Buellia disciformis*
–	*Caloplaca holocarpa*
–	*Candelariella vitellina*
–	*Catinaria atropurpurea*
–	*Cliostomum pallens*
–	*Elixia flexella*
–	*Lecanora boligera*
–	*Lecanora fuscescens*
–	*Lecanora laxa*
–	*Lecanora persimilis*
–	*Lecanora pulicaris*
–	*Lecanora sp.*
–	*Lecanora subintricata*
–	*Lecidea leprarioides*
–	*Lecidea nylanderi*
–	*Lecidea porphyrospoda*
–	*Lecidella elaeochroma*
–	*Leptorhaphis sp.*
–	*Letharia vulpina*
–	*Lobaria pulmonaria*
–	*Melanelia exasperata*
–	*Melanelia sp.*
–	*Micarea denigrata*
–	*Micarea prasina*

Common Name	Scientific Name
–	*Micarea sylvicola*
–	*Mycoglaena sp nov.* (new species)
–	*Ochrolechia arborea*
–	*Ochrolechia gowardii*
–	*Phaeocalicium flabelliforme*
–	*Physcia tenella*
–	*Placynthiella uliginosa*
–	*Pycnora elachista* (new species)
–	*Ramalina sp.*
–	*Rhizocarpon grande*
–	*Rinodina metaboliza*
–	*Rinodina orculata*
–	*Rinodina septentrionalis*
–	*Rinodina sp.*
–	*Scoliciosporum perpusillum*
–	*Scoliciosporum umbrinum*
–	*Trapeliopsis flexuosa*
–	*Trapeliopsis granulosa*
–	*Usnea scabiosa*
–	*Usnea sp.*
–	*Xanthoria fallax*
–	*Xylographa opegraphella sensu lato*
–	*Xyloschistes platytropa*
abraded camoflage lichen	*Melanelia subaurifera*
alder needles	*Phaeocalicium compressulum*
alder stickpin	*Stenocybe pullatula*
American starburst lichen	*Imshaugia placorodia*
Arthonioid group	*Arthonioid group*
black woodscript lichen	*Xylographa parallela (also X. abietina)*
black-eyed rim lichen	*Lecanora circumborealis*
boreal oakmoss lichen	*Evernia mesomorpha*
chalky ramalina	*Ramalina pollinaria*
chestnut wrinkle-lichen	*Tuckermannopsis sepincola*
fringed wrinkle-lichen	*Tuckermannopsis americana* *(also Cetraria halei or C. ciliaris)*
fused rim-lichen	*Lecanora symmicta*
gray starburst lichen	*Parmeliopsis hyperopta*
green starburst lichen	*Parmeliopsis ambigua*
hammered shield moss	*Parmelia sulcata*
hooded rosette lichen	*Physcia adscendens*
monk's-hood lichen	*Hypogymnia physodes*
northern camoflage lichen	*Melanelia septentrionalis*
old man's beard	*Bryoria furcellata*
old man's beard	*Bryoria fuscescens*
old man's beard	*Bryoria glabra*
old man's beard	*Bryoria lanestris*
old man's beard	*Bryoria simplicior*
old man's beard	*Usnea cavernosa*
old man's beard	*Usnea filipendula*
old man's beard	*Usnea glabrata*
old man's beard	*Usnea hirta*
old man's beard	*Usnea lapponica*
old man's beard	*Usnea scabrata*

Common Name	Scientific Name
old man's beard	*Usnea subfloridana*
old man's beard	*Usnea substerilis*
powdered sunshine lichen	*Vulpicida pinastri (also Tuckermannopsis pinastri)*
punctured ramalina	*Ramalina dilacerata*
salted starburst lichen	*Imshaugia aleurites*
Sea-storm lichen	*Cetrelia olivetorum*
spraypaint	*Icmadophila ericetorum*
star rosette lichen	*Physcia stellaris*
variable wrinkle-lichen	*Tuckermannopsis orbata (also Cetraria orbata)*
Wildlife[c]	
Mammals[d][e]	
bat spp.	*Myotis spp.*
beaver	*Castor canadensis*
big brown bat	*Eptesicus fuscus*
black bear	*Ursus americanus*
Canada lynx	*Lynx canadensis*
coyote	*Canis latrans*
deer spp.	*Odocoileus spp.*
fisher	*Martes pennanti*
fisher/marten	*Martes spp.*
grey wolf	*Canis lupus*
little brown bat	*Myotis lucifugus*
marten	*Martes americana*
moose	*Alces alces*
muskrat	*Ondatra zibethicus*
red bat	*Lasiurus borealis*
red squirrel	*Tamiasciurus hudsonicus*
silver-haired bat	*Lasionycteris noctivagans*
snowshoe hare	*Lepus americanus*
weasel spp.	*Mustela spp.*
white-tailed deer	*Odocoileus virginianus*
woodland caribou	*Rangifer tarandus*
Amphibians/Reptiles[f]	
boreal chorus frog	*Pseudacris triseriata*
Canadian toad	*Bufo hemiophrys*
western (boreal) toad	*Bufo boreas*
wood frog	*Rana sylvatica*
Birds[g]	
alder flycatcher	*Empidonax alnorum*
American bittern	*Botaurus lentiginosus*
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American wigeon	*Anas americana*
barred owl	*Strix varia*
bay breasted warbler	*Dendroica castanea*
black tern	*Chlidonias niger*
black-capped chickadee	*Parus atricapillus*
blue-winged teal	*Anas discors*
Bonaparte’s gull	*Larus philadelphia*
boreal chickadee	*Parus hudsonicus*
boreal owl	*Aegolius funereus*
brown creeper	*Certhia americana*
bufflehead	*Bucephalus albeola*

Common Name	Scientific Name
Canada goose	*Branta canadensis*
chipping sparrow	*Spizella passerina*
clay-colored sparrow	*Spizella pallida*
common goldeneye	*Bucephala clangula*
common loon	*Gavia immer*
common merganser	*Mergus merganser*
common raven	*Corvus corax*
common yellowthroat	*Geothlypis trichas*
Connecticut warbler	*Oporornis agilis*
dabbler and diver spp.	–
dark-eyed junco	*Junco hyemalis*
downy woodpecker	*Picoides pubescens*
goldern-crowned kinglet	*Regulus satrapa*
gray jay	*Perisoreus canadensis*
great blue heron	*Ardea herodias*
great gray owl	*Strix nebulosa*
great horned owl	*Bubo virginianus*
greater yellowlegs	*Tringa melanoleuca*
grebe spp.	*Podiceps spp.*
green-winged teal	*Anas crecca*
hairy woodpecker	*Picoides villosus*
hermit thrush	*Catharus guttatus*
least flycatcher	*Empidonax minimus*
lesser yellowlegs	*Tringa flavipes*
Lincoln's sparrow	*Melospiza lincolnii*
long-eared owl	*Asio otus*
magnolia warbler	*Dendroica magnolia*
mallard	*Anas platyrhynchos*
mourning warbler	*Oporornis philadelphia*
northern harrier	*Circus cyaneus*
northern hawk owl	*Surnia ulula*
northern saw-whet owl	*Aegolius acadicus*
northern waterthrush	*Seiurus noveboracensis*
ovenbird	*Seiurus aurocapillus*
palm warbler	*Dendroica palmarum*
pileated woodpecker	*Dryocopus pileatus*
raptor spp.	–
red-eyed vireo	*Vireo olivaceus*
red-necked grebe	*Podiceps grisegena*
ring-necked duck	*Aythya collaris*
rose-breasted grosbeak	*Pheucticus ludovicianus*
ruby-crowned kinglet	*Regulus calendula*
ruffed grouse	*Bonasa umbellus*
sandhill crane	*Grus canadensis*
short-eared owl	*Asio flammeus*
solitary sandpiper	*Tringa solitaria*
sora	*Porzana carolina*
spruce grouse	*Dendragapus canadensis*
Swainson's thrush	*Catharus ustulatus*
swamp swallow	*Melospiza georgiana*
Tennessee warbler	*Vermivora peregrina*
tree swallow	*Tachycineta bicolor*
white-throated sparrow	*Zonotrichia albicollis*

Common Name	Scientific Name
white-winged crossbill	*Loxia leucoptera*
Wilson's snipe (common snipe)	*Gallinago gallinago*
Wilson's warbler	*Wilsonia pusilla*
yellow-bellied flycatcher	*Empidonax flaviventris*
yellow-bellied sapsucker	*Sphyrapicus varius*
yellow-rumped warbler	*Dendroica coronata*
Fish(h)	
Arctic grayling	*Thymallus arcticus*
brook stickleback	*Culaea inconstans*
burbot	*Lota lota*
cisco	*Coregonus artedi*
fathead minnow	*Pimephales promelas*
finescale dace	*Phoxinus neogaeus*
flathead chub	*Platygobio gracilis*
goldeye	*Hiodon alosoides*
Iowa darter	*Etheostoma exile*
lake chub	*Couesius plumbeus*
lake trout	*Salvelinus namaycush*
lake whitefish	*Coregonus clupeaformis*
longnose dace	*Rhinichthys cataractae*
longnose sucker	*Catostomus catostomus*
mountain whitefish	*Prosopium williamsoni*
ninespine stickleback	*Pungitius pungitius*
northern pike	*Esox lucius*
northern redbelly dace	*Phoxinus eos*
pearl dace	*Semotilus margarita*
river shiner	*Notropis blennius*
slimy sculpin	*Cottus cognatus*
spoonhead sculpin	*Cottus ricei*
spottail shiner	*Notropis hudsonius*
trout-perch	*Percopsis omiscomaycus*
walleye	*Sander vitreus*
white sucker	*Catostomus commersoni*
yellow perch	*Perca flavescens*
Invertebrates(i)(j)	
	Pisidium / Sphaerium
	Leptophlebia
amphipod	*Gammarus lacustris*
amphipod	*Hyalella azteca*
amphipods	Amphipoda
aquatic worms	Oligochaeta
aquatic worms	Naididae
aquatic worms	Enchytraeidae
aquatic worms	Lumbriculidae
aquatic worms	Tubificidae
beetle	*Optioservus*
beetle	Coleoptera
biting midge	*Bezzia*
biting midge	*Culicoides*
biting midge	*Probezzia*
biting midges (no-see-ums)	Ceratopogonidae
biting midges (no-see-ums)	Ceratopogoninae
black flies	Simuliidae

Common Name	Scientific Name
caddisflies	Trichoptera
caddisflies	Brachycentridae
caddisflies	Hydropsychidae
caddisflies	Helicopsychidae
caddisflies	Leptoceridae
caddisfly	*Brachycentrus*
caddisfly	*Hydropsyche*
caddisfly	*Oecetis*
caddisfly	*Nemotaulius*
caddisfly	*Molanna*
caddisfly	*Polycentropus*
caddisfly	*Glossosoma*
clams	Pelecypoda (Bivalvia)
copepods	Cyclopoida
copepods	Harpacticoida
crane flies	Tipulidae
crane fly	*Hexatoma*
dance flies	Empididae
dance fly	*Hemerodromia*
dragonflies	Anisoptera
dragonflies	Gomphidae
dragonflies and damselflies	Odonata
dragonfly	*Ophiogomphus*
fingernail clam	*Sphaerium*
fingernail clams	Sphaeriidae
horse flies and deer flies	Tabanidae
leech	*Glossiphonia complanata*
leech	*Helobdella stagnalis*
leech	*Erpobdella punctata*
leeches	Hirudinea
leeches	Glossiphoniidae
leeches	Erpodbellidae
long-legged flies	Dolichopodidae
mayflies	Ephemeroptera
mayfly	*Ametropus neavei*
mayfly	*Baetis*
mayfly	*Baetisca*
mayfly	*Caenis*
mayfly	*Ephemera*
mayfly	*Hexagenia limbata*
mayfly	*Heptagenia*
mayfly	*Tricorythodes*
midge	*Cladopelma*
midge	*Cryptochironomus*
midge	*Cryptotendipes*
midge	*Demicryptochironomus*
midge	*Glyptotendipes*
midge	*Microtendipes*
midge	*Pagastiella*
midge	*Paracladopelma*
midge	*Paralauterborniella*
midge	*Polypedilum*
midge	*Robackia*

Common Name	Scientific Name
midge	*Saetheria*
midge	*Stictochironomus*
midge	*Tribelos*
midge	*Pseudochironomus*
midge	*Cladotanytarsus*
midge	*Micropsectra*
midge	*Paratanytarsus*
midge	*Rheotanytarsus*
midge	*Stempellinella*
midge	*Tanytarsus*
midge	*Epoicocladius*
midge	*Rheosmittia*
midge	*Heterotrissocladius*
midge	*Ablabesmyia*
midge	*Procladius*
midges	Chironomidae
midges	Chironomini
midges	Pseudochironomini
midges	Tanytarsini
midges	Orthocladiinae
midges	Tanypodinae
round worms	Nematoda
seed shrimp	Ostracoda
shore flies or brine flies	Ephydridae
snail	*Lymnaea*
snail	*Physa*
snail	*Helisoma*
snail	*Valvata sincera*
snails	Gastropoda
stoneflies	Plecoptera
stoneflies	Perlidae
stonefly	*Isogenus elongatus*
stonefly	*Pteronarcys dorsata*
stonefly	*Arcynopteryx curvata*
stonefly	*Arcynopteryx parallela*
stonefly	*Isoperla*
true flies	Diptera
water fleas	Cladocera
water fleas	Chydoridae
water fleas	Macrothricidae
water mites	Hydracarina

(a) Johnson, D., L. Kershaw, A. MacKinnon and J. Pojar. 1995.
(b) Moss, E.H. 1983.
(c) Merritt, R. W. and K. W. Cummins. 1996.
(d) Smith, H.C. 1993.
(e) Burt, W.H. 1976.
(f) Russell, A.P. and A.M. Bauer. 1993.
(g) National Geographic Society. 1983.
(h) Nelson, J.S. and M.J. Paetz. 1992.
(i) Clifford, H. F. 1991.
(j) Bouchard, R.W., Jr. 2004.
– = No common/scientific name available.

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APPENDIX 2-IV

QUALITY ASSURANCE AND QUALITY CONTROL

THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.

APPENDIX 2-IV

QUALITY ASSURANCE AND QUALITY CONTROL

TABLE OF CONTENTS

SECTION **PAGE**

1 INTRODUCTION

Data used in support of Environmental Impact Assessments (EIAs) must be of sufficient quality to ensure that the conclusions are not compromised. Established and proven Quality Assurance and Quality Control (QA/QC) procedures have been applied to the completion of the EnCana FCCL Ltd. (EnCana) Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project). These procedures were implemented to ensure that the data collected are of known, acceptable and defensible quality and that proper procedures (e.g., database management, electronic file management, document control, report reviewing procedures) were followed.

An overview of the components of the QA/QC procedures and overall objectives are presented below:

- use of standardized field sampling protocols for the EIA including:
  - relevant Technical Procedures and Specific Work Instructions (SWIs) for baseline field activities;
  - established and consistent procedures for recording field data;
  - established and consistent procedures for sample handling including identification, preservation and transport; and
  - proper health and safety procedures.
- selection of accredited laboratories to ensure high-quality analytical data; and
- application of established and rigorous documentation management processes including:
  - data entry, database management and audit procedures;
  - document control procedures (e.g., coding, version control, back-up management and safe storage of documents related to the Project); and
  - document review procedures.

The Project team includes a management team to oversee the entire Project and a technical team for each component of the Project (i.e., wildlife, water quality). Each component has a Component Lead who ensures their component meets all its objectives. The component-specific issues, technical approach and scope of work for each component of the EIA are described in detail in the corresponding sections of this Application. Component Leads were responsible for ensuring compliance with the QA/QC procedures.

2 FIELD PROCEDURES

The following sections describe the field procedures, including protocols for field methodology, audits, record keeping, sample handling (i.e., sample identification, preservation, sample QC, shipping) and health and safety. Field procedures are developed with consideration of recognized regulatory guidelines and requirements.

2.1 FIELD METHODS

Technical Procedures are detailed sampling protocols used by field personnel to ensure sampling techniques are standardized and defensible. Established Technical Procedures were used for most field sampling programs; however, where alternate methods were used, they are described in detail in the appropriate section of the EIA.

Specific Work Instructions were also used for field sampling programs. The SWI includes: project personnel; details of where and when to sample; specific sampling instructions (including reference to relevant Technical Procedures); level of effort required; schedule for the fieldwork; site map; and any applicable contingency plans.

2.2 FIELD RECORD KEEPING

The Field Crew Lead was responsible for ensuring that all pertinent information on field activities and sampling efforts were recorded in the appropriate data sheet and/or in a waterproof bound logbook. Field notes and datasheets were coded and stored within each component’s filing system. A tracking sheet of these file locations was kept in the Project master file.

2.3 SAMPLE HANDLING

Sampling protocols (including sample identification, preservation, sample QC and storage), selection of sample containers and the amount of material collected followed detailed Technical Procedures and the requirements of the analytical laboratory (e.g., sample volumes or weights). The laboratory requirements, as well as sample containers and preservatives, were provided by the selected laboratory based on the parameters to be analyzed and the required detection limits.

2.4 SAMPLE SHIPPING

Sample shipping required the use of Chain-of-Custody (COC) forms, which documented the travel of samples from the field crew's possession to the laboratory log-in. Chain-of-Custody forms provide a complete list of the contents of the shipment (i.e., sample codes), dates and times samples were collected, analysis requested, shipping information and possession history of the shipment.

Sample containers were securely packed inside a cooler with appropriate packing materials and ice packs before shipping. The original signed COC forms were placed in a zip-locked bag inside the cooler. The field Crew Lead maintained a copy of the COC documentation. Samples were transported from the sampling area to the selected laboratory by an authorized carrier as soon as possible after collection.

The COC form was completed when the container arrived at the laboratory and the log-in personnel recorded the date, time and condition of the sample arrival. The laboratory was aware of the sampling date and time to ensure that analysis was completed within the specified time limits.

2.5 HEALTH AND SAFETY

Each field program for the Project required a detailed Health and Safety Plan (HASP) to be completed by the Crew Lead, which was then reviewed and approved by the Component Lead, the Project Manager and the Project Health and Safety Administrator. Completed HASPs contain site-specific information (including site map(s) and Universal Transverse Mercator [UTM] co-ordinates), field personnel contact information, emergency information, field level risk assessment, emergency call down procedure, pre-field meeting notes, tail-gate meeting notes, check-in logs and a blank incident/accident report form. At the end of each program a post-field debrief meeting between the Project Health and Safety Administrator and the field crew was conducted and noted in the HASP. Relevant information (including hazard identifications) was communicated to other crews working in the areas and the completed HASPs were filed in the Project Master File. Any near misses or incidents were reported immediately to Golder's Health and Safety department as well as to EnCana.

3 LABORATORY PROCEDURES

Only laboratories accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL) were selected to complete analysis of samples for the Project. Under CAEAL's accreditation program, a performance evaluation assessment is conducted annually for the laboratory's procedures, methods and internal quality control. Laboratories were also required to provide written protocols for the analytical methods used, including the target detection limit for each chemical tested.

The COC form provided clear instructions to the laboratory on the analysis requested for each sample. Samples were identified and tracked by means of sample location (station) and replicate identifiers. Any transfer of samples between or within laboratories was tracked through COC procedures.

Laboratory quality control criteria included analysis of QC samples. Field blanks were used to evaluate the effects of collection, handling and analysis of samples on data quality. Duplicate samples were used to evaluate the precision of the sampling method and laboratory results. All excess sample materials were archived by the labs for future reference.

Upon receipt of the laboratory results Component Leads reviewed the data sets. Concentrations in blank samples greater than five times the analytical detection limit in the field blanks were considered to indicate the possibility of contamination. Duplicate measurements with a difference greater than 20% were considered to signal a possible error in analysis. In these instances sample re-runs were requested, or potential errors were considered when interpreting the data.

4 DOCUMENTATION

4.1 DATA MANAGEMENT

At the end of each program, data sheets were reviewed and checked for completeness by the relevant Component Lead or designate. Prior to data entry, analysis and output requirements were reviewed to ensure the database conformed to the necessary specifications. Upon completion of entry into the database, data entries were checked against the original data sheets. Ten percent of the data entries, or a minimum of one hundred entries were checked for every dataset.

A management system for data control and filing was used for the Project. This system ensured that the most current information was stored in a single location for use by team members. This practice ensured efficient QA/QC procedures and was available to other teams and the client as required.

Each component was assigned an electronic project directory. Subdirectories were named by the task code number and title. Data files within the subdirectories were named according to content and date of revision. Files were archived as they became either outdated or redundant to ensure that all files were current.

4.2 DOCUMENT CONTROL

The Project produced large quantities of written material, including correspondence, field data, data reports from laboratories, documentation of analysis and reports. The document control system operated as follows:

- Field records, materials and reports received or produced in-house were dated, coded and filed according to the relevant task.
- Copies of documents transferred to subconsultants or the client were photocopied along with the accompanying transmittal and were stored in the Project master files.
- Documents received from external parties such as subcontractors or the client were logged in an incoming documents ledger and filed in the Project master files.

- The Project master files were maintained by the Project Management team and located in a locked file with restricted access. Draft Project reports and application sections were completed by Component Leads and reviewed by a Senior Advisor in the relevant discipline before submission to the Project Management Team for the final review process.

4.3 FINAL REVIEW AND DOCUMENTATION PROCESS

The final Project application is a compilation of several independent sections, reports and appendices. As stated above, each section submitted to the Project Management Team were reviewed first by the Component Lead and then by a Senior Advisor. Once received by the Project Management Team each document underwent an extensive review and documentation process including:

- complete document format including, for example, correct headings and page layouts;
- technical review of each section for consistency and compliance with Project-specific conventions;
- complete check of references, cross-references, tables and figures;
- complete review by the Project Manager and Project Director as appropriate;
- review by the EnCana representatives;
- review of all comments and edits received from EnCana representatives with document authors to ensure technical content is not compromised; and all questions and comments are addressed; and
- final review and approval by technical Senior Advisor, Project Manager, Project Director and the EnCana representatives.

This review process was managed and documented by the Project Coordinator. Electronic and paper copies of each report were archived as they were superseded and a single current version was made available for each step of the process. A QA/QC check of the edits and changes incorporated was completed at each stage of the process. A tracking sheet was completed for each document stating the dates each step was completed and by whom.

5 ABBREVIATIONS

CAEAL	Canadian Association for Environmental Analytical Laboratories
COC	Chain-of-Custody
e.g.	For example
EIA	Environmental Impact Assessment
EnCana	EnCana FCCL Ltd.
HASP	Health and Safety Plan
i.e.	That is
QA/QC	Quality Assurance/Quality Control
SWI	Specific Work Instructions
UTM	Universal Transverse Mercator

APPENDIX 2-V

CLIMATE CHANGE CONSIDERATIONS

**THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.**

APPENDIX 2-V

CLIMATE CHANGE CONSIDERATIONS

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1 INTRODUCTION

Evaluations of climate change are required as part of the Environmental Impact Assessment (EIA) for new projects in Alberta. Guidance on how such evaluations should be made is provided both by the EIA Terms of Reference (TOR) for the EnCana FCCL Ltd. (EnCana) Christina Lake Thermal Expansion Project Phases 1E, 1F and 1G (the Project) (Alberta Environment [AENV] 2009) as well as in federal guidance documents (FPTCCCEA 2003).

This section has been prepared to summarize the findings with regards to potential climate change impacts and to address regulatory guidance with respect to climate change issues.

1.1 GUIDANCE FOR INCORPORATING CLIMATE CHANGE

The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) issued a general guidance document in November 2003 for practitioners to use when incorporating climate change issues into environmental assessments (FPTCCCEA 2003). The guidance document sets out the following two approaches for incorporating climate change considerations:

- Greenhouse Gas (GHG) considerations where the proposed project may contribute to GHG emissions; and
- impact consideration where changing climates may have an impact on the proposed project.

The federal guidance document indicates that projects are typically more closely aligned with one type of consideration or the other, but provides for cases where both considerations could be addressed.

In this application, production and management of GHG emissions is addressed in the Air Quality section of the EIA (Volume 3, Section 1). Consideration and predictions of how changing climates may have an effect on the Project are addressed in this Appendix.

2 CLIMATE CHANGE

2.1 ASSESSMENT APPROACH

An evaluation of the potential effects of climate change on the Project and the assessment predictions as required by the TOR requires an understanding of historic climate changes in order to predict how it might change in the future.

Determining historic climate change is relatively straightforward, relying on the long-term climate records. The closest long-term source for the Project is the climate station located near the community of Cold Lake and the available records are from the years 1951 to 2000. This data was used to determine recent climatic trends in the Project area.

Climate forecasts for the Cold Lake area were used to determine future climate changes. Applicable climate forecast data from the Canadian Climate Impacts Scenarios Project internet site run by the Canadian Institute for Climate Studies ([CICS] 2005, internet site) have been considered to ensure a thorough evaluation. For example, when the forecasted temperature change for a given model and scenario is presented, the corresponding forecasted precipitation change for the same model and scenario is also presented.

This assessment focused on the changes to temperature and precipitation to represent the impacts of climate change on the Project. Temperature and precipitation are the most common parameters for determining climate change and can be used as indicators for other parameters. Historical temperature and precipitation records and forecast data were also readily available. Wind speed and solar radiation forecast data were incorporated into the climate change assessments for air quality and water quality, respectively.

2.1.1 Climate Forecast Models

Climate forecasts require the use of sophisticated mathematical computer models called General Circulation Models (GCMs). These models simulate the interactions of airborne emissions, the atmosphere, land surfaces and oceans and can take several months to run. The Intergovernmental Panel on Climate Change (IPCC) has made use of several different GCMs. The seven models presented in Table 1 are recommended for use by the IPCC (IPCC 2005, internet site). Canadian forecast data from these models has been made available by the CICS as part of the Canadian Climate Impacts Scenarios Project.

Table 1 General Circulation Models Considered in the Assessment

Research Centre/Model Name	Abbreviation	Country	Model Resolution[a] [km²]
Centre for Climate System Research/National Institute for Environmental Studies	CCSR/NIES	Japan	168,000
Canadian Global Coupled Model (Version 2)	CGCM2	Canada	74,000
Commonwealth Scientific and Industrial Research Organization Mark 2	CSIRO MK2b	Australia	95,000
Max Planck Institute for Meteorology/Deutsches Klimarechenzentrum	ECHAM4/OPYC3	Germany	41,000
Geophysical Fluid Dynamics Laboratory	GFDL R30	United States	44,000
Hadley Centre Coupled Model	HadCM3	United Kingdom	50,000
National Centre for Atmospheric Research Parallel Climate Model[b]	NCAR-PCM	United States	41,000

(a) The model resolution represents the area of each grid cell used in the respective models.

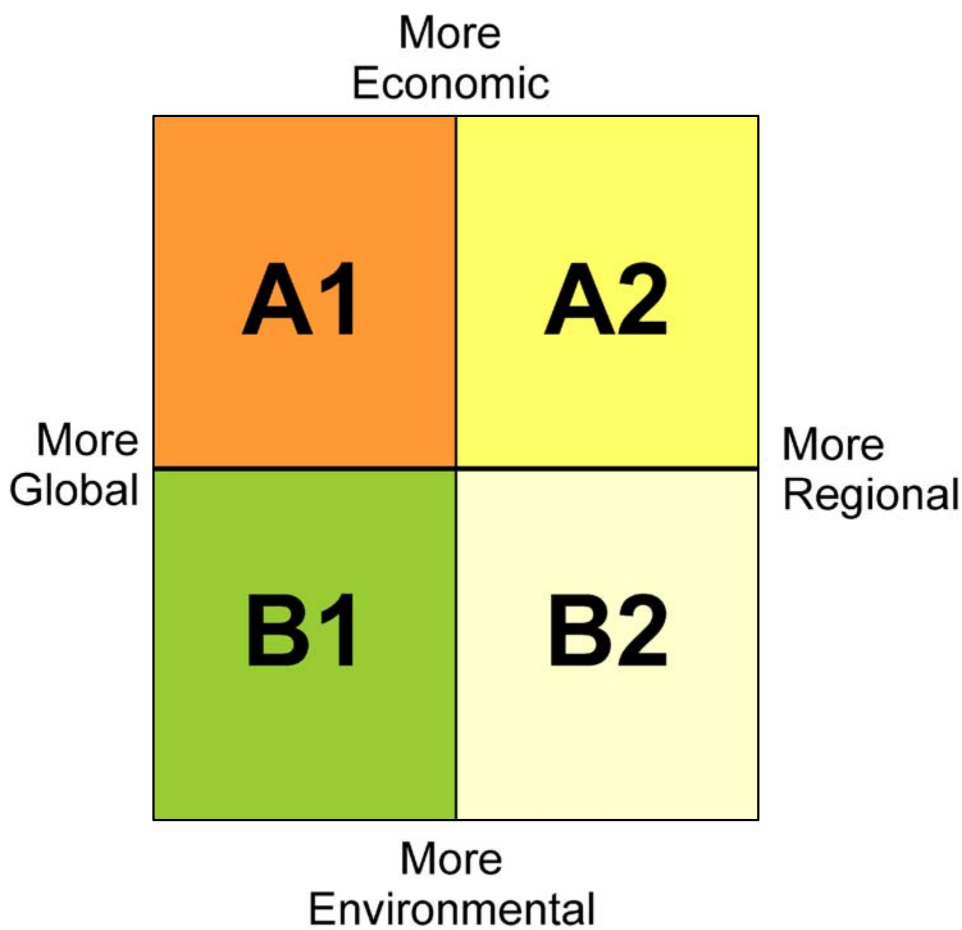
(b) Canadian climate forecasts from the NCAR-PCM model were not available from the CICS internet site.

2.1.2 Forecast Scenarios

Given the wide range of inputs available to GCMs, the IPCC has established a series of global GHG emission scenarios based on four potential socio-economic development paths. The *Third Assessment Report* (IPCC 2001a) identifies these scenarios as ***A1***, ***B1***, ***A2*** and ***B2***. The ***A1*** and ***A2*** scenarios represent a focus on economic growth while the ***B1*** and ***B2*** scenarios represent a shift towards more environmentally conscious solutions to growth. Both scenarios ***A1*** and ***B1*** include a shift towards global solutions while the ***A2*** and ***B2*** scenarios include growth based on more localized and regional approaches. Figure 1 provides an illustrative summary of the four emission scenarios, which are described more fully in the IPCC Special Report on Emissions Scenarios (IPCC 2000).

Although the IPCC has not stated which of the emission scenarios is most likely to occur, the ***A2*** scenario most closely reflects the current global socio-economic situation, and is closely related to the emission scenario (***IS92a)*** that was used by IPCC in its historical climate assessments. In relation to the ***A2*** scenario, scenarios ***A1***, ***B1*** and ***B2*** result in lower long-term GHG emissions over the next century. Within the ***A1*** scenario, the following three classifications of growth indicators are included:

- fossil-fuel intensive (FI): a socio-economic condition that was dependent on fossil fuels for energy. For example, the first half of the 21st century would be sub-categorized as A1FI due to increasing population and a high dependency on fossil fuels for energy;
- non-fossil-fuel intensive (T): a socio-economic condition that was less fossil-fuel dependent; and
- balanced (B): a socio-economic condition that relied on both fossil fuels and non-fossil-fuels.



PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE EMISSION SCENARIOS

Golder Associates
Calgary, Alberta

PROJECT 06-1346-003.9300			FILE No. Climate Change...	
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CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

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While the IPCC supports all of these scenarios, forecast data is not available from each scenario for all seven of the GCMs listed in Table 1. A summary of the forecast data available from the CICS internet site is provided in Table 2. All available models and emissions scenarios were considered in this assessment.

Table 2 Summary of Available Climate Forecasts

Climate Model	Forecast Period	SRES Scenario[a]					
		A1FI	A1T	A1	A2	B1	B2
CCSR/NIES	2010 to 2069	n/d	A1T	A1(1)	A2(1)	B1(1)	B2(1)
CGCM2	2010 to 2069	n/d	n/d	n/d	A2(1) A2(2) A2(3) A2(x)	n/d	B2(1)
CSIRO MK2b	2010 to 2069	n/d	n/d	A1(1)	A2(1)	B1(1)	B2(1)
ECHAM4/OPYC3	2010 to 2069	n/d	n/d	n/d	A2(1)	n/d	B2(1)
GFDL R30	2010 to 2069	n/d	n/d	n/d	A2(1)	n/d	B2(1)
HadCM3	2010 to 2069	A1FI	n/d	n/d	A2(1) A2(2) A2(3) A2(x)	B1(1)	B2(1) B2(2)
NCAR-PCM[b]	2010 to 2069	n/d	n/d	n/d	n/d	n/d	n/d

(a) The numbers in parenthesis beside the SRES scenarios represent the model ensemble number. An ensemble simulation consists of several modelling runs for the same scenario but with different initial conditions. Each of these runs is referred to by an ensemble number.

(b) Canadian climate forecasts from the NCAR-PCM model were not available from the CICS internet site (CICS 2005, internet site).

n/d = No data.

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

2.1.3 Baseline Climate

An analysis of climate change not only depends on the future conditions but also on the baseline climate to which the predictions are compared. Baseline climate information is important for describing average conditions, spatial and temporal variability and anomalous events, as well as calibrating and testing climate models (CICS 2005, internet site).

The IPCC recommends that 1961 to 1990 be adopted as the climatological baseline period in assessments (CICS 2005, internet site). This period has been selected since it is considered to:

- be representative of the present-day or recent average climate;
- be of a sufficient duration to encompass a range of climatic variations, including several significant weather anomalies;

- cover a period for which data on all major climatological variables are abundant, adequately distributed over space and readily available;
- include data of sufficiently high quality for use in evaluating impacts; and
- be comparable with baseline climatologies used in other impact assessments.

The scenarios available from CICS are based on the 1961 to 1990 baseline period; therefore, this assessment is also based on the same period.

2.2 HISTORIC CLIMATE CHANGE

Temperature and precipitation normals for the Project area were obtained from the Cold Lake Airport meteorological station which is operated by the Meteorological Service of Canada. Analyzing historic climate change in the Cold Lake region involves reviewing current climate normals. Climate normals refer to calculated averages of observed climate values for a given location over a specified time period. The World Meteorological Organization recommends that climate normals be prepared at the end of every decade for a 30-year period (e.g., 1961 to 1990; 1971 to 2000). Table 3 provides a summary of the climate normals observed at Cold Lake. The four seasonal values were determined as follows:

- spring – March, April and May;
- summer – June, July and August;
- fall – September, October and November; and
- winter – December, January and February.

Table 3 Observed Multiple Climate Normals – Cold Lake

Climate Data	Season	Observed Normals	
		Temperature [°C]	Precipitation [mm]
Cold Lake (1951 to 1980)	annual	1.2	461.4
	spring	1.9	82.3
	summer	15.7	233.6
	fall	13.7	82.9
	winter	-15.5	62.1
Cold Lake (1961 to 1990)	annual	1.5	432.4
	spring	2.5	78.7
	summer	15.8	221.9
	fall	14.2	76.8
	winter	-15.1	54.6
Cold Lake (1971 to 2000)	annual	1.8	427.2
	spring	3.2	81.7
	summer	15.9	217.3
	fall	14.3	78.2
	winter	-14.5	50.9

Table 4 provides a listing of the observed changes in climate conditions relative to the 1961 to 1990 climate normals. The comparison shows that the 1951 to 1980 period was 0.2°C cooler and received 6% more precipitation annually than the 1961 to 1990 period. The 1971 to 2000 period was 0.3°C warmer and received slightly less precipitation than the 1961 to 1990 period.

Table 4 Observed Climate Change – Cold Lake Relative to 1961 to 1990 Normals

Climate Data	Season	Observed Climate Change[a]	
		Temperature [°C]	Precipitation [%]
1951 to 1980 normals	annual	-0.2	+6.3
	spring	-0.6	+4.4
	summer	-0.2	+5.0
	fall	-0.4	+7.4
	winter	-0.4	+12.1
1971 to 2000 normals	annual	+0.3	-1.2
	spring	+0.6	+3.7
	summer	+0.0	-2.1
	fall	+0.1	+1.8
	winter	+0.6	-7.3

[a] Observed climate change was determined as the change relative to the 1961 to 1990 normals.

2.3 FUTURE CLIMATE CHANGE

Climate forecast data from various models and emissions scenarios were analyzed to determine potential climate change in the region. Since the models are susceptible to annual variability, the analysis uses the average of 30 years of data, centred on the decade of interest. The future conditions have been represented by the 30-year period between 2010 and 2039, which would represent the life of the Project excluding the post operations management and reclamation period of the Project.

Two separate forecasts of climate change have been presented. The first forecast provides the change between the 2010 to 2039 period and the baseline period (1961 to 1990). The second forecast represents the climate change expected over the life of the Project, acknowledging that some of the changes in climate since the baseline period will have already occurred.

2.3.1 Climate Change Relative to the Baseline (1961 to 1990)

The forecasted change in climate relative to the baseline is the difference between the modelled 30-year average for 1961 to 1990 and the modelled future conditions, as represented by the 30-year period between 2010 and 2039. This 30-year average would be representative of the Project life as illustrated in Figure 2.

The forecast changes in temperature and precipitation between the baseline and future conditions (i.e., 2010 to 2039), presented in Tables 5 through 10, were determined for each of the models/scenarios available on the (CICS 2005, internet site) for the corresponding model grid cell that covered the Project and the Cold Lake region. Summer values represent data from June, July and August, and winter values represent data from December, January and February.

Figure 3 illustrates the annual climate change forecasts relative to the baseline period, while the summer and winter change forecasts are illustrated in Figure 4, both based on the data in Table 5 to Table 10.

Table 5 Centre for Climate System Research/National Institute for Environmental Studies Climate Forecasts Relative to the Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
CCSR/NIES	A1T	annual	+1.1	-0.7
		summer	+1.0	-2.0
		winter	-0.1	-4.6
CCSR/NIES	A1(1)	annual	+1.6	n/a
		summer	+1.2	n/a
		winter	+1.0	n/a
CCSR/NIES	A2(1)	annual	+1.0	-1.7
		summer	+1.1	-3.4
		winter	+0.3	-2.1
CCSR/NIES	B1(1)	annual	+1.3	+4.1
		summer	+1.1	+8.6
		winter	+0.9	-2.2
CCSR/NIES	B2(1)	annual	+1.7	+5.5
		summer	+1.7	+5.5
		winter	+1.0	-1.9

n/a = Precipitation data are not available for the CCSR/NIES A1(1) scenario.

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

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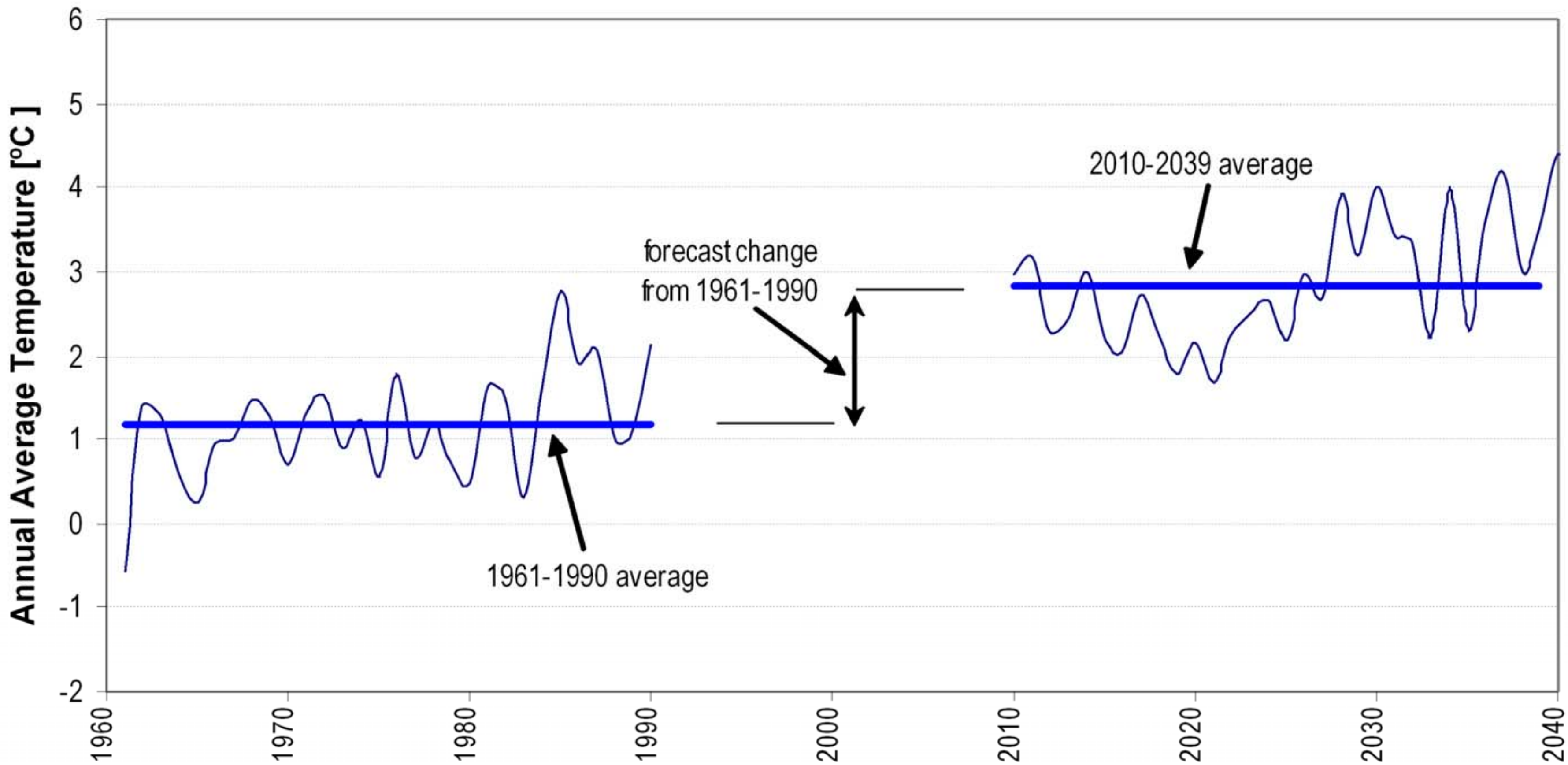

PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

DETERMINING CLIMATE CHANGE RELATIVE TO BASELINE (1961 TO 1990)

Golder Associates
Calgary, Alberta

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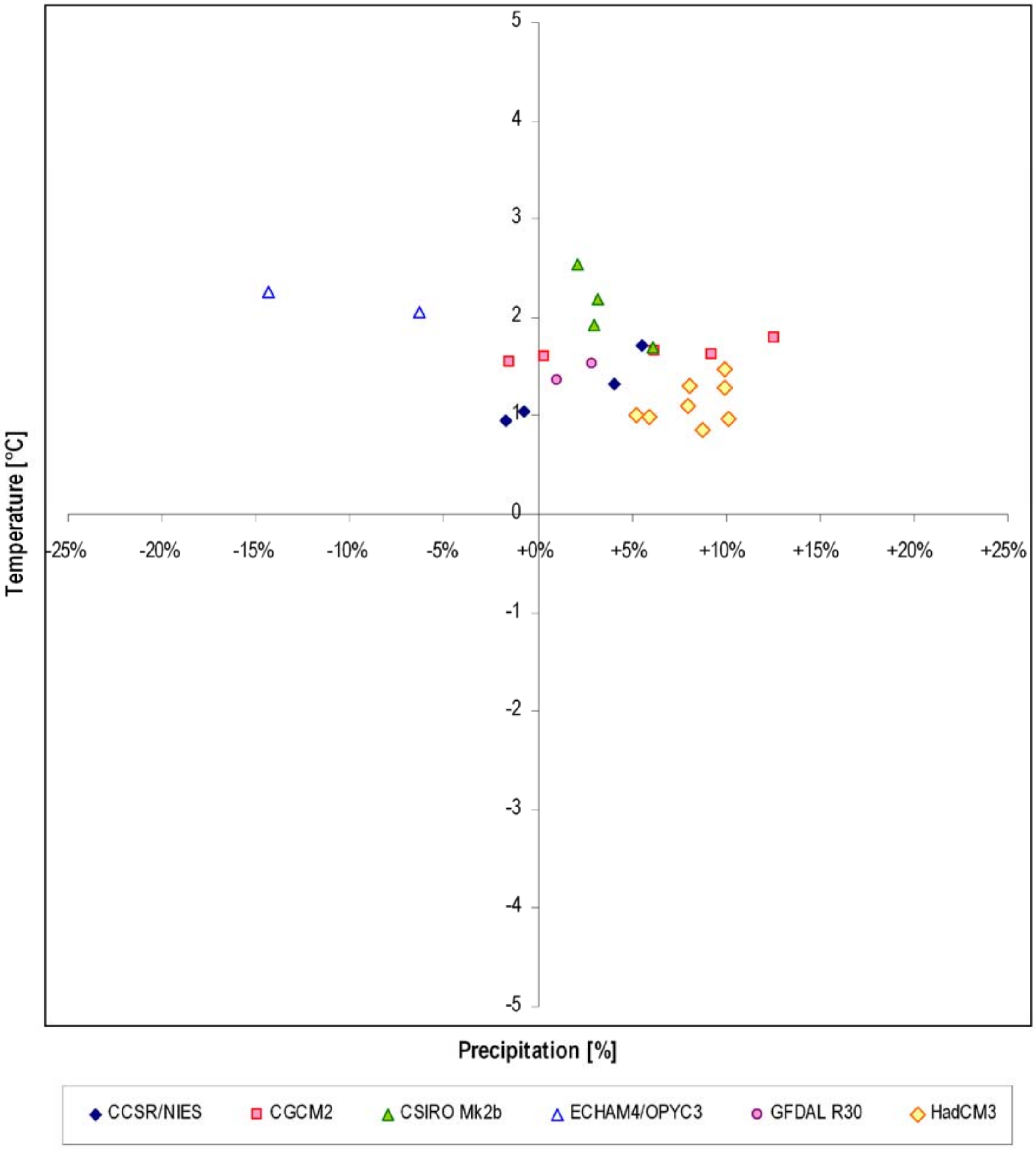
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		



PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

FORECAST ANNUAL CLIMATE CHANGE RELATIVE TO BASELINE (1961 TO 1990)

Golder Associates
Calgary, Alberta

PROJECT 06-1346-003.9300			FILE No. Forecast...Baseline	
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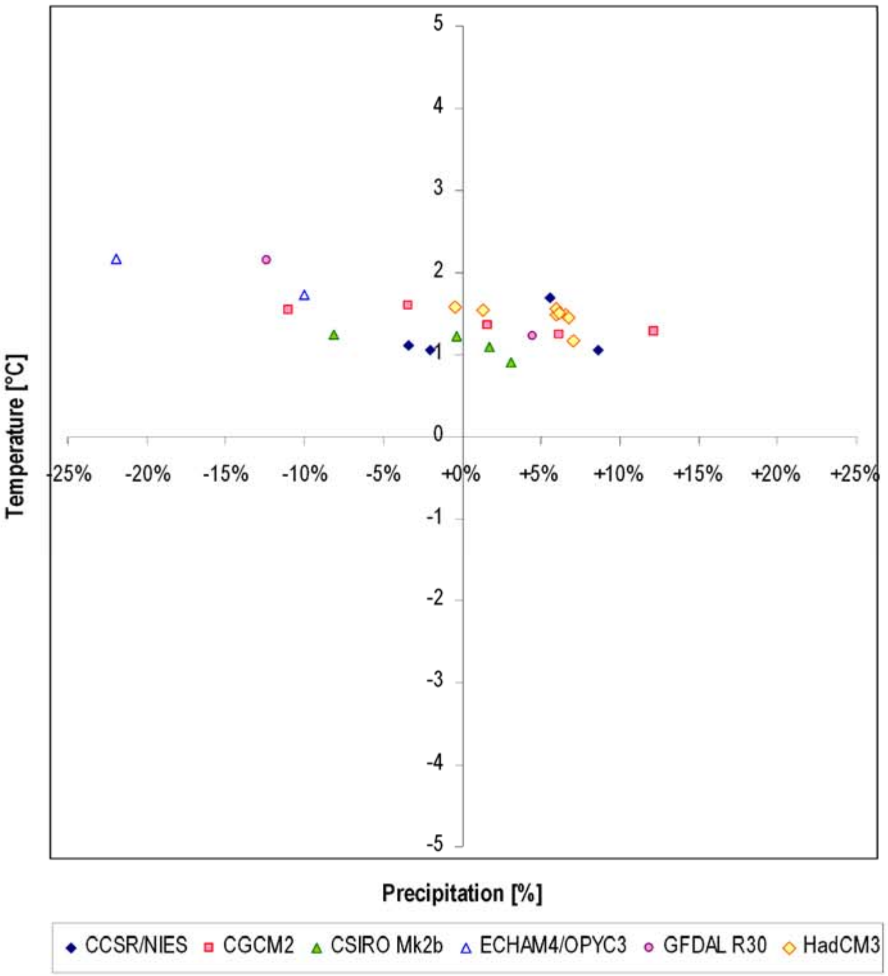
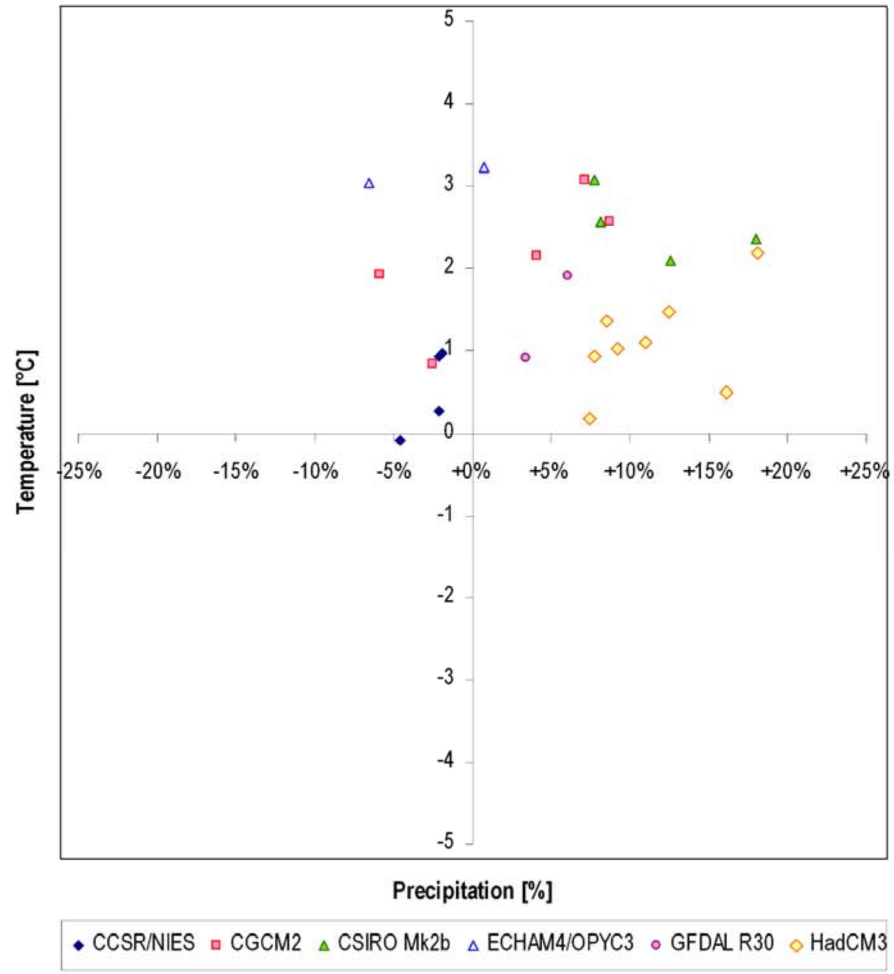


Summer



Winter

PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

FORECAST SUMMER AND WINTER CLIMATE CHANGE RELATIVE TO BASELINE (1961 TO 1990)

Golder Associates
Calgary, Alberta

PROJECT	06.1346.003.9300		FILE No.	Forecast Summer-...
DESIGN	LD	06/08/09	SCALE AS SHOWN	REV. 0
CADD	TRE	17/08/09		
CHECK	LD	18/09/09	**FIGURE: 4**	
REVIEW	IGG	18/09/09		

Table 6 Canadian Global Coupled Model (Version 2) Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
CGCM2	A2(1)	annual	+1.6	-1.5
		summer	+1.6	-11.0
		winter	+0.8	-2.5
CGCM2	A2(2)	annual	+1.8	+12.6
		summer	+1.3	+12.2
		winter	+2.6	+8.8
CGCM2	A2(3)	annual	+1.6	+9.3
		summer	+1.2	+6.2
		winter	+3.1	+7.1
CGCM2	A2(x)	annual	+1.7	+6.2
		summer	+1.4	+1.6
		winter	+2.2	+4.1
CGCM2	B2(1)	annual	+1.6	+0.4
		summer	+1.6	-3.4
		winter	+1.9	-5.9

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 7 Commonwealth Scientific and Industrial Research Organization Mark 2 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
CSIRO Mk2b	A1(1)	annual	+1.9	+3.0
		summer	+1.2	-8.1
		winter	+2.1	+12.6
CSIRO Mk2b	A2(1)	annual	+1.7	+6.1
		summer	+0.9	+3.1
		winter	+2.4	+18.0
CSIRO Mk2b	B1(1)	annual	+2.2	+3.2
		summer	+1.1	+1.8
		winter	+2.6	+8.2
CSIRO Mk2b	B2(1)	annual	+2.5	+2.1
		summer	+1.2	-0.3
		winter	+3.1	+7.7

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 8 ECHAME4/OPYC3 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
ECHAM4/OPYC3	A2(1)	annual	+2.3	-14.3
		summer	+2.2	-22.0
		winter	+3.0	-6.5
ECHAM4/OPYC3	B2(1)	annual	+2.1	-6.3
		summer	+1.7	-10.0
		winter	+3.2	+0.8

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 9 Geophysical Fluid Dynamics Laboratory Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
GFDL R30	A2(1)	annual	+1.5	+2.9
		summer	+1.2	+4.5
		winter	+1.9	+6.0
GFDL R30	B2(1)	annual	+1.4	+1.1
		summer	+2.2	-12.4
		winter	+0.9	+3.4

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 10 HadCM3 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
HadCM3	A1FI	annual	+1.3	+8.1
		summer	+1.5	+6.6
		winter	+1.4	+8.5
HadCM3	A2(1)	annual	+0.8	+8.8
		summer	+1.5	+5.9
		winter	+0.2	+7.4
HadCM3	A2(2)	annual	+1.5	+10.0
		summer	+1.5	+6.7
		winter	+2.2	+18.1
HadCM3	A2(3)	annual	+1.0	+5.9
		summer	+1.6	+5.9
		winter	+0.9	+7.7
HadCM3	A2(x)	annual	+1.1	+7.9
		summer	+1.5	+6.1
		winter	+1.1	+11.0
HadCM3	B1(1)	annual	+1.3	+9.9
		summer	+1.2	+7.1
		winter	+1.5	+12.5
HadCM3	B2(1)	annual	+1.0	+10.1
		summer	+1.5	+1.3
		winter	+0.5	+16.2
HadCM3	B2(2)	annual	+1.0	+5.3
		summer	+1.6	-0.4
		winter	+1.0	+9.2

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 11 provides a summary of the range of changes in temperature and precipitation forecasts relative to the baseline for each of the 26 modelled climate forecast scenario combinations. Annual forecast changes in temperature range from +0.8 to +2.5°C while annual forecast changes in precipitation range from -14.3 to +12.6%.

Table 11 Comparison of Climate Change Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	Period	Change from Baseline (1961 to 1990)	
		Temperature [°C]	Precipitation [%]
CCSR/NIES	annual	+1.0 to +1.7	-1.7 to +5.5
	summer	+1.0 to +1.7	-3.4 to +8.6
	winter	-0.1 to +1.0	-4.6 to -1.9
CGCM2	annual	+1.6 to +1.8	-1.5 to +12.6
	summer	+1.2 to +1.6	-11.0 to +12.2
	winter	+0.8 to +3.1	-5.9 to +8.8
CSIRO MK2	annual	+1.7 to +2.5	+2.1 to +6.1
	summer	+0.9 to +1.2	-8.1 to +3.1
	winter	+2.1 to +3.1	+7.7 to +18.0
ECHAM4/OPYC3	annual	+2.1 to +2.3	-14.3 to -6.3
	summer	+1.7 to +2.2	-22.0 to -10.0
	winter	+3.0 to +3.2	-6.5 to +0.8
GFDL R30	annual	+1.4 to +1.5	+1.1 to +2.9
	summer	+1.2 to +2.2	-12.4 to +4.5
	winter	+0.9 to +1.9	+3.4 to +6.0
HadCM3	annual	+0.8 to +1.5	+5.3 to +10.1
	summer	+1.2 to +1.6	-0.4 to +7.1
	winter	+0.2 to +2.2	+7.4 to +18.1

While all of the forecast information is valuable, it is not practical to evaluate the potential effects for every possible scenario. The challenge of selecting the appropriate scenarios to be evaluated can be addressed by using the approach of Burn (2003). Specifically, model forecasts are ranked in ascending order by annual average temperature, summer (i.e., June, July and August) average temperature, winter (i.e., December, January and February) average temperature, annual precipitation, summer precipitation and winter precipitation. Temperature has priority over precipitation in the ranking. Within each of the six ranking methods, the combinations of models and scenarios are ranked and the temperature and precipitation changes for the 3rd highest (88th percentile), 12th highest (approximately the median) and 23rd highest (12th percentile) scenarios are determined. Burn (2003) recommended using the 86th percentile forecasts in environmental assessments in the Mackenzie Valley, which are approximated by the 3rd highest ranked values in Table 12.

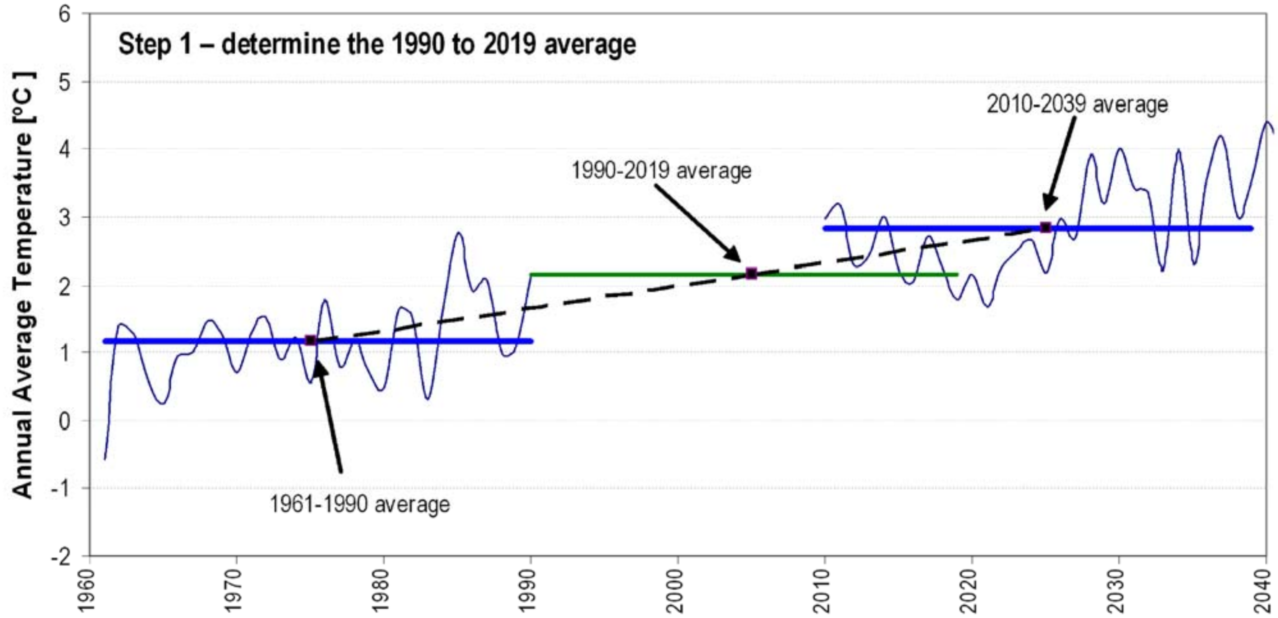
Table 12 Summary of Ranked Climate Scenarios Based on Change Relative to Baseline (1961 to 1990)

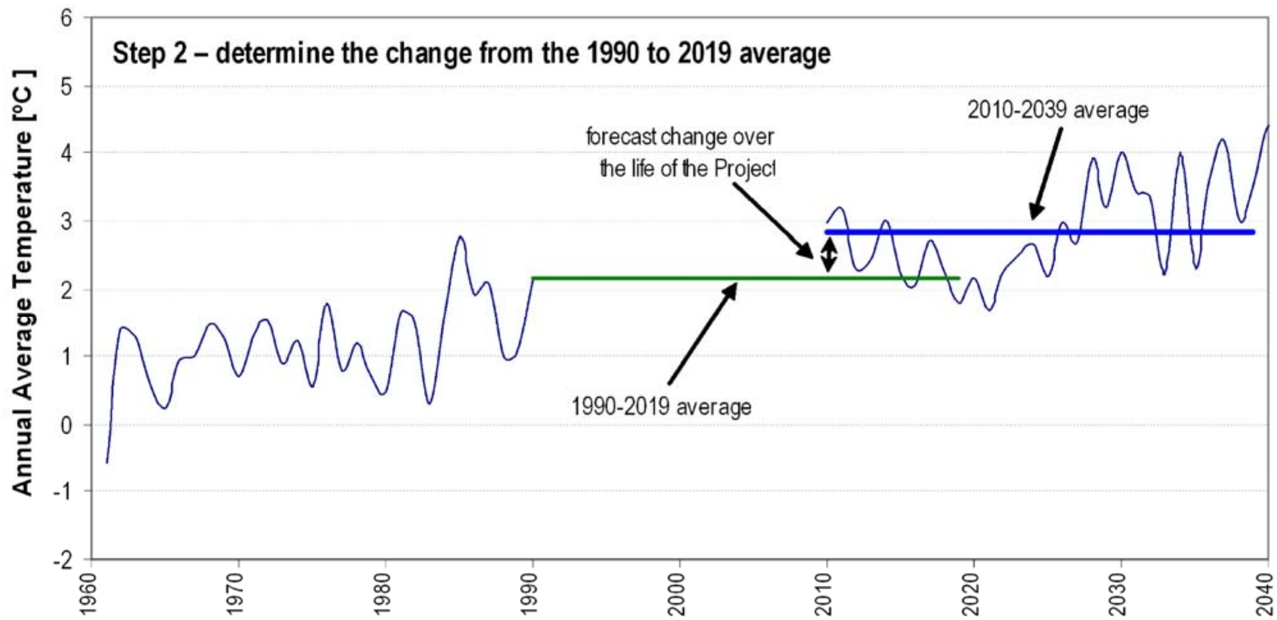
Ranking Method	Rank	Model and SRES Scenario	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
annual temperature	3rd highest	CSIRO Mk2–B1(1)	+2.2	+3.2
	12th highest	CCSR/NIES–A1(1)	+1.6	+0.0
	23rd highest	HadCM3–A2(3)	+1.0	+5.9
summer temperature	3rd highest	ECHAM4/OPYC3-B2(1)	+1.7	-10.0
	12th highest	HadCM3–A1FI	+1.5	+6.6
	23rd highest	CSIRO Mk2–B1(1)	+1.1	+1.8
winter temperature	3rd highest	CSIRO Mk2–B2(1)	+3.1	+7.7
	12th highest	GFDL R30–A2(1)	+1.9	+6.0
	23rd highest	HadCM3–B2(1)	+0.5	+16.2
annual precipitation	3rd highest	HadCM3–A2(2)	+1.5	+10.0
	12th highest	CCSR/NIES–B2(1)	+1.7	+5.5
	23rd highest	CCSR/NIES–A2(1)	+1.0	-1.7
summer precipitation	3rd highest	HadCM3–B1(1)	+1.2	+7.1
	12th highest	CSIRO Mk2–A2(1)	+0.9	+3.1
	23rd highest	CGCM2–A2(1)	+1.6	-11.0
winter precipitation	3rd highest	HadCM3–B2(1)	+0.5	+16.2
	12th highest	HadCM3–A2(3)	+0.9	+7.7
	23rd highest	CCSR/NIES–A1T	-0.1	-4.6

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

2.3.2 Climate Change Over the Project Life

While the forecast climate change relative to the baseline presented in Section 2.3.1 is interesting from an academic perspective and for comparison to historic observations, these predictions do not indicate how the climate might change over the life of the Project. To determine how climate might change over the life of the Project, it is necessary to determine the difference between the climate near the end of the Project life, represented by the 30-year average for 2010 to 2039, and the 30-year average centred on the current conditions. This acknowledges that some of the changes in climate since the baseline period will have already occurred. Therefore, the current period is represented by the 30-year period from 1990 to 2019, which was scaled for each model/scenario combination using the baseline and 2010 to 2039 forecasts as illustrated in Figure 5.





PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

DETERMINING CLIMATE CHANGE
OVER THE PROJECT LIFE

Golder Associates
Calgary, Alberta

PROJECT 06-1346-003.9300			FILE No. Determining Change..	
DESIGN	LD	06/08/09	SCALE AS SHOWN	REV. 0
CADD	TRE	25/08/09	**FIGURE: 5**	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

Future changes in temperature and precipitation have been determined for each of the 26 model and scenarios combinations. Tables 13 to 18 provide a summary of the forecast change over the life of the Project (i.e., difference between 2010 to 2039 average and 1990 to 2019 average) for the Cold Lake area.

Table 13 CCSR/NIES Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
CCSR/NIES	A1T	annual	+0.4	-0.3
		summer	+0.4	-0.8
		winter	0.0	-1.8
CCSR/NIES	A1(1)	annual	+0.6	n/a
		summer	+0.5	n/a
		winter	+0.4	n/a
CCSR/NIES	A2(1)	annual	+0.4	-0.7
		summer	+0.4	-1.4
		winter	+0.1	-0.9
CCSR/NIES	B1(1)	annual	+0.5	+1.6
		summer	+0.4	+3.5
		winter	+0.4	-0.9
CCSR/NIES	B2(1)	annual	+0.7	+2.2
		summer	+0.7	+2.2
		winter	+0.4	-0.8

n/a = Precipitation data are not available for the A1(1) scenario.

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 14 CGCM2 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
CGCM2	A2(1)	annual	+0.6	-0.6
		summer	+0.6	-4.4
		winter	+0.3	-1.0
CGCM2	A2(2)	annual	+0.7	+5.0
		summer	+0.5	+4.9
		winter	+1.0	+3.5
CGCM2	A2(3)	annual	+0.7	+3.7
		summer	+0.5	+2.5
		winter	+1.2	+2.8
CGCM2	A2(x)	annual	+0.7	+2.5
		summer	+0.5	+0.7
		winter	+0.9	+1.6
CGCM2	B2(1)	annual	+0.6	+0.1
		summer	+0.6	-1.4
		winter	+0.8	-2.4

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 15 CSIRO Mk2b Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
CSIRO Mk2b	A1(1)	annual	+0.8	+1.2
		summer	+0.5	-3.2
		winter	+0.8	+5.0
CSIRO Mk2b	A2(1)	annual	+0.7	+2.4
		summer	+0.4	+1.2
		winter	+0.9	+7.2
CSIRO Mk2b	B1(1)	annual	+0.9	+1.3
		summer	+0.4	+0.7
		winter	+1.0	+3.3
CSIRO Mk2b	B2(1)	annual	+1.0	+0.9
		summer	+0.5	-0.1
		winter	+1.2	+3.1

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 16 ECHAM4/OPYC3 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
ECHAM4/OPYC3	A2(1)	annual	+0.9	-5.7
		summer	+0.9	-8.8
		winter	+1.2	-2.6
ECHAM4/OPYC3	B2(1)	annual	+0.8	-2.5
		summer	+0.7	-4.0
		winter	+1.3	+0.3

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 17 GFDL R30 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
GFDL R30	A2(1)	annual	+0.6	+1.2
		summer	+0.5	+1.8
		winter	+0.8	+2.4
GFDL R30	B2(1)	annual	+0.5	+0.4
		summer	+0.9	-4.9
		winter	+0.4	+1.3

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

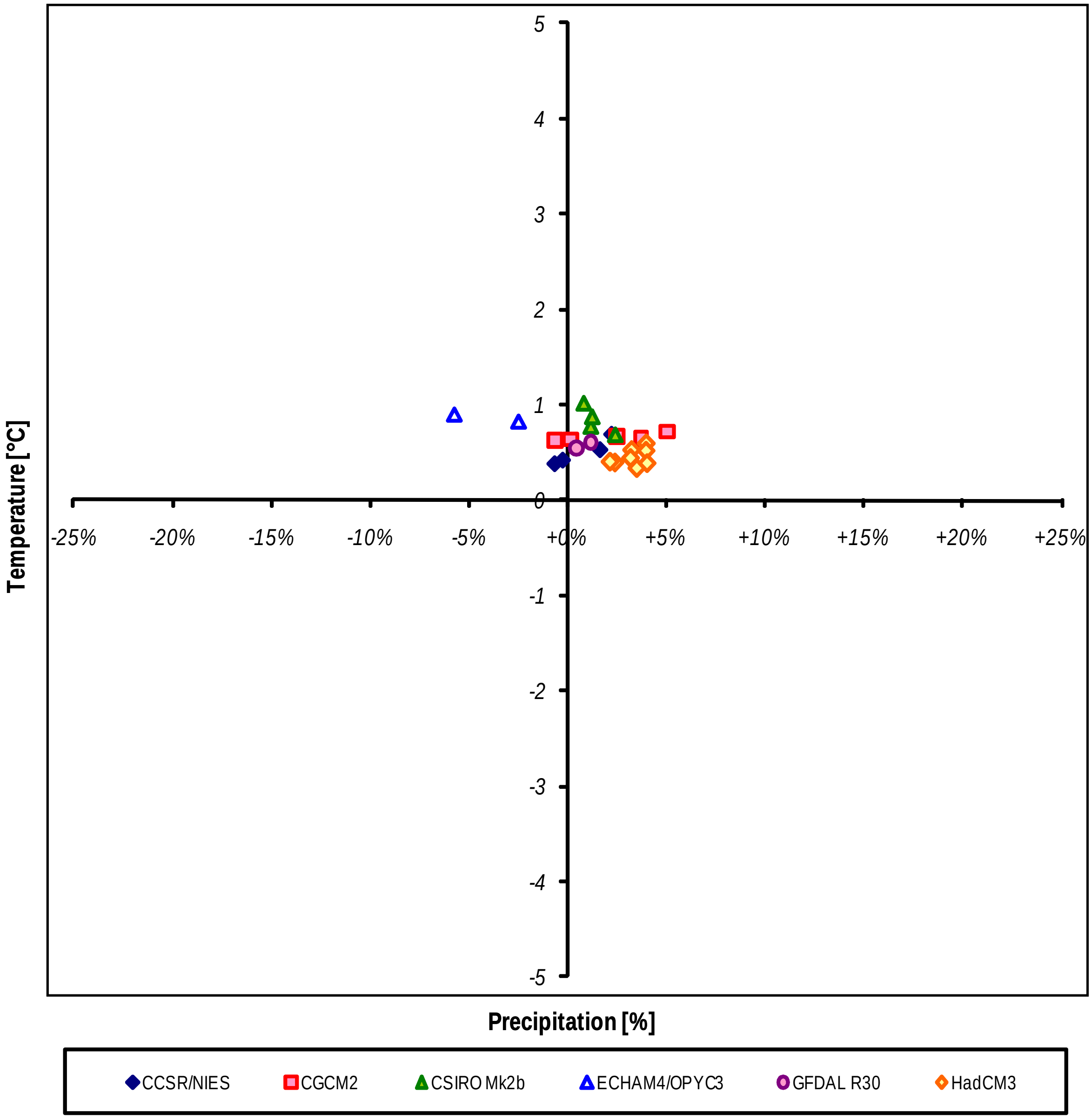
Table 18 HadCM3 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario	Season	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
HadCM3	A1FI	annual	+0.5	+3.2
		summer	+0.6	+2.6
		winter	+0.5	+3.4
HadCM3	A2(1)	annual	+0.3	+3.5
		summer	+0.6	+2.4
		winter	+0.1	+3.0
HadCM3	A2(2)	annual	+0.6	+4.0
		summer	+0.6	+2.7
		winter	+0.9	+7.2
HadCM3	A2(3)	annual	+0.4	+2.4
		summer	+0.6	+2.4
		winter	+0.4	+3.1
HadCM3	A2(x)	annual	+0.4	+3.2
		summer	+0.6	+2.5
		winter	+0.4	+4.4
HadCM3	B1(1)	annual	+0.5	+4.0
		summer	+0.5	+2.8
		winter	+0.6	+5.0
HadCM3	B2(1)	annual	+0.4	+4.0
		summer	+0.6	+0.5
		winter	+0.2	+6.5
HadCM3	B2(2)	annual	+0.4	+2.1
		summer	+0.6	-0.2
		winter	+0.4	+3.7

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Figure 6 illustrates the forecast changes in annual precipitation and temperature over the life of the Project. The forecasted changes in the summer and winter temperature and precipitation are illustrated in Figure 7.

Table 19 provides a summary of the forecast changes in temperature and precipitation over the life of the Project. Annual forecast changes in temperature range from 0.3 to 1.0°C. Annual forecast changes in precipitation range from -5.7 to +5.0%.



PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

FORECAST ANNUAL CLIMATE CHANGE OVER THE PROJECT LIFE

Golder Associates
Calgary, Alberta

PROJECT 06-1346-003.9300			FILE No. Forecast Annual...Life	
DESIGN	LD	06/08/09	SCALE AS SHOWN	REV. 0
CADD	TRE	17/08/09	**FIGURE: 6**	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

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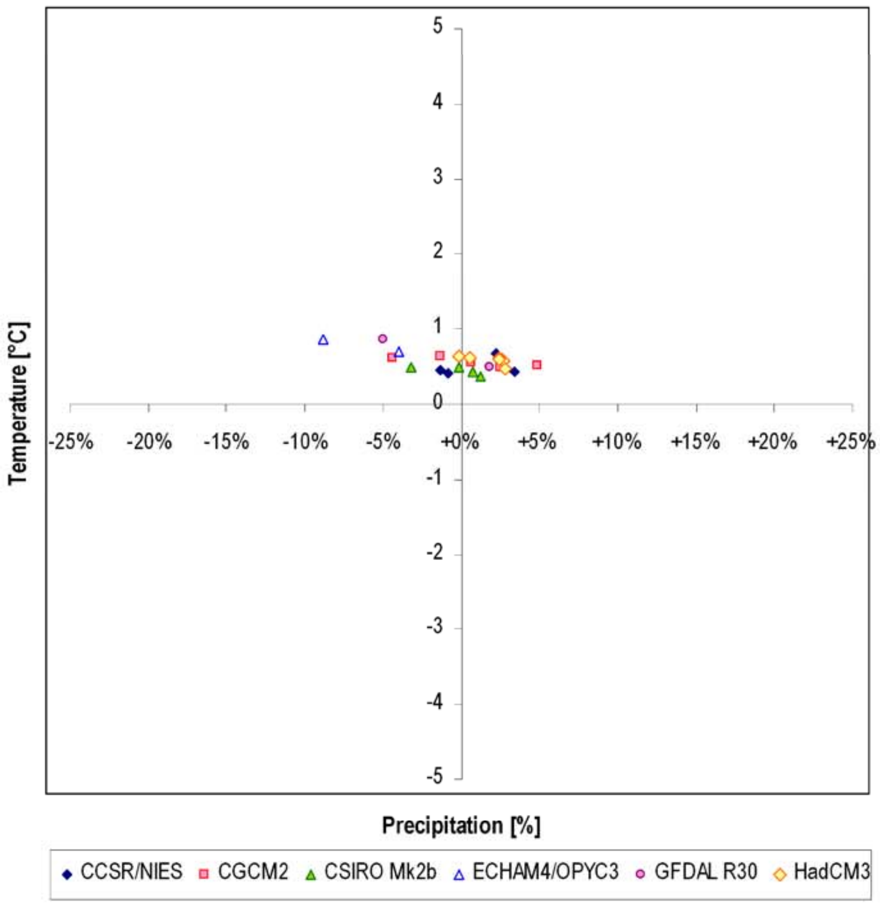
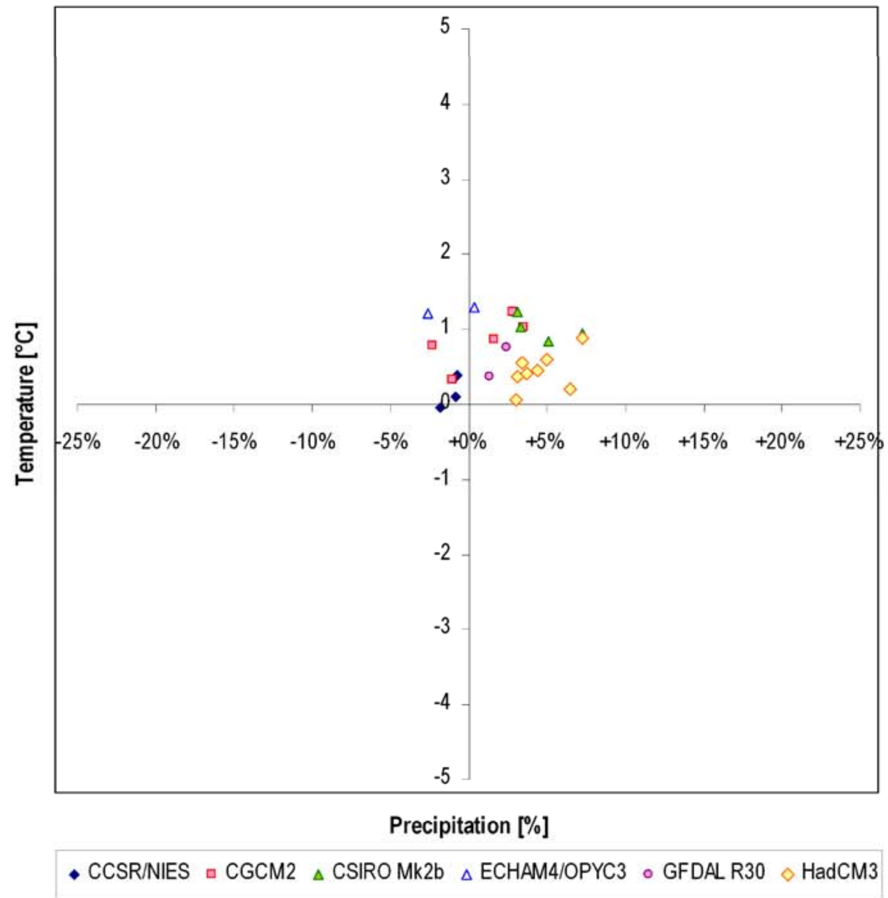


Summer



Winter

PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

FORECAST SUMMER AND WINTER CLIMATE CHANGE OVER THE PROJECT LIFE

Golder Associates
Calgary, Alberta

PROJECT	06.1346.003.9300		FILE No.	Forecast Summ...Life
DESIGN	LD	06/08/09	SCALE AS SHOWN	REV. 0
CADD	TRE	17/08/09		
CHECK	LD	18/09/09	**FIGURE: 7**	
REVIEW	IGG	18/09/09		

Table 19 Comparison of Climate Change Values Over the Project Life

Climate Model	Period	Change Over Life of Project	
		Temperature [°C]	Precipitation [%]
CCSR/NIES	annual	+0.4 to +0.7	-0.7 to +2.2
	summer	+0.4 to +0.7	-1.4 to +3.5
	winter	0.0 to +0.4	-1.8 to -0.8
CGCM2	annual	+0.6 to +0.7	-0.6 to +5.0
	summer	+0.5 to +0.6	-4.4 to +4.9
	winter	+0.3 to +1.2	-2.4 to +3.5
CSIRO MK2	annual	+0.7 to +1.0	+0.9 to +2.4
	summer	+0.4 to +0.5	-3.2 to +1.2
	winter	+0.8 to +1.2	+3.1 to +7.2
ECHAM4/OPYC3	annual	+0.8 to +0.9	-5.7 to -2.5
	summer	+0.7 to +0.9	-8.8 to -4.0
	winter	+1.2 to +1.3	-2.6 to +0.3
GFDL R30	annual	+0.5 to +0.6	+0.4 to +1.2
	summer	+0.5 to +0.9	-4.9 to +1.8
	winter	+0.4 to +0.8	+1.3 to +2.4
HadCM3	annual	+0.3 to +0.6	+2.1 to +4.0
	summer	+0.5 to +0.6	-0.2 to +2.8
	winter	+0.1 to +0.9	+3.0 to +7.2

As discussed in the previous section, the approach from Burn (2003) was used for choosing scenarios to evaluate climate change in northern Canada. The model forecasts were ranked by annual, summer and winter average temperature, as well as the annual, summer and winter precipitation. For each of the six ranking methods, the combinations of models and scenarios have been ranked and the temperature and precipitation changes for the 3rd highest (88th percentile), 12th highest (approximately the median) and 23rd highest (12th percentile) scenarios determined. The ranked model scenarios are provided in Table 20.

Table 20 Ranked Forecast Scenarios for Climate Change Over the Project Life

Ranking Method	Rank	Model and SRES Scenario	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
annual temperature	3rd highest	CSIRO Mk2b–B1(1)	+0.9	+1.3
	12th highest	CCSR/NIES–A1(1)	+0.6	n/a
	23rd highest	HadCM3–A2(3)	+0.4	+2.4
summer temperature	3rd highest	ECHAM4/OPYC3–B2(1)	+0.7	-4.0
	12th highest	HadCM3–A1FI	+0.6	+2.6
	23rd highest	CSIRO Mk2b–B1(1)	+0.4	+0.7
winter temperature	3rd highest	CSIRO Mk2b–B2(1)	+1.2	+3.1
	12th highest	GFDL R30–A2(1)	+0.8	+2.4
	23rd highest	HadCM3–B2(1)	+0.2	+6.5

Table 20 Ranked Forecast Scenarios for Climate Change Over the Project Life (continued)

Ranking Method	Rank	Model and SRES Scenario	Change Over Project Life	
			Temperature [°C]	Precipitation [%]
annual precipitation	3rd highest	HadCM3–A2(2)	+0.6	+4.0
	12th highest	CCSR/NIES–B2(1)	+0.7	+2.2
	23rd highest	CCSR/NIES–A2(1)	+0.4	-0.7
summer precipitation	3rd highest	HadCM3–B1(1)	+0.5	+2.8
	12th highest	CSIRO Mk2b–A2(1)	+0.4	+1.2
	23rd highest	CGCM2–A2(1)	+0.6	-4.4
winter precipitation	3rd highest	HadCM3–B2(1)	+0.2	+6.5
	12th highest	HadCM3–A2(3)	+0.4	+3.1
	23rd highest	CCSR/NIES–A1T	-0.0	-1.8

n/a = Not available.

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

2.4 MODEL SCENARIOS FOR USE IN ENVIRONMENTAL ASSESSMENTS

As outlined in Sections 2.3.1 and 2.3.2, the climate models and scenarios were ranked by annual, summer and winter average temperature, as well as the annual, summer and winter precipitation. For each ranking methods, the 3rd highest (88th percentile), 12th highest (approximately the median) and 23rd highest (12th percentile) scenarios were determined. For the purposes of the environmental assessment, the combinations of models and scenarios that yielded the 3rd highest changes in annual, summer and winter temperatures along with the 3rd and 23rd highest changes in annual, summer and winter precipitation over the Project life will be carried forward into the assessment. These nine combinations of models and scenarios are consistent with the Indian and Northern Affairs Canada (INAC) recommendations for representing the upper bounds for changes in temperature and upper and lower bounds for changes in precipitation. Tables 21 to 29 show the results of these combinations and the upper bounds. For reference, the tables include the change from the baseline information for each model forecast.

Table 21 provides the predicted changes for the upper annual temperature scenario, corresponding with the CSIRO Mk2b–B1(1) model forecast. This scenario and model combination yielded the 3rd highest forecast of annual temperature change.

Table 21 Future Climate Trend Forecasts — Upper Annual Temperature

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
CSIRO Mk2b–B1(1)	annual	+2.2	+3.2	+0.9	+1.3
	spring	+3.2	+11.6	+1.3	+4.6
	summer	+1.1	+1.8	+0.4	+0.7
	fall	+1.8	-8.7	+0.7	-3.5
	winter	+2.6	+8.2	+1.0	+3.3

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 22 provides the climate change for the upper summer temperature scenario, corresponding with the ECHAM4/OPYC3–B2(1) model forecast. This scenario and model combination yielded the 3rd highest forecast of summer temperature change, which corresponds with the 88th percentile prediction.

Table 22 Future Climate Trend Forecasts — Upper Summer Temperature

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
ECHAM4/OPYC3–B2(1)	annual	+2.1	-6.3	+0.8	-2.5
	spring	+1.5	-9.3	+0.6	-3.7
	summer	+1.7	-10.0	+0.7	-4.0
	fall	+1.8	-6.6	+0.7	-2.7
	winter	+3.2	+0.8	+1.3	+0.3

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 23 provides the climate change for the upper winter temperature scenario, corresponding with the CSIRO Mk2b–B2(1) model forecast. This scenario and model combination yields the 3rd highest forecast (i.e., 88th percentile prediction) of winter temperature change.

Table 23 Future Climate Trend Forecasts — Upper Winter Temperature

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
CSIRO Mk2b–B2(1)	annual	+2.5	+2.1	+1.0	+0.9
	spring	+3.8	+10.9	+1.5	+4.4
	summer	+1.2	-0.3	+0.5	-0.1
	fall	+2.0	-9.8	+0.8	-3.9
	winter	+3.1	+7.7	+1.2	+3.1

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 24 provides the climate change for the upper annual precipitation scenario that corresponds with the HadCM3–A2(2) model forecast. This scenario and model combination yielded the 3rd highest forecast of annual precipitation change (i.e., 88th percentile prediction).

Table 24 Future Climate Trend Forecasts — Upper Annual Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
HadCM3–A2(2)	annual	+1.5	+10.0	+0.6	+4.0
	spring	+0.8	+7.7	+0.3	+3.1
	summer	+1.5	+6.7	+0.6	+2.7
	fall	+1.5	+7.4	+0.6	+3.0
	winter	+2.2	+18.1	+0.9	+7.2

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 25 provides the climate change for the upper summer precipitation scenario that corresponds with the HadCM3–B1(1) model forecast. This scenario and model combination yielded the 3rd highest (i.e., 88th percentile) forecast of summer precipitation change.

Table 25 Future Climate Trend Forecasts — Upper Summer Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
HadCM3–B1(1)	annual	+1.3	+9.9	+0.5	+4.0
	spring	+1.3	+8.3	+0.5	+3.3
	summer	+1.2	+7.1	+0.5	+2.8
	fall	+1.2	+11.9	+0.5	+4.7
	winter	+1.5	+12.5	+0.6	+5.0

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 26 provides the climate change for the upper winter precipitation scenario that corresponds with the HadCM3–B2(1) model forecast. This scenario and model combination yielded the 3rd highest forecast of winter precipitation change (i.e., 88th percentile prediction).

Table 26 Future Climate Trend Forecasts — Upper Winter Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
HadCM3–B2(1)	annual	+1.0	+10.1	+0.4	+4.0
	spring	+0.5	+19.7	+0.2	+7.9
	summer	+1.5	+1.3	+0.6	+0.5
	fall	+1.4	+3.1	+0.6	+1.2
	winter	+0.5	+16.2	+0.2	+6.5

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 27 provides the climate change for the lower annual precipitation scenario that corresponds with the CCSR/NIES–A2(1) model forecast. This scenario and model combination yielded the 23rd highest (12th percentile) forecast of annual precipitation change.

Table 27 Future Climate Trend Forecasts — Lower Annual Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
CCSR/NIES–A2(1)	annual	+1.0	-1.7	+0.4	-0.7
	spring	+1.6	+2.3	+0.6	+0.9
	summer	+1.1	-3.4	+0.4	-1.4
	fall	+0.8	-3.7	+0.3	-1.5
	winter	+0.3	-2.1	+0.1	-0.9

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 28 provides the climate change for the lower summer precipitation scenarios that corresponds with the CGCM2–A2(1) model forecast. This scenario and model combination yielded the 23rd highest forecast (12th percentile) change for annual precipitation.

Table 28 Future Climate Trend Forecasts — Lower Summer Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
CGCM2–A2(1)	annual	+1.6	-1.5	+0.6	-0.6
	spring	+3.0	+8.5	+1.2	+3.4
	summer	+1.6	-11.0	+0.6	-4.4
	fall	+0.8	-1.2	+0.3	-0.5
	winter	+0.8	-2.5	+0.3	-1.0

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

Table 29 provides the climate change for the lower winter precipitation scenario that corresponds with the CCSR/NIES–A1T model forecast. This scenario and model combination yielded the 23rd highest (i.e., 12th percentile) forecast of winter precipitation change.

Table 29 Future Climate Trend Forecasts — Lower Winter Precipitation

Climate Model	Season	Change from Baseline (1961 to 1990)		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
CCSR/NIES-A1T	annual	+1.1	-0.7	+0.4	-0.3
	spring	+2.5	+4.1	+1.0	+1.6
	summer	+1.0	-2.0	+0.4	-0.8
	fall	+0.8	-0.3	+0.3	-0.1
	winter	-0.1	-4.6	-0.0	-1.8

Note: Shaded row indicates 3rd highest ranking for titled climate parameter.

3 EFFECT OF CLIMATE CHANGE ON AIR QUALITY PREDICTIONS

3.1 INTRODUCTION

Changing climate could alter some meteorological parameters that could, in turn, affect air quality and the EIA air predictions. The primary linkages between climate change and air quality are summarized in Table 30. Each of the linkages listed in the table will be discussed separately below.

Table 30 Primary Links Between Climate Change and Air Quality

Precipitation	Temperature	Wind Speed
Acid Deposition		
Higher rainfall rates would result in higher wet deposition and Potential Acid Input (PAI). Lower rainfall rates would result in lower wet deposition and PAI.	Increased temperatures during the spring could result in more of the precipitation falling in the form of rain, which would result in higher wet deposition and PAI.	no linkage
Atmospheric Dispersion		
no linkage	no linkage	Higher wind speeds tend to enhance dispersion resulting in lower short-term concentrations. Lower wind speeds tend to hinder dispersion resulting in higher short-term concentrations.
Ground-Level Ozone		
no linkage	Increased temperatures could result in an enhanced potential for ozone formation.	no linkage

3.2 ACID DEPOSITION

As per Table 30, increased rainfall could lead to higher wet deposition. Since frozen precipitation is a relatively small contributor to PAI, warming temperatures that could cause a shift from snowfall to rainfall create a small incremental contribution to PAI.

Of the scenarios identified, the greatest effect on the PAI predictions is likely to occur with the upper summer precipitation case because summer rainfall has the greatest effect on PAI. As shown in Table 20 and detailed in Table 25, the HadCM3 model with the B1(1) scenario yielded the 3rd highest or 88th percentile estimates for changes in summer precipitation over the Project life. The forecasts associated with this scenario and model are reproduced in Table 31.

Table 31 Upper Bound Forecasts for Changes in Summer Precipitation Over the Project Life

Climate Model	Season	Precipitation Change [%]	
		Change Between Baseline and 2010 to 2039	Change Over Project Life
HadCM3–B1(1)	annual	+9.9	+4.0
	spring	+8.3	+3.3
	summer	+7.1	+2.8
	fall	+11.9	+4.7
	winter	+12.5	+5.0

Since the current GCMs do not have the resolution necessary to simulate all of the parameters necessary to model PAI, it is not feasible to model this specific scenario. However, it is possible to compare the 2002 meteorological data set used to model PAI in the Project region with the observed climate normals to see whether the current predictions can offer an indication of how changing climate may affect the PAI.

Table 32 compares the 2002 meteorological data set, that was used to model PAI to the 1961 to 1990 Cold Lake climate normals. The annual precipitation during 2002 was 37.7% lower than normal and rainfall was 45.8% lower during the summer months.

Table 32 Comparison of 2002 Precipitation to Climate Normal

Season	1961 to 1990 Normals [mm]	2002 Observation [mm]	Difference from Normals for 2002 Observation [%]
annual	432.4	269.3	-37.7
spring	78.7	73.0	-7.2
summer	221.9	120.3	-45.8
fall	76.8	52.0	-32.3
winter	54.6	24.0	-56.0

In contrast, the upper bound summer precipitation forecast for scenario B1(1) from the HadCM3 model indicated a change in summer precipitation of +7.1% from the baseline.

The average summer precipitation in 2002 was 46% lower than normal which would result in lower deposition rates than could be expected in the future.

As discussed in the air emission effects assessment (Volume 3, Section 4), the effects of acidifying emissions on soils, vegetation, and lakes and streams are considered negligible as a result of the Project. Because of these negligible changes and the short-term nature of the Project, climate change is not expected to alter the conclusions of the acidification assessment.

3.3 ATMOSPHERIC DISPERSION

Table 33 presents a summary of the range of forecast wind speed changes from the baseline and over the Project life. Forecast changes in wind speed range from -3.1 to +9.2% over the Project life.

Table 33 Comparison of Forecast Changes in Wind Speed

Climate Model	Period	Wind Speed Change [%]	
		Change Between the Averages of Baseline and 2010 to 2039	Change Over Project Life
CCSR/NIES	annual	-5 to -0.9	-3.1 to -0.6
	summer	-3.1 to +1.7	-1.9 to +1.1
	winter	-8.3 to +0.1	-5.2 to 0
CGCM2	annual	+5.4 to +5.4	+3.4 to +3.4
	summer	+1.5 to +1.5	+0.9 to +0.9
	winter	+8.5 to +8.5	+5.3 to +5.3
CSIRO MK2	annual	-1.9 to -0.4	-1.2 to -0.2
	summer	-5.2 to -3.9	-3.3 to -2.5
	winter	-1.5 to +4	-0.9 to +2.5
ECHAM4/OPYC3	annual	+6.2 to +6.8	+3.8 to +4.3
	summer	-2.4 to -1.1	-1.5 to -0.7
	winter	+14 to +14.7	+8.8 to +9.2
GFDL R30[a]	annual	n/a	n/a
	summer	n/a	n/a
	winter	n/a	n/a
HadCM3	annual	-1.2 to +2.8	-0.7 to +1.8
	summer	-3.8 to -1.4	-2.4 to -0.9
	winter	+0.2 to +9.5	+0.1 to +5.9

[a] Wind speed data were not provided for this model.

n/a = Not available.

Table 34 shows the forecast change in wind speed for the ranked scenarios over the Project life (as shown in Table 20). Generally, lower wind speeds are associated with increased ground-level concentrations. Therefore, the lower bound predictions from Table 34 represent the conditions most likely to affect the air quality predictions. Available GCMs do not have the resolution necessary to simulate all of the parameters necessary to complete dispersion modelling for the Project region. However, it is possible to compare the 2002 meteorological data set used in the modelling with the observed Cold Lake climate normals and forecast trends.

Table 34 Summary of Climate Scenarios for Wind Speed

Ranking Method	Rank	Model and SRES Scenario	Wind Speed Change [%]	
			Change Between the Averages of Baseline and 2010 to 2039	Change Over Project Life
annual temperature	3rd highest	CSIRO Mk2b–B1(1)	-0.4	-0.2
	12th highest	CCSR/NIES–A1(1)	n/a	n/a
	23rd highest	HadCM3–A2(3)	+0.4	+0.2
summer temperature	3rd highest	ECHAM4/OPYC3–B2(1)	+0.5	+0.2
	12th highest	HadCM3–A1FI	-2.1	-0.9
	23rd highest	CSIRO Mk2b–B1(1)	-0.8	-0.3
winter temperature	3rd highest	CSIRO Mk2b–B2(1)	+0.4	+0.1
	12th highest	GFDL R30–A2(1)	n/a	n/a
	23rd highest	HadCM3–B2(1)	+1.6	+0.7
annual precipitation	3rd highest	HadCM3–A2(2)	+0.4	+0.1
	12th highest	CCSR/NIES–B2(1)	-1.7	-0.7
	23rd highest	CCSR/NIES–A2(1)	-1.8	-0.7
summer precipitation	3rd highest	HadCM3–B1(1)	-2.7	-1.1
	12th highest	CSIRO Mk2b–A2(1)	-0.3	-0.1
	23rd highest	CGCM2–A2(1)	+4.8	+1.9
winter precipitation	3rd highest	HadCM3–B2(1)	+1.6	+0.7
	12th highest	HadCM3–A2(3)	+1.3	+0.5
	23rd highest	CCSR/NIES–A1T	-7.0	-2.8

n/a = Not available.

Note: SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 35 shows how the average wind speeds in 2002 compared to the long-term normals for the region. During 2002, the annual wind speeds were 6.6% below the climate normals. The difference between the 2002 annual average wind speed and the baseline normal (-6.6%) is similar to the largest forecast change in wind speed of -7.0%.

Table 35 Comparison of 2002 Average Wind Speeds to Climate Normals

Season	Average Wind Speed [km/hr] 1961 to 1990 Normals	2002 Observation	Difference from Normals for 2002 [%]
annual	12.1	11.3	-6.6
spring	13.1	13.3	1.5
summer	12.3	12.2	-0.8
fall	12.2	10.9	-10.7
winter	10.6	8.8	-17.0

Table 36 shows the frequency of occurrence of different wind speed categories for the 1961 to 1990 normals and 2002. Overall, 2002 had about the same number of calm hours as the normals and about 5% more hours with wind speeds less than 10 km/hr.

Table 36 Comparison of Wind Speed Categories

Wind Speed Category	Frequency of Occurrence [%] 1961 to 1990 Normals	2002 Observation	Difference from Normals for 2002 [%]
calm	11.8	11.7	-0.1
1 to 5 km/hr	8.7	10.4	1.7
6 to 10 km/hr	25.8	29.1	3.3
11 to 15 km/hr	23.1	22.4	-0.7
16 to 20 km/hr	15.2	14.1	-1.1
>20 km/hr	15.5	12.2	-3.3

Depending on the models considered, the average wind speeds in the Cold Lake Region are predicted to either increase (i.e., enhanced dispersion) or decrease (i.e., reduced dispersion). However, 2002 data used to model concentrations in the region had average wind speeds below historic observation and had a greater number of hours with lower wind speeds. Therefore, it is expected that the 2002 wind speed data used in the assessment of climate change and air quality results in ground-level concentrations that are higher than those if historic normals were used. The impacts of climate change are not expected to affect the conclusions of the air quality assessment.

3.4 GROUND-LEVEL OZONE

Ozone is an essential part of the upper atmosphere that protects us from most of the sun's harmful ultra-violet radiation. Ozone can also be present at the earth's surface. Ground-level ozone in Canada can be the result of photochemical ozone formation, stratospheric intrusion and long-range transport.

The meteorological conditions ideally suited to the formation of ground-level ozone are rare in northern Alberta. This has led to suggestions that photochemical ozone formation is not possible in northeastern Alberta because the region does not experience the necessary weather conditions. Monitoring data from the region has shown patterns of ozone concentrations that are consistent with photochemical ozone formation (i.e., hourly ozone concentrations that rise to peak levels near the middle of the day and then fall off rapidly at night). However, the low number of hours when the observed ozone readings were above the Alberta Ambient Air Quality Objectives (AAAQOs) suggests that photochemical reactions are relatively weak in the region. This is likely due to the relatively cool regional temperatures compared to the optimal conditions for ozone formation (i.e., more than 25°C). However, changing climate may result in higher temperatures and enhance the potential for photochemical ozone formation in the region.

Summer temperature is one of the climate parameters likely to affect ground-level ozone concentrations. The forecasts from the ECHAM4/OPYC3 model for scenario B2(1) yielded the upper summer temperatures over the life of the Project. Table 37 summarizes the climate trends forecast for that model and scenario combination (reproduced from Table 22).

Table 37 Upper Bound Forecasts for Changes in Summer Temperature Over the Project Life

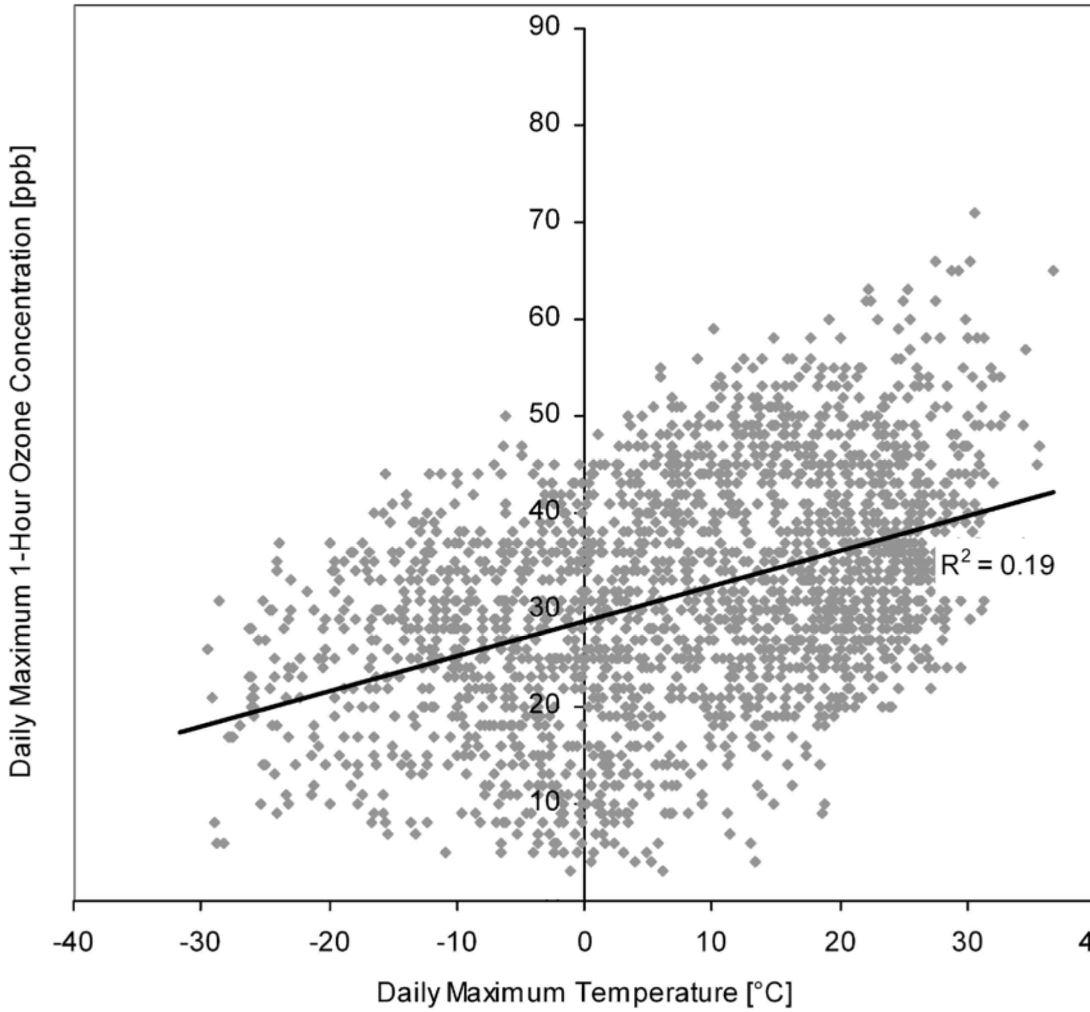
Climate Model	Season	Temperature Change [°C]	
		Change between the averages of Baseline and 2010 to 2039	Change over Project Life
ECHAM4/OPYC3–B2(1)	annual	+2.1	+0.8
	spring	+1.5	+0.6
	summer	+1.7	+0.7
	fall	+1.8	+0.7
	winter	+3.2	+1.3

While higher summer temperatures could result in an increased potential for ground-level ozone formation in the region, this relationship is not clearly evident from the monitoring results from stations operated by the Wood Buffalo Environmental Association (WBEA). Figure 8 presents a comparison of daily maximum temperatures and the corresponding 1-hour maximum ozone concentration. This data was collected at the WBEA Athabasca Valley Station from 1998 through 2004. Monitoring results at the Patricia McInnes, Fort McKay and Fort Chipewyan stations demonstrate similar patterns as those shown in Figure 8.

As illustrated in Figure 8, there is a weak positive correlation between maximum temperature and peak ozone concentrations (R^2 = 0.19, assuming a linear trend). On days when temperatures are greater than 30ºC, ozone concentrations range from approximately 24 to 71 ppb. There are also high ozone concentrations occurring during periods when the daily maximum temperature is below 0ºC. Although the upper summer temperature forecast change of +0.7°C (Table 37) over the life of the Project may result in increased daily maximum temperatures, this may not correspond to increased peak ozone concentrations. It is predicted that these changes may not correspond to peak ozone concentrations.

3.5 SUMMARY

In conclusion, the air quality predictions in the assessment are considered representative of conditions over the life of the Project since the 2002 meteorological data (temperature and wind speed) cover the range of climate forecast values. Due to lower precipitation amounts, the use of 2002 data in the air modelling may underestimate deposition rates that may be expected in the future. The effect of climate change on ground-level ozone concentrations is not clearly established; however, current observations show that an increase in temperature may not correspond to increased peak ozone concentrations.



PROJECT

ENCANA

CHRISTINA LAKE
THERMAL EXPANSION PROJECT
PHASES 1E, 1F AND 1G

TITLE

COMPARISON OF DAILY MAXIMUM TEMPERATURES AND DAILY MAXIMUM 1-HOUR OZONE CONCENTRATIONS

Golder Associates
Calgary, Alberta

PROJECT 06-1346-003.9300			FILE No. Comparison DailyMax	
DESIGN	LD	06/08/09	SCALE AS SHOWN	REV. 0
CADD	GMF	12/08/09	**FIGURE: 8**	
CHECK	LD	18/09/09		
REVIEW	IGG	18/09/09		

L:\2006\1344-OIL SANDS\1346\06-1346-003\9300\9315\Fig 8 Comparison-DailyMax.dwg Sep 18, 2009 - 2:21pm

4 EFFECT OF CLIMATE CHANGE ON HYDROGEOLOGY PREDICTIONS

4.1 INTRODUCTION

Climate change forecasts from six GCMs are discussed in Section 2 of this Appendix. The GCMs were used to predict changes in temperature and precipitation for as many as six different IPCC scenarios. Forecast results for the 2010 to 2039 period in the Cold Lake area are compared to baseline data collected at Cold Lake over a 30-year baseline period of 1961 to 1990. The forecast results predict average annual temperatures will increase between 0.8 and 2.5˚C and the average annual precipitation rate will decrease as much as 14.3% or increase as much as 12.6%.

All else being equal, an increase in temperature could increase evaporation rates and therefore decrease groundwater recharge rates and water levels. Given that the predicted change in temperature is relatively small and that the range of predicted change in precipitation is relatively large, a change in temperature of the predicted magnitude is expected to have no direct measurable effect on groundwater levels in comparison to the effect due to the predicted change in precipitation levels. Changes in precipitation within the predicted range may affect shallow groundwater availability and surface water-groundwater interactions.

Decreased precipitation rates may lower the shallow water table resulting in decreased discharge to surface waterbodies and decreased recharge from shallow, near-surface aquifers to deeper aquifers. Conversely an increase in precipitation rates may raise the shallow water table and increase the amount of discharge to surface waterbodies and recharge to deep aquifers.

The primary linkages between climate change and hydrogeology are summarized in Table 38 and evaluated with respect to EIA predictions in the following discussion.

Table 38 Primary Links Between Climate Change and Hydrogeology

Hydrogeology Attribute	Change in Temperature (Increase)	Change in Precipitation	
		Increase	Decrease
water levels/aquifer productivity	no detectable effect	More recharge would result in higher water levels and aquifer productivity.	Less recharge would result in lower water levels and aquifer productivity.
change in groundwater flux	no detectable effect	More recharge would result in more groundwater discharge to surface waterbodies and deeper aquifers.	Less recharge would result in less groundwater discharge to surface waterbodies and deeper aquifers.
water quality	no linkage	no linkage	no linkage

4.2 DISCUSSION

In the Project area, groundwater in the Quaternary, Tertiary and Cretaceous hydrostratigraphic units are recharged by surface water and precipitation. Baseline climate data have been collected at Cold Lake over a 30-year period from 1961 to 1990. The average annual precipitation rate between 1961 and 1990 is 432.4 mm/year.

Shallow groundwater levels are known to fluctuate as a result of seasonal changes in precipitation. In periods of lower relative precipitation (fall and winter) recharge decreases and groundwater levels drop. In periods of higher relative precipitation (summer), recharge increases and groundwater levels rise. The effects of seasonal fluctuations generally decrease with increasing depth from surface. Seasonal changes in hydraulic head become muted and are ultimately undetectable when separated from surface by sufficient distance or low permeability hydrostratigraphic units.

Similar to these observed seasonal fluctuations, the average shallow groundwater level in the Project area will likely increase or decrease over time in response to changes in the annual precipitation rate. If the annual precipitation rate decreases, groundwater levels in the shallow sediments will likely decrease, resulting in decreased discharge to surface waterbodies and underlying aquifers (specifically the Empress Channel and Mannville aquifers including the Middle Clearwater and McMurray Aquifers). If the annual precipitation rate increases, groundwater levels in the shallow sediments will likely increase, resulting in increased discharge to surface waterbodies and underlying aquifers.

4.3 PROJECT IMPACTS AND UNCERTAINTIES INTRODUCED BY CLIMATE CHANGE

The Project requires up to 10,210 m^3/d of saline make-up water for the operation of the Project. This water will be sourced primarily from the Middle Clearwater and the McMurray aquifers, which occur at depths of approximately 290 and 400 mbgs, respectively. An additional 450 m^3/d of groundwater will be sourced from the Empress Channel Aquifer and used for utility purposes. The potential for groundwater withdrawal to decrease shallow groundwater levels and impact surface waterbodies was assessed in Volume 4, Section 5.1 of this application. Make-up water withdrawal associated with the Project is not expected to result in detectable drawdown in near surface aquifers. Similarly no detectable change in groundwater discharge to or from surface waterbodies is predicted to occur over the timeframe of the Project.

As discussed above, climate change may result in changes in precipitation and therefore changes in groundwater conditions. In the scenario of decreased precipitation, the following changes to groundwater conditions may occur:

- lowering of the water table;
- decreased discharge to surface waterbodies; and
- decreased recharge to underlying aquifers.

In the scenario of increased precipitation the following changes to groundwater conditions may occur:

- rising of the water table;
- increased discharge to surface waterbodies; and
- increased recharge to underlying aquifers.

These potential climate-related changes represent an effect to groundwater resources but are independent of the predicted effects related to make-up water withdrawal. Most specifically related to this assessment, is the potential change in recharge to the Empress and Mannville aquifers. Over time, water levels in the Empress and Mannville aquifers would potentially respond to a climate change related long-term increase or decrease in precipitation. This effect however will be substantially muted and temporally delayed as compared to water level changes in the uppermost aquifers. Given that climate-related water level changes in the Empress Channel, Middle Clearwater and McMurray aquifers will be slight (possibly non-detectable) and may not occur during the lifetime of the Project, the uncertainties related to climate change with respect to the conclusions of the Empress and Mannville hydrogeologic impact assessment are judged to be negligible.

Ongoing water level monitoring in the Empress Channel, Middle Clearwater and McMurray aquifers and selected overlying aquifers will be conducted throughout the lifetime of the Project. If observed water level changes differ significantly with respect to water level changes predicted in this assessment, adjustments to project operation may be required.

4.4 SUMMARY

The Hydrogeology Impact Assessment Methodology and impact assessment results (Volume 4, Section 5.1) support the following conclusions regarding climate change and its influence on hydrogeology:

- climate change is predicted to result in higher temperatures and either increased or decreased precipitation in the Project area;
- the potential effect to groundwater levels, aquifer productivity and change in groundwater flux as a result of the predicted increase in temperature is interpreted to be non-detectable in comparison to the effect due to the predicted changes in precipitation;
- the climate related changes in precipitation may result in three changes to shallow hydrogeology: an increase or decrease of the water table, increased or decreased discharge to surface waterbodies, and increased or decreased recharge to deeper aquifers;
- the climate-related impacts would exist whether groundwater withdrawal associated with the Project was occurring or not; and
- the impact assessment results for the Project are not sensitive to the uncertainties related to climate change.

5 EFFECT OF CLIMATE CHANGE ON HYDROLOGY PREDICTIONS

5.1 INTRODUCTION

The potential effects of the Project on local and regional hydrology were assessed in Volume 4, Section 5.2 of this application. Surface runoff, streamflows and lake levels are the result of the interaction between many factors including vegetation, surficial geology and climate. Climate change therefore has the potential to impact key climatic factors, most notably precipitation and temperature, which affect hydrology. Table 39 summarizes the hydrologic variables that may be impacted by climate change due to changes in temperature and precipitation.

Table 39 Primary Links Between Climate Change and Hydrology

Hydrology Attribute	Change in Temperature (Increase)	Change in Precipitation	
		Increase	Decrease
open water areas and lake water levels	increased evaporation and therefore decreased lake levels and open water areas (if precipitation unchanged or decreased)	increased lake levels and open water areas (unless offset by temperature increase)	decreased lake levels and open water areas
streamflows	increased evaporation and evapotranspiration and therefore decreased streamflows (if precipitation unchanged or decreased)	increased streamflows (unless offset by temperature increase)	decreased streamflows
stream geomorphic conditions and suspended sediments	no direct linkage	if extreme rainfall events increase in magnitude or frequency, potential for increased erosion, suspended sediment loads and geomorphic change	decreased precipitation will result in decrease channel forming flows and hence change in stream geomorphology

5.2 REVIEW OF KEY CLIMATE FACTORS WITH AN INFLUENCE ON HYDROLOGY

Section 2 of this Appendix evaluated the potential impacts of climate change on precipitation and temperature over the Project life, as well as historic climate change as measured by a comparison of climate normals for the Cold Lake meteorological station.

The analysis of climate normals for Cold Lake for the periods 1951 to 1980, 1961 to 1990 and 1971 to 2000 were presented in Section 2.2 of this appendix. The results of this may be summarized as follows:

- mean annual temperatures increased over the three periods from 1.2°C (1951 to 1980) to 1.5°C (1961 to 1990) to 1.8°C (1971 to 2000); and
- mean annual precipitation decreased from 461 mm to 432 to 427 mm for the same periods.

Mean temperature and precipitation for each season (spring, summer, fall and winter) followed similar trends.

To predict changes in temperature and precipitation over the life of the Project, forecasts from individual GCMs were employed. The GCM model forecasts were ranked by annual, summer and winter average temperature, as well as the annual, summer and winter precipitation. For each of the six ranking methods, the combinations of models and scenarios were ranked and the temperature and precipitation changes for the 3rd highest (88th percentile), 12th highest (approximately the median) and 23rd highest (12th percentile) scenarios. A summary of the forecasted changes in temperature and precipitation over the Project life (i.e., the change from 2010 to 2039) and between the 1961 to 1990 climate normals and 2039 are provided in Table 40. This table summarizes the information presented in Tables 21 through 27 in Section 2.4.

Table 40 Summary of Future Climate Trend Forecasts

Variable	Model	Change from 1961 to 1990 Baseline		Change Over Project Life	
		Temperature [°C]	Precipitation [%]	Temperature [°C]	Precipitation [%]
upper annual temperature	CSIRO Mk2b–B1(1)	+2.2	+3.2	+0.9	+1.3
upper summer temperature	ECHAM4/OPYC3–B2(1)	+1.7	-10.0	+0.7	-4.0
upper winter temperature	CSIRO Mk2b–B2(1)	+3.1	+7.7	+1.2	+3.1
upper annual precipitation	HadCM3–A2(2)	+1.5	+10.0	+0.6	+4.0
upper summer precipitation	HadCM3–B1(1)	+1.2	+7.0	+0.5	+2.8
upper winter precipitation	HadCM3–B2(1)	+0.5	+16.2	+0.2	+6.5
lower annual precipitation	CCSR/NIES–A2(1)	+1.0	-1.7	+0.4	-0.7
lower summer precipitation	CGCM2–A2(1)	+1.6	-11.0	+0.6	-4.4
lower winter precipitation	CCSR/NIES-A1T	-0.1	-4.6	-0.0	-1.8

The results from Table 40 may be summarized as follows:

- The 3rd highest GCM forecasts a temperatures increases of 1.2°C in the winter over the Project life and 3.1°C in winter relative to the 1961 to 1990 climate normals. Smaller summer and annual temperature increases are also forecast. Increases in precipitation are forecast for these model scenarios in winter and annually, but decreases are forecast for summer.
- The 3rd highest GCM forecasts a precipitation increase of 6.5% in winter over the Project life, and of 16.2% relative to the 1961 to 1990 climate normals. The models predict smaller summer and annual precipitation increases, coupled with temperature increases of up to 1.5°C.
- The 3rd lowest GCM predicts decreases in precipitation of 4.4% in summer over the Project life and 11% relative to the 1961 to 1990 normals. Smaller decreases are predicted for annual and winter precipitation. The GCMs predict corresponding temperatures increases from nearly 0 to 1.6°C.

In addition to long-term seasonal and annual changes to temperature and precipitation, there is a possibility of impacts from climate change on extreme precipitation events, which could in turn impact peak runoff rates, and stream erosion and geomorphic stability. Differing opinions exist concerning the historical trends in extreme rainfall events. Frich et al. (2001) showed that the maximum annual five-day total precipitation data for the region show a positive trend of greater than 15% for the period of 1961 to 1990. Other researchers have also reported increases in heavy precipitation, and snowfall amounts north of 55°N (IPCC 2001b; Zhang et al. 2000a,b). However, Hogg and Carr (1985) found that there is a slight but insignificant increase in extreme rainfall across Canada.

5.3 ANALYSIS

While there are some surface water withdrawals for dust suppression, ice road construction and drilling, the primary effect of the Project on surface water hydrology within the Aquatic Resources Local Study Area (LSA) and Regional Study Area (RSA) is due to changes in land surface. Most changes will result in a negligible change or increase in runoff. For example, land types such as roads, cutlines, well pads and much of the plant site will generate higher runoff than the natural watershed, where water is often ponded and prone to evaporation. There are some very small areas, most notably a small portion of the plant sites, from which no runoff will be released, but overall the effect of the Project will be an increase in runoff.

The Project effects on hydrology were evaluated in Volume 4, Section 5.2. Because the surface disturbances due to the Project comprise only a small fraction of the RSA, the impacts on the four watersheds presented in Volume 4, Section 5.2 of the EIA is expected to be negligible. Land disturbances within the RSA represent only 0.2% of the total land area and 1.1% of the most affected sub-watershed (Christina Lake at its outlet). Regionally, therefore, the effects of the Project on hydrology are expected to be negligible. Changes to regional hydrology over the Project life would therefore occur primarily due to the effects of climate change, and would not be appreciably influenced by the Project.

Within the LSA, the potential effects of the Project were considered to be large enough that further assessment was required. Changes to runoff were calculated for each type of land disturbance within the LSA for both the Baseline Case and the Application Case. These results are summarized in Volume 4, Section 5.2. Changes in land use due to the Project are forecast to increase runoff within the LSA by approximately 8% relative to pre-development conditions. Existing and approved developments also contribute to a predicted increase in runoff of 10%, for a total change of 18% relative to pre-development conditions. Potential effects within some watersheds are potentially higher, with predicted runoff increases of up to 23% due to existing and approved projects and the Project. Upon reclamation, the effects of surface disturbances on hydrology will be significantly reduced.

There is a general agreement amongst GCMs of increased temperature within the Project area, and therefore increased evaporation and evapotranspiration is expected. There is less agreement between models on changes to precipitation: the 3rd highest GCMs predict an increases in annual and seasonal precipitation, while the 3rd lowest GCMs predict decreases in annual and seasonal precipitation. The combination of increased temperature and decreased precipitation would result in decreased runoff, while the combination of increased in temperature and precipitation is unclear, and could result in either increased or decreased runoff (and vary seasonally).

Detailed computer modelling would be necessary to quantify the potential changes to hydrology of climate change and changes to land type. This level of investigation was not considered warranted for the level of surface disturbance associated with the Project. However, a qualitative assessment has been made of the combination of the effects of climate change and the Project on surface water hydrology.

If the effect of climate change were an overall decrease in runoff, then this decrease in runoff would be partially or totally offset by the anticipated increases in runoff caused by surface disturbances. After reclamation, the increased runoff caused by Project disturbances would become negligible, and most changes from the present day to local and regional hydrology would be due to climate change alone.

If the effect of climate change were an increase in runoff, then the increased runoff from the Project would add to this increase. This effect would occur if increased runoff were to occur on an annual or seasonal basis, or due to more frequent or extreme precipitation events. The potential effects of increased runoff are increased water supply, larger lake, pond and wetlands surface areas, as well as increased flooding, increased erosion within watercourses and consequent increased suspended solids loads. The latter two effects occur primarily due to increases in peak runoff rather than moderate long-term increases in runoff.

Due to the relatively small and disperse nature of Steam Assisted Gravity Drainage (SAGD) development, it is expected that the impact of the moderate increases in runoff predicted will be negligible due to the generally flat topography of the LSA and RSA, the attenuating effects of ponds, wetlands and large waterbodies such as Christina Lake, and the mitigation measures proposed in Volume 4, Section 3. The latter commits EnCana to several measures designed to reduce the effects of surface disturbances on peak runoff, the most notable being the design of berms and retention ponds to contain and slowly release the 24 hour, 25-year storm event from the well pads and plant and camp sites. These measures will serve to improve the quality of water released to the environment, and will minimize local effects of increased runoff on receiving streams and wetlands.

5.4 SUMMARY

There is considerable uncertainty regarding the magnitude of the potential impacts of climate change on hydrology within the LSA and RSA. However, it is clear that if climate change were to decrease runoff, then the increased runoff Project surface disturbances would either partially or totally offset these climate change induced effects. If climate change were to instead increase runoff, then there would be a net increase in runoff within the LSA and RSA. Potential negative impacts of increased peak runoff include flooding, erosion and geomorphic instability of channels.

Given the relatively small disturbance area occupied by the Project, the generally flat topography of the LSA and RSA, and the attenuating effects of ponds, wetlands and large waterbodies such as Christina Lake, the predicted impact of the Project on local hydrology is small. The predicted changes resulting from climate change are not expected to change the predictions of the EIA.

6 EFFECT OF CLIMATE CHANGE ON SURFACE WATER QUALITY PREDICTIONS

6.1 INTRODUCTION

The Project effects on water quality were assessed in Volume 4, Section 5.3. Climate change has the potential to affect water quality indirectly through changes in hydrologic variables and directly through changes in water temperature (Table 41). A review and discussion of existing studies and information on climate change with reference to surface water quality in the region is provided in Section 6.2. The interrelation of climate change and potential effects of the Project on water quality are described in Section 6.3.

Table 41 Primary Links Between Climate Change and Water Quality

Water Quality Attribute	Change in Temperature (Increase)	Change in Precipitation	
		Increase	Decrease
water quality via changes to water levels and flows	increased evapotranspiration	increases to inflows and outflows of rivers and lakes	decreases to inflows and outflows of rivers and lakes
direct changes to water quality	lower dissolved oxygen concentrations and saturation levels deepening lake thermoclines and longer stratification periods shortening of ice-cover periods	decreases in nutrients and parameter concentrations from changes in residence times and assimilative capacity	increases in nutrients and parameter concentrations from changes in residence times and assimilative capacity

6.2 LITERATURE REVIEW

Most of the existing literature is focused on effects of climate change on meteorological parameters, such as air temperature and precipitation, and not on water quality. Changes to meteorological parameters such as air temperature and precipitation can lead to changes in infiltration, snow cover, evapotranspiration and ultimately, streamflow, which could affect water quality (Chalecki and Gleick 1999; Murdoch et al. 2000). Most of the literature that describes potential effects of climate change on water quality focuses on water temperature, dissolved oxygen and nutrients. Changes in streamflow due to climate warming have the potential to alter prediction of effects on streamflow and sediment loadings to local waterbodies.

Anthropogenic (human-induced) effects, such as changes in land and water use management related to climate change, may have similar or greater impacts on water quality than climate change itself, depending on the region (Cruise et al. 1999; Hutjes et al. 1998; Murdoch et al. 2000). Many studies have focused on differentiating these effects (Cruise et al. 1999; Interlandi and Crockett 2003; Moore et al. 1997; Ramstack et al. 2004; Walker et al. 2000; Worrall et al. 2003). However, anthropogenic effects are not always considered in the literature, so conclusions regarding the effects of climate change on water quality must be carefully evaluated. A summary of key findings is provided below.

Increased air temperatures are expected to increase surface water temperatures and result in shorter ice-covered periods in rivers and lakes (Beltaos 2000; Cohen 1995, 1997a; Fang and Stefan 1997, 2000; Fang et al. 1999; Jansen and Hesslein 2004; Magnuson et al. 1997; Ozaki et al. 2003; Prowse and Beltaos 2002; Stefan et al. 1993). Shorter ice-covered periods should allow biochemical reactions that normally cease during anoxic (i.e., ice cover) conditions to occur for a longer period, because of increased aeration.

Warmer water temperature would also favour algal growth during the open-water period and could increase rates of microbial action and weathering, which in turn may result in increased rates of nutrient loading to lakes. Overall, these changes may be reflected in increased primary productivity, or the accumulation of greater algal biomass in standing waters (Rouse et al. 1997). Increased biological activity could lead to increased oxygen demands, with a net result of lower overall dissolved oxygen concentrations in the water column. In addition, dissolved oxygen saturation levels decrease with rising water temperature, limiting the volume of oxygen in the water column (Thomann and Mueller 1987).

Climate change may also lead to changes in lake hydrodynamics. Warmer water temperatures could lead to deepened thermoclines and alter the ratio of water present in the epilimnion and hypolimnion. Stefan et al. (1993) expect longer stratification periods for certain types of lakes, which may prevent lake mixing and thereby limit the influx of oxygen from the surface to the hypolimnion. Temperate dimictic lakes (i.e., those that mix twice a year) may become monomictic (i.e., mix once a year), and cold monomictic lakes may become stratified (Hostetler and Small 1999; Magnuson et al. 1997; Schindler 1997; Stefan et al. 1993). Maxwell et al. (1997) and Schindler (2001) also concluded that warmer air temperatures and lower streamflows could lead to the reduction, if not the disappearance, of many wetlands. Since some wetlands act as purification facilities, water chemistry in some receiving streams may also change.

Some studies have been completed on the effect of climate and anthropogenic changes on targeted water quality parameters (Boesch et al. 2001; Boorman 2003; Cruise et al. 1999; Interlandi and Crockett 2003; Moore et al. 1997; Ramstack et al. 2004; Struyf et al. 2004; Walker et al. 2000; Worrall et al. 2003). Differences in water temperature due to climate change could potentially result in changes in solubility (Thomann and Mueller 1987). Most of the studies focus on nutrients, which is generally an issue in densely populated areas with heavy agricultural activities. Limited attention has so far been given to metals or organics.

Based on these studies it appears that the main pathway for effects on water quality may be through changes in surface flow. For example, warmer air temperatures may gradually increase evaporation, which could lead to a reduction in water levels and flows in lakes and rivers. This reduction in assimilative capacity could, subsequently, lead to increased in-stream concentrations. The linkage between warmer air temperature and reduced surface water flow has not, however, been clearly established (Section 5.2), as the various climate change models presented in Section 2.1 predict either increases or decreases in precipitation, with increased temperature.

6.3 ANALYSIS

Although some climate change effects on water quality cannot be ruled out, past modelling experience for oil sands EIAs suggests that the effects on water quality resulting from increased air and water temperatures would likely be small and not measurable (Shell 2005). Similarly, climate change is not expected to measurably affect the predicted effects of the Project on water quality.

There is a general agreement amongst GCMs of increased temperature within the area occupied by the Project. Increased air temperatures resulting from climate change are likely to increase the temperature of surface waters. This could increase algal productivity in the surface waters (Rouse et al. 1997) resulting in lower nutrient levels and increased oxygen demand. These affects, however, are independent of the Project and increases in temperature will not change any of the Project's affects on the surface waters.

There is not a strong agreement between models on changes to precipitation: the 3rd highest GCMs predict relatively large increases in precipitation, while the 3rd lowest GCMs predict decreases. Increased precipitation could lead to increased site runoff (Section 5.3); however, with mitigation measures proposed in Volume 4, Section 3 of the EIA it is expected that site runoff will be contained as much as possible and it is not expected than increased runoff will have a significant effect on the surface water quality. The increased site runoff could also be limited by the increased evaporation due to the predicted temperature increase (Section 5.3).

Project-related activities have the potential to effect water quality through an increase in suspended sediments in surface water runoff and the release of treated domestic wastewater (Volume 4, Section 5.3). Based on the anticipated management of both the surface water runoff and the treated domestic water, the effects on surface water quality due to these processes were predicted to be negligible (Volume 4, Section 5.3). The management practices are not expected to change as a result to changes in the climate. Thus, the conclusions of the water quality assessment are not expected to change.

6.4 SUMMARY

Based on EnCana's proposed management of runoff, no effects are predicted on water quality from this pathway. Under climate change scenarios evaluated in this assessment, the conclusions of the water quality assessment would remain unchanged.

7 EFFECT OF CLIMATE CHANGE ON FISH AND FISH HABITAT PREDICTIONS

7.1 INTRODUCTION

Changing climate could alter some watercourse and waterbody parameters that could, in turn, affect fish and fish habitat and associated EIA predictions. The primary links between climate changes and fish and fish habitat are summarized in Table 42.

Table 42 Primary Links Between Climate Change and Fish and Fish Habitat

Fish and Fish Habitat Attribute	Change in Water Temperature (Increase)	Change in Precipitation	
		Increase	Decrease
changes to stream discharge	increased evapotranspiration	increases to inflows and outflows of rivers and lakes decreases in lake residence times increase in size and location stream habitats increased connectivity between waterbodies	decreases to inflows and outflows of rivers and lakes increases in lake residence times reduction in size and location of stream habitats reduced connectivity between waterbodies
changes to water levels	increased evapotranspiration from surface of lakes and rivers	increase in size and location of littoral and pelagic zone, wetlands and stream habitats	reduction in size and location of littoral and pelagic zone, wetlands and stream habitats
changes to water quality and aquatic thermal regimes	lower dissolved oxygen concentrations and saturation levels deepening lake thermoclines and longer stratification periods shorter ice-covered periods	decreases in nutrients and parameter concentrations from changes in residence times and assimilative capacity	increases in nutrients and parameter concentrations from changes in residence times and assimilative capacity

7.2 APPROACH

The approach included a literature review to compile existing information concerning the effects of climate change on freshwater fish populations and fish habitats, with emphasis on northern Alberta. This information was used as a basis for a general evaluation of the potential cumulative effects of the Project under climate change. The results of the literature review are presented in Section 7.3. The assessment was also based on the outcome of the analyses conducted by the hydrology (Section 5.3) and water quality (Section 6.3) components to assess the effects of climate change on watercourses and waterbodies in the Aquatic Resources LSA and RSA.

Specific predictions regarding changes in water temperature and thermal regime effects on fish and fish habitat due to climate change were not completed as there are no predicted affects of the Project on thermal regime in any watercourse or waterbody and, therefore, no predicted cumulative effects resulting from climate change.

7.3 LITERATURE REVIEW

Annual surface temperatures have generally increased during the 20th century (as described in Section 5.2). This increase in global average surface temperatures is said to have been accompanied by retreat of glaciers and a reduction in the duration of lake and river ice cover by two weeks in the middle and high latitudes of the northern hemisphere (Shuter et al. 2002). It is predicted that global surface temperatures will continue to increase with the most pronounced effects occurring at high latitudes and during the winter. Greater variation in precipitation and increased frequency of droughts and floods are also predicted (Shuter et al. 2002).

Human-induced climate change scenarios for northern Canada include further temperature increases (Reist 1994). Climate changes are expected to be accompanied by more extreme variation in precipitation as well as continued reductions in periods of ice cover for lakes and rivers. Climate changes are expected to have both indirect and direct physical effects on aquatic environments in northern parts of Canada (Von Finster 2001, internet site). Many of these physical changes are interrelated but for practical purposes can be placed into five categories:

- changes to water budget;
- changes to aquatic thermal regimes;

- changes to water quality;
- reduced system stability; and
- changes to aquatic connectivity.

With consideration of the Project area, potential linkages of climate change to physical changes to aquatic systems within each of these five categories include the following:

1) Changes to Water Budget:

- changes to total inflow of surface waters;
- increased evaporation from the surface of lakes and rivers;
- reduced outflow from lakes; therefore, reduced flows to outlet streams and rivers, resulting in the dewatering of stream channels downstream of the outlets;
- reduced recharge of aquifers located upslope of the lakes;
- modifications to river flow;
- modifications to water level and volume of lakes;
- modifications to size and location of marginal habitats such as the littoral zones, wetlands and stream banks; and
- changes to residence time of water in lakes.

2) Changes to Aquatic Thermal Regimes:

- warmer average water temperatures;
- earlier onset of stratification in lakes;
- changes in evaporation;
- warmer and deeper hypolimnion in lakes;
- warmer groundwater source;
- shorter winters and longer summers; and
- reduced ice cover and earlier ice-off.

3) Changes to Water Quality:

- changes to oxygen availability (e.g., reduced oxygen under increasing water temperature);
- changes to the availability of nutrients due to changes in lake residence times and inflow;
- altered density of groundwater discharges; and
- changes to turbidity as a result of lower sedimentation which can lead to greater light penetration and thus productivity.

4) Reduced System Stability:

- more frequent flooding events;
- more frequent drought events;
- increased deposition of organic or inorganic sediments into streams; and
- fluctuating water levels.

5) Changes to Aquatic Connectivity:

- reduced connectivity between waterbodies due to the transition of permanent streams to ephemeral waterbodies; and
- decreased connectivity of waterbodies under reduced surface and groundwater conditions (fragmentation).

Changes to the aquatic ecosystem as a result of the climate change relationships described above can potentially result in changes to growth, recruitment and abundance of fish populations, changes to fisheries yields, changes to geographical distribution of fish species, changes to fish health and changes to species diversity and community composition.

7.4 ANALYSIS

This section provides an assessment of the possible cumulative effects of climate change on the specific predictions for the Project related to fish and fish habitat that are sensitive to the possible relationships provided above. These relationships include potential effects on fish habitat, fish abundance, fish health, and fish and fish habitat diversity.

There were no residual impacts predicted in the Fish and Fish Habitat assessment for the Project for changes in fish health, fish abundance, and fish and fish habitat diversity. The linkage analysis for effects on fish habitat was considered to be valid through the pathway of increased sediment deposition associated with construction of watercourse crossings, and direct changes to fish habitat and benthic invertebrate communities from watercourse crossings. The direction of the effect from watercourse crossings was considered to be negative and negligible in magnitude.

Therefore, there was no environmental consequence of the Project on fish habitat, fish health or fish abundance. As potential effects were considered to result in no or negligible residual impacts, the cumulative effects of climate change would not be expected to change the overall effects assessment and classification for the Project.

As discussed in the hydrology component (Section 5), Project effects (i.e., on stream discharge, water levels and channel morphology) were considered to be negligible and short-term, and mitigated as appropriate; the potential longer-term effects (i.e., beyond the operational life of the Project) of climate change are not likely to be influenced by the Project.

Climate change is also not expected to measurably affect the predicted effects of the Project on water quality (Section 6). Based on the mitigation measures and management practices to be employed, effects on surface water quality were predicted to be negligible.

As described above, any additional changes to stream discharge, water levels, channel morphology and water quality due to the effects of climate change were predicted to be negligible; thus, predicted changes to fish habitat, fish abundance, fish health, or fish and fish habitat diversity for the Project due to climate change were also considered to be negligible over the operational life of the Project.

7.5 SUMMARY

Predicted changes to fish habitat, fish abundance, fish health, and fish and fish habitat diversity for the Project under climate change scenarios evaluated in this assessment would remain unchanged from the Fish and Fish Habitat assessment.

8 EFFECT OF CLIMATE CHANGE ON TERRESTRIAL RESOURCES PREDICTIONS

8.1 INTRODUCTION

The evaluation of the potential effects of climate change on terrestrial resources predictions considers the potential effects that climate change may have on vegetation, soils and wildlife (Table 43).

Soil is a part of the natural world that is both affected by and contributes to climate change. Research indicates that climate change threatens to significantly affect soil in a variety of ways. This is discussed further in Section 8.3.2.

Potential vegetation responses to climate change include: persistence in the modified climate, migration to more suitable climates or extinction. Potential persistence outcomes include: gradual genetic adaptation of populations, phenotypic plasticity (individual variations in properties produced by given genotypes in conjunction with the environment), or ecological buffering (edaphic climax as opposed to climatic climax) (Theurillat and Guisan 2001). Evidence in the fossil record concerning past climate change has indicated that species are more likely to respond by migration as opposed to adapting genetically. Thus, increased temperature could result in migration of species to traditionally cooler areas, including migration further north and higher in elevation (Theurillat and Guisan 2001).

Table 43 Primary Links Between Climate Change and Terrestrial Resources

Terrestrial Resources Attribute	Precipitation	Temperature
Soil and Terrain	• Increased precipitation would lead to increased leaching of soil nutrients in some soils, especially if temperature is increasing decomposition. • Decreased precipitation could lead to a decrease in soil moisture possibly reducing root and microbial activity, negatively effecting litter decomposition and soil respiration. • Increased precipitation could lead to short-term positive increases in gross nitrogen (N) mineralization and hence nutrient availability. • Increased precipitation is predicted to cause sustained high mineralization and nitrification rates. Changes to soil biogeochemistry resulting in increases in N mineralization levels could result in short-term increases in vegetation productivity.	• Increased winter air temperatures could affect snowpack depth which affects soil temperature and both the start and length of the growing season. Furthermore, a reduced snowpack would reduce soil moisture which in combination with higher summer temperatures, may lead to an increase in summer soil moisture stress for vegetation. • Changes in air temperature are expected to result in chemical, hydrological and biological changes in the soil environment. For example: changes to the structure (e.g., horizon development), productivity, nutrient status, quality, litter composition and decay, and nutrient cycling. • As the air temperature increases, decomposition occurs more rapidly, which may potentially contribute to climate change.

Table 43 Primary Links Between Climate Change and Terrestrial Resources (continued)

Terrestrial Resources Attribute	Precipitation	Temperature
Vegetation	• Changes in precipitation have the potential to effect vegetation through changes in soil properties including moisture and temperature.	• Warm and dry summer conditions increase respiration rates, reduce photosynthate production, reduce leaf area, and reduce energy reserves. • With increased temperatures, as areas become drier, fire return intervals are expected to become shorter and fire intensities are expected to increase. • Warm summer temperatures lengthen the growing season by accelerating snowmelt. • Changes in the climate could lead to changes in the development pattern of species, affecting inter-specific and dependant relationships within natural communities. • Spatial distribution and species composition of the boreal forests are expected to change with the anticipated change in climate. • Climate change will not cause species mortality but will alter competitive interaction among plants. Increased temperature could result in migration of species to traditionally cooler areas.
Wildlife	• Reductions in precipitation could lower water levels during fall and winter, which could reduce the probability of spring flooding in wetlands and deltas, affecting wildlife species that utilize these habitats.	• Wildlife species with a body size of more than 1kg will be most affected by shifts in landscape structure associated with the rapid forest cover changes from wildfires. • Changing fire patterns will likely affect the distribution of caribou.

8.2 APPROACH

An evaluation of the historic changes in temperature and precipitation as well as the predicted changes in the future was completed for the Project. The possible changes in temperature and precipitation were then considered in the evaluation of effects to soils and vegetation for the success of what will be a reclaimed landscape for the Project. However, given the complex nature of soils and vegetation responses to changes in climate, it is not possible to accurately assess how Project effects are affected by predicted climatic changes. Thus, specific information concerning project effects on soils and vegetation in relation to climate change are not described. Instead, a general assessment of possible vegetation and soils responses is presented from a review of the literature, from which general conclusions can be drawn.

8.3 ANALYSIS

8.3.1 Potential Future Changes in Temperature

The reclaimed landscape for the Project will be planted with typical boreal forest vegetation communities. These vegetation communities are found at various latitudes and elevations throughout the boreal forest and are exposed to a range of climatic conditions. To determine a range of temperatures in the boreal forest, temperature data from Athabasca, Alberta was chosen to reflect the warmer extent of temperatures and Yellowknife, North West Territories (NWT) was chosen to represent the cooler extent of temperatures. An analysis of temperature data from Athabasca to Yellowknife was performed to evaluate whether predicted future temperatures in the Cold Lake area will be within the range of temperatures currently experienced in the boreal forest region. Climate normal data is taken from the Canadian Climate Normals 1971 to 2000 (Environment Canada 2007a, internet site).

Average annual temperatures in the boreal forest range from 2.1°C (Athabasca) to –4.6°C (Yellowknife) (Environment Canada 2007a, internet site). The average annual temperature in Cold Lake is 1.7°C. The predicted future climate trends indicate that the average annual temperature is expected to rise between +0.4 and +1.3°C in the Cold Lake area over the life of the Project (Table 21 and Table 22). Based on these predicted trends, annual average temperatures in the Cold Lake may potentially fall outside of the range of average annual temperatures currently experienced in the boreal forest. Consequently, an increase in average annual temperature could result in changes in the spatial distribution and composition of plant species in the Cold Lake region reflective of a warmer climate.

The minimum monthly temperatures observed in Athabasca and Yellowknife are –19.9 and –30.9°C, respectively (Environment Canada 2007a, internet site). The minimum monthly temperature in Cold Lake is –21.7°C, with future climate trends predicting between a +1.0 to +1.2°C increase in minimum monthly temperatures over the life of the Project (Table 21 and Table 23). This predicted trend indicates that minimum monthly temperatures in the Cold Lake area will be within the temperature range already being experienced in the boreal forest region.

The maximum monthly temperatures observed in Athabasca and Yellowknife are 22.2 and 21.1°C, respectively (Environment Canada 2007a, internet site). The maximum monthly temperature in Cold Lake (22.9°C) is currently warmer than the maximums observed in the boreal forest. This suggests that maximum monthly temperatures in the boreal forest are more localized phenomena. The future climate trends for maximum monthly temperatures in Cold Lake are predicted to increase between +0.4 and +0.7°C over the life of the Project. Although the future monthly maximum temperature for Cold Lake is predicted to be higher than other boreal forest regions in Alberta or the NWT, it is still within the temperature range experienced by other boreal forest regions in Canada. For example, the monthly maximum temperature at Bissett, Manitoba is 24.9°C.

Tables 21 to 29 model climatic variables applicable to vegetation growth and the predicted future normals to 2039. Upper summer temperature, and upper and lower precipitation account for the growing season and moisture availability required for vegetation development. An average summer temperature between 16.3 and 16.6°C is predicted for the Cold Lake region. Average winter temperatures are expected to range between –14.5 and –13.2°C. Annual rainfall is predicted to vary from 416.5 to 444.3 mm per year.

Table 44 lists the climate ranges for all tree species found in the RSA. As a major component of boreal vegetation communities, tree species show the range of climate variation for which boreal species are adapted. The forecasted Cold Lake normals for between 2010 and 2039 are within these species ranges of tolerances (Section 2.4).

Table 44 Boreal Tree Species' Ranges of Climatic Tolerance

Tree Species	Summer (July) Mean Temperature [°C]	Lowest Mean Temperature [°C]	Highest Mean Temperature [°C]	Mean Annual Precipitation [mm]
aspen	16 to 23	-34 to -61	32 to 41	180 to 1,020
balsam poplar	12 to 24	-18 to -62	30 to 44	150 to 1,400
paper birch	13 to 21	n/d	n/d	300 to 1,520
jack pine	13 to 22	-21 to -46	29 to 38	250 to 1,400
white spruce	13 to 21	-29 to -54	34 to 43	250 to 1,270
black spruce	16 to 24	-34 to -62	27 to 41	380 to 760
tamarack	13 to 24	-29 to -62	29 to 43	180 to 1,400
balsam fir	16 to 18	n/d	n/d	390 to 1,400

n/d = No data.

Note: Table adapted from Burns and Honkala (1990).

8.3.2 Soil Responses to Climate Change

The primary result of increased air temperatures are subsequent increases in soil temperatures (Golder 2005; Gundersen et al. 2006; Nakawatase and Peterson 2006). Increased winter air temperatures could also affect snowpack depth (Nakawatase and Peterson 2006). Snowpack depth affects soil temperature and both the start and length of the growing season (Körner 1995). Furthermore, a reduced snowpack would reduce soil moisture (Nakawatase and Peterson 2006), which in combination with higher summer temperatures, may lead to an increase in summer soil moisture stress for vegetation.

Changes in air temperature are also expected to result in chemical, hydrological and biological changes in the soil environment (Golder 2005). Changes to the structure (e.g., horizon development), productivity, nutrient status and quality may be a result of warming soils. A variety of research predicts changes in the rates of soil/litter decomposition and nutrient cycling (Gundersen et al. 2006; Jamieson et al. 1999; Price et al. 1999). Changes in soil decomposition rates/litter decay rates are predicted to increase between 4 to 7% in northern Alberta (Golder 2005).

Many researchers have also suggested that increased precipitation would lead to increased leaching of soil nutrients in some soils, especially if temperature is increasing decomposition. Conversely, a decrease in soil moisture under warming and decreased precipitation could reduce root and microbial activity, negatively effecting litter decomposition and soil respiration (Luo and Zhou 2006). Jamieson et al. (1999) predicted short-term positive increases in gross nitrogen (N) mineralization and hence nutrient availability. Gundersen et al. (2006) also predicted sustained high mineralization and nitrification rates. Another report found that the response to temperature increases was an increase of 46% in net nitrogen mineralization (Rustad et al. 2001). Boreal forest growth is strongly limited by the availability of nitrogen in the soils (Jerabkova et al. 2006). Changes to soil biogeochemistry resulting in increases in nitrogen mineralization levels could result in short-term increases in vegetation productivity.

Greenhouse gases increase levels of carbon dioxide (CO_2) and nitrogen (N) deposition to the soils. While both may act as a fertilizer, nitrogen deposition is also speculated to acidify soils and reduce tree growth in some circumstances (Loehle 2003). Soil is one of the largest sources of carbon in the world (Soil-Net 2006, internet site). It is primarily accumulated through plants which "fix" the carbon from carbon dioxide (CO_2); the soil then directly absorbs the carbon as the plants decay. Gundersen et al. (2006) found that increased atmospheric CO_2 initially results in increased storage of carbon in the upper soil layers and biomass. However, carbon is naturally broken down in the soil and released to the atmosphere as CO_2 gas. As the air temperature increases, decomposition occurs more rapidly, which may potentially contribute to climate change (Jamieson et al. 1999; Zhou et al. 2005). Complex interactions exist among variables such as temperature, moisture, decomposition and nutrient cycling. Thus, medium to long-term effects of climate change to soil biogeochemistry have been more difficult to predict (Jamieson et al. 1999).

8.3.3 Vegetation Responses to Climate Change

Research indicates that the southern boundary of the central Canadian boreal forest is controlled by water limitations and fire frequency, while the northern boundary is controlled by temperature limitations (Brooks et al. 1998). As temperature and precipitation are two of the dominant controlling factors in the central Canadian boreal forest boundary, they are two of the most important factors to look at when considering vegetation response to climate change in the boreal forest.

Temperature affects many processes in plants including photosynthesis, respiration and growth, as well as the flux of pollutants to the plant (Brooks et al. 1998). Warm and dry summer conditions increase respiration rates, reduce photosynthate production, reduce leaf area and reduce energy reserves (Nakawatase and Peterson 2006). Furthermore, in areas that become drier, fire return intervals are expected to become shorter and fire intensities are expected to increase (Golder 2005; Nakawatase and Peterson 2006). Warm summer temperatures lengthen the growing season by accelerating snowmelt. Theurillat and Guisan (2001) conclude that since the early 1960s the average annual growing season in a European study area has lengthened 11 days, and is the result of an increase in mean annual air temperature.

Precipitation also has many effects on vegetation, with the most prominent being on soil properties including moisture and temperature (Brooks et al. 1998). An important factor regarding changes in climate is that seasonal distribution of increased precipitation and temperature are usually more important than annual amounts (Brooks et al. 1998). Bell and Threshow (2002) also indicates that changes in the climate could lead to changes in the development pattern of species, thus affecting inter-specific and dependant relationships within natural communities.

Spatial distribution and species composition of the boreal forests are expected to change with the anticipated change in climate (Jamieson et al. 1999; Loehle 2003; Zhou et al. 2005). Biogeographic models predict widespread species migration (i.e., southern communities migrating northward) (Nakawatase and

Peterson 2006). Some research predicts that many important species, particularly northern pines (*Pinus* spp.) and spruces (*Picea* spp.) may be extirpated from some areas because of climate change (Scheller and Mladenoff 2005; Walker et al. 2002). The previous discussion indicated the forecasted climate normals for the Cold Lake region are within the climatic ranges of tolerance for boreal tree species (Table 39).

Loehle (2003) states that the rate at which a forest can be invaded, even by a much superior competitor, is limited by the rate at which openings become available (i.e., by disturbance). Climate change will not cause species mortality but will alter competitive interaction among plants. Species mortality would open up forest canopy leaving an ecosystem vulnerable to invasion from weeds. As this is not predicted to be the case, climate change should not increase weed invasion in intact forest. Intact forests are resistant to invasion and their response to moderate climate change should be slow with a prolonged transition on the order of 500 to 3,000 years. It will take forests hundreds to thousands of years for the population to come to a new equilibrium. Reclaimed ecosystems may be less resistant to invasion than established ecosystems (Loehle 2003).

Recent observations have strengthened the concept that species respond individually to climate change and not as a cohesive unit (Brooks et al. 1998; Loehle 2003; Nakawatase and Peterson 2006). Qinfeng et al. (2004) report that growth trajectories and responses of species under the same climate regimes were clearly highly individualistic, and even the same species performed differently under different climate conditions or when planted with different species. Because forest growth responds differently to climactic variability in different environments, management of forest ecosystems will need to consider growth response at local to watershed scales (Nakawatase and Peterson 2006).

Disturbance plays an important role in a community's response to climate change. Active competition among trees is largely confined to the seedling and sapling stage, with the duration of canopy occupancy also playing a competitive role (Loehle 2003). Forest invasion is limited by open spaces which are created via disturbance. It has been found that increased disturbance speeds up competitive displacement and clearly speeds up the invasion process. Disturbance may accelerate the shift toward more southern species, although the effect is variable across the landscape (Scheller and Mladenoff 2005).

8.3.4 Wildlife Responses to Climate Change

Climate change may impact wildlife by changing boreal forest, river and delta habitat conditions within the boreal forest natural region. The boreal forest is home to the largest diversity of birds in North America. Surveys in the region have identified 197 species of birds (Doucet 2004). The region was also identified as a primary migratory route for water birds. A total of 44 mammal species, 23 to 27 fish species, over 191 taxa of phytoplankton, and well over 50 taxa of benthic invertebrates have been identified within the region (Doucet 2004).

With respect to wildlife, the effects of climate change are difficult to predict (Cohen 1997b). The lack of long-term data, complexity of life cycles and incomplete information on wildlife responses to previous environmental changes impede research. Ecosystems will not move entirely in response to climate change, rather, each species will react differently (Markham 1996). In general natural adaptation can take three main forms, including evolution, acclimatization or migration to suitable sites, with the latter probably the most common response (Markham 1996; Reed 2001).

The current rate of climate change creates a situation in which many organisms are unlikely to be able to adapt or migrate fast enough (Markham 1996; Weber and Flannigan 1997). Changes in climatic conditions are predicted to range from one to two orders of magnitude faster than the rates experienced by the boreal forest during the past 100,000 to 200,000 years (Weber and Flannigan 1997). Poleward migration rates of 1.5 to 5.5 km/yr would be necessary, a fact which severely restricts the development and migration of ecosystems (Gear and Huntley 1991 in Weber and Flannigan 1997). This has the potential to reduce biodiversity by selecting for highly mobile and opportunistic species (Peters and Darling 1985 in Markham 1996; Malcolm et. al. 2002).

Wildlife face further challenges in regards to migration. For example, although most birds are extremely mobile, some species will not cross open clearings even as small as tree fall gaps (Markham 1996). Therefore, ecosystems already stressed by human activities will be more vulnerable to climactic threats. Other animals are associated with specific vegetation species or formations and may fail to migrate or may migrate in synchrony with the availability of transient food sources.

Another concern is the affect of increasing wildfires to wildlife migration (Cohen 1997b). It has been largely recognized that the new climate scenario may result in increased fire frequency and an increase in the area to potentially be burned (Rothman and Herbert 1997 in Cohen 1997a; Weber and Flannigan 1997; Li et. al. 2000; Natural Resources Canada 2007, internet site). Wildlife species with a body size of more than 1kg will be most affected by shifts in landscape structure associated with the rapid forest cover changes from wildfires (Thompson et al. 1997 in Weber and Flannigan 1997). An example is the impacts of wildfire to caribou habitat; the distribution and abundance of terrestrial lichens are reduced and will not recover for decades following a fire (Boutin et. al. 2006). Thus, changing fire patterns will likely affect the distribution of caribou.

Another challenge associated with climate change could be lower water levels during fall and winter (Kerr 1997 in Cohen 1997a), which could reduce the probability of spring flooding in wetlands and deltas (Cohen 1997a). Flooding is vital, especially to the perched ponds and lakes that are separated from the open-water channel system. In-stream flow requirements for ecological purposes are very important for fish, birds and other wildlife. The Peace-Athabasca Delta provides important habitat for fish, migratory waterfowl, and large populations of waterfowl, muskrat, beaver and free-ranging wood bison (Cohen 1997a; Environmental Research and Studies Centre 2007; Environment Canada 2007b, internet site). This delta has recently experienced low water levels (Kerr 1997 in Cohen 1997a) that have been attributed to climate variation and the flow regulation of the Bennet Dam (Environmental Research and Studies Centre 2007). During prolonged dry periods in the last 25 years, some aquatic ecosystems have turned into terrestrial ecosystems. This may cause declines in fish and small-mammal habitats and populations (Environment Canada 2007b, internet site).

Changes to water flow are predicted due to climate change. Increased evaporation is expected to offset increased precipitation and reduce river flows, causing fish stocks to decline (Baxter 2006). Studies imply that low flows also reduce oxygen levels during winter months, when rivers are sealed under ice and snow, because of continued respiration and decomposition of organic matter. Reduced oxygen concentrations under ice are known to be detrimental to the eggs and fry of fall-spawning species such as lake whitefish and bull trout. Other concerns are that late fall-early winter river stages may be too low for fall spawning fish to reach spawning sites or to allow fry to occupy key nursery sites in the river during winter (Environmental Research and Studies Centre, 2007).

8.4 SUMMARY

Climate change may have effects on both soils, vegetation and wildlife. Soil conditions may be altered through increases in summer moisture stress, short-term increases in productivity and potential increases to decomposition rates. However, the medium to long-term effects to soil conditions are difficult to predict. In terms of vegetation, the predicted responses to climate change can include persistence, migration or extinction of specific species or groups of species. Regardless of which response vegetation has to climate change, it is important to note that each species will adapt based on their most limiting factors, thus entire communities may not respond in the same way, or at all, to changes in climate. Wildlife species will all react differently to climate change;

response and adaptation could be accomplished through evolution, acclimatization, and most likely, migration to suitable sites.

In light of the range of potential effects climate change can have on soils, vegetation and wildlife, it is not possible to accurately predict the degree to which climate change may affect the conclusions provided in the EIA. Nonetheless, there are some general conclusions that can be derived given the understanding of general soil, vegetation and wildlife responses to climate change.

Vegetation and wetlands resources, which includes wildlife habitat in the proposed Project area will be affected primarily through surface disturbances associated with construction of the Project. Changes to the Project area vegetation due to climate change are not likely to occur during the construction, operation and reclamation phases of the Project. In the longer term, a possible effect may occur if invasive species in open (i.e., disturbed) areas, supported by changed climatic conditions, alter post-development landscapes. Additionally, for boreal tree species in the Project region, the forecasted temperature normals to 2039 are within the range of tolerance for these species. Thus, shifts in the abundance or distribution of boreal trees species in the Project area are not likely to occur, at least over the short to mid-term period. No changes are expected in EIA predictions with regards to vegetation and wetlands resources.

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10 GLOSSARY

Acidification	The decrease of acid neutralizing capacity in water, or base saturation in soil, caused by natural or anthropogenic processes. Acidification is exhibited as the lowering of pH.
Alberta Ambient Air Quality Objective (AAAQO)	Alberta Ambient Air Quality Objective levels are established for several air compounds under Section 14 of the *Environmental Protection and Enhancement Act* (EPEA). The AAAQOs form an integral part of the management of air quality in the province, and are used for reporting the state of the environment, establishing approval conditions, evaluating proposed facilities with air emissions, assessing compliance near major air emission sources and guiding monitoring programs.
Alberta Environment (AENV)	Provincial ministry that looks after the following: establishes policies, legislation, plans, guidelines and standards for environmental management and protection; allocates resources through approvals, dispositions and licenses, and enforces those decisions; ensure water infrastructure and equipment are maintained and operated effectively; and prevents, reduces and mitigates floods, droughts, emergency spills and other pollution-related incidents.
Ambient Air	The air in the surrounding atmosphere.
Anthropogenic	Caused by human activity.
Aquifer	A body of rock or soil that contains sufficient amounts of saturated permeable material to yield economic quantities of water to wells or springs. Any water-saturated body of geological material from which enough water can be drawn at a reasonable cost for the purpose required. An aquifer in an arid prairie area required to supply water to a single farm may be adequate if it can supply 1 m^3/d. This would not be considered an aquifer by any industry looking for cooling water in volumes of 10,000 m^3/d. A common usage of the term aquifer is to indicate the water-bearing material in any area from which water is most easily extracted.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.

Benthic Invertebrates	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their lifestages dwelling on bottom sediments in the waterbody. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.
Biodiversity	The variety of plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected.
Boreal Forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.
Channel	The bed of a stream or river.
Connectivity	A measure of how connected or spatially continuous a corridor or matrix is.
Dissolved Oxygen (DO)	Measurement of the concentration of dissolved (gaseous) oxygen in the water, usually expressed in milligrams per litre (mg/L).
Drawdown	Lowering of water level caused by pumping. It is measured for a given quantity of water pumped during a specified period, or after the pumping level has become constant.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.
Edaphic	Referring to the soil. The influence of the soil on plant growth is referred to as an edaphic factor.

Epilimnion	A freshwater zone of relatively warm water in which mixing occurs as a result of wind action and convection currents.
Fragmentation	The process of breaking into pieces or sections. For example, dividing contiguous tracts of land into smaller and less connected sections through site clearing (e.g., for roads).
Geomorphic	The natural evolution of surface soils and landscape over long periods.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Groundwater Recharge	Water that enters the saturated zone by a downward movement through soil and contributes to the overall volume of groundwater.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
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.
Hydrostratigraphic Unit	A formation, part of a formation, or group of formations in which there are similar hydrologic characteristics allowing for grouping into aquifers or confining layers.
Hypolimnion	The deep, cold layer of a lake lying below the metalimnion (thermocline) during the time a lake is normally stratified.
Local Study Area (LSA)	Defines the spatial extent directly or indirectly affected by the project.
Morphology	Morphology or fluvial geomorphology is the term used in the description of closure drainage designs that replicate natural analogues. It describes the process and the structure of natural systems that are to be replicated in constructed drainage channels, including regime relationships for various channel parameters such as width, depth, width/depth ratio, meander wavelength, sinuosity, bed material, gradient and bank slope.
Pelagic	Inhabiting open water, typically well off the bottom. Sometimes used synonymously with limnetic to describe the open water zone (e.g., large lake environments).

Potential Acid Input (PAI)	A composite measure of acidification determined from the relative quantities of deposition from background and industrial emissions of sulphur, nitrogen and base cations.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.
Runoff	The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope soil characteristics, land usage and quantity and intensity of precipitation.
Solar Radiation	The principal portion of the solar spectrum that spans from approximately 300 nanometres (nm) to 4,000 nm in the electromagnetic spectrum. It is measured in W/m^2, which is radiation energy per second per unit area.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Steam Assisted Gravity Drainage (SAGD)	An in-situ oil sands recovery technique that involves the use of two horizontal wells, one to inject steam and a second to produce the bitumen.
Suspended Sediments	Particles of matter suspended in the water. Measured as the oven dry weight of the solids, in mg/L, after filtration through a standard filter paper. Less than 25 mg/L would be considered clean water, while an extremely muddy river might have 200 mg/L of suspended sediments.
Taxa	A group of organisms of any taxonomic rank (e.g., family, genus, or species).

Thermocline A layer within a waterbody where the temperature changes rapidly with depth.

Turbidity An indirect measure of suspended particles, such as silt, clay, organic matter, plankton and microscopic organisms, in water.

Water Table The water table is the level at which the groundwater pressure is equal to atmospheric pressure.

Waterbody A general term that refers to ponds, bays, lakes, estuaries and marine areas.

Watercourse A general term that refers to riverine systems such as creeks, brooks, streams and rivers.

Watershed The area of land bounded by topographic features that drains water to a larger waterbody such as a river, wetlands or lake. Watershed can range in size from a few hectares to thousands of kilometres.

Wetlands Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or “peatlands,” and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

Wildlife Under the *Species at Risk Act*, wildlife is defined as a species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus that is wild by nature and is native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.

11 ABBREVIATIONS

°	Degree
%	Percent
>	More than
°C	Temperature in degrees Celsius
AAAQO	Alberta Ambient Air Quality Objectives
AENV	Alberta Environment
CICS	Canadian Institute for Climate Studies
CO_2	Carbon dioxide
e.g.	For example
EIA	Environmental Impact Assessment
EnCana	EnCana FCCL Ltd.
et al	Group of authors
FPTCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment
GCM	General Circulation Model
GHG	Greenhouse Gas
i.e.	That is
INAC	Indian and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
km/h or km/hr	Kilometres per hour
km^2	Square kilometre
Km/yr	Kilometres per year
LSA	Local Study Area
m^3/d	Cubic metres per day
mbgs	Metres below ground surface
mm	Millimetre
mm/yr	Millimetres per year
N	Nitrogen
N	North
NWT	Northwest Territories
PAI	Potential Acid Input
ppb	Parts per billion
RSA	Regional Study Area
SAGD	Steam Assisted Gravity Drainage
TOR	Terms of Reference

WBEA	Wood Buffalo Environmental Association

APPENDIX 2-VI

MONITORING PROGRAMS

**THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.**

APPENDIX 2-VI

MONITORING PROGRAMS

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1 INTRODUCTION

EnCana FCCL Ltd. (EnCana) has committed to undertaking numerous monitoring programs in relation to the Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project). Monitoring programs will be implemented for aspects of the Project which have been predicted to have an effect on the environmental and social resources in the Project area, including air quality, aquatic resources, terrestrial resources and social resources.

EnCana has a comprehensive suite of monitoring programs currently in place for the Christina Lake Thermal Project (CLTP). These monitoring programs will be expanded, as necessary, to encompass the Project. EnCana will periodically complete a trend analysis of the monitoring data on a program by program basis to evaluate the success of the various monitoring programs. This analysis will be used to determine if any changes or adjustments to the monitoring programs are required. EnCana will work with Alberta Environment (AENV) to design updated monitoring programs as necessary.

2 AIR QUALITY

As part of the current CLTP *Environmental Protection and Enhancement Act* (EPEA) approval (48522-00-09) issued on July 3, 2008, EnCana is required to conduct ambient air quality monitoring. EnCana is required to setup a continuous ambient air quality monitoring station for the measurement of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and hydrogen sulphide (H_2S) for three months of each calendar year and four passive monitoring stations for the measurement of H_2S and total sulphation levels.

EnCana has a Continuous Emissions Monitoring System (CEMS) on the B-1725 steam generator constructed in Phase 1B. The CEMS system monitors oxides of nitrogen. Additionally, the B-101 steam generator requires a manual stack survey annually monitoring oxides of nitrogen. Air monitoring on future steam generators will be complaint with the current EPEA approval.

EnCana is also involved in regional air monitoring initiatives as detailed in Section 6.2 of this appendix.

3 AQUATIC RESOURCES

3.1 HYDROGEOLOGY

The potential hydrogeologic effects were described with respect to the following project activities:

- surface facility operations (including Steam Assisted Gravity Drainage [SAGD] well drilling and completion);
- groundwater withdrawal;
- wastewater injection; and
- steam injection.

This section describes existing and proposed groundwater monitoring plans for each of the operation components.

3.1.1 Surface Facilities

A network of groundwater monitoring wells has been installed at the existing CLTP central plant site. Groundwater monitoring wells serve to monitor background groundwater elevations and groundwater quality in addition to potential shallow impacts to groundwater quality originating from process operations. Baseline groundwater elevation and groundwater quality data has been collected at the existing monitoring wells since 2001 (Westwater 2008). Data from the groundwater monitoring program will provide information on:

- geologic and hydrogeologic properties of the shallow Quaternary sediments;
- pre-development groundwater levels and groundwater chemistry; and
- potential changes to groundwater quality related to the Project.

The existing groundwater monitoring well network primarily focuses on the shallowest groundwater-bearing zones and therefore targets the most vulnerable hydrostratigraphic unit with respect to potential effects associated with surface facility operations. Monitoring wells are installed adjacent to areas exposed to potential sources of accidental releases. Nested pairs have been installed to provide a measure of the direction and magnitude of the vertical hydraulic gradient and monitor groundwater quality below the water table aquifer. Monitoring wells have also been installed hydraulically upgradient of the site to serve as background (control) wells. The monitoring well network will be expanded as needed to provide adequate groundwater monitoring of the expanded central plant facility for the Project.

Groundwater samples are collected regularly from each monitoring well and analyzed for field parameters, including temperature, pH, Electrical Conductivity (EC), Dissolved Oxygen (DO) and Oxidation Reduction Potential (ORP). Laboratory analyses may include the indicator parameters, which are based on potential effect to groundwater quality associated with heavy oil facilities listed in Table 1.

Table 1 Analytical Parameters That May be Used in the Groundwater Monitoring Program

Source of Effect	Routine[(a)]	Dissolved Metals[(b)]	Dissolved Organic Carbon	BTEX, F1 and F2[(c)]	NO_2-NO_3 and NH_4	Phenols
Bitumen	---	---	X	X	---	X
Diluent	---	---	X	X	---	---
Produced Water	X	X	X	X	---	---
Sewage Lagoons	---	---	---	---	X	---
Process Chemicals	X	---	X	---	---	---

(a) Routine water includes EC, pH, total dissolved solids, sodium, potassium, calcium, magnesium, manganese, iron, hydroxide, chloride, carbonate, bicarbonate, sulphate, hardness and alkalinity.

(b) Dissolved metals include aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, phosphorus, selenium, silicon, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc and zirconium.

(c) BTEX includes benzene, toluene, ethylbenzene and xylenes, F1 includes hydrocarbon fractions C_5-C_{10} and F2 includes hydrocarbon fractions C_{10}-C_{16}.

X Analytical parameter recommended to be included in groundwater monitoring program in vicinity of identified potential source.

--- Analytical parameter not recommended to be included in groundwater monitoring program in vicinity of identified potential source.

Should significant changes in groundwater quality be detected, an incident-specific groundwater response plan will be developed and implemented (Section 3.1.5).

3.1.2 Steam Injection

Changes in groundwater quality due to thermal heat originating from the SAGD well bore is a potential concern in northeast Alberta. A groundwater monitoring program was initiated at a representative CLTP well pad in 2001 (Westwater 2008). The monitoring was developed to document pre-development conditions and to monitor changes in temperature.

The monitoring program will continue to include water levels, temperature, and analysis of major ions and dissolved metals, including arsenic. Should significant changes in groundwater quality be detected, a groundwater response plan will be implemented (Section 3.1.5). At least one additional Project well pad will be incorporated into the monitoring program for the Project.

3.1.3 Groundwater Withdrawal

EnCana will responsibly manage groundwater usage by operating all wells as per the terms and conditions of associated groundwater diversion (*Water Act*) licenses. In addition, EnCana will responsibly manage the Project groundwater usage by:

- Monitoring actual water usage from the Empress Channel, Middle Clearwater and the McMurray aquifers.
- Monitoring water level changes in selected aquifers near the groundwater source wells.
- Conducting annual reviews and interpretations of water level and water usage data including a comparison of actual changes in water level compared to the predicted changes. If necessary, the annual review will include recommendations to further mitigate effects and/or improve monitoring.
- Collaborating with other SAGD operators in the region through the Christina Lake Regional Water Management Agreement.

3.1.4 Wastewater Injection

Disposal wells will be drilled, completed and tested following all requirements outlined in *Energy Resources Conservation Board (ERCB) Directive 051: Injection and Disposal Wells* (EUB 1994). Each disposal well will be equipped with a surface-installed turbine meter, flow choke and a pressure recorder. The wellhead injection pressure and injection rate for each well will be monitored daily.

3.1.5 Groundwater Response Plan

If major changes in groundwater quality are detected as a result of Project operations, an incident-specific response plan will be developed and implemented. Aspects of the plan include:

- conducting confirmatory sampling;

- notifying AENV on confirmation of effect; and
- identifying the source(s) of the effect.

Once the source of the effect has been identified, a site-specific risk management strategy based on the nature and concentration of contaminants and potential receptors in the area will be developed. The risk management strategy will be submitted to AENV for approval and may include a site-specific remediation plan. The risk management strategy will then be implemented.

3.2 HYDROLOGY

3.2.1 Surface Disturbances

EnCana has a surface water hydrology monitoring program for its current CLTP operations that is integrated, where appropriate, with the wetlands monitoring program. This program will be expanded to include the areas potentially affected by the Project. Specifically, the hydrologic monitoring program for surface disturbances includes the components listed below:

- Culvert installations at road crossings and wetlands areas are monitored regularly, particularly during or following high runoff periods. This monitoring consists of regular inspections. Excessive sedimentation, debris, or ice accumulation will be removed to maintain the flow capacity of the culvert. Screens may be added to culvert inlets to prevent blockage in areas of potential beaver activity. In the wetlands areas, water levels are monitored to ensure that they remain equal on both sides of access roads.
- Re-graded areas are inspected for evidence of erosion or instability, and repaired or stabilized as required. Revegetation efforts are monitored and maintained to ensure vegetation growth and survival. Replanting occurs if survival of vegetation is inadequate.
- Drainage courses disturbed during construction are inspected to ensure that riparian vegetation and stable drainage conditions have been re-established.
- Regular monitoring of the stormwater ponds ensures adequate storage capacity is available and prevents any uncontrolled releases from the plant and well pad drainage systems. The downstream drainage path from the slow release lines is also inspected each time pumpoff is initiated to ensure that the terrain is absorbing the water with no apparent vegetation stress and that no downstream channel development or erosion is occurring. If required, remedial measures such as re-directing the drainage, extending or perforating release lines,

incorporating bio-technical erosion control measures or revegetation efforts are employed to correct potential areas of concern before they could become a problem.

- Winter program and dust control activities will follow the conditions of the temporary water withdrawal requirements of the temporary water withdrawal licences. These requirements consist of flow and water level monitoring programs for the CLTP. Streamflow and lake level monitoring will be conducted at selected watercourses and waterbodies potentially affected by the Project. Consistent with previous practice, a detailed monitoring plan will be presented to AENV as part of permitting requirements under the *Water Act* and EPEA however, no changes to the proposed CLTP programs are anticipated due to the Project monitoring.

3.2.2 Watercourse Crossings

A monitoring program will be implemented to ensure that watercourse crossing effects are kept to a minimum, with particular emphasis on sediment generation caused by construction and operation as well as potential effects to upstream water levels caused by improperly constructed or maintained bridges or culverts. The monitoring program will include the following:

- inspection of culverts to ensure proper operation particularly during or following high runoff periods; and
- inspection of all watercourse crossings to ensure that properly installed sediment control measures are in place during and following construction.

3.3 WATER QUALITY

Water quality monitoring for the Project will involve two components: 1) monitoring of surface water runoff from the site (industrial runoff); and 2) ambient monitoring of watercourses in the Project area.

Industrial runoff from the site will be controlled. Clean water from the surrounding areas will be prevented from entering facilities by diverting water around the facilities. All facility area industrial runoff will be pumped or otherwise directed to retention ponds for containment and testing prior to release to the surrounding muskeg. Water from the retention ponds will be sampled as per EPEA approval requirements prior to discharge into natural areas.

Ambient water quality monitoring established for the CLTP will be continued to ensure that the local streams remain unaffected by the CLTP. In the current program, two main watercourses in the CLTP area are monitored. Water quality samples and field measures are collected three times per year at stations upstream and downstream of the CLTP and Project areas. Water samples collected from watercourse monitoring stations are currently analysed for the water quality parameters listed in Table 2.

The water quality monitoring at Sunday Creek and an unnamed watercourse, established in 2006, will continue in the future on a weekly basis from May to October. Weekly sampling and analyses will include pH, chloride, TSS and visible oil sheen. Monthly sampling and analyses will include total aluminum, arsenic, lead, cadmium, mercury, nickel, vanadium, zinc and barium.

EnCana is a participant in the Regional Aquatics Monitoring Program (RAMP) RAMP, which is described in Section 6.4. The water quality parameters selected for EnCana's monitoring program are consistent with RAMP programs.

Table 2 Surface Water Quality Parameters

Group	Parameters	
field parameters	temperature pH turbidity	dissolved oxygen (DO) specific conductivity
conventional variables	colour dissolved organic carbon (DOC) total organic carbon (TOC) pH specific conductivity	total alkalinity total dissolved solids (TDS) total hardness total suspended solids (TSS)
major ions	bicarbonate calcium carbonate chloride magnesium	potassium sodium sulphate sulphide
nutrients	nitrate+nitrite ammonia nitrogen total Kjeldahl nitrogen	total phosphorus dissolved phosphorus chlorophyll *a*
total and dissolved metals	aluminum antimony arsenic barium beryllium bismuth boron cadmium calcium chromium cobalt copper iron lead	lithium manganese mercury[(a)] molybdenum nickel selenium silver[(a)] strontium thallium tin titanium uranium vanadium zinc
organics	naphthenic acids total phenolics	total recoverable hydrocarbons

(a) Ultra-trace mercury and silver (e.g., 0.6 ng/L for total mercury, 0.5 ng/L for total silver).

4 TERRESTRIAL RESOURCES

Terrestrial resources monitoring programs for the Project will build on the programs proposed for the CLTP (Golder 2007; Matrix 2007). EnCana intends to establish the proposed programs, review findings, implement any modifications and if necessary develop additional programs for the Project. Any new monitoring programs will benefit from the knowledge acquired from the existing CLTP monitoring programs and EnCana's adaptive management approach. The specific details and methods for any new monitoring programs will be developed in consultation with AENV before implementation.

The following sections provide a summary of the methods and protocols of the proposed monitoring programs. With exception of the Reclamation Monitoring Program, all programs have been submitted to AENV.

4.1 WETLANDS

EnCana has implemented a wetlands monitoring program developed for the CLTP that is designed to determine whether wetlands are affected by changes to the groundwater levels or by linear developments and/or permanent infrastructure (i.e., well pads) within wetlands. The monitoring program provides a summary of the background hydrogeology, hydrology and wetlands vegetation conditions at the Project, and the potential effects to the hydrogeology, hydrology and wetlands vegetation conditions from the Project. The effectiveness of the Wetlands Best Management Practices will be evaluated to determine the effectiveness in maintaining natural drainage patterns and near surface water hydrology within wetlands in the EnCana lease.

4.1.1 Wetlands Vegetation

Wetlands vegetation can be used to measure Project effects to wetlands ecosystems because wetlands contain a diverse assembly of plant species. Also, the plants in wetlands ecosystems have rapid growth rates and respond directly to abiotic and biotic changes in the environment. Plant communities in wetlands have been found to change in response to impacts such as hydrologic changes, nutrient enrichment, sediment loading, metal deposition and other pollutants.

Wetlands vegetation monitoring sites will be selected to provide baseline information and potential effects on wetlands structure and function from the Project. Baseline sites will be located in areas not affected by the Project, while others will be located in areas with the potential to be effected by the Project. Site selection will be based on the following factors:

- wetlands types most responsive to changes in groundwater quantity and quality;
- wetlands that can be linked to groundwater and surface water monitoring sites;
- proximity to plant facilities and major infrastructure, such as roadways; and
- potential sites for ponding or impoundment.

Fen, swamp and marsh wetlands types are more sensitive to changes to groundwater and surface water because they are connected to both surface and groundwater. Bog wetlands types are isolated from groundwater changes and only receive water via precipitation. Therefore more monitoring sites will be placed in fen, swamp and marsh wetlands types.

To ascertain if the Project is affecting the structure and function of wetlands types, the following parameters will be measured at each monitoring site:

- plant species composition (including trees and shrubs), height and percent cover;
- water table depth;
- water chemistry (EC, pH and TDS);
- soil profile and classification; and
- appearance (as documented in photos).

Once sites have been selected they will be monitored every year for the first two years of the Project and then every two years after that, for the life of the Project.

4.2 WILDLIFE

The wildlife and biodiversity monitoring program will include surveys to assess wildlife changes from the Project and the effectiveness of mitigation strategies, with a focus on listed species occurring within the Local Study Area (LSA) (e.g., woodland caribou). EnCana will contribute information collected as part of its wildlife monitoring program to regional wildlife databases, such as Alberta Sustainable Resource Development's (ASRD's) Fish and Wildlife Management Information System (FWMIS) database.

4.2.1 Woodland Caribou

Local Woodland Caribou

As part of the current wildlife monitoring program, EnCana will monitor use of the Project area by woodland caribou. Methods for monitoring will include incidental wildlife sightings documented by on-site staff through a wildlife sighting card program, and remote camera monitoring. Roads will be monitored during winter to ensure that snow berms are not too high and that gaps are left to facilitate wildlife movement at regular intervals. Caribou monitoring is consistent with previously proposed caribou monitoring programs for neighbouring operators. Caribou observations and responses to habitat enhancement measures (Section 4.2.3) will also be monitored.

Remote cameras were deployed for an eight-week period during the spring (May to June 2009) movement period and will be deployed again during the fall movement period. The remote camera monitoring will be repeated the following year to obtain two years of continuous data. The remote camera program will be re-evaluated based on results obtained, and on the relevance of data at measuring long-term responses of caribou movement from the Project.

All woodland caribou data obtained during the local monitoring program will be summarized within annual conservation and reclamation plans as well as within annual Caribou Protection Plans (CPPs) and a 5-year comprehensive summary report. Raw data will also be provided to the Alberta Caribou Committee (ACC) and to ASRD for incorporation within the provincial FWMIS database.

Regional Caribou

To stay informed of future caribou landscape planning objectives, population monitoring results and caribou research, EnCana will continue to participate with the ACC. In addition, EnCana is committed to a collaborative regional wildlife monitoring program with neighbouring operators (i.e., MEG Energy Corporation, Devon Canada Corporation), which will include maintaining consistency on timing of the local monitoring programs and survey methods to obtain information on wildlife including woodland caribou movement at a more regional level. EnCana will continue to advocate the collection of regional distribution, abundance and movement data for caribou in the Christina Lake region through the ACC Research Subcommittee.

4.2.2 Above-Ground Pipeline Monitoring

Monitoring to assess the effects of barriers to wildlife movement will include surveys of wildlife tracks and wildlife presence in relation to Above-Ground Pipelines (AGP) and crossing opportunities (i.e., areas of elevated pipe or over-the-pipe crossing structures). This assessment will evaluate if movements are being affected and determine the effectiveness of the mitigation measures employed. Monitoring objectives for the above-ground pipeline crossing structures will include: relative use of the crossing structures for different wildlife species, seasonal differences in use and changes in movement patterns over the life of the Project. Methods used for monitoring include winter tracking surveys and remote cameras to document the use of crossing structures during all seasons.

Winter track surveys were employed along the entire length of current AGP including sections encompassing crossing structures in March 2009. Winter track surveys followed the Alberta Biodiversity Monitoring Institute (ABMI) protocols with some modifications, and previously established protocols for the CLTP that have successfully recorded moose, lynx, weasel species, fisher and other wildlife (e.g., Golder 2004).

Remote cameras will measure use of above-ground pipeline crossing structures and elevated sections of pipe by mammals at different times of the year. Target species include moose, woodland caribou and black bear. Use of remote cameras will complement winter track surveys and extend pipeline monitoring through the spring, summer and fall seasons. Cameras were placed at elevated sections of pipe to detect successful crossing by wildlife species and to detect those individuals that did not cross but walked along the pipeline Rights-of-Way (ROW). These cameras will be deployed all year long.

Data obtained during the local monitoring program will be summarized within annual conservation and reclamation plans, annual CPPs, and a 5-year comprehensive summary report as applicable. Raw data will also be provided to ASRD for incorporation within the provincial FWMIS database and when applicable, to the ACC.

4.2.3 Wildlife Monitoring

The objective of the wildlife monitoring program is to identify possible project conflicts with focal species by monitoring their abundance and distribution in space and time such that appropriate mitigation can be quickly implemented to maintain biodiversity. In 2009, winter track surveys, breeding bird surveys and amphibian/marsh bird surveys were conducted. A wildlife habitat enhancement program was also implemented.

The objectives of the winter track survey are to determine the distribution, habitat use and relative abundance of ungulates and small and medium-sized carnivores. The winter track surveys were completed in March 2009. They were designed to provide coverage of the study area within representative vegetation types. Winter track surveys follow, in part, the ABMI, and previously established protocols for the CLTP that have successfully recorded moose, deer, lynx, snowshoe hare, weasel species, fisher/marten and other wildlife species (Golder 2007).

The objectives of breeding bird surveys are to describe species presence, relative abundance, habitat use and classification of birds within the various habitat types (i.e., ecosite phases and wetlands types). The breeding bird survey was conducted at stations positioned along transects using standard point-count methods described in the ABMI (www.abmp.arc.ab.ca) in June 2009. The ABMI protocol is designed to measure presence and relative abundance of breeding birds, including focal species for the CLTP, such as woodpeckers, western tanager, cape-may warbler and bay-breasted warbler. Survey protocols and methods for this study also followed methods from previous baseline monitoring for the CLTP area (e.g., Golder 2007).

The objective of amphibian surveys are to determine the presence, distribution and habitat associations of boreal chorus frog, wood frog, boreal (western) toad and Canadian toad. The objective of marsh bird surveys are to determine the presence, distribution and habitat associations of sora rail, yellow rail, Virginia rail, American bittern and pied-billed grebe. Marsh bird survey plots corresponded with amphibian survey plots and were completed at the same time. Protocols followed the ‘Vertebrate Search protocol’ under the ABMI (www.abmp.arc.ab.ca).

All wildlife monitoring surveys will be completed during the first two years of the program to provide sufficient information for evaluating habitat-use trends, effects of mitigation plans and corrective measures. Monitoring will continue in Year 4 and 7 for evaluating temporal changes in, and long-term impacts of CLTP on population sizes of focal species. Modifications to the program may be recommended depending upon information arising from the evaluation of results of each year's program. Annual reports will be completed and included with the annual Conservation and Reclamation Plans. Data obtained from the surveys will be submitted to FWMIS annually.

4.3 RECLAMATION

The objectives of the reclamation monitoring program are to evaluate the success of reclamation measures and to adjust or modify these measures where necessary to ensure the following:

- the land is reclaimed to the proposed land capability classes to meet equivalent land capability requirements;
- the replacement of all salvaged topsoil and subsoil material on all re-contoured areas are such that replacement depths meet approval conditions;
- that vegetation growth on reclaimed land is self sustaining;
- invasive species are under control as per the *Alberta Weed Control Act* (Province of Alberta 2002);
- the habitat to sustain pre-disturbance wildlife carrying capacities can be obtained; and
- reclamation certification can be attained.

The objectives will be met through regular site inspections, additional reclamation procedures over time (if necessary), evaluation of the monitoring program results on reclaimed areas and other naturally regenerating disturbances such as seismic lines and rights-of-ways, and extrapolation of data from other oil sands and heavy oil projects where applicable. Vegetation, soil, wildlife and biodiversity monitoring will be coordinated on reclaimed sites and naturally regenerating disturbances to provide an indication of the potential (soil conditions) and the realized reclamation (vegetation conditions) of reclaimed/regenerating areas and the ability of the monitoring sites to provide the habitat necessary to support desired wildlife species (e.g., Canadian toad).

Monitoring will examine the soil capability to support vegetation growth by comparing the pre-disturbance average soil depths to the replacement average depth. As well, other soil physical and chemical parameters, such as pH, texture, and organic matter will be recorded, to allow calculation of post reclamation Land Capability for forestry (CEMA 2006). Vegetation monitoring will utilize permanent vegetation plots to assess plant species composition, height, percent cover and vigour on the following types of sites:

- well pads;
- borrow pits;
- seismic lines; and
- pipeline ROW.

Photo-monitoring of the permanent plots will also be implemented to provide a comparable visual record of growth conditions during each monitoring period. Details of the reclamation monitoring program will be provided to AENV for approval before the program begins.

EnCana will produce an annual Conservation and Reclamation (C&R) Report summarizing the previous years' activities in terms of development activities, facility areas to be constructed in the following year, reclamation activities, reclamation monitoring and planned activities for the following year. This report will be submitted to AENV annually.

4.4 BIODIVERSITY

EnCana recognizes the importance of long-term, large-scale monitoring of a wide range of taxa to measure changes in biodiversity that may result from anthropogenic (human-caused) disturbances. As such, EnCana will support the regional ABMI programs as they emerge. In addition, EnCana will implement a local Biodiversity Monitoring Program to monitor the cumulative effects of the Project on biodiversity using established ABMI protocols, where feasible, and modifying the protocols when necessary to address project-specific disturbances.

Biodiversity monitoring will include standard monitoring of regional species of conservation concern, but will also consider the surrogate concept and a suite of umbrella species, defined as those species whose conservation is expected to confer protection to a large number of co-occurring species (Roberge and Angelstam 2004; Sergio et al. 2006). The surrogate species program offers simple, ecologically based solutions for monitoring long-term cumulative effects of the Project on biodiversity. This approach will be conducted in accordance with ABMI protocols where feasible, for mammals, breeding birds and wetlands vertebrates and will ensure comparable indices of biodiversity for future monitoring.

Focal animals and taxonomic groups for this monitoring program include felids (e.g., cats), terrestrial mustelids (e.g., weasels, otters), owls (Sergio et al. 2006) and moose (Snaith and Beazley 2002), all of which have been recorded in the Project area and can be used to quantify changes in biodiversity. Data collected for the Wetlands Monitoring Program (Section 4.1) and the Wildlife Monitoring Program (Section 4.2) will also contribute to the Biodiversity Monitoring Program. The goal is to identify possible Project conflicts with focal species by monitoring their abundance and distribution in space and time such that appropriate mitigation can be quickly implemented to maintain biodiversity.

4.4.1 Index of Biological Integrity Program

Upon completion of the second year of the habitat-based biodiversity program, the development of a multi-metric Index of Biological Integrity (IBI) (Stevens et al. 2006; Coppedge et al. 2006) will be considered for monitoring and measuring the ecological condition of the Project. The wildlife-based IBI is an inexpensive bio-monitoring tool that can be used to monitor regional changes in ecological condition into the future. The IBI program provides a tool for calculating scores (0 to 100) for locations of interest and for calculating targets for restoration and mitigation. High scores (e.g., more than 80) reflect healthy landscapes and low scores (e.g., less than 40) reflect degraded landscapes.

4.4.2 Analysis and Reporting

Biological data will be summarized per site (i.e., transect, station or wetlands site) for each year of the program, and adjusted for effort and to standard units employed by the ABMI. This will allow for comparisons with regional trends in the abundance of large mammals and breeding birds, and the general composition of wildlife communities. As part of an adaptive management plan for evaluating threats to biodiversity, Analysis of Variance (ANOVA) and regression methods will examine for effects of proximity to plant facilities on track densities and occurrences of focal species using at least two years of species data plus environmental information as covariates. This approach will ensure that potential threats to biodiversity can be accurately identified and quickly addressed with appropriate mitigation. Temporal trends in populations will be quantified upon compilation of data from the second year of the monitoring program and will complement spatial tests and models in quantifying influences of the Project on biodiversity. Statistical analyses will focus on species or families that occur at relatively high densities in the study area.

All biodiversity data obtained during the local monitoring program will be summarized within annual conservation and reclamation plans. A 5-year comprehensive summary report of the Biodiversity Monitoring Program will also be compiled and submitted within the annual conservation and reclamation plan for that year. Applicable raw data will be provided to the ABMI, and ASRD for incorporation within the provincial FWMIS database.

5 SOCIO-ECONOMIC

No formal monitoring program is proposed. However, EnCana monitors the effect of its operations continually through its ongoing engagement with stakeholders. In addition, EnCana will co-operate with community stakeholders, other developers in the Conklin area, and the RCMP to monitor the traffic situation on Secondary Highway 881.

6 REGIONAL MONITORING INITIATIVES

EnCana is currently an active member of the Regional Issues Working Group (RIWG), the Cumulative Environmental Management Association (CEMA) and the RAMP. EnCana takes participation in Wood Buffalo Environmental Association (WBEA) projects such as the mobil monitoring vans in Conklin and Janvier. Below is a summary of the mandate of each organization.

6.1 WOOD BUFFALO ENVIRONMENTAL ASSOCIATION

The WBEA is a dynamic collaboration of communities, industry and government within the Regional Municipality of Wood Buffalo (RMWB). The WBEA consists of four key activities that are described as follows:

- Regional Air Monitoring Network: The Regional Air Monitoring Network currently comprises 13 monitoring stations equipped with several continuous air monitoring instruments. The purpose of this program is to monitor the ambient environment and produce monitoring results within the RMWB.
- Terrestrial Environmental Effects Monitoring (TEEM) Program: The TEEM Program is designed to detect possible changes in soil chemistry and tree growth resulting from acid deposition, as well as to monitor certain other indicators of environmental stress. This program includes collection and review of data from a series of cyclical monitoring activities that are undertaken at annual or five-year intervals.
- Human Exposure Monitoring Committee (HEMC): The WBEA formed HEMC in late 2002 with a mandate to develop and implement a strategy and program for ongoing human exposure monitoring in the Oil Sands Region. The decision to form a committee within WBEA followed from the results of the Alberta Oil Sands Community Exposure and Health Effects Assessment Program (AOSCEHEAP), completed in 1997, through which continued monitoring was recommended. The activities of AOSCEHEAP were documented in a series of reports issued by Alberta Health and Wellness (2000a,b,c). In 2005, the HEMC completed exposure monitoring in Fort McMurray and Fort Chipewyan (WBEA 2007). Plans are also being assembled by the committee to branch out monitoring studies to other communities. HEMC is being implemented as a partnership of regional, provincial and national health authorities and the WBEA.
- Communications Committee: The mandate of the Communications Committee is to develop a plan to create awareness of the WBEA in the community. The focus of the work is to connect with students and youth, as well as to promote an advertising campaign aimed at enhancing recognition of the WBEA in the community at large.

6.2 CUMULATIVE ENVIRONMENTAL MANAGEMENT ASSOCIATION

The CEMA is a multi-stakeholder forum established to design management systems to address cumulative effects of regional development in the RMWB in northeastern Alberta. The Regional Sustainable Development Strategy for the Athabasca Oil Sands (RSDS), an AENV initiative closely aligned to CEMA, provides a regulatory 'backstop' by which stakeholders can make recommendations to regulators on the management of cumulative effects. Currently, CEMA has several working groups.

The NO_X/SO_2 Management Working Group (NSMWG), whose mandate is to develop a management plan (system) for NO_X and SO_2 emissions as they relate to acidification and eutrophication, as well as ground-level ozone. In 2004, an acidification management plan (CEMA 2004) was endorsed by the Alberta Government based on recommendations from CEMA members. In 2006, the NSMWG also developed the Ozone Management Framework for the Regional Municipality of Wood Buffalo Area (CEMA 2006) that is based on the federal and provincial ozone frameworks.

The Trace Metals and Air Contaminants Working Group (TMAC), whose mandate is to assess the risks posed by trace metals and air contaminants to human health and ecosystems under existing environmental management systems. The TMAC issued recommendations for trace metals management in 2002 (TMAC 2002).

Previously separate from CEMA, as part of the Reclamation Advisory Committee (RAC), the Reclamation Working Group (RWG) joined CEMA in May 2001. The RWG is tasked with providing recommendations related to reclamation of surface disturbance areas in the region. The group's mandate is to provide recommendations to regulators on a reclamation process that meets the needs and values of stakeholders in the region while maintaining sustainable environmental integrity.

The main objective for the RWG is to define the process and standards by which developed land will return to sustainable ecosystems with desired end land use values. The RWG has six subgroups that aid in completing the necessary research for the group. The six subgroups and their respective objectives are reviewed below.

The RWG issued a landscape design checklist in 2004 (RWG 2004) that was subsequently approved by CEMA for recommendation to the responsible departments of government. The checklist is a concise and comprehensive checklist of design objectives for creation (design, construction, reclamation and maintenance) of landforms and landscapes in the Athabasca Oil Sands Region. It is the intention that this checklist provides the overall framework for design and assessment of all reclaimed landscapes and landforms in the region.

The Sustainable Ecosystem Working Group (SEWG) was formed to address three interrelated themes of the RSDS, namely Sustainable Ecosystems, Biodiversity and Wildlife. The overall purpose of SEWG is to recommend a management system to address cumulative effects on ecosystems and landscapes in the RMWB.

In 2004, the SEWG updated its Terms of Reference and associated Work Plan. Input was sought from the Alberta government and other stakeholders in 2005 to confirm that the plans of SEWG are consistent with regional needs and meet the mandate of CEMA.

Work to date by SEWG has resulted in the adoption by CEMA of three management tools designed to address cumulative land disturbance and ecosystem fragmentation as a result of existing and planned development activities:

6.3 REGIONAL ISSUES WORKING GROUP

The RIWG was formerly known as the Regional Infrastructure Working Group. The vision for RIWG is to provide a proactive process that promotes the responsible, sustainable development of resources within the Regional Municipality of Wood Buffalo for the benefit of all stakeholders. The RIWG mission is to:

- facilitate planning for growth in the Oil Sands Region;
- facilitate effective and efficient resolution of issues;
- involve all of the resource developers and affected stakeholders in planning; and
- develop plans for sharing benefits with Aboriginal stakeholders.

Several sub-committees have been created under RIWG, including Childcare, Communications, Co-Generation, Housing, Transportation, Southern Athabasca Oilsands Producers (SAOP), Athabasca Tribal Council/Athabasca Resource Developers (ATC/ARD), and Education and Employment. The activities that RIWG is involved in include:

- annual surveys to support industry updates and for planning purposes;
- an annual survey of capital expenditure and production forecasts of oil sands firms in co-operation with Canadian Association of Petroleum Producers;
- communication and collaboration on operational, development and community issues of mutual interest;
- an annual survey of new hires by oil sands companies in the Fort McMurray area; and
- an annual survey of co-generation capacity.

The RIWG produces an annual forecast of:

- revenues to government (royalties and taxes); and
- population of the urban area of Wood Buffalo.

The RIWG produces ad hoc products on an as needed basis, including, for example:

- traffic assessments of Highways 63 and 881;
- presentations to regional stakeholders, such as the Fort McMurray Construction Association; and
- presentations to the Alberta Government, including the Standing Policy Committee on Energy and Sustainable Resources.

6.4 REGIONAL AQUATICS MONITORING PROGRAM

The RAMP was initiated in 1997. It is a joint environmental monitoring program that assesses the health of rivers, lakes and wetlands in the Oil Sands Region of northeastern Alberta.

The program’s design identifies and addresses potential impacts of oil sands development. It is frequently adjusted to reflect monitoring results, technological advances and community concerns.

The RAMP is a multi-stakeholder initiative, with industry funding members and non-funding members including regulators, Aboriginal groups, Environmental Non-Governmental Organizations (ENGOs) and other stakeholders (e.g., local communities). Benefits to non-funding members include the following:

- receiving information relevant to their concerns or issues related to aquatic environments;
- increasing confidence in the information that is collected;
- communication of the state of the aquatic environment; and
- ensuring that sharing of information and addressing of issues continue beyond oil sands developments until closure.

As the Oil Sands Region experienced rapid growth from 1997 to 2001, changes to RAMP were made annually. These changes not only affected RAMP's objectives and organizational structure, but the study area and study design as well. Potential sampling methods, sentinel species and reference lakes and streams were also evaluated during this period.

A Peer Review was funded by RAMP of its entire program in 2004. The review was conducted to ensure that the program is designed with a scientific basis and to ensure that predictions were measurable and had statistical validity. Based on the recommendations made by the Peer Review Team, RAMP is beginning implementations by starting with a review of all industry members Environmental Impact Assessment (EIA) predictions. Upon completion of the EIA review, RAMP Technical members can ensure that the program designs are the endpoint measurements suggested in the original EIA predictions.

The RAMP objectives evolved since its initiation with the revision of the program objectives in 2001 focused on "scientifically defensible" data collection that incorporate flexibility and technological advances into monitoring activities. In addition, the program was designed to work with other relevant, current and historical research and monitoring programs. This evolution of RAMP resulted in the following program objectives:

- to monitor aquatic environments in the oil sands area to detect and assess cumulative effects and regional trends;
- to collect scientifically defensible baseline and historical data to characterize variability in the oil sands area;
- to collect data against which predictions contained in EIAs can be verified;

- to collect data that may be used to satisfy the monitoring required by regulatory approvals of developments in the oil sands area;
- to recognize and incorporate traditional knowledge (including Traditional Ecological Knowledge and Traditional Land Use studies) into the monitoring and assessment activities;
- to communicate monitoring and assessment activities, results and recommendations to communities in the RMWB, regulatory agencies, environmental committees/organizations and other interested parties;
- to design and conduct various RAMP activities such that they have the flexibility to be adjusted, on review, to reflect monitoring results, technological advances and community concerns; and
- to seek co-operation with other relevant research and monitoring programs where practical, and generate interpretable results which can build on their findings and on those of historical programs.

The RAMP was designed as a long-term monitoring program that incorporated both traditional and scientific knowledge. Specific programs in RAMP were established each year by committees and subcommittees after consultation with industrial, Aboriginal, environmental and regulatory stakeholders and expert independent consultants. Through the years, the program included the following environmental monitoring in the Oil Sands Region:

- water quality and sediment in rivers;
- fish in rivers;
- benthic invertebrates in rivers and two lakes;
- water quality in wetlands and acid-sensitive lakes;
- aquatic vegetation; and
- hydrology and climate (monitoring began in 1995, but became a component of RAMP in 2000).

The RAMP study areas have evolved since its inception, with changes made to address new interest areas or development locations. The program now has a Regional Study Area (RSA) and a Focus Study Area. The RSA covers a large portion of northeastern Alberta and is consistent with the CEMA Water Working Group study area (i.e., the RMWB). The focus study area is located within the RSA boundary and includes watersheds where oil sands development was occurring or planned as well as areas downstream of those developments. The key watercourses or waterbodies within the RAMP study area include:

- the Athabasca River and Peace Athabasca delta;

- tributaries to the Athabasca River including the Steepbank, Muskeg, MacKay, Ells, Tar, Calumet, Firebag and Christina rivers as well as Poplar, Donald, McLean and Fort creeks;
- Shipyard, Isadore's, Kearl and McClelland lakes; and
- Acid-sensitive lakes in northeastern Alberta.

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8 GLOSSARY

Alberta Environment (AENV)	Provincial ministry that looks after the following: establishes policies, legislation, plans, guidelines and standards for environmental management and protection; allocates resources through approvals, dispositions and licenses, and enforces those decisions; ensure water infrastructure and equipment are maintained and operated effectively; and prevents, reduces and mitigates floods, droughts, emergency spills and other pollution-related incidents.
Alberta Sustainable Resource Development (ASRD)	Alberta Sustainable Resource Development (ASRD) is one of the Alberta Ministries whose mission is to encourage balanced and responsible use of Alberta's natural resources through the application of leading practices in management, science and stewardship. ASRD works with Albertans across the province to ensure a balance between the economic, environmental and social values of our province. They fight forest fires, manage fish and wildlife, oversee the development of Alberta's forests, and manage the use of public lands.
Benthic Invertebrates	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their life stages dwelling on bottom sediments in the waterbody. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.
Biodiversity	The variety of plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected.
Biotic	The living organisms in an ecosystem.

Bitumen A highly viscous, tarry, black hydrocarbon material having an API gravity of about 9 (specific gravity about 1.0). It is a complex mixture of organic compounds. Carbon accounts for 80 to 85% of the elemental composition of bitumen, hydrogen 10%, sulphur 5%, and nitrogen, oxygen and trace elements form the remainder.

Bog Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks.

Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.

Borrow Pit A bank or pit from which earth is taken for use in filling or embanking. Often used in the construction of roads.

Carnivore Any of an order of mammals that feed chiefly on flesh or other animal matter rather than plants.

Ecosystem An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.

Fen Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters. Minerotropic peat-forming wetlands that receive surface moisture from precipitation and groundwater. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.

Fragmentation The process of breaking into pieces or sections. For example, dividing contiguous tracts of land into smaller and less connected sections through site clearing (e.g., for roads).

Groundwater That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.

Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Hydrogeology	The study of the factors that deal with subsurface water (groundwater) and the related geologic aspects of surface water. Groundwater as used here includes all water in the zone of saturation beneath the earth's surface, except water chemically combined in minerals.
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.
Local Study Area (LSA)	Defines the spatial extent directly or indirectly affected by the project.
Oil Sands Region	The Oil Sands Region includes the Fort McMurray – Athabasca Oil Sands Subregional Integrated Resource Plan (IRP), the Lakeland Subregional IRP and the Cold Lake – Beaver River Subregional IRP.
Receptor	The person or organism subjected to exposure to chemicals or physical agents.
Regional Aquatics Monitoring Program (RAMP)	RAMP was established to determine, evaluate and communicate the state of the aquatic environment in the Athabasca Oil Sands Region.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Risk	The likelihood or probability that the toxic effects associated with a chemical or physical agent will be produced in populations of individuals under their actual conditions of exposure. Risk is usually expressed as the probability of occurrence of an adverse effect, i.e., the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to the factor. Risk is expressed as a fraction without units and takes values from 0 (absolute certainty that there is no risk, which can never be shown) to 1.0, where there is absolute certainty that a risk will occur.

Runoff The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.

Sediment Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope soil characteristics, land usage and quantity and intensity of precipitation.

Sentinel Species Species that can be used as an indicator of environmental conditions.

Species A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.

Steam Assisted Gravity Drainage (SAGD) An in-situ oil sands recovery technique that involves the use of two horizontal wells, one to inject steam and a second to produce the bitumen.

Traditional Environmental (or Ecological) Knowledge (TEK) Knowledge and understanding of traditional resource and land use, harvesting and special places.

Traditional Land Use (TLU) Activities involving the harvest of traditional resources such as hunting and trapping, fishing, gathering medicinal plants and travelling to engage in these activities. Land use maps document locations where the activities occur or are occurring.

Watercourse A general term that refers to riverine systems such as creeks, brooks, streams and rivers.

Wetlands Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or “peatlands,” and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

Wildlife

Under the *Species at Risk Act*, wildlife is defined as a species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus that is wild by nature and is native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.

9 ABBREVIATIONS

ABMI	Alberta Biodiversity Monitoring Institute (formerly the ABMP)
ABMP	Alberta Biodiversity Monitoring Program
ACC	Alberta Caribou Committee
AENV	Alberta Environment
AGP	Above Ground Pipelines
ANOVA	Analysis of Variance
AOSCHEAP	Alberta Oil Sands Community Exposure and Health Effects Assessment Program
ASRD	Alberta Sustainable Resource Development
ATC/ARD	Athabasca Tribal Council/Athabasca Resource Developers
CEMS	Continuous Emissions Monitoring System
CLTP	Christina Lake Thermal Project
CPP	Caribou Protection Plan
C&R	Conservation and Reclamation
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
ENCANA	EnCana FCCL Ltd.
ENGO	Environmental non-Governmental Organizations
EPEA	Alberta *Environmental Protection and Enhancement Act*
FWMIS	Fish and Wildlife Management Information System
H_2S	Hydrogen sulphide
HEMC	Human Exposure Monitoring Committee of the Wood Buffalo Environmental Association
IBI	Index of Biological Integrity
LSA	Local Study Area
NSWMWG	NO_x/SO_2 Management Working Group
NO_2	Nitrogen dioxide (gas)
ORP	Oxidation Reduction Potential
RAC	Reclamation Advisory Committee
RAMP	Regional Aquatics Monitoring Program
RIWG	Regional Issues Working Group
RSA	Regional Study Area
RWG	Reclamation Working Group of CEMA
ROW	Rights-of-way

SAGD	Steam Assisted Gravity Drainage
SAOP	Southern Athabasca Oil Sands Producers
SEWG	Sustainable Ecosystems Working Group of CEMA
SO_2	Sulphur dioxide
TDS	Total Dissolved Solids
TEEM	Terrestrial Environmental Effects Monitoring Program of WBEA
TOC	Total Organic Carbon
TSS	Total Suspended Solids
WBEA	Wood Buffalo Environmental Association

APPENDIX 2-VII

REGIONAL DEVELOPMENTS

THIS DOCUMENT HAS NOT BEEN PRINTED.
IT IS PROVIDED ON THE "CHRISTINA LAKE THERMAL EXPANSION PROJECT, PHASES 1E, 1F AND 1G" COMPACT DISK ENCLOSED.

APPENDIX 2-VII

REGIONAL DEVELOPMENTS

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LIST OF TABLES

1 INTRODUCTION

This appendix provides information on developments located within the region of EnCana FCCL Ltd.'s (EnCana's) Christina Lake Thermal Expansion Project, Phases 1E, 1F and 1G (the Project). This information is provided to aid reviewers in comparing the scale of the Project to other developments in the region. For the purpose of this appendix, the region has been defined as the boundaries of the air modelling domain used in the assessment, as it is the largest spatial boundary considered in the Environmental Impact Assessment (EIA).

The types of developments presented in this appendix include oil sands developments, gas plants and compressor stations, and other developments including aggregate resources, communities, forestry, pipelines and roadways. Existing linear disturbances less than 10 m in width (e.g., seismic lines) are not presented in this appendix.

Information on these developments was gathered from permitting applications, EIAs, internet sites and media releases.

Sections 2 to 4 provide the following information on each of the regional developments:

- relevant information on the type of operation or operations;
- the existing and/or approved production (in either barrels of bitumen or barrels of synthetic crude oil);
- disturbance footprint; and
- common project air emissions (e.g., sulphur dioxide [SO_2] and oxides of nitrogen [NOx]).

2 OIL SANDS DEVELOPMENTS

2.1 ALBIAN SANDS ENERGY INC.

Albian Sands Energy Inc. (Shell Canada Energy, Chevron Canada Resources and Western Oil Sands) is the operator of the following projects:

- Muskeg River Mine; and
- Muskeg River Mine Expansion Project.

These projects are located in the western portion of Lease 13, 30 and 90, about 75 km north of Fort McMurray. The Muskeg River Mine Projects include open pit truck and shovel mining as well as extraction and utilities operations. Bitumen product is shipped via pipeline to an upgrading facility (Scotford) near Fort Saskatchewan, Alberta. The Muskeg River Mine started production in 2002. The Muskeg River Mine Expansion Project was approved in 2007.

Albian Sands production is provided in Table 1, disturbance areas in Table 2 and air emissions in Table 3.

Table 1 Albian Sands Production

Component	Status	Capacity[a] [bpd]
Muskeg River Mine	existing/approved	155,000
Muskeg River Mine Expansion Project	approved	115,000
Total		**270,000**

[a] Bitumen production.

Table 2 Albian Sands Disturbance Areas

Component	Status	Disturbance [ha]
Muskeg River Mine	existing/approved	4,385
Muskeg River Mine Expansion Project	approved	8,135
Total		**12,520**

Table 3 Albian Sands Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Muskeg River Mine and Muskeg River Mine Expansion Project	0.61	0.61	31.68	27.03	1.61	26.80	0.13

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

2.2 CANADIAN NATURAL RESOURCES LIMITED

The Canadian Natural Resources Limited (Canadian Natural) oil sands operations include:

- Burnt Lake Project;
- Primrose North, South and Wolf Lake In-Situ Project;
- Horizon Oil Sands Project;
- Primrose East In-Situ Project; and
- Kirby Pilot Project (decommissioned).

The Canadian Natural Burnt Lake Project, and Primrose North, South and Wolf Lake projects are located in the Cold Lake Air Weapons Range (CLAWR). The Primrose East Project, which was approved in early 2007, will be fully integrated with the existing Primrose and Wolf Lake operations. The Canadian Natural Horizon Oil Sands Project is located on Oil Sands Leases 6, 7, 10 and 18, about 15 km north of the community of Fort McKay, on the west side of the Athabasca River. Canadian Natural started construction of the Horizon Project in 2004, with commissioning and initial production scheduled for 2008. Full target production is targeted for 2011. The Kirby Pilot Project is located 88 km northeast of Lac La Biche and has been decommissioned.

Canadian Natural production is provided in Table 4, disturbance areas in Table 5 and air emissions in Table 6.

Table 4 Canadian Natural Production

Component	Status	Capacity[a] [bpd]
Burnt Lake Project	existing	900
Primrose North, South and Wolf Lake In-Situ Project	existing	88,000
Primrose East In-Situ Project	approved	32,000
Horizon Oil Sands Project	approved	270,000
Kirby Pilot Project (decommissioned)	existing	0
Total		**390,900**

(a) Bitumen production.

Table 5 Canadian Natural Disturbance Areas

Component	Status	Land Disturbance [ha]
Burnt Lake Project	existing	457
Primrose North, South and Wolf Lake In-Situ Project	existing	1,288
Primrose East In-Situ Project	approved	7,218
Horizon Oil Sands Project	existing	17,317
Kirby Pilot Project (decommissioned)	existing	11
Total		**26,291**

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

Table 6 Canadian Natural Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Burnt Lake Project	0.30	0.30	0.27	0.23	0.02	0.01	0.00
Primrose East Project	2.00	2.00	2.56	2.06	0.19	0.14	0.01
Primrose North Project	2.00	2.00	2.88	1.64	0.15	0.11	0.01
Primrose South Project	3.35	3.35	5.07	3.07	0.27	0.17	0.02
Wolf Lake Project	3.35	3.35	2.02	1.24	0.11	0.11	0.04
Horizon Project	7.63	12.70	48.67	33.44	2.31	157.28[b]	2.31[b]
Total	**18.63**	**23.70**	**61.47**	**41.68**	**3.04**	**157.83**	**2.38**

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

(b) VOC and TRS emissions include the maximum daily emissions from tailings ponds. Variable emission rates were used for the tailings ponds as detailed in Section 4 of Appendix 3-I.

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

2.3 CONNACHER OIL AND GAS LTD.

Connacher Oil and Gas Ltd. (Connacher) began development of the Great Divide Project following approval in June 2006. The Great Divide Project is located near Conklin, about 80 km southwest of Fort McMurray. The Great Divide project is expected to produce 10,000 bpd of bitumen by Q3 2009. Initial development is located west of Highway 63, with future plans to develop east of the highway.

Connacher production is provided in Table 7, disturbance area in Table 8 and air emissions in Table 9.

Table 7 Connacher Production

Component	Status	Capacity [bpd]
Great Divide Project	approved	10,000[a]

[a] Bitumen production.

Table 8 Connacher Disturbance Area

Component	Status	Land Disturbance [ha]
Great Divide Project	approved	26,509[a]

[a] Represents lease area as exact footprint not determined at this time.

Table 9 Connacher Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Great Divide Project	0.40	0.40	0.45	0.40	0.04	0.03	0.00

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

2.4 CONOCOPHILLIPS CANADA

The ConocoPhillips Canada (ConocoPhillips) Surmont Commercial Steam Assisted Gravity Drainage (SAGD) Project is located about 60 km southeast of Fort McMurray. The Surmont Project began construction in 2004, following regulatory approvals in 2003. The project life is anticipated to be 30 years with peak production in 2016.

ConocoPhillips production is provided in Table 10, disturbance area in Table 11 and air emissions in Table 12.

Table 10 ConocoPhillips Production

Component	Status	Capacity [bpd]
Surmont Commercial SAGD	existing/approved	110,000[a]

[a] Bitumen production.

Table 11 ConocoPhillips Disturbance Area

Component	Status	Disturbance [ha]
Surmont Pilot and Commercial SAGD	existing/approved	1,800

Table 12 ConocoPhillips Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Surmont Pilot Project	0.16	0.16	0.08	0.08	0.01	0.01	0.00
Surmont Commercial Project	1.00	1.00	4.86	5.06	0.37	0.33	0.00
Total	**1.16**	**1.16**	**4.94**	**5.14**	**0.38**	**0.34**	**0.00**

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

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

2.5 DEVON CANADA CORPORATION

The Devon Canada Corporation (Devon) operates the Jackfish SAGD Project located about 15 km east of Conklin, and the project is anticipated to have a 20-year operational life. The Jackfish Project was approved by regulators in 2004.

The Jackfish 2 SAGD Project, (J2) located adjacent to the initial Jackfish SAGD Project, received regulatory approval in 2008. Once fully operational in 2012, the J2 project is anticipated to produce an additional 35,000 barrels per day (5,565 m3/d), or more, of bitumen for twenty years. Total recoverable reserves for J2 are estimated at over 300 million barrels.

Devon production is provided in Table 13, disturbance areas in Table 14 and air emissions in Table 15.

Table 13 Devon Production

Component	Status	Capacity[a] [bpd]
Jackfish SAGD Project	existing	35,000
Jackfish 2 SAGD Project	approved	35,000
Total		**70,000**

[a] Bitumen production.

Table 14 Devon Disturbance Areas

Component	Status	Disturbance [ha]
Jackfish SAGD Project	existing	238
Jackfish 2 SAGD Project	approved	1,904
Total		**2,142**

Table 15 Devon Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Jackfish SAGD Project	2.00	2.00	2.17	1.39	0.13	0.09	0.00
Jackfish 2 SAGD Project	2.00	2.00	2.17	1.39	0.13	0.11	0.00
Total	**4.00**	**4.00**	**4.33**	**2.78**	**0.25**	**0.20**	**0.00**

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

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

2.6 ENCANA FCCL LTD.

The EnCana oil sands operations include:

- Foster Creek Pilot;
- Foster Creek Thermal Project Phases 1A to 1E; and
- Christina Lake Thermal Project Phases 1A to 1D.

The EnCana Foster Creek and Christina Lake thermal projects are SAGD developments located south of Fort McMurray in areas near Conklin, Alberta and in the CLAWR.

EnCana production is provided in Table 16, disturbance areas in Table 17 and air emissions in Table 18.

Table 16 EnCana Production

Component	Status	Capacity[a] [bpd]
Foster Creek Pilot	existing	3,000
Foster Creek Thermal Project Phases 1A to 1E	existing	120,000
Christina Lake Thermal Project Phases 1A to 1D	existing/approved	98,800
Total		**221,800**

[a] Bitumen production.

Table 17 EnCana Disturbance Areas

Component	Status	Disturbance [ha]
Foster Creek Pilot	existing	317
Foster Creek Thermal Project Phases 1A to 1E	existing	515
Christina Lake Thermal Project Phases 1A to 1D	existing	1,362
Total		**2,194**

Table 18 EnCana Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Foster Creek Pilot Project	0.24	0.24	0.39	0.18	0.02	0.02	0.00
Foster Creek Thermal Project Phases 1A to 1E	2.71	2.71	5.55	9.95	0.38	0.63	0.00
Christina Lake Thermal Project Phases 1A to 1D	2.82	2.85	3.34	3.02	0.27	0.21	0.03
Total	**5.77**	**5.79**	**9.28**	**13.15**	**0.67**	**0.86**	**0.03**

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

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

2.7 HUSKY ENERGY INC.

The Husky Energy Inc. (Husky) oil sands operations include:

- Tucker Thermal Project;
- Sunrise Thermal Project; and
- Caribou Lake Thermal Demonstration Project.

The Husky Tucker Thermal Project is located in the Cold Lake area south of the Imperial Oil Resources Limited (Imperial Oil) Cold Lake In-Situ Project. The Tucker Thermal Project is expected to start with four well pads, with up to 12 well pairs per well pad. Husky expects that up to eight additional well pads may be required over the 35-year project life.

The Husky Sunrise Thermal Project is on leases located about 5 km south of Kearl Lake, which is about 60 km northeast of Fort McMurray. The Sunrise Project will use SAGD technology to develop the resource, with planned production to start in 2010 to 2012.

The Caribou Lake Thermal Project is located approximately 70 km north west of Cold Lake. The Caribou Lake Thermal Project contains 2.5 million barrels of discovered resource in the Clearwater sands deposits and may be developed with established techniques, such as simulations use of SAGD and Cyclic Steam Stimulation (CSS) processes. The start-up date for the Caribou Lake Thermal Project is still to be determined.

Husky production is provided in Table 19, disturbance areas in Table 20 and air emissions in Table 21.

Table 19 Husky Production

Component	Status	Capacity[(a)] [bpd]
Tucker Thermal Project	existing	30,000
Sunrise Thermal Project	approved	200,000
Caribou Lake Thermal Project	approved	10,000
Total		**240,000**

(a) Bitumen production.

Table 20 Husky Disturbance Areas

Component	Status	Disturbance [ha]
Tucker Thermal Project	existing	288
Sunrise Thermal Project	approved	534
Caribou Lake Thermal Project	approved	198
Total		**1,020**

Table 21 Husky Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_x [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Baseline Case							
Tucker Thermal Project	1.20	1.20	1.44	0.42	0.14	0.12	0.00
Sunrise Thermal Project	1.18	1.18	6.61	20.56	0.00	0.19	0.00
Caribou Lake Thermal Project	0.91	0.91	0.66	0.47	0.04	0.03	0.00
Total	**3.29**	**3.29**	**8.72**	**21.45**	**0.18**	**0.34**	**0.00**

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

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

2.8 IMPERIAL OIL RESOURCES LIMITED

Oil sands operations for Imperial Oil include:

- Cold Lake In-Situ Project;
- Nabiye and Mahihkan North Expansion; and
- Imperial Oil Resources Ventures Limited's Kearl Oil Sands Project – Mine Development.

Imperial Oil received approval for its Cold Lake In-Situ Project in 1983. Additional approvals followed for the Muskwa development area, the Mahihkan development area and the Leming Plant and field facilities. All Imperial Oil Cold Lake facilities are currently operational with approximately 2,500 active wells.

Imperial Oil received regulatory approval in 2004 to expand its heavy oil operations near Cold Lake with the development of the Nabiye and Mahihkan North areas of the existing Cold Lake leases. The developments will occur over the next 5 to 10 years and will result in an increase in production of 30,000 bpd from the Cold Lake facility. The Nabiye and Mahihkan North developments will include construction of new well pads, steam-generating equipment, bitumen processing and water treatment facilities.

The Kearl Oil Sands Project (Kearl Project) will be centred on Lease 36, north of Kearl Lake. The Kearl Project will include a truck and shovel mining. Initial production from the Kearl Project is planned for 2010.

Imperial Oil production is provided in Table 22, disturbance areas in Table 23 and air emissions in Table 24.

Table 22 Imperial Oil Production

Component	Status	Capacity[a] [bpd]
Cold Lake In-Situ Project	existing	126,000
Nabiye and Mahihkan North Expansion	existing/approved	30,000
Kearl Oil Sands Project	approved	300,000
Total		**456,000**

[a] Bitumen production.

Table 23 Imperial Oil Disturbance Areas

Component	Status	Disturbance [ha]
Cold Lake In-Situ Project	existing	2,986
Nabiye Expansion	approved	417
Mahihkan North Expansion	existing/approved	423
Kearl Oil Sands Project	approved	21,179
Total		**25,005**

Table 24 Imperial Oil Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Cold Lake In-Situ Project, Nabiye Expansion and Mahihkan North Expansion	18.56	18.56	12.80	10.89	1.56	0.72	0.00
Kearl Oil Sands Project	0.67	0.67	42.68	28.60	1.97	156.69[b]	0.77[b]
Total	**19.23**	**19.23**	**55.47**	**39.49**	**3.52**	**157.41**	**0.77**

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

[b] VOC and TRS emissions include the maximum daily emissions from tailings ponds. Variable emission rates were used for the tailings ponds as detailed in Section 4 of Appendix 3-I.

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

2.9 JAPAN CANADA OIL SANDS LIMITED

The Japan Canada Oil Sands Limited (JACOS) Hangingstone In-Situ Pilot Project is located southwest of Fort McMurray.

JACOS production is provided in Table 25, disturbance areas in Table 26 and air emissions in Table 27.

Table 25 JACOS Production

Component	Status	Capacity [bpd]
Hangingstone In-Situ Pilot	existing	11,000[a]

[a] Bitumen production.

Table 26 JACOS Disturbance Area

Component	Status	Disturbance [ha]
Hangingstone In-Situ Pilot Project	existing	420

Table 27 JACOS Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Hangingstone In-Situ Pilot Project	1.63	1.63	0.70	0.53	0.04	0.04	0.00

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

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

2.10 MEG ENERGY CORP.

MEG Energy Corp. (MEG) currently operates a SAGD pilot on its oil sands leases located between Conklin and Janvier, south of Fort McMurray. MEG is currently constructing the commercial phase of their SAGD operations (25,000 bpd) and expect to commission the facility in the first quarter of 2009.

MEG's existing and approved oil sands projects include:

- Christina Lake Regional Project – Pilot 1;
- Christina Lake Regional Project – Phase 2; and
- Christina Lake Regional Project – Phase 2B.

MEG production is provided in Table 28, disturbance areas in Table 29 and air emissions in Table 30.

Table 28 MEG Oil Sands Production for Planned Developments

Component	Status	Capacity[a] [bpd]
Christina Lake Regional Project – Pilot 1	existing	3,000
Christina Lake Regional Project – Phase 2	approved	22,000
Christina Lake Regional Project – Phase 2B	approved	35,000
Total		**60,000**

[a] Bitumen production.

Table 29 MEG Disturbance Areas

Component	Status	Disturbance [ha]
Christina Lake Regional Project – Phase 1	existing	5
Christina Lake Regional Project – Phase 2	approved	273
Christina Lake Regional Project – Phase 2B	approved	24
Total		**302**

Table 30 MEG Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Christina Lake Regional Project – Phase 1	0.00	0.00	0.21	0.19	0.02	0.01	0.00
Christina Lake Regional Project – Phase 2, 2B	1.53	1.53	5.98	4.14	0.35	0.20	0.02
Total[b]	**1.53**	**1.53**	**6.19**	**4.33**	**0.37**	**0.22**	**0.02**

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

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

2.11 OPTI CANADA INC. AND NEXEN CANADA LTD.

The OPTI Canada Inc. and Nexen Canada Ltd. (OPTI/Nexen) Long Lake Pilot and Commercial Project is located 40 km southeast of Fort McMurray and 8 km southeast of Anzac. The projects include an in-situ bitumen recovery operation, on-site upgrading operations including gasification facilities to convert upgrader by-products to syngas, and cogeneration facilities to use the syngas to produce steam and power.

The OPTI/Nexen production is provided in Table 31, disturbance areas in Table 32 and air emissions in Table 33.

Table 31 OPTI/Nexen Production

Component	Status	Capacity [bpd]
Long Lake Pilot Project	existing	72,000[a]
Long Lake Commercial Project	approved	140,000[b]

[a] Bitumen production.

[b] Synthetic crude oil.

Table 32 OPTI/Nexen Disturbance Area

Component	Status	Disturbance [ha]
Long Lake Pilot and Commercial Project	existing/approved	883

[a] Represents lease area as exact footprint not determined at this time.

Table 33 OPTI/Nexen Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Baseline Case							
Long Lake Pilot Project	0.15	0.15	0.50	0.27	0.02	0.03	0.00
Long Lake Commercial Project	13.63	18.42	10.93	8.95	0.73	2.48	0.11
Total[b]	**13.78**	**18.57**	**11.43**	**9.22**	**0.75**	**2.51**	**0.11**

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

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

2.12 PETROBANK ENERGY AND RESOURCES

Petrobank Energy and Resources Ltd. (Petrobank), received approval for the Whitesands Pilot Project in early 2004. The Whitesands Pilot Project is located on 42 sections of oil sands leases near Conklin, Alberta.

The Whitesands Pilot Project will be the first in the region to develop a field scale test of the patented Toe-to-Heel-Air-Injection (THAI) heavy oil recovery technology. The in-situ technology combines a vertical air injection well with a horizontal production well.

Petrobank production is provided in Table 34, disturbance area in Table 35 and air emissions in Table 36.

Table 34 Petrobank Production

Component	Status	Capacity [bpd]
Whitesands Pilot Project and Whitesands Project Expansion	existing	1,900[a]

[a] Bitumen production.

Table 35 Petrobank Disturbance Area

Component	Status	Disturbance [ha]
Whitesands Pilot Project	existing	78

Table 36 Petrobank Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Baseline Case							
Whitesands Pilot Project	2.00	2.00	0.20	9.22	0.14	0.05	0.02

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

2.13 PETRO-CANADA

The Petro-Canada oil sands developments included in the assessment are:

- Dover SAGD and VAPEX Pilots;
- MacKay River In-Situ Project; and
- Meadow Creek In-Situ Project.

The Dover SAGD Pilot and VAPEX Pilot are two Petro-Canada projects that are being decommissioned. Petro-Canada has two approved SAGD developments, one of which is currently operational. The MacKay River development is currently ramping up to production of 30,000 bpd. The recently approved Meadow Creek Project has a planned production of up to 80,000 bpd of bitumen.

Petro-Canada production is provided in Table 37, disturbance areas in Table 38 and air emissions in Table 39.

Table 37 Petro-Canada Production

Component	Status	Capacity [bpd]
Dover SAGD and VAPEX Pilots	existing	999[a][b]
MacKay River In-Situ	existing	33,000[a]
Meadow Creek In-Situ	approved	80,000[a]
Total		**113,999**[a]

(a) Bitumen production.

(b) Production from pilots is variable, with integration of the facilities into the MacKay River Project being planned.

Table 38 Petro-Canada Disturbance Areas

Component	Status	Disturbance [ha]
Dover SAGD and VAPEX Pilots	existing	22
MacKay River In-Situ	existing	152
Meadow Creek In-Situ	approved	1,629
Total		**1,803**

Table 39 Petro-Canada Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Baseline Case							
Dover SAGD and VAPEX Pilot[b]	0.50	0.50	0.33	0.12	0.02	0.01	0.00
MacKay River In-Situ	1.00	1.00	5.01	4.45	0.19	0.44	0.00
Meadow Creek In-Situ	1.48	1.48	7.18	5.62	0.48	0.24	0.00
Total	2.98	2.98	12.52	10.19	0.69	0.69	0.00

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

(b) Emissions from the Dover SAGD Pilot project include emissions from the VAPEX Pilot project, which is an amendment to the Dover SAGD Pilot.

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

2.14 PETRO-CANADA OIL SANDS INC. (FORMERLY FORT HILLS ENERGY CORPORATION)

Petro-Canada Oil Sands Inc. (formerly Fort Hills Energy Corporation [Fort Hills]) is a partnership among Petro-Canada, UTS Energy Corporation and Teck Cominco Ltd. The Fort Hills Project, which is located about 90 km north of Fort McMurray in an area north of the Syncrude Aurora North Mine, was approved in October 2002.

The Fort Hills Project includes land development in association with its open pit mining operations and associated infrastructure, truck and shovel open pit mining operation, water withdrawal from the Athabasca River and air emissions associated with facility operations and the mining fleet.

The Fort Hills Project production is provided in Table 40, disturbance areas in Table 41 and air emissions in Table 42.

Table 40 Petro-Canada Oil Sands Inc. (Fort Hills) Production

Component	Status	Capacity [bbl/d]
Fort Hills Oil Sands Project	approved	190,000[a]

[a] Bitumen production.

Table 41 Petro-Canada Oil Sands Inc. (Fort Hills) Disturbance Area

Component	Status	Disturbance [ha]
Fort Hills Oil Sands Project	approved	12,584

Table 42 Petro-Canada Oil Sands Inc. (Fort Hills) Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_x [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Fort Hills Oil Sands Project	1.73	1.73	26.74	5.24	0.72	15.14	0.00

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

2.15 SHELL CANADA LIMITED

The Shell Canada Limited (Shell) developments include the Jackpine Mine – Phase 1 operation, which is located in the eastern portion of Lease 13. Commissioning and start up of the Jackpine Mine – Phase 1 plant is planned for 2010, with a planned production rate of 200,000 bpd.

In July 2006, Shell acquired BlackRock Ventures Inc. and is currently developing the Orion Environmental and Operating Renewal (EOR) Project, an in-situ project located near Hilda Lake. The Orion EOR project will be developed in two phases over a 25-year project life.

Shell production is provided in Table 43, disturbance areas in Table 44 and air emissions in Table 45.

Table 43 Shell Production

Component	Status	Capacity[a] [bpd]
Jackpine Mine – Phase 1	approved	200,000
Orion EOR Project	existing/approved	20,000
Total		**220,000**

[a] Bitumen production.

Note: Planned production across the Athabasca Oil Sands Project is to achieve 770,000+ bpd.

Table 44 Shell Disturbance Areas

Component	Status	Disturbance [ha]
Jackpine Mine – Phase 1	approved	8,154
Orion EOR Project	existing/approved	77
Total		**8,231**

Table 45 Shell Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Baseline Case							
Jackpine Mine – Phase 1	0.33	0.33	18.33	12.29	0.87	18.14	0.14
Orion EOR Project	0.90	0.90	1.26	0.41	0.10	0.09	0.00
Total	1.23	1.23	19.59	12.70	0.96	18.23	0.14

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

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

2.16 STATOILHYDRO CANADA

StatoilHydro Canada (StationHydro) operates 1,110 km^2 of oil sands leases. Production for the StatoilHydro Leismer Demonstration Project is planned for late 2009/early 2010.

The project entails production from 22 horizontal well pairs linked to four well pads using SAGD.

StatoilHydro production is provided in Table 46, disturbance areas in Table 47 and air emissions in Table 48.

StatoilHydro Canada took over North American Oil Sands Corp. in 2007. North American publicly disclosed the Kai Kos Dehseh SAGD Project located approximately 75 km south of Fort McMurray in 2006, with application made for a demonstration project. StatoilHydro received approval in 2007 for the Leismer Demonstration Project and applied in March 2008 for the commercial project.

Statoil Hydro production is provided in Table 46, disturbance areas in Table 47 and air emissions in Table 48.

Table 46 StatoilHydro Production

Component	Status	Capacity[a] [bpd]
Leismer Demonstration Project	existing	10,000

[a] Bitumen production.

Table 47 StatoilHydro Disturbance Area

Component	Status	Disturbance [ha]
Leismer Demonstration Project	existing	4,464

Table 48 StatoilHydro Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Leismer Demonstration Project	0.91	0.91	1.04	0.06	0.08	0.06	0.00

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

2.17 SUNCOR ENERGY INC.

The Suncor Energy Inc. (Suncor) oil sands developments include a combination of open pit mining and extraction operations, in-situ operations, upgrading operations and support infrastructure. Suncor oil sands developments include:

- Base Plant Upgrader;

- Millennium Upgrader including (the Millennium Coker Unit [MCU] and Millennium Vacuum Unit [MVU]);
- Voyageur Upgrader;
- Steepbank Mine;
- Millennium Mine (including Lease 86/17);
- South Tailings Pond;
- North Steepbank Mine Extension
- Fee Lot 2;
- Firebag Enhanced Thermal Solvent (ETS); and
- Firebag SAGD Project.

Suncor also co-operates a utilities plant with TransAlta on Lease 86/17. Suncor oil sands operations began in 1967. The Suncor oil sands base operation is located on opposite sides of the Athabasca River. The areas are connected by a bridge across the Athabasca River from the Lease 86/17 west-side operations to the Steepbank and Millennium mining operations on the east side of the Athabasca River. The Suncor Voyageur Project was approved in 2006, with construction starting early 2007

Suncor production is provided in Table 49, disturbance areas in Table 50 and air emissions in Table 51.

Table 49 Suncor Production

Component	Status	Capacity [bpd]
Suncor Lease 86/17 and Base Plant Upgrader, Steepbank and Millennium mines, and South Tailings Pond	existing/approved	360,000[(b)]
Firebag Operations (including Phases 4 to 6)	existing/approved	140,000[(a)]
Voyageur Project (North Steepbank Mine Extension and Voyageur Upgrader)	approved	190,000[(b)]
Total		**690,000**[(a)(b)]

(a) Bitumen production.

(b) Synthetic crude oil.

Table 50 Suncor Disturbance Areas

Component	Status	Disturbance [ha]
Suncor Lease 86/17 and Base Plant Upgrader, Steepbank and Millennium mines, and South Tailings Pond	existing/approved	18,429
Fee Lot 2	existing/approved	745
Firebag ETS and SAGD	existing/approved	1,322
Voyageur Project - North Steepbank Mine Extension	approved	3,787
Voyageur Project - Voyageur Upgrader	approved	1,004
Total		**25,287**

Table 51 Suncor Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Suncor Lease 86/17 and Base Plant Upgrader, Steepbank and Millennium mines, and South Tailings Pond	42.45	62.94	67.82	31.65	6.27	187.51[b]	2.15[b]
Firebag SAGD	6.27	6.45	21.83	16.74	1.47	0.98	0.10
Firebag ETS	0.17	0.17	0.21	0.12	0.01	0.03	0.00
Voyageur Project - North Steepbank Mine Extension	0.10	0.10	16.79	18.01	0.88	7.12	0.03
Voyageur Project - Voyageur Upgrader	6.88	14.34	6.11	5.01	0.44	1.27	0.05
Total	55.86	83.99	112.76	71.54	9.07	196.91	2.33

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

(b) VOC and TRS emissions include the maximum daily emissions from tailings ponds. Variable emission rates were used for the tailings ponds as detailed in Section 4 of Appendix 3-I.

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

2.18 SYNCRUDE CANADA LTD.

The Syncrude Canada Ltd. (Syncrude) operations include:

- Mildred Lake Mining and Extraction;
- Aurora North Mine;
- Aurora South Mine; and
- Mildred Lake Upgrader Expansion and Emissions Reduction Program (ERP).

The Syncrude operations include open pit mines, a utilities plant, a bitumen extraction plant and an upgrading facility that processes bitumen and produces light, sweet crude oil for domestic consumption and export. The Syncrude mining operation is now a truck and shovel operation. Production from the Syncrude operation began in 1978.

Syncrude production is provided in Table 52, disturbance areas in Table 53 and air emissions in Table 54.

Table 52 Syncrude Production

Component	Status	Capacity [bpd]
Syncrude Mildred Lake Mining and Extraction	existing/approved	220,000[(a)]
Aurora North Mine	existing/approved	195,000 [(a)]
Aurora South Mine	approved	195,000 [(a)]
Mildred Lake Upgrader Expansion and ERP	existing/approved	474,000[(b)]
Total		**610,000[(a)(b)]**

(a) Bitumen production.

(b) Synthetic crude oil.

Table 53 Syncrude Disturbance Areas

Component	Status	Disturbance [ha]
Mildred Lake Mining and Extraction	existing/approved	17,636[(a)]
Aurora North Mine	existing/approved	7,980
Aurora South Mine	approved	8,966
Mildred Lake Upgrader Expansion and ERP	existing/approved	n/a
Total		**34,582**

(a) Value represents original disturbance footprint without consideration of reclamation.

n/a = Not applicable.

Table 54 Syncrude Air Emissions

Component	Emission Rates[(a)]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Mildred Lake Mining Extraction, Upgrader and ERP	67.06	100.06	61.73	81.01	6.59	58.17	1.62
Aurora North Mine	0.04	0.04	15.48	3.74	0.56	7.90	0.06
Aurora South Mine	0.03	0.03	12.28	2.94	0.48	7.77	0.06
Total	**67.12**	**100.12**	**89.49**	**87.69**	**7.63**	**73.84**	**1.75**

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

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

2.19 TOTAL E&P JOSLYN LTD.

In late 2005, Total E&P Joslyn Ltd. (Total Joslyn) acquired Deer Creek Energy Limited. Total Joslyn now operates the Joslyn Creek SAGD Project located 65 km north of Fort McMurray, near Fort McKay. Joslyn Creek SAGD Phase 1 and Commercial began production in late 2006.

Total Joslyn production is provided in Table 55, disturbance areas in Table 56 and air emissions in Table 57.

Table 55 Total Joslyn Production

Component	Status	Capacity[(a)] [bpd]
Joslyn Creek SAGD Project - Phase I and Commercial	existing	12,000

(a) Bitumen production.

Table 56 Total Joslyn Disturbance Area

Component	Status	Disturbance [ha]
Joslyn Creek SAGD Project - Phase I and Commercial (Phase II)	existing	86

Table 57 Total Joslyn Air Emissions

Component	Emission Rates[(a)]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Joslyn Creek SAGD Project – Phase 1 and Commercial	0.74	0.74	0.51	0.48	0.04	0.04	0.00

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

3 GAS PLANTS AND COMPRESSOR STATIONS

Information is provided below on gas plants and compressor stations that were considered in the air quality assessment of the EIA.

3.1 CANADIAN NATURAL RESOURCES LIMITED

Information on Canadian Natural operations in the region is provided in Table 58.

Table 58 Summary of Canadian Natural Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Chard 1	0.00	0.00	0.14	0.01	0.00	0.00	0.00
Cowpar 1	0.50	0.50	0.46	0.04	0.00	0.01	0.00
Kettle River	0.60	0.60	0.03	0.00	0.00	0.00	0.00
Newby 1	1.08	1.08	0.06	0.00	0.00	0.00	0.00
Wiau Lake	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Kirby West	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Moose Hills	0.00	0.00	0.03	0.02	0.00	0.00	0.00
Elk Point	0.00	0.00	0.06	0.04	0.000	0.00	0.00
Chard 2	0.00	0.00	0.87	0.60	0.00	0.00	0.00
Chard 3	0.00	0.00	0.30	0.08	0.00	0.00	0.00
Cowpar 2	0.00	0.00	0.21	0.13	0.00	0.00	0.00
Cowpar 3	0.00	0.00	0.21	0.13	0.00	0.00	0.00
Newby 2	0.00	0.00	0.32	0.59	0.00	0.00	0.00
Rio Alto 1	0.00	0.00	0.14	0.02	0.00	0.00	0.00
Rio Alto 2	0.00	0.00	0.19	0.04	0.00	0.00	0.00
Rio Alto 3	0.00	0.00	0.09	0.02	0.00	0.00	0.00
Rio Alto 4	0.00	0.00	0.23	0.01	0.00	0.00	0.00
Rio Alto 5	0.00	0.00	0.21	0.05	0.00	0.00	0.00
Irish Creek	0.00	0.00	1.12	0.06	0.00	0.02	0.00
Kehiwin	0.00	0.00	0.48	0.03	0.00	0.01	0.00
Field Compressors1 to 13	0.00	0.00	0.98	0.08	0.00	0.03	0.00
Total	2.18	2.18	6.21	1.97	0.02	0.10	2.18

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

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

3.2 DEVON CANADA CORPORATION

Information on Devon operations in the region is provided in Table 59.

Table 59 Summary of Devon Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Hangingstone 1	0.00	0.00	1.15	0.09	0.00	0.03	0.00
Surmont 1	0.00	0.00	4.36	0.34	0.01	0.13	0.00
Surmont West	0.00	0.00	1.74	0.14	0.00	0.05	0.00
Pony Creek 1	0.00	0.00	0.11	0.01	0.00	0.00	0.00
Kirby North 1	0.00	0.00	0.04	0.14	0.00	0.00	0.00
Kirby South 1	0.00	0.00	0.74	0.06	0.00	0.02	0.00
Chard 1	0.00	0.00	0.30	0.02	0.00	0.01	0.00
Leismer East	0.00	0.00	3.01	0.23	0.01	0.09	0.00
Chard 2	0.00	0.00	0.17	0.03	0.00	0.00	0.00
Chard 3	0.00	0.00	0.23	0.03	0.00	0.00	0.00
Hangingstone 2	0.00	0.00	0.09	0.02	0.00	0.00	0.00
Kirby North 2	0.00	0.00	0.32	0.06	0.00	0.00	0.00
Kirby South 2	0.00	0.00	0.08	0.03	0.00	0.00	0.00
Kirby South 3	0.00	0.00	0.26	0.06	0.00	0.00	0.00
Kirby South 4	0.00	0.00	0.03	0.05	0.00	0.00	0.00
Leismer 1	0.00	0.00	0.04	0.10	0.00	0.00	0.00
Leismer 2	0.00	0.00	0.04	0.10	0.00	0.00	0.00
West Surmont 1	0.00	0.00	0.09	0.02	0.00	0.00	0.00
West Surmont 2	0.00	0.00	0.09	0.02	0.00	0.00	0.00
West Surmont 3	0.00	0.00	1.20	0.52	0.00	0.00	0.00
Total	0.00	0.00	14.09	2.07	0.03	0.34	0.00

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

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

3.3 ENCANA CORPORATION

Information on EnCana operations in the region is provided in Table 60.

Table 60 Summary of EnCana Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
North Caribou	0.00	0.00	0.86	2.31	0.13	0.02	0.00
South Caribou	0.00	0.00	0.66	1.45	0.07	0.02	0.00
Primrose North	0.00	0.00	0.83	0.19	0.02	0.02	0.00
Field Compressors 1 to 25	0.00	0.00	3.44	0.27	0.01	0.10	0.00
Compressor Engine 1	0.00	0.00	0.11	0.02	0.00	0.00	0.00
Compressor Engine 2	0.00	0.00	0.11	0.02	0.00	0.00	0.00
Total	0.00	0.00	6.01	4.26	0.23	0.17	0.00

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

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

3.4 HUSKY ENERGY INC.

Information on Husky operations in the region is provided in Table 61.

Table 61 Summary of Husky Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Agnes Lake	0.00	0.00	0.71	0.05	0.00	0.02	0.00
Thornbury	0.00	0.00	0.44	0.03	0.00	0.01	0.00
Compressor Engine	0.00	0.00	0.12	0.06	0.00	0.00	0.00
Total	0.00	0.00	1.27	0.15	0.00	0.03	0.00

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

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

3.5 PARAMOUNT

Information on Paramount operations in the region is provided in Table 62.

Table 62 Summary of Paramount Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Quigley	0.00	0.00	0.26	0.03	0.00	0.01	0.00
Hangingstone	0.00	0.00	0.20	0.02	0.00	0.01	0.00
Kettle River	0.00	0.00	0.23	0.04	0.00	0.01	0.00
Compressor Stations 1 to 9	0.00	0.00	1.92	0.93	0.00	0.01	0.00
Total	0.00	0.00	2.61	1.01	0.01	0.03	0.00

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

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

3.6 VIKING ENERGY

Information on Viking Energy operations in the region is provided in Table 63.

Table 63 Summary of Viking Energy Gas Plant Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Wappau	0.00	0.00	0.36	0.03	0.00	0.01	0.00
Chard	0.00	0.00	0.62	0.20	0.00	0.00	0.00
Compressor Station 1	0.00	0.00	0.18	0.04	0.00	0.00	0.00
Compressor Station 2	0.00	0.00	0.36	0.13	0.00	0.00	0.00
Total	**0.00**	**0.00**	**1.52**	**0.40**	**0.00**	**0.01**	**0.00**

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

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

3.7 SUNCOR

Information on Suncor operations in the region is provided in Table 64.

Table 64 Summary of Suncor Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Tweedie	0.00	0.00	1.50	0.35	0.00	0.00	0.00

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

3.8 OTHER GAS PLANT OPERATIONS

Information on other operations in the region are summarized in Table 65.

Table 65 Summary of Other Gas Plant Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
AltaGas John Lake North	0.00	0.00	0.58	0.13	0.00	0.05	0.00
AltaGas Compressor Stations 1 to 3	0.00	0.00	0.82	0.10	0.00	0.00	0.00
AltaGas Thornbury South	0.00	0.00	0.67	0.23	0.00	0.00	0.00
AltaGas Winefred North	0.00	0.00	1.11	0.27	0.00	0.00	0.00
BP St. Lina	0.00	0.00	0.91	0.13	0.00	0.05	0.00
BP Leismer	0.00	0.00	2.30	0.31	0.01	0.11	0.00
BP Amoco	0.00	0.00	3.96	0.09	0.00	0.00	0.00
BP Compressor Stations 1 to 5	0.00	0.00	0.47	0.22	0.00	0.00	0.00
BP Kirby South	0.00	0.00	4.24	1.67	0.01	0.01	0.00
BP Primrose/Kirby	0.00	0.00	0.39	0.36	0.00	0.00	0.00

Table 65 Summary of Other Gas Plant Air Emissions (continued)

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Ish Compressor	0.00	0.00	0.27	0.05	0.00	0.00	0.00
Northstar Frenman Lake	0.00	0.00	0.49	0.03	0.00	0.01	0.00
Northstar Compressor Stations 1 and 2	0.00	0.00	0.57	0.36	0.00	0.00	0.00
Talisman Compressor Station	0.00	0.00	0.17	0.01	0.00	0.00	0.00
Transwest Winefred South	0.00	0.00	1.27	0.30	0.00	0.00	0.00
Total	0.00	0.00	18.23	4.26	0.04	0.25	0.00

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

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

3.9 WILLIAMS LIQUIDS EXTRACTION AND STORAGE

In 2001 Williams built an olefins cryogenic liquids extraction facility near the Suncor Lease 86/17 operations. This project is known as the Hydrocarbon Liquids Conservation Project. This project recovers higher value natural gas liquids and olefins and transports them to processing facilities near Redwater where they are fractionated into products such as butane and propane.

Information on the Williams Liquids Extraction and Storage operations is provided in Table 66.

Table 66 Summary of Williams Energy Liquids Extraction and Storage Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Liquids Extraction and Storage Plant	0.00	0.00	0.02	0.02	0.00	0.24	0.00

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

4 OTHER DEVELOPMENTS

4.1 AGGREGATE RESOURCES

Birch Mountain Resources Ltd.

Birch Mountain Resources Ltd. (Birch Mountain) holds metallic and industrial mineral rights over an extensive portion of the Athabasca Valley. Birch Mountain received regulatory approval for its Muskeg Valley Quarry in June 2005. The quarry is located on the east side of the Athabasca River in an area east of Fort McKay.

The Muskeg Valley Quarry includes a truck and shovel waste rock and overburden operation, shovel and remote crushing operations for the limestone, sorting and washing operations as well as loading and weighing facilities. The project started operations in December 2005 and will operate through three phases until its anticipated closure in 2035.

Birch Mountain production is provided in Table 67 and air emissions are listed in Table 68.

Table 67 Birch Mountain Production

Component	Status	Peak Capacity [tonnes per year of limestone]
Muskeg Valley Quarry	existing	6,900,000

Table 68 Birch Mountain Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Muskeg Valley Quarry	0.02	0.02	0.88	0.30	0.05	0.05	0.00

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

4.2 COLD LAKE WEAPONS RANGE AND AIRFORCE BASE

The CLAWR and Airforce Base covers an area of 1.7 million hectares straddling the Alberta/Saskatchewan border. The Canadian Forces has used this site for an air weapons training base since 1954. Air emissions for the CLAWR are provided in Table 69.

Table 69 Cold Lake Weapons Range and Air Force Base Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Cold Lake Air Force Base	0.00	0.00	0.06	0.04	0.00	0.00	0.00
Cold Lake Weapons Range	0.53	0.53	9.99	40.19	0.21	0.14	0.00
Total	0.53	0.53	10.05	40.23	0.21	0.14	0.00

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

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

4.3 COMMUNITIES

The location and population of communities in the region are listed in Table 70. Emissions information for municipalities in the region are provided in Table 71.

Table 70 Summary of Communities in the Region

Community	Location	Population
Aznac	45 km southeast of Fort McMurray on Secondary Highway 881	714
Conklin	140 km southeast of Fort McMurray at the convergence of the Jackfish River and Christina Lake	299
Draper	a few km south of Fort McMurray	185
Fort Chipewyan	225 km north of Fort McMurray	1007
Fort Fitzgerald	200 km north of Fort Chipewyan	2
Fort McMurray[a]	450 km north of Edmonton	65,400
Fort McKay	55 km north of Fort McMurray on the west side of the Athabasca River	737
Gregoire Lake Estates	32 km southeast of Fort McMurray adjacent to Gregoire Lake Provincial Park, on the shores of Gregoire (Willow) Lake	248
Janvier	100 km southeast of Fort McMurray	178
Mariana Lake	along Highway 63, 100 km south of Fort McMurray	9
Saprae Creek	25 km southeast of Fort McMurray	737
Hinterland[b]	n/a	43
First Nations Reserves[c]	n/a	1,036

(a) The work camp, hotel/motel and campground population residing in Fort McMurray are included in the total.

(b) "Hinterland" means sparsely populated region outside of Urban and Rural Service Areas, and does not include First Nations Reserves, Work Camps and Campgrounds.

(c) Source: Department of Indian Affairs and Northern Development, First Nations Profiles Population Data as of June 2007.

n/a = Not applicable.

Source: RMWB (Regional Municipality of Wood Buffalo). 2007. *Municipal Census 2007.* Fort McMurray, AB.

Table 71 Summary of Air Emissions Information for Municipalities

Municipality	Emission Rates[a]			
	Stream-day SO_2[b] [t/sd]	Calendar-day SO_2[b] [t/cd]	NO_X[b] [t/d]	VOC [t/d]
Fort McMurray	0.26	0.26	1.69	4.87
Fort McKay	0.01	0.01	0.02	0.08
Anzac	0.01	0.01	0.02	0.06
Janvier	0.00	0.00	0.01	0.03
Conklin	0.00	0.00	0.01	0.02
Fort Chipewyan	0.01	0.01	0.03	0.10
Beaver Lake	0.00	0.00	0.01	0.03
Bonnyville	0.03	0.03	0.18	0.39
Canoe Lake	0.01	0.01	0.02	0.06
Cold Lake	0.07	0.07	0.34	0.75
Cold Lake (IR 149)	0.00	0.00	0.01	0.02
Cold Lake (IR 149B)	0.00	0.00	0.00	0.01
Elizabeth Métis Settlement	0.01	0.01	0.02	0.06
Heart Lake	0.00	0.00	0.00	0.01
Kehiwin	0.01	0.01	0.02	0.06
La Loche	0.01	0.01	0.05	0.16
Lac La Biche	0.02	0.02	0.08	0.18
Peter Pond	0.01	0.01	0.02	0.06
Pierceland	0.00	0.00	0.02	0.06
St. Paul	0.03	0.03	0.16	0.34
Total	0.47	0.47	2.70	7.34

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

(b) Community emissions for SO_2 and NO_X were used for regional predictions only. Predictions of exposure levels within communities used background concentrations to represent local sources of SO_2 and NO_X emissions, as discussed in Volume 3, Appendix 3-V.

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

4.4 FORESTRY

The majority of timber rights in the region have been granted to Alberta Pacific Forest Industries Inc. (Al-Pac) under a Forest Management Agreement (FMA). Al-Pac harvests coniferous timber under a joint planning agreement with Northland Forest Products Ltd, and is actively harvesting forest resources throughout the region. Forestry development plans are defined and detailed by Al-Pac in annual operating plans

Al-Pac has timber rights over a surface area of 17,958 ha.

Northland Forest Products operates a mill north of Fort McMurray. Air emissions from the mill are presented in Table 72.

Table 72 Northland Forest Products Air Emissions

Component	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Northland Forest Products	0.02	0.02	0.19	25.00	0.19	2.12	0.00

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

4.5 PIPELINES

Major pipeline operators in the region, a description of the pipeline product and the total disturbance area are listed in Table 73.

Table 73 Major Pipelines in the Region

Operator	Pipeline Product	Disturbance [ha]
Access Pipeline Inc.	low vapour pressure products	916
Alberta Oil Sands Pipeline Ltd.	crude oil	1,387
AltaGas Ltd.	natural and fuel gas	7,851
AltaGas Utilities Inc.	natural gas	2,053
ATCO Gas and Pipelines Ltd.	natural gas	1,761
Baytex Energy Ltd.	crude oil, natural gas, fuel gas, oil well effluent, and fresh and salt water	1,529
BlackRock Ventures Inc.	crude oil, natural gas, fuel gas, oil well effluent and low vapour pressure products	587
Bonavista Petroleum Ltd.	natural gas, fuel gas, oil well effluent and salt water	1,552
BP Canada Energy Company	natural gas, fuel gas, salt water and oil well effluent	4,810
Canadian Natural Resources Limited	crude oil, natural gas, fuel gas, oil well effluent, fresh and salt water, and low vapour pressure products	34,279
Canetic Resources Inc.	natural gas, oil well effluent and salt water	980
Cold Lake Pipeline Ltd.	crude oil, and high and low vapour pressure products	1,650
ConocoPhillips Canada Resources Corp.	crude oil, natural gas, fuel gas, oil well effluent, and fresh and salt water	2,665
County of Vermillion River Co-op	natural and fuel gas	897
Crescent Point Resources Ltd.	natural gas	501
Daylight Energy Ltd.	natural and fuel gas	669
Devon Canada Corporation	crude oil, natural gas, fuel gas, oil well effluent, and fresh and salt water	9,646
East Peace Gas Co-op Ltd.	natural gas	1,003
Enbridge Pipelines (Athabasca) Inc.	crude oil and low vapour pressure products	2,565
EnCana FCCL Ltd.	natural gas, fuel gas, oil well effluent, salt water and low vapour pressure products	537
EnCana Oil & Gas Co. Ltd.	natural gas, fuel gas, oil well effluent, salt water and low vapour pressure products	8,286
Galleon Energy Inc.	natural gas, fuel gas, salt water and oil well effluent	1,545
Harvest Operations Corp.	crude oil, natural gas and oil well effluent	2,023
Husky Oil Operations Limited	crude oil, natural gas, fuel gas, oil well effluent, high and low vapour pressure products, and fresh and salt water	15,052
Imperial Oil	crude oil, natural gas, fuel gas, oil well effluent, high and low vapour pressure products, and fresh and salt water	1,813
Invasion Energy Inc.	natural gas and salt water	1,102
Iteration Energy Ltd.	natural gas and salt water	821

Table 73 Major Pipelines in the Region (continued)

Operator	Pipeline Product	Disturbance [ha]
Keyera Energy Ltd.	crude oil, natural gas and salt water	1,282
MEG Energy Corp	natural gas, oil well effluent and salt water	802
North East Gas Co-op Ltd.	natural and fuel gas	530
North Peace Gas Co-op Ltd.	natural gas	1,008
Nova Gas Transmission Ltd.	crude oil and natural gas	17,344
Paramount Energy Operating Corp.	natural gas, fuel gas, oil well effluent and salt water	11,686
Penn West Petroleum Ltd.	crude oil, natural gas, oil well effluent and salt water	1,089
Primewest Energy Inc.	natural gas, and fresh and salt water	724
Rainbow Pipeline Company Ltd.	crude oil	792
Set Resources Inc.	natural gas	519
Suncor Energy Inc.	crude oil, natural gas, fuel gas, oil well effluent, high and low vapour pressure products, and fresh and salt water	2,444
Talisman Energy Inc.	crude oil, natural gas, fuel gas, and fresh and salt water	4,516
Terasen Pipelines (Corridor) Inc.	crude oil and low vapour pressure products	1,727
TransCanada Pipeline Ventures Ltd.	natural gas	665
True Energy Inc.	natural gas	600

4.6 ROADWAYS

The primary roadways in the region, their general locations and their disturbance footprint are listed in Table 74.

Table 74 Major Roadways in the Region

Roadway	General Location	Disturbance [ha]
MEG/EnCana Christina access road	runs from Secondary Highway 881 to Christina Lake	32
Secondary Highway 881	runs from Highway 63 south through the region	1,848
Highway 63/963	runs through the region south of Fort McMurray to the Lougheed Bridge near Fort McKay and then to its northern point at Bitumount	1,883
Fort Chipewyan Winter Road	access road to Fort Chipewyan	647
Canterra Road	runs from Highway 63 east turning south of Kearl Lake	194
Petro-Canada Access Road	gravel road from Highway 63 to the Petro-Canada and Dover SAGD developments	199
Canadian Natural Horizon Access Road	gravel road from Highway 63 to the Canadian Natural Horizon Project site	143

4.7 POWER LINES

The primary power lines in the region and their disturbance areas are listed in Table 75.

Table 75 Primary Power Lines in the Region

Power Line	Description	Disturbance [ha]
ATCO Dover-McMillan	240 kV transmission line between the Dover and McMillan power substations	1,314
ATCO McMillan-Charron	240 kV transmission line between the McMillian and Charron substations.	595
Dover-Muskeg River	260 kV transmission line, 53 km long to provide further transmission to the mining areas of northern Alberta and the population centres of the central and southern areas of Alberta	275
Firebag Transmission Line	double-circuit 260-kV transmission line, 2 km long that crosses the Athabasca River from Suncor's Millennium Substation to the new substation east of the Athabasca River	246

5 ABBREVIATIONS

Al-Pac	Alberta-Pacific Forest Industries Inc.
bpd	Barrels per day
CLAWR	Cold Lake Air Weapons Range
CO	Carbon monoxide
CSS	Cyclic Steam Simulation
EIA	Environmental Impact Assessment
EOR	Environmental and Operating Renewal
ERP	Emissions Reduction Program
ETS	Enhanced Thermal Solvent
FMA	Forest Management Agreement
ha	Hectare
J2	Jackfish 2 SAGD Project
JACOS	Japan Canada Oil Sands Limited (Hangingstone Project)
kV	Kilovolt
MCU	Millennium Coker Unit
MEG	MEG Energy Corp.
MVU	Millennium Vacuum Unit
NO_X	Oxides of nitrogen (NO, NO_2) (gas), or all nitrogen species (e.g., NO_X, N_2O, N_3O)
$PM_{2.5}$	Particulate matter with a mean aerodynamic diameter of 2.5 microns (µm) or smaller
RMWB	Regional Municipality of Wood Buffalo
SAGD	Steam Assisted Gravity Drainage
SO_2	Sulphur dioxide
t/cd	Tonnes per calendar day
t/d	Tonnes per day
t/sd	Tonnes per stream day
THAI	Toe-to-Heel-Air-Injection
TRS	Total Reduced Sulphur
VOC	Volatile Organic Compound